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Mortality Risk and Human Capital Investment: The Legacy of Landmines in Cambodia

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MORTALITY RISK AND HUMAN CAPITAL INVESTMENT: THE LEGACY OF LANDMINES IN CAMBODIA

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Abstract

Life expectancy plays a key role in determining households' optimal investment in children's human capital accumulation. This paper examines this relationship by looking at a unique case of Cambodia and the nation's prevalence of landmines. Extensive usage of landmines during its long civil conflict since the 1970s was followed by large international effort of landmine clearance operation. A two-fold increase in landmine clearance effort during the periods 2004-2005 in affected areas, has led to a subsequent sharp fall in landmine casualty rates. Together with the male-biased characteristic of landmine accidents, all three variations allow us to estimate the impact of working-age mortality risk on skill formation using a difference-in-difference-in-difference model. To deal with the unobservable, landmine casualty rates are also instrumented by the stock of dangerous land in neighbouring areas. We find a strong negative effect of landmine mortality on both schooling and health investment outcomes. When the mortality risk from such a fearful event as landmine accidents is replaced by a more common incident of traffic accidents, any mortality effect on schooling outcomes is no longer detected. This is evidence of a role played by subjective life expectation in optimal decision making on the households.

JEL: I10, I20, O15.

Keywords: Mortality Risk, Cambodia, Landmines, Human Capital Investment, Subjective Probability

1. Introduction

Earlier theoretical literature predicts that an increase in life expectancy raises the optimal level of human capital accumulation (Becker, 1964; Ben-Porath, 1967). Lower mortality is thought to raise the expected return to the investment by increasing the expected total lifetime productive gains from labour market and also the horizon over which the benefits from investments earlier in human capital can be enjoyed (e.g. Galor and Weil, 1999; Soares, 2005; De la Croix and Licandro, 1999; Cervellati and Sunde, 2005; Hazan, 2012). To test this theory, many empirical studies provide analysis investigating the relationship between mortality and education outcomes.

Using cross-country data in a context of comparative development, mortality is found not to be associated with higher education attainment in some studies (Acemoglu and Johnson, 2007; Lorentzen et al., 2008) whilst others (Bils and Klenow, 2000 and Manuelli and Seshadri, 2007) find a significant positive relationship. Beyond inclusive findings, statistical estimations using cross-sectional - data have proven difficult to pin down the causal relationship between life expectancy and human capital development.

Recent literature focuses on the circumstance of a specific health condition, which can pose an effect on mortality outside infancy, to investigate its role on household investments in their children. In a developing country context, many recent studies exploit regional variation in health conditions and identity causal effects of life expectancy on individual human capital development (e.g. Fortson, 2011 on HIV in African; Jayachandran and Lleras-Muney, 2009 on maternal mortality in Sri Lanka). Oster et al. (2013) and Stoler and Meltzer (2013) also find positive effect of individual-level impact of personal health-related mortality risks on individuals' own human capital investment decisions. They were able to find that not only does mortality risk negatively affect human capital investment, but, more importantly, that it is the timing of the realisation of the risk that led to a reduction in human capital investment.

In this study, I step aside from a conventional focus on the types of mortality risk that come from deadly diseases, illnesses or breakthroughs in healthcare innovation. Instead, this paper examines the role of a non-medical source of mortality risk on human capital investment. More precisely, I will focus on the human capital implications of mortality risk occurring from usage of warfare weaponry and other materials that are capable of terminating lives. Mortality risk derived from warfare weaponry is distinct from that of general deadly diseases in two ways. First, it is a source of mortality risk that is very much capable of directly and instantaneously changing an individual's lifespan. Second, in comparing to catching common diseases, the risk of dying from warfare weaponry carries heavily an element of fright and fear.

A number of studies (e.g. Kahneman and Tversky, 1979; Slovic et al., 1982) argue that an availability heuristic may exaggerate the level of risk beyond its statistical level in the cases where substantial publicity of the event or emotions are at play. Therefore, it is possible that individuals' investment decisions may not homogeneously response to mortality risk from low probability events vis-á-vis high probability ones. A key contribution of this research is to provide empirical evidence of the causal effect of non-health mortality risk on human capital accumulation. Another contribution is that this paper will pay attention a role in which fear and fright perception may have on individuals' evaluation of their subjective life expectancy. I will show that under an influence of heuristic probability, individuals may not necessarily allocate equal weighting to equivalent mortality risks of the same statistical magnitude. As a result, individuals may adjust their economic behaviours differently when facing with different sources of mortality risk.

To tackle these questions, this paper takes on the case of landmines in Cambodia and examines how the variation of mortality risk as a result of this lethal ordinance affects human capital investment behaviours. More precisely, it will compare the schooling outcomes among adjacent birth cohorts who would otherwise be analogous, but otherwise are faced with different magnitude of landmine-induced mortality risk. Cambodia fits the research agenda for a number of reasons. First of all, prime-age adults remain the main sufferers of mine casualties in Cambodia, accounting for 80 percent of total casualties (CMVIS, 2012). Precisely, this is the type of mortality risk that does not affect the whole lifespan of an individual but more specifically at the ages where individuals are active in the labour market. This allows the analysis to concentrate on working ages survival probability, which is argued to be more relevant than the risk early on in the life-cycle to determining schooling decisions (Cervellati and Sunde, 2013; De la Croix and Licandro, 2013; Strulik and Vollmer, 2013).

The identification strategy in this paper exploits three key variations of landmine-related mortality risk: spatial, temporal and gender variation. First, landmine prevalence are spatially differently across Cambodia where the western part is more heavily affected due to retreat strategies of Khmer Rouge at the end of the civil conflict in the 1980s.

The temporal variation of mortality risk is benefited from the international collaboration of landmine clearance operations, as a major post-conflict recovery action. The two-fold expansion of landmine clearance operations during the periods of 2004-2005 has led to a sharp decline in landmine casualties. This implies that suddenly adjacent birth cohorts of equivalent backgrounds are faced with very different levels of prime-age mortality risk. That is, to them and their parents, the younger cohorts then gain a higher expected lifetime working hours and a longer horizon to enjoy these benefits. As a result, for the affected households, this discontinuous change will directly affect their optimal investment decision in terms of the schooling for their children.

The third variation is derived from the male-bias nature of landmine casualties in Cambodia whereby adult males account for around 90 percent of total landmine casualties in the past 20 years (CMVIS; Roberts, 2011). Therefore, the changes in the variation of landmine mortality, particularly in the decline in year 2005, contribute directly to life expectancy of the males whilst leave that of the females unchanged. This, in effect, allows the empirical strategy to use the females as a main comparison group in analysing the mortality effect on human capital development.

Using data from the 1998 and 2008 Cambodia census (IPUMS), my initial empirical exercise uses a difference-in-difference-in-difference (DDD) specification. The data on landmine casualties by district and province level between 1979- 2010 is obtained from Cambodia Mine Action Authority database. The outcome of interest is an individual's school attainment. Using the full specification, I find that a unit increase in the landmine casualty rate (per 1000 local prime-age population) relates to a 4.5 percentage point (pp.) decrease in the probability of having attained a primary school level. For secondary school level, the effect is higher at 6.1 pp.

To account for any potential omitted variable bias, landmine casualty rate at district level is instrumented by the average stock of dangerous land (from landmine prevalence) in surrounding provinces. This is because landmine clearance operation is found to be directly related to landmine casualties in the area. Under the instrument variable specification, the effect of landmine mortality becomes 5.5 pp. under the full specification for primary school level and 13.6 pp. for secondary school level.

Next, I investigate a potential role of heuristic probability in influencing human capital investment decision. I compare the effect on schooling outcomes in Cambodia between the event with low probability, available heuristic characteristic (landmine accidents) and that with high probability (road traffic accidents). Most of all, both of these mortality sources are non-health, prime-age and male-biased. To do so, the same DDD analysis is repeated, with the road accident as the source of mortality variation. In addition, we instrument for road accidents by using averaged neighbouring province road network. Whilst the findings at the province-level shows a negative and significant effect of mortality risk on human capital investment behaviour when landmine casualty rate is the mortality variation, I do not find the same results in the specification with road traffic accidents. With reference to the literature and the arguments we illustrated above, we therefore believe that a possible key mechanism driving our findings on the effect of landmine mortality on schooling decision is the subjectively quantified variation in life expectancy, and not the objective one.

This paper is related to growing literature which tries to understand the legacy of civil conflict on economic development (see Justino, 2009 and Blattman and Miguel, 2010 for the review). I show that an active recovery plan, the landmine clearance operation in this case, can help set a nation both directly (via the improvement of physical capital) and indirectly (via reduction in mortality risk) to a more enhancing growth path. Moreover, this study also contributes to the understanding of the legacy of armed conflicts on human capital development. A number of micro-studies have shown a key mechanism in which the prevalence of weaponry usage reduces investments in human capital is through the contemporary level of local violence (Akresh and de Walque, 2008); Shemyakina, 2011; Leon, 2012; Gerardino, 2013; Millán, 2014), with mortality risk as a possible pathway (Gerardino, 2013). In this study, the periods of interest are post-conflict and are the time when Cambodia has been relative peaceful. In this case, this study will be more able in identifying solely the role of mortality risk on human capital development.

The paper is organised as follows: the next section discusses the context surrounding landmines in Cambodia. Section 2. describes historical background of landmines in Cambodia and gives an overview of educational institutions in the country. Section 3. explores a simple conceptual framework and theoretical hypothesis. Section 4. and 5. describe the data. Section 6. discusses the empirical strategy and estimation findings. Section 7. presents robustness checks and explores on possible mechanisms. Section 8. concludes.

2. Background of Landmines in Cambodia

2.1. Historical Background of Landmines in Cambodia

Landmines had been laid in Cambodia since the 1950s during the years of civil conflicts. However, it became more heavily used as a weapon of choice towards the end of the Khmer Rouge era by 1979. The areas in the Northern and North-western parts of the country, especially along borders with Thailand, are where the predominant amount of landmines were laid and later recovered. It is estimated that nearly 44 percent of Cambodia's land is affected by landmines (CMAA, 2001b). This is 4,460 km^2 or equivalently 3,037 suspected mined areas. Approximately 10 percent of the mined land directly affect the livelihood of communities (equivalent to 446 km^2).

The practice of landmine laying is indeed non-random as it is one of the main strategies during the Khmer Rouge civil war. During its retreat away from the Vietnamese invasion, Khmer Rouge army laid landmines to prevent the invaders' advance from the Eastern and South-eastern regions. Given the nature of the war, most of the mine laying activities occurred outside the capital city, Phnom Penh. Despite being strategically laid to block out the enemies, it is worth noting that landmines are not found either strictly in remote parts of the country, or the most infertile parts. A number of towns, for example Battambang and Rattana Mondul situated in the western part of the country, were rather much prosperous areas prior to 1979 (Davies and Dunlop, 1994). Moreover, given that Khmer Rouge profoundly imposed a restructuring of a fundamentally agrarian utopian state across the country, differential economic conditions were thus neutralised across the country during their brutal reign (Etcheson, 1984; Kiernan, 2001; Weitz, 2009).

This suggests that contemporary economic conditions were not determinant factors of landmine laying decision. In additional, it is safe to say that we expect no link between spatial correlation between mine prevalence and educational inputs. Khmer Rouge's ruling had led to a complete eradication of the educated class along with the educational infrastructure during its era (Kiernan, 2001; MoEYS, various years).

The magnitude of landmine usages began to decline along with the on-going internal violence as a result of the Paris peace treaty, signed in 1991. However, it is not until the sign of Mine Ban Treaty in 1997 that the fresh laying of landmines came to a virtual end. Since the departure of the UN care-taker (UNTAC) in 1993, Cambodian societies have been relatively free from violent conflicts. Most of all, the relatively peaceful society in Cambodia after the ceasefire allows the analysis to rule out the entailing effect of violence associated with weapon usage in other contexts (Camacho, 2008; Leon, 2012, Mansour and Rees, 2012; Gerardino, 2013)[1].

2.2. Landmine Clearance Operations and Landmine Casualties

Landmine clearance operations: Humanitarian landmine clearance efforts began in 1992, during the period of UNTAC peacekeeping presence in spite of existing on-going minor fighting in the region. Up to now, there are 3 main agencies: CMAC, Halo Trust, MAG operating in Cambodia[2]. By 2004, the total areas of 162 km^2 have been cleared, at an approximate rate of 15 km^2 per year. In the years 2004/2005, a number of fundamental changes of techniques and methods of landmine clearance were introduced. These included the utilisation of non-technical and technical survey in order to facilitate the landmine-marking process, in prior to a full clearance (CMAA).

As a consequence, by the end of the year 2005, mine clearance agencies achieved highest productivity at 32 km^2 per year- equivalent to over 100 percent increase in productivity (CMAA, 2005). Subsequently, this results in the rise of 100% in the number of landmines recovered nationally, of which the rate remains stable thereafter up to 2010. Figure 1 shows the magnitude of landmine clearance productivity at the national level over the years. There is a noticeably sharp decline of the level of clearance around the year 2005[3].

Landmine casualties: CMVIS collects and maintains the full list of landmine-related casualties in Cambodia from 1979 until present. The information of an incident contains its precise location, profile of the victim, the activity performed at the time as well as the victim's intention. Prior to the ceasefire in the early 1990s, the majority of casualties were found to be of military exercise. In contrast, the data from the recent decade indicates that landmine accidents are more likely to occur either during travelling or working in the field (CMVIS). More importantly, the statistics shows that landmine casualties over time are found to be male-biased. Working-age men are among the heavily affected, with on

[1]One of the advantages of this setting is that without on-going fightings during the period of interest, we are able separately identify landmine casualties as a sole variation of mortality risk.

[2]Over 90 percent of the funding is internationally financed (Authority, iousa).

[3]I run tests for structural breaks with the data on clearance productivity at province level, and find evidence supporting the break around the years 2004 to 2006 (Chow, 1960; Jayachandran and Lleras-Muney, 2009).

average 80-90% of the total casualties across regions (CMAA; CMVIS, various years).

The level of landmine casualties in Cambodia (defined as deaths and injuries) has been on a steady decline over time. Prior to 1999, the decrease of landmine casualties was a by-product of the peace treaty and a subsequent ending of the armed conflict. During 1999-2004, the casualty level became more constant, at an average of 800 casualties per year. During the same time in 2004-2005 when a sharp increase in landmine clearance productivity is observed, the level of landmine casualties nationally experienced a sharp, simultaneous decline (see Figure 2).

Figure 3 presents the spatial distribution (at district level) of landmine clearance productivity and landmine casualty rate for the periods before and after 2005. Together with the evidence from Figure 1 and Figure 2, this indicates a negative correlation whereby the increase in clearance productivity is corresponded to a decrease in landmine casualties[4].

Furthermore, all districts in Cambodia are ranked in percentile by the averaged intensity of its landmine casualty prevalence during 2001-2004 (prior to the change in 2005). Figure 4 show time-series plots of landmine casualty rates between the districts below the 45^{th} percentile and those above 65^{th} percentile[5] . The figure shows that amongst the districts with already low intensity of landmine casualty rates in the years before 2005, not much changes are observed after 2005. On the other hand, the districts with high casualty intensity show dramatic decline in the years post-2005. In Figure 4, the similar findings are found when the landmine clearance productivity rate is considered instead[6].

Landmine casualties and life expectancy: Over the years, an average life expectancy in Cambodia increases from 57 years in 1998 to 64 years in 2011 for females and similarly from 54 to 62 years during the same period for males. Many factors have contributed to such a change, including a decline in child mortality as well as maternal mortality (World Bank (2013)).

The landmine casualty census from CMVIS indicates that between the years 2005-2011, males in their prime ages account for the largest share of the casualties. By comparing the effect of the change of landmine clearance productivity in 2005 and a nation-wide decrease

[4]Alternatively, a variable for stocks of *dangerous* land at district level is constructed from the data. Then, a fixed effect model regresses the stocks *dangerous* land on landmine casualties at district level.)

[5]I choose the $45^{th}/65^{th}$ cut-off criteria to separate between the low and high intensity groups while omitting the middle group (instead of at the median) in order to make the distinction more obvious. All in all, similar patterns are also found when I vary the cut-off points

[6]Districts are grouped by low clearance intensity (below the 45^{th} percentile) and high intensity (above the 65^{th} percentile).

in landmine casualties around the same time, almost a twofold decrease of landmine casualties for Cambodian adult males is observed. In contrast, there is not much changes for the Cambodian adult females. At the same time, the younger age groups do not at all experience that same decline in the casualty level (Table 2).

To evaluate how sizeable the impact of landmine casualties has on the overall life expectancy, Table 1 compares landmine casualties from 2005-2011 to the total mortality at province level. Precisely, the denominator is the total mortality level is calculated as the average across all provinces, constant at 2008[7]. For adult males, the size of province-level landmine casualties in 2005 is equal to 17.4 percent of the total province-average male mortality. On the other hand, landmine casualties counts for only 1.23% for females. Among working-age males, the relative size of landmine casualties declines by 80 percent between the years 2005 and 2008, in contrast to less than 20 percent for females.

These numbers can be interpreted as the marginal effect of landmine casualties on total life expectancy in a year-on-year basis on a hypothetical event where the entire level of landmine casualties is eradicated in a certain year. The findings show that landmine-mortality risk faced by males have seen an approximate twofold decrease nationally whereas it remains considerably stable and unchanged for the female counterpart. This also contributes to the reduction in males' mortality risk overall. As an implication, the empirical identification will also rely on this gender-bias characteristic of landmine casualties. Given that they come from the same locality, a male individual would get to experience a decline in mortality risk whilst his female equivalent would not.

2.3. Educational Institutions: Costs and Benefits of Schooling in Cambodia

Costs of education: After the Khmer Rouge regime ended in 1979, Cambodia's educational institutions were restarted from zero, and have since been gradually developed. The educational system had a major reform in 1996 and the education years were set to a 12-year formula of 6+3+3. Since 2000, a National Education Strategic Plan of Education-for-All has been in place to implement a universal education policy. It introduced a *free* education of 6 years of basic education for all children of certain age cohorts in the country. The main aim was to reduce cost burdens to schooling by primarily abolishing the start

[7] Ideally, landmine casualties would be compared to total mortality in the province at the same corresponding year. Unfortunately, Cambodia do not keep record of vital statistics. Therefore, the landmine casualty data is compared with the total mortality level from the year 2008.

of school year fees in primary schools.

In spite of the efforts, children education in Cambodia remains somewhat costly for the majority of households in the country[8]. Data from Cambodia Household Socio-Economic Survey indicates that costs of education get more expensive the higher the level of qualification. In 2004, with relation to the median level of household disposable income, costs of schooling at primary school level accounts for 13 percent for a rural household. It rises to 132 percent at upper secondary school when schooling is no longer free and it reaches almost 700 percent an undergraduate degree (Cambodia National Institute of Statistics).

Forgone earning from the child's labour market activity plays another key contribution to the total costs of schooling. And indeed, child labour remains a key issue in Cambodia. The Cambodia Child Labour Survey (CCLS) in 2001 indicates that approximately 50% of children aged 7-14 were economically active. This rate is slightly higher than the low income countries' average. Nonetheless, only 9 percent of these children worked exclusively. That means most Cambodian children in the 2001 survey both worked and went to school.

Statistics on schooling: Official statistics show a steady rise of the enrolment rate of primary school children, with a completion rate shows much stronger improvement. Net enrolment rate at primary school education stands at 90 percent in 2008. On the other hand, the rate for secondary school remains low at 38 percent (World Bank (2008)), with a marginally smaller for girls. It is reported that among the 15-17 years old age group, the share of economically active children far exceeds those remain in education. While enrolment ratio at primary school is similar across regions, the drop-out rates during primary school level in remote and rural area stand approximately 50 percent higher than urban areas. Similarly, in 2005, 91 percent of primary school students in urban area progress to a secondary school level whilst only 26 percent did so from remote areas.

When the provinces are ranked and grouped by the intensity of landmine casualty rate, the evolution of educational characteristics over time do not differ between each group. However, the differences are in the levels where the provinces with low landmine intensity have higher educational outcomes than the provinces from the high intensity group. Figure 5 shows that they share a similar pattern over time. Moreover, Figure 6 shows that within each group, there is no gender difference in term of the trends in the educational statistics

[8]MoEYS (2005) and Bray and Bunly (2005) calculate that despite the exclusion of school fees, direct costs of primary school per pupil in 2004 is at 160,000 riels for urban household and 71,000 riels for rural household (USD 1 is exchanged from Cambodia Riels 4,000). Especially in urban areas, the bulk of these expenses come from costs of uniform and equipment as well as supplementary tutoring.

prior to the change of landmine mortality risk in 2005.

3. Conceptual Framework

Parents in Cambodian households are faced with children's schooling decision. Public funded education at the primary school makes it less costly than other qualifications for a parent to invest in the child's human capital. The rising returns of outside options in the labour market also makes is less attractive to send the child, especially the older ones, to school. The Ben-Porath mechanism (Ben-Porath, 1967; Becker, 1964) predicts that parents' investment decisions will response to an increase in the expected net lifetime return to schooling. Therefore, parents will invest more when children's life expectation increases, allowing a longer horizon of productive life as well as the duration in which the benefits can be enjoyed (Hazan, 2009; Cervellati and Sunde, 2013).

However, the extent to which parents can adjust their optimal investments depends heavily on the ability to transfer credit over the life-cycle. The role of financial market imperfections is expected to be important for Cambodia households. Financial constraints could mean that the same change in mortality may not have a homogeneous effect on human capital outcomes in different schooling qualifications[9].

In this framework, the decline in mortality is exogenous and the forward-looking parents response instantaneously to the change. With no uncertainty, parental investment is translated directly to the observed outcome of human capital accumulation. There is no gender-bias in parental response. In sum, the effects of mortality risk on the returns of human capital investments are homogeneous for boys and girls. However, when the risk is gender-specific mortality, only parents of a particular gender adjust their investments[10]. Therefore, a decrease in landmine mortality risk in Cambodia will affect the pay-off of schooling and consequently an increase in human capital investment for Cambodian boys, with no changes amongst the girls.

[9] See a simple theoretical framework with and without financial market imperfections in the Appendix A.2. Given the education structure in Cambodia, the role of financial constraints are expected to be more severe in higher education levels. This is because primary school education in Cambodia is publicly sponsored.

[10] Because each parent only has one child, the conceptual framework presented here is abstract from an additional effect of the subsequent intra-household reallocation of resources.

4. Description of the Data

4.1. Individual Schooling Data

Individual education outcomes are taken from Cambodia IPUMS 1998 and 2008, a 10 percent sample of the census record. The main outcome of interest is individuals' probability of attaining a particular level of school qualification.

In order to examine to causal relationship between mortality risk and education decision of the households, the age cohorts of interest in the 2008 census are selected according to two main criteria (depending also on a school qualification in question: (i) primary school or (ii)secondary school level)). To be defined as the so-called *treated* cohorts, first, the child' s age in 2005 cannot exceed the maximum age of a typical student at that educational level. In details, her age is not more than 12 or 18 years old for a primary school a secondary school in 2005, respectively. This condition implies that when her parents observe the sharp local change of landmine mortality in the year 2005, they are able to credibly react to the change by adjusting their investment response. Second, for econometricians to detect any behavioural response in the data, an individual must be old enough for her schooling status to be observable in the data in 2008. In sum, the *treated* cohorts are individuals aged 3-12 in 2005 (that is age cohorts of 6-15 years old in the 2008 census) for the primary school analysis and aged 9-17 years old in 2005 (equivalent to aged 12-20 in the 2008 census) for the secondary school.

The *control* cohorts are the cohorts with the identical ages as the *treated* cohorts, but are taken from the 1998 census. These are the individuals who are faced with the level of landmine mortality risk in the years prior to the change in landmine mortality. In the empirical analysis, I sub-divide each *treated* and *control* cohorts into as sub-groups of three consecutive ages. In total, there are three sub-groups for each of the *treated* and *control* cohorts. The main empirical exercise will focus on the difference in the outcomes across these two census.

Alternatively, the analysis will focus only on the individuals from the 2008 census. Note that the *control* cohorts from the 1998 are the exact birth cohorts as those who are ten years older in the 2008 census. Therefore, the alternative *control* cohorts are equivalent to the cohorts of 16-25 year old in 2008 for the primary school and 22-30 years old in 2008 for the secondary school. Analogously, these individuals would have faced landmine mortality risk of the years prior to the discontinuity in 2005 when their schooling decisions are finalised (see Appendix A.3 for an illustration.)[11].

An individual's probability of attaining a qualification is constructed as follows. At a given level, I assign a value of 1 to those whose school status is classified as *completed* and zero otherwise. This criterion is also applied to those who only obtain an incomplete level of the qualification. For those attending school at the time of a census, I assign a value of 1 for being at school at the particular qualification or higher and zero otherwise. Note that, by construction, I assume that someone with a final year of a qualification is as good as someone in their first year.

4.2. Landmine Casualties

The Cambodia Mine Victims Information System (CMVIS) provides the data for landmine casualties in Cambodia. The Cambodian Mine Action and Victim Assistance Authority (CMAA) collects the census of casualties nationwide from 1979. This study focuses on the dataset from the year 1997 to 2010. I calculate landmine casualty rates at the province level (24) and the district level (156). Additionally, I am able to distinguish the rates between different ages and genders. Note that landmine casualties are defined inclusively the deaths as well as the injuries from a landmine accident. For now, we decide to combine all the counts and refer to it as *landmine mortality*.

The individual-level data from IPUMS is then matched with CMVIS landmine datasets at 2 levels of current residence locality: district and province. Then, the mortality rate (LMR hereafter) is normalised by dividing total landmine mortality level by the total adult population age (defined as between 18 and 35 years old) within a locality[12]. To minimise measurement error of the mortality rate, I calculate a three-year running average of LMR for the years after 2005 (2007-2009) and a similar rate of 10 years before (1997-1999), for each locality (Jayachandran and Lleras-Muney, 2009)[13]. Subsequently, the post-2005 rate is assigned to the *treated* cohorts while the pre-2005 rate is matched with the *control* cohorts. All rates are thus presented in a unit of per 1,000 adult population in a given locality. Provided that there are no other changes from other mortality risks at the locality

[11] The larger period gap (i.e. going back 20 years) had been initially considered for another alternative control group. However, the control group from 1988 census would not have fitted the common trend assumption, as these children were living through the height of the Khmer civil war conflict.

[12] The reason why adult population is used is because this is the ages with at least 80 percent share of landmine accidents in Cambodia.

[13] Low frequency data of mortality rate is preferred in order to avoid noise from the data and also allow for a clearer distinction between our *control* and *treated* cohorts.

in the same manner during the period of interest, this is equivalent to assigning the children from the *treated* cohorts with an unexpected, positive shock on their life expectancy, in relation to the control ones from the same area.

4.3. Other Related Datasets

CMAA provides measures of district-level landmine clearance productivity year-on-year. Also, it keeps the current states of *dangerous* lands in each locality by 2013. The Yale' s Cambodia Genocide Database for GIS bombing locations during the Vietnam War and mass graves during the 1970s Civil War period in Cambodia is also consulted for more district-level characteristics.

We seek other year-on-year variables at locality levels from Commune Database (Cambodia Ministry of Planning), series of annual reports from Ministry of Education and Sports and Socio-Economic Surveys from National Institute of Statistics. Data on health-related mortality is obtained from Ministry o Public Health' s reports and the 2008 Cambodia Mortality database. In sum, we have variables on education infrastructure, health-related conditions, and related economic circumstances (for example poverty rate and rice production activities).

5. Descriptive Statistics

5.1. Summary Statistics and Balancing Test

In this section, we start by presenting summary statistics of key characteristics of individuals and households. Using Cambodia IPUMS 1998 Cambodia Commune Data from the nearby year (SEILA, 2002), we compares some characteristics between households from high intensity of landmine casualty rate (averaged of the 1997-1999 rate) and households living areas with low intensity. We further divide each intensity group into outcomes for males and females when available. The findings from spatial comparison in Table 3 show that low intensity areas had slightly preferred socio-economic conditions than the high intensity areas. Across areas, education attainment look higher in low intensity area. However, within the area, we observe comparable education outcomes between males and females, especially within the areas with high intensity of *pre-treatment* LMR.

The domination of Khmer Rouge regime in Cambodia and in particular its implementation of equal agrarian society ensures that there should not be any statistical correlation between the spatial choices of landmines usages with the education endowments across areas. Nevertheless, we need to ensure that the local development conditions in recent years had not influenced decisions regarding landmine clearance effort and subsequently landmine mortality risk. We perform another balancing test exercise with data at district level to find evidence that the increase of landmine clearance productivity around the year 2005 was not determined by human capital conditions in the area at the time. To do this, we group all districts in Cambodia according to its level of total landmine clearance during 2005-2007. Table 3 compares some observable characteristics between districts with landmine clearance below the 45^{th} percentile and those with above the 65^{th} percentile.

5.2. Accounting for Common Trend Assumption

The exercise in this section is to make certain that the crucial Common Trend assumption is maintained. That is, each confounding variable between the *treated* and *control* cohorts share similar time-variant behaviours. In the context of this paper, we focus on the time trend of each key factor that may directly affect the education outcomes (from both the demand and supply side) or indirectly influence the level of aggregate mortality risk. Precisely, we present evidence of the common trends of these factors across two interacted dimensions namely (i) landmine casualty rate intensity (high and low); and (ii) gender (male and female)[14].

Figure 8 presents aggregate health-related mortality rates from the 2008 census for males and females across different age levels. Across all ages, Cambodian females have marginally lower mortality rate than males. Nonetheless, the variations from both groups look to synchronize over time. The similar pattern is found when all four sub-groups are compared (at province level) suggesting the absence of potential structural change in general mortality risk during the time and provides support of a common trend of general mortality across the groups.

To validate the common trend assumption on education variables, we conduct a similar exercise with schooling outcomes across school age cohorts, comparing among four sub-groups. Figure shows that at each level of education, whilst female school attendance is lower than males. The levels of school attendance among four sub-groups fluctuate over time in the same manner. On the supply side, the same exercise is applied to the level of educational infrastructure, for example, the number of schools. The findings demonstrate

[14]Eventually, four groups are constructed: high-male; high-female; low-male and low-female.

that there is no trend difference between areas of high and low intensity of LMR[15]. In sum, No sharp change in the supply side of education is observed around the year 2005 when theses localities experienced an abrupt change in LMR (Figure 5).

One potential caveat is that landmine clearance operation may also change general economic well-being of a locality. Note that the level differences in the economic gains between areas of low and high LMR intensity do not invalidate our identification design when use triple differences strategy[16]. Nonetheless, the economic trend is investigated to make sure that changes of economic circumstances among localities did not have any discontinuities, if at all around the year 2005. Using poverty rates as a proxy for economic well-being, Figure 7 shows that the local poverty rates between both groups changed with a similar trend over time (2002-2012). Most of al, no discontinuity of the poverty rates is observed over time.

6. Empirical Analysis

This section presents estimation strategies to identify a causal effect of a change in a non-health mortality risk on parents' optimal investment decisions on child's schooling.

6.1. Difference-in-Difference-in-Difference

To do so, a *difference-in-difference-in-difference* method (DDD hereafter) is used as the main empirical strategy. Three variations (spatial, temporal and gender) are exploited in order to identify a causal effect of mortality risk on human capital accumulation. First, the spatial variation of landmine prevalence and casualties in Cambodia is derived from the historical retreat strategies the Khmer Rouge away from the Vietnamese invasion at the end of the turbulent civil conflict in the 1980s. To block and slow down the invasion from the Cambodia-Vietnam borders, the Khmer Rouge troop exercised landmine-laying as its preferred military option. As an implication, the western part of Cambodia is much more heavily affected by landmines than its eastern region (see Figure 3). Second, the temporal variation is obtained from the landmine clearance operations and the two-fold expansion their productivity around the years 2004-2005. As shown previously in Figure 1 and 2,

[15]It is plausible that with the on-going effort nationally to achieve the targets set by Millennium Development Goals, certain localities may have experienced different trends in other confounding effects.

[16]On an assumption that there is no gender-bias effects from general economic well-being, girls and boys from the same locality will experience the evolution of their human capital equally. Therefore, once this confounding effect is differenced out following a difference-in-difference strategy, the mortality risk effect will be identified.

the increase in the number of landmines being recovered is directly linked to a subsequent sharp decline in landmine casualties, particularly in the affected areas. This event implies that amongst the landmine-affected areas, adjacent birth cohorts from the same locality would suddenly face with a much different level of mortality risk. For the unaffected areas, in contrast, they do not experience such a change in their expected longevity.

The timing of the abrupt decline of landmine casualties allows for any differences in schooling decisions amongst adjacent birth cohorts from the same locality to be examined. A key identifying assumption for a causal interpretation is that whilst facing a different magnitude of the reduction in their exposure to mortality risk, these individuals are otherwise comparable. And that, upon observing such a change in the objective mortality risk in their locality, the parents update their perception of prime-age life expectancy of their children at an instance. Thus, to the affected households, this discontinuous change will directly affect their optimal investments in their children's schooling.

The gender variation is obtained from the unique pattern of landmine casualties in Cambodia that they are predominately males. In the past 20 years, adult males accounts for 90 percent of total landmine casualties (CMVIS, Roberts, 2011). And as shown in the previous section (see Table 1), the expansion of landmine clearance effort in 2005 had led to a sharp decline in the male's level of risk whilst not much changes for the females'. This gender differential of landmine mortality risk is exploited as the final variation for the empirical exercise.

The main analysis uses individual schooling information from the 1998 and 2008 Cambodia census. Altogether, the data comprises of 624 grouped observations, which are derived from gender (2), district of residence (156) and census year (2)[17].

The DDD estimation is as follows:

$$\begin{aligned} HC_{L,G,Y} &= \beta_0 + \beta_1 Mine_{L,Y} Male_G \\ &\quad + \theta_1[\mu_L Male_G] + \theta_2[\mu_L \gamma_Y] + \theta_3[\gamma_Y Male_G] + \epsilon_{L,G,Y} \end{aligned} \tag{1}$$

where $HC_{L,G,Y}$ is our outcome of interest- a probability of attaining a level of qualification (primary school level and secondary school level) for each cohort (3-age grouping), living in a locality (L) and is found in a census year (Y). The variable of interest, $Mine_{L,Y}$, is a rate of landmine casualties per 1000 adult population (aged 18-35) in a locality. In the

[17] Alternatively, the analysis the data can also be done at the province level to supplement the key findings. In which case, the data is made up of 96 grouped observations (24 provinces of residence).

main regressions when the comparison is between the same age cohorts from two different census, $Mine_{L,Y}$ takes two values. For the *control* cohorts, they are assigned a three-year running average rate of 1997-1999 as the LMR before the sharp change in 2005. For the *treatment* age cohorts, they are assigned the three-year running average LMR of 2007-2009 as the rate of casualties after the sharp change in 2005. The specification includes a dummy for male ($Male_G$), all double interactions between gender ($Male_G$), province (μ_L) and IPUMS census year (γ_Y) and a random error term ($\epsilon_{L,G,Y}$). Note that among the age cohorts at each schooling outcome of interest, the analysis subsequently puts together each age into a group of three consecutive age cohorts in the regression exercises (Jayachandran and Lleras-Muney, 2009).

As described previously, the first difference comes from the geographical difference of the changes in LMR. The second difference is derived from comparing the same age cohorts across the census years. And the third difference is the male-female comparison, given the same census and locality of residence. We obtain our estimates using linear probability models with the robust standard errors and clustered at province of residence. Given the prediction from the theoretical framework, we expect β_1 to have a negative sign, indicating that mortality risk has a negative impact of human capital investment decision. And if the model is correctly specified, β_1 is a consistent estimate of the effect of having one unit increase in mortality rate on schooling probability.

Key identification assumptions for a causal interpretation of β_1 are (i) education institutions and endowment in localities was not a predetermination of the location choice of landmine laying activities in the first place; (ii) that the sharp, two-fold increase of landmine clearance and subsequently the fall of LMR in 2005 was not anticipated by Cambodian households many years before; (iii) that households response instantaneously to changes in mortality risk; and (iv) we are able to observe the direct consequence of households' investment decision in our schooling measures in the data.

Given the empirical design, females from the same locality and same census are required to act as a good *control* for the equivalent males. More precisely, the comparable males and females should share common behaviour responses to inputs (of human capital production)[18]. Note also that in Equation 1, by using the dummy ($Male_G$) in the treatment assignment, we assume that landmine casualties affect only the male population in the

[18]It is advocated that conditional on locality and census, it must be ensured that $\frac{\Delta HC_{male}}{\Delta Mortality_{male}} = \frac{\Delta HC_{female}}{\Delta Mortality_{male}}$ and that for other confounding factors, X, we expect to see $\frac{\Delta HC_{male}}{\Delta X_{male}} = \frac{\Delta HC_{female}}{\Delta X_{male}}$

area. On the other hand, the effect of LMR on females is assumed away when a zero value is assigned to the female population. In the next step, this assumption will be relaxed and allow the mortality risk exposed by each gender to come directly from the casualty rates which are specific to each group. Therefore, $Mine_{L,Y}Male_G$ is replaced with $Mine_{L,Y,G}$ and the alternative estimation equation becomes:

$$\begin{aligned} HC_{L,G,Y} &= \beta_0 + \beta_1 Mine_{L,Y,G} \\ &\quad + \theta_1[\mu_L Male_G] + \theta_2[\mu_L \gamma_Y] + \theta_3[\gamma_Y Male_G] + \epsilon_{L,G,Y} \end{aligned} \tag{2}$$

This specification also includes confounding variables, X which potentially vary across locality, gender and time. Note that the variations in LMR in Cambodia are direct implications of the on-going landmine clearance operation. Therefore, I account for the confounding effect from income by controlling for average poverty at province level-with the years corresponding to each census cohort. In addition, another variable, *rice income*, is constructed to capture direct gains from having more agricultural lands as a result of landmine clearance. To do this, I use the knowledge that the main source of income to Cambodia households, particularly in the rural area, is rice production. Approximately 80 percent of all available land in Cambodia are used for rice growing activity (Cambodia Socio-Economic Survey; Cambodia Commune Database). It is reported that after the allocation of de-mined land for resettlements, the second largest proportion of de-mined land (approximately 30 percent) are returned to the local population for agricultural activities (CMAA). Therefore, we calculate annual income of rice harvesting for each district, using the information on annual land clearance, yield productivity for each geography and average rice prices from the nearest trading market. We finally calculate the three-year average income for the periods corresponding to LMR at the district level.

Estimates from two-census comparison: Table 5 shows the estimation results from the specification which compare the same age cohorts but across different census years. The baseline model finds that a unit increase in LMR is related to 6 pp. decrease in the probability of attaining primary school education. The magnitude of the mortality effect reduces slightly when we add extra controls in order to account for confounding factors.

The inclusion of potential rice income from having more safe land reduces the size of LMR to 5.4 pp. In the models with time-varying poverty rates and other health-related mortality rates at province level (namely malaria infection rate, child mortality and maternal mortality), the effect of LMR is at 4.5 pp for the primary school outcome.

For secondary school, the baseline model finds that a unit rise in landmine casualty leads to 4.2 pp decrease in schooling. By adding more controls as previously, the effect is at 6.1 pp. Note that there is a difference in the size of the mortality effect between the two levels of schooling. This finding is aligned with the conceptual framework where the effect of mortality risk is hypothesised to be larger under the condition with higher financial constraint.

Estimates from within-census comparison: Table 6 presents the analysis where the *treated* cohorts are compared with the *control* cohorts from the same census year (in 2008 census). Precisely, this *control* group is the exact same group (same birth cohorts) as in the previous exercise. For the *control* group, I basically track the same birth cohorts from the 1998 census ten years forward and locate them again in the 2008 census. The analysis in this part compares schooling behaviours of the *children* in the same census who, however, faced rather different mortality risk at the time when their parents make schooling investments.

For primary school level, one unit increase in LMR is related to 1.5 pp. in baseline model and at 1 pp. in the full model. For the secondary school level, the effect is higher at 3.5 pp in the full specification. Again, the difference in the magnitude between *free* school qualification (primary school) and costly secondary school is observed in this Cambodia sample.

Estimates from using gender-specific LMR: To allow landmine risk to have non-zero effect on both males and females, we run our estimation according to Equation 2 by using gender-specific landmine casualty rates with the two-census approach. Essentially, this specification permits spatial and time variation of LMR within the female population, even if their life expectancy are only minimally affected by landmine prevalence. Table 7 shows that, given the relaxed assumption, the magnitude of LMR is robust at 4.24 pp. for the primary school outcome. On the other hand, the negative effect on LMR on the probability of having some secondary school when parents are allowed to response to changes in the variation of female's expected longevity, the effect of landmine mortality risk is reduced to 3.1 pp. in the full specification.

6.2. Instrumental Variable

The causal interpretation of the findings from the DDD specification relies heavily on the fact that other changes apart from LMR over this decade is gender-neutral. In the previous analysis, we are able to control for all the changes that is gender-locality, gender-time, and locality-time using our double interaction fixed effects. As seen in the previous section, the specification also takes into account the possibility of gender-bias income effect which may bias the results. A main caveat is that households may also adjust their behaviours in a more heterogeneous manner, as a result of having experienced landmine incidence in their area. And if such a change happens simultaneous with gender, locality and time, the findings may be biased. In order to mitigate this omitted variable bias, I incorporate the technique of Two-Stage Least Square (2SLS) to the DDD model.

An ideal instrumental variable (IV) is required to be strongly correlated with the changes of LMR over time, but does not have any other influences on households education decisions. Given that the pattern of LMR is influenced directly by the landmine clearance operation, I therefore exploit this variable to construct an instrumental variable. To do so, I exploit the information from the 2012 Cambodia Baseline Survey (of landmine prevalence in communes) as well as the landmine clearance database from CMAA. The level of *dangerous* lands, which were not yet de-mined by landmine agencies, is calculated for each province-year. We then calculate the proportion of uncleared, *dangerous* areas per total area in a province. However, using the variation directly may invalidate the exclusion restriction. It is because landmine clearance operations are likely to lead to changes in other confounding factors, which may affect educational decisions of households in the area aside the change in mortality risk.

Therefore, for each province, the *dangerous* area of its neighbouring provinces (defined as having shared border) is constructed. This is a valid instrumental variable based on two main identifying assumptions (Bai et al., 2013; Bartik, 1991; Bound and Holzer, 2000). First, it is assumed that the pattern of landmine clearance at each province is determined by the clearance operation planning at the national level. Therefore, this aggregate *shock* ensures that there is spatial correlation between the province of interest and its neighbours. The second assumption is that, however, how landmine casualties are influenced by the landmine clearance and the remains of *dangerous* land areas at each point in time are a province-specific event. That is there is no spill-overs of landmine mortality risk between neighbouring provinces. Households' decisions are not affected by what happened in other provinces. Given that our instrument is constructed at the province level, we argue the large spatial area size will mitigate spill-overs across its neighbouring regions. Statistical evidence indicate that migration in Cambodia is indeed high. However, around 80-90 percent of the migration movement is within province. Therefore, we believe that using the averaged *dangerous* land areas of neighbouring provinces do not violate the exclusion restriction in this analysis.

The first-stage regression for the Two-Stage Least Square specification is as follows:

$$Mine_{L,Y}Male_G = \omega_0 + \omega_1 NeighbourDangerLand_{L,Y}Male_G + \varepsilon IV_{L,G,Y} \quad (3)$$

Mortality effect under 2SLS models: First, I run the 2SLS regressions with the specification in Equation 1, using two-census comparison. In Table 5, the first-stage regressions show a strong and positive relationship between stock of *dangerous* land in neighbouring provinces and LMR of the locality of interest (F-test on the excluded variables are at 20.75 for the primary school models and 20.50 for the secondary school models).

For the primary school models, by accounting for omitted variable bias, the effect of LMR becomes 9.9 pp. in the baseline specification and 5.5 pp. under the full specification (controlling for health and economic conditions). For the secondary school models, we find that a unit rise in LMR leads to 13.6 pp in the probability of having had some secondary school education[19].

Next, we repeat the 2SLS exercise with Equation 2 using gender-specific landmine casualties. The first-stage specification is similar to Equation 3 but with $Mine_{L,Y,G}$ instead. The findings are presented in Table 7. Under the full specification, the negative effect of LMR on the probability of primary school attainment is estimated at 3.1 pp. For secondary school level, the effect is found to be larger at 6.8 pp. in the full model. In addition, the size of the mortality risk effect is higher for the costly education level (i.e. secondary school) than that found at *free* school level (i.e. primary school). Additionally, by comparing the results between the specification using a *male dummy* and the specification with gender-specific LMR, it is found by allowing parents' decisions to also response to the variation of female's landmine mortality risk, the *intention-to-treat* effect becomes smaller.

[19]See results from other specification modification can be found in the Online Appendix.

7. Robustness Checks

7.1. Health Investments as Alternative Measures

In this section, the empirical specifications (looking at the age cohorts from different survey years) to the Cambodia Demographic Health Surveys (CDHS thereafter). The main objective here is to test if mortality risk, using LMR as a proxy, displays a negative effect on other measures of human capital as well as at a different stage of development. In particular, parental investment in child's physical health capital will be analysed.

The data from the CHDS allows for the focus on the age cohorts of 1-5 years old from 3 different years of the CDHS (2000, 2005 and 2010). Considering the timing of the change in LMR, the cohorts from 2000 and 2005 are classified as the *control* group whilst the same age cohorts from 2010 are the *treament* group[20]. The outcomes of interest is the probability of the child having been vaccinated (a list of vaccination types) and received micro-nutrition treatment. I apply the DDD specification analogously to Equation 1 in the previous section.

From Table 10, an increase in mortality risk, defined as LMR, leads to a decrease in healthy behaviours of the household. More precisely, the DDD analysis shows a reduction of the probability of a child being vaccinated. In the specification A, where the children from the CDHS 2000 (*control*) and the CDHS 2010 (*treated*) are being compared, a unit increase in landmine casualty rate (at district level) leads to 4 pp. decline in the probability of a child receiving BCG vaccination; 4.3 pp. decline in polio vaccination; and 3.9 pp decline in measles vaccination. There is a weaker but insignificant effect of landmine mortality of the probability of a child receiving vitamin A dosage before 5 years old. When the children cohorts from CDHS 2005 are included as an additional control group (and are assigned the 2001-2003 average of LMR), the magnitude of effect of mortality risk gets larger by twofold and more significant in the full specification (controlling for time-varying economic conditions and health-related mortality rates). In sum, the analysis using the CDHS provides supportive evidence that mortality risk (with LMR as a proxy) has a negative significant effect on human capital investment.

[20] In the main specification, cohorts from CDHS 2010 are assigned LMR of the averaged 2007-2009 and those from CDHS 2000 and CDHS 2005 are assigned the rate of the averaged 1997-1999. Alternatively, for CDHS 2005, I assign the three-year average of LMR during 2001-2003 so that the cohorts from each survey year are faced with a different level of landmine mortality risk

7.2. Comparing the Effect of Mortality Risk between Landmine Accidents and Road Accidents

As said, a key research interest in analysing the role of landmine-mortality risk on human capital development is that this risk is caused by the event that is orthogonal to healthcare improvements or medical breakthroughs. Therefore, the empirical exercises in this study have provided evidence that such a mortality risk, in form of LMR in Cambodia, do poses a negative effect on households' decisions of human capital investment. This section turns to another source of mortality risk, *road traffic accidents*, which shares many closely-related features to landmine mortality, but with one stark contrast. Analogous to landmine accidents, it is a non-health source of mortality risk. Across various causes of death in Cambodia, road accidents are the top reason for casualties, especially among the prime-age population. Most of all, the statistics show that males are the dominant victims of such accidents (see Figure 9). In sum, these characteristics of road traffic accidents allow for the application of the same empirical strategy, using DDD, in order to test if such a source of mortality risk influences human capital investment decisions of the Cambodian households.

Nevertheless, there is a stark difference between landmine accidents and road traffic accidents- the fundamental of dread and the role of *availability heuristic*(Kahneman and Tversky, 1979; Slovic et al., 1982; Slovic, 1987). The risk of being exposed to explosive warfare weaponry like landmines have two keys features that road accidents do not possess. First, as many other causes of death, road accidents are more likely to be controllable or, to the least, avoidable. In contrast, landmines are much less observable by being buried underground. In many areas in Cambodia, minefields are still being recovered. Despite being cleared marked in a lot of areas, landmine accidents continue to occur while the victims are travelling or working in the field (CMAA; CMVIS). Given the severity of *unobservable* manifestation of harm, it becomes much more difficult for households to adapt or adjust their behaviours in the prevalence of landmines in the area. Second, because road accidents happen more frequently, the events become more common. Therefore, such a source of risk is perceived to be less salient than a rarer but more psychologically traumatic event of landmine accidents Slovic, 1987.

On the one hand, the subjective survival probability of the households responses to new updated information from all sources of mortality (Hurd and McGarry, 2002). On the other hand, the same magnitude of mortality rate from landmine accident and road traffic accident may not be translated equally to the same level of mortality risk perceived by the Cambodian households. Being a *low probability event*, the households are more likely to assign higher *subjective* mortality risk to a landmine accident whilst subjectively attenuate the risk from a common road traffic accident (Kahneman and Tversky, 1979). And if households' decisions on investment are influenced by the subjective mortality risk, we expect, in our empirical exercise, that the effect of road traffic accident on education outcome would be smaller or attenuated to zero.

Hence, we modify our previous DDD specification and estimate a possible causal effect of road traffic accident mortality risk on education attainment in Cambodia. Figure 10 displays the distribution of road accident at province level for the years 1997-1999 and 2007-2009. And we compare the schooling outcomes under the event of *low probability* (landmine accidents) with events of *high probability* (road traffic accidents) (Slovic, 1987). The main estimation equation using DDD for road traffic accidents is as follows:

$$\begin{aligned} HC_{L,G,Y} &= \beta_0 + \beta_1 Roadacc_{L,Y} Male_G \\ &\quad + \theta_1[\mu_L Male_G] + \theta_2[\mu_L \gamma_Y] + \theta_3[\gamma_Y Male_G] + \epsilon_{L,G,Y} \end{aligned} \tag{4}$$

where $Roadacc_{L,Y}$ is road accident rate per 10,000 adult population in a locality L in census year Y. Again, the empirical analysis uses individual schooling characteristics from the 1998 and 2008 Cambodia census[21]. Given the data availability, the analysis is performed at the province level. Additional covariates are number of motor vehicles and population across time for each locality[22].

Road accident data with DDD: The traffic accident rates at each province are computed over the same period as the LMR, using the data from Cambodia Road Traffic and Victim Information System (RTAVIS). The data contains all reported incidents and fatalities by traffic police and hospitals in the country. Given the data availability, the level of locality is at province-level The road traffic casualty rates are calculated from the share of fatalities amongst the prime-age adult population (18-35 years old). Again, the three-year average casualty rates at province level from the years 1997-1999 are assigned to the

[21] Key variables defined analogously to our initial specification with landmine mortality rate.

[22] The data sources are census data, SEILA and Cambodia Commune Database

control age cohorts and the 2007-2009 average rates are assigned to the *treated* cohorts[23]. The analysis focuses on the same two school cohorts- primary school and secondary school level as before[24].

In contrast to the findings using LMR, the estimates from the regressions with road accident mortality are not statistically significant at any level of education- although it indicates a negative relationship between them (see Table 11) If, as in the conceptual framework, all causes of mortality risk are perceived objectively equivalent by the households, it is expected to observe a negative and significant result as found in the specifications with LMR. On the other hand, if the investment decision is, in fact, influenced by subjective mortality risk, it is possible that different conclusions may be drawn from different causes of death.

Before coming to a conclusion, I investigate if the insignificant effect of traffic accidents is caused by potential omitted variable bias or attenuation bias. To do so, I run the DDD specification whilst use an instrumental variable for $Road_{L,Y}$. The ideal instrument will need to have a strong correlation with changes road traffic casualty rates and it will not have any other influences on education decision of the household in the locality. Given reports from Cambodia authorities[25], it is shown that straight roads and road junctions are key causes of road accidents within a province (RTAVIS). However, it is possible that own road networks may be correlated to other confounding variables, for example economic prosperity of the province, which may violate the exclusion restriction.

To overcome this, measures of road networks are constructed[26] at a given time (1997 for *before* and 2007 for *after*) of neighbouring provinces (with shared borders). Under two key assumptions that the road constructions in each province is led by national agenda but road accidents themselves are province-specific, this is the instrumental variable for road $Road_{L,Y}$. The first stage regression of the Two-Stage Least Square for the road traffic accident specification is:

$$Roadacc_{L,Y}Male_G = \omega_0 + \omega_1 NeighbourRoadnetwork_{L,Y}Male_G + \varepsilon^{IV}_{L,G,Y} \qquad (5)$$

[23]This is the exact assignment rule as previously conducted with LMR.

[24]That is, the empirical exercise compares individuals aged 6-15 year old between the 1998 and the 2008 census for primary school attainment and the 12-20 year old for secondary school attainment.

[25]Cambodia Road Traffic Accident and Victim Information System provide annual reports on traffic accidents across Cambodia. By compiling data from hospitals and police authorities, its data contains information includes causes and location of accidents.

[26]the variable is constructed from data maintained by Cambodia Ministry of Planning and Cambodia Land and Environment Atlas and Resource (CLEAR) project.

Road accident with 2SLS: Table 12 reports the results using 2SLS with traffic accident. The first stage result shows a strong significant relationship between the magnitude of road networks of neighbouring provinces and the traffic accident rate in the province in a given year (F-test on the excluded variable are 34.18 and 33.40). In the second-stage, after controlling for time-varying covariates (economic conditions, motor vehicles), it shows that there is no significant relationship between road traffic accident and education outcomes, in both primary and secondary school level. To allow comparison with landmine accidents, I re-run the 2SLS with DDD specification (Equation 1 and 3) using LMR at province level. See Table 13 for the findings[27].

In sum, whilst the analysis provides evidence for a negative and significant effect of mortality risk on human capital investment behaviour when LMR is considered, the same results are no longer found road traffic accidents are used. With reference to the literature and the arguments illustrated above, it shows that a possible key mechanism driving the findings on the effect of landmine mortality on schooling decision in this study is the subjectively quantified variation in life expectancy, and not the objective one (e.g. Krimsky and Golding, 1992; Kilka and Weber, 2001).

8. Discussions

8.1. Landmine Clearance Operation and Gains in Household Wealth

Here, I investigate whether landmine clearance operation leads to improvement in households wealth or income. I test this proposition with asset data, available in the CDHS 2000, 2005 and 2010. This exercise is important to the identification strategy in this study. Given evidence that income itself can have a gender-bias effect (that is households tend to spend or invest more in boys than girls when their wealth or income increase) (e.g. Strauss and Thomas, 1995; Behrman, 1988 ; Gupta, 1987), a common trend assumption between males and females may be challenged.

The asset regression is similar to the previous exercise with the CDHS datasets. THe households from the CDHS 2000 and the CDHS 2005 are considered as the *control* group while the CDHS 2010 as the treatment group. The LMR are assigned correspondingly (see the previous section on health outcomes). The households of interest are those with

[27]we also run the DDD specification at province level with CDHS data and find significant results with landmine mortality risk.

children age 8-22 years old (at the survey year) [28] .

$$Asset_{L,Y} = \lambda_0 + \lambda_1 Clearance_{L,Y} + \varepsilon^{asset}_{L,Y} \tag{6}$$

where $Asset_{L,Y}$ is a measure of asset in a household (DHS-constructed Household Wealth Index and total household asset) and $Clearance_{L,Y}$ is the productivity rate of landmine clearance operation in a specific district L, for a given survey year Y. From the estimations (using repeated cross-section at district level), landmine clearance productivity does not seem to have a statistical significant effect on household wealth. I also run Equation 6 with a Two-Stage Least Square specification in order to mitigate omitted variable problems. By instrumenting $Clearance_{L,Y}$ with $NeighbourClearance_{L,Y}$, a three-year average rate of landmine clearance of neighbouring provinces, I do not find evidence supporting changes in household wealth using CDHS dataset (see Table 14).

8.2. Incentives for Schooling Investments

This section examines what benefits a Cambodia household may gain from investing in child's higher schooling, particularly in an agrarian economy.

A reason is that education allows higher mobility for children to get out of the agricultural sector and move into alternative sectors with higher pays (e.g. Malamud and Wozniak, 2010; Wozniak, 2010; Machin et al., 2012). Furthermore, this may also encourage higher spatial mobility and thus an urbanisation, away from the previous resided area and thus allows lower mortality risk from landmines. The expected lifetime utility would be greater not only because of an additional decrease in landmine mortality at adulthood but also other gains from education (see Oreopoulos and Salvanes, 2011 for a review).

Even when individuals do not end up moving out of the agricultural section, earning distributions from Cambodia Labour Force surveys over the years suggest that there are returns to be gain from a higher education without migration. Moreover, statistics from the Cambodia Socio-Economic surveys show that around 20 percent of urban individuals with secondary school education are in the agriculture section, with nearly 40 percent amongst those who live in rural areas. Figure 11 compare the earning distributions between working in agriculture and other occupations available in more urban areas (for example, food manufacturing, retail and services in hotels and restaurants). The earning distribution of

[28] Therefore, they are of the equivalently same birth cohorts as the census cohorts.

agriculture does exhibit the right tail, indicating over 30 percent chance of high earning (being in higher than the 40^{th} percentile of average wage in Cambodia in 1998-2001).

9. Conclusions

Economic theories of human capital development assert that life expectancy plays a key role in determining households' optimal level of schooling investments. So far, this study has investigated a causal relationship and illustrated supporting evidence by using landmines in Cambodia as the measure of mortality risk. Landmine casualties differ from previous studies in the literature in a way that this is a mortality risk variation which is not derived from a conventional improvement in health environment. Instead, the study examined a key variation of mortality risk that is caused by a powerful lethal device, namely landmines.

This study use DDD specifications to estimate the corresponding change in schooling and health investment. The decrease in LMR led to an increase in the probablity of school attendance. Furthermore, in a 2SLS specification where LMR is instrumented by stock of *dangerous* lands among neighbouring provinces, a unit decrease in LMR caused a 5.5 percentage points increase in the probabiity at primary school level and a 13.6 percentage points increase at secondary school level. For physical health investment, there is a sizeble negative effect of LMR on the likelihood of vaccination amongst children age under-five in the CDHS sample.

In the next step, LMR is replaced with road traffic accident rates and run with the identical analysis. This exercise is as if substituting the same level of one objective mortality risk by another. If it is the objective mortality risk that drives households' investment behaviours and thus the outcomes, a similar effect under road traffic accident will be expected. However, in both the DDD and IV specification, no statistically significant effect of road traffic mortality risk on educational outcomes is detected.

Provided that (i) households do exaggerate the risk from landmine casualty rate but instead attenuate the risk caused by a much common, less terrorised event of road accident and (ii) it is *subjective* mortality risk that influences investment behaviour, it is not expected to see a strong relationship between road accident mortality and human capital outcomes. The empirical exercises in this study present supportive evidence for this mechanism. To conclude, this paper and its findings from the causal analysis advocate for a role of life expectancy on optimal decision making, particularly in human capital investment.

More strongly, there is evidence that different findings between various causes of mortality risk demonstrate a strong consideration for differentiating between objective and subjective risk or probability within the framework of household optimisation (e.g. see Dominitz and Manski, 1996; Attanasio and Kaufmann, 2009).

References

Acemoglu, D. and D. Autor (2009). Lectures in labor economics. *Unpublished manuscript, Department of Economics, Massachusetts Institute of Technology, Cambridge, MA. Retrieved from http://economics. mit. edu/files/4689*.

Acemoglu, D. and S. Johnson (2007). Disease and development: The effect of life expectancy on economic growth. *Journal of Political Economy 115*(6).

Akresh, R. and D. de Walque (2008). Armed conflict and schooling: Evidence from the 1994 rwandan genocide.

Andersson, N., C. Palha da Sousa, and S. Paredes (1995). Social cost of land mines in four countries: Afghanistan, bosnia, cambodia, and mozambique. *BMJ 311*(7007), 718–721.

Attanasio, O. and K. Kaufmann (2009). Educational choices, subjective expectations, and credit constraints. Technical report, National Bureau of Economic Research.

Attanasio, O. P. (2009). Expectations and perceptions in developing countries: their measurement and their use. *The American Economic Review*, 87–92.

Authority, C. M. A. (variousa). *Cambodia Mine Action Authority Annual Report.*

Authority, C. M. A. (variousb). *Cambodia Mine Action Authority Implemented Work Action Report.*

Authority, C. M. A. (variousc). *Cambodia Mine Victims Information System Report.*

Bai, J., S. Jayachandran, E. J. Malesky, and B. A. Olken (2013). Does economic growth reduce corruption? theory and evidence from vietnam. Technical report, National Bureau of Economic Research.

Bartik, T. J. (1991). Who benefits from state and local economic development policies?

Becker, G. S. (1964). Human capital: a theoretical analysis with special reference to education. *National Bureau for Economic Research, Columbia University Press, New York and London*.

Becker, G. S. (1994). Human capital. *University of Chicago Press Economics Books*.

Becker, G. S. (2009). *Human capital: A theoretical and empirical analysis, with special reference to education.* University of Chicago Press.

Behrman, J. R. (1988). Intrahousehold allocation of nutrients in rural india: Are boys favored? do parents exhibit inequality aversion? *Oxford Economic Papers*, 32–54.

Ben-Porath, Y. (1967). The production of human capital and the life cycle of earnings. *The Journal of Political Economy*, 352–365.

Bils, M. and P. J. Klenow (2000). Does schooling cause growth? *American economic review*, 1160–1183.

Blattman, C. and E. Miguel (2010). Civil war. *Journal of Economic Literature*, 3–57.

Bleakley, H. (2007). Disease and development: evidence from hookworm eradication in the american south. *The Quarterly Journal of Economics 122*(1), 73–117.

Bound, J. and H. J. Holzer (2000). Demand shifts, population adjustments, and labor market outcomes during the 1980s. *Journal of labor Economics 18*(1), 20–54.

Bray, M. and S. Bunly (2005). *Balancing the books: Household financing of basic education in Cambodia*. Comparative Education Research Centre, University of Hong Kong Hong Kong.

Cam-NIS (2006). Cambodia commune database.

Cam-NIS (various). Cambodia socio-economic survey.

Camacho, A. (2008). Stress and birth weight: evidence from terrorist attacks. *The American Economic Review*, 511–515.

Cervellati, M. and U. Sunde (2005). Human capital formation, life expectancy, and the process of development. *American Economic Review*, 1653–1672.

Cervellati, M. and U. Sunde (2013). Life expectancy, schooling, and lifetime labor supply: Theory and evidence revisited. *Econometrica 81*(5), 2055–2086.

Chow, G. C. (1960). Tests of equality between sets of coefficients in two linear regressions. *Econometrica 28*(3), 591–605.

CMAA (2001a). *Cambodia Mine Action Authority Annual Report*.

CMAA (2001b). *Cambodia Mine Action Authority Level 1 Survey Report*.

CMVIS (2012). *Cambodia Mine Victims Information System Report*.

Cobey, J. C. (1995). War of the mines: Cambodia, landmines and the impoverishment of a nation. *JAMA 274*(5), 429–429.

Davies, P. and N. Dunlop (1994). *War of the Mines: Cambodia, Landmines and the Impoverishment of a Nation*. Pluto Press London.

De la Croix, D. and O. Licandro (1999). Life expectancy and endogenous growth. *Economics Letters 65*(2), 255–263.

De la Croix, D. and O. Licandro (2013). The child is father of the man: Implications for the demographic transition. *The Economic Journal 123*(567), 236–261.

Delavande, A., X. Giné, and D. McKenzie (2011). Measuring subjective expectations in developing countries: A critical review and new evidence. *Journal of Development Economics 94*(2), 151–163.

Dominitz, J. and C. F. Manski (1996). Eliciting student expectations of the return to schooling. *Journal of Human Resources 31*(1), 1–26.

Etcheson, C. (1984). *The rise and demise of Democratic Kampuchea*. Westview.

Fortson, J. G. (2011). Mortality risk and human capital investment: The impact of hiv/aids in sub-saharan africa. *The Review of Economics and Statistics 93*(1), 1–15.

Galor, O. and D. N. Weil (1999). From malthusian stagnation to modern growth. *American Economic Review*, 150–154.

Galor, O. and D. N. Weil (2000). Population, technology, and growth: From malthusian stagnation to the demographic transition and beyond. *American economic review*, 806–828.

Gerardino, M. P. The effect of violence on the educational gender gap.

Gerardino, M. P. (2013). The effect of violence on the educational gender gap. *mimeo*.

Gibson, J., S. Barns, M. Cameron, S. Lim, F. Scrimgeour, and J. Tressler (2007). The value of statistical life and the economics of landmine clearance in developing countries. *World Development 35*(3), 512–531.

Gigerenzer, G. (2004). Dread risk, september 11, and fatal traffic accidents. *Psychological science 15*(4), 286–287.

Gildestad, B. (2005). Cost-benefit analysis of mine clearance operations in cambodia, 2nd draft report. *Nordic Consulting Group, for the Cambodian Mine Action Authority (CMAA) and UNDP*.

Gupta, M. D. (1987). Selective discrimination against female children in rural punjab, india. *Population and development review*, 77–100.

Harris, G. (2000). The economics of landmine clearance: case study of cambodia. *Journal of International Development 12*(2), 219–225.

Hazan, M. (2009). Longevity and lifetime labor supply: Evidence and implications. *Econometrica 77*(6), 1829–1863.

Hazan, M. (2012). Life expectancy and schooling: new insights from cross-country data. *Journal of Population Economics 25*(4), 1237–1248.

Hazan, M. and H. Zoabi (2006). Does longevity cause growth? a theoretical critique. *Journal of Economic Growth 11*(4), 363–376.

Hurd, M. D. and K. McGarry (2002). The predictive validity of subjective probabilities of survival*. *The Economic Journal 112*(482), 966–985.

Hurt, L. S., C. Ronsmans, and S. Saha (2004). Effects of education and other socioeconomic factors on middle age mortality in rural bangladesh. *Journal of epidemiology and community health 58*(4), 315–320.

Jayachandran, S. and A. Lleras-Muney (2009). Life expectancy and human capital investments: Evidence from maternal mortality declines. *The Quarterly Journal of Economics 124*(1), 349–397.

Justino, P. (2009). Poverty and violent conflict: A micro-level perspective on the causes and duration of warfare. *Journal of Peace Research 46*(3), 315–333.

Kahneman, D. and A. Tversky (1979). Prospect theory: An analysis of decision under risk. *Econometrica: Journal of the Econometric Society*, 263–291.

Kiernan, B. (1985). *How Pol Pot came to power: a history of communism in Kampuchea, 1930-1975.* Verso London.

Kiernan, B. (1996). *The Pol Pot regime: race, power, and genocide in Cambodia under the Khmer Rouge, 1975-79.* Yale University Press New Haven, CT.

Kiernan, B. (2001). Myth, nationalism and genocide. *Journal of Genocide Research 3*(2), 187–206.

Kilka, M. and M. Weber (2001). What determines the shape of the probability weighting function under uncertainty? *Management science 47*(12), 1712–1726.

Krimsky, S. and D. Golding (1992). Social theories of risk.

Leon, G. (2012). Civil conflict and human capital accumulation the long-term effects of political violence in perú. *Journal of Human Resources 47*(4), 991–1022.

Lleras-Muney, A. (2005). The relationship between education and adult mortality in the united states. *The Review of Economic Studies 72*(1), 189–221.

Lorentzen, P., J. McMillan, and R. Wacziarg (2008). Death and development. *Journal of Economic Growth 13*(2), 81–124.

Lucas, A. M. (2010). Malaria eradication and educational attainment: evidence from paraguay and sri lanka. *American economic journal. Applied economics 2*(2), 46.

Machin, S., K. G. Salvanes, and P. Pelkonen (2012). Education and mobility. *Journal of the European Economic Association 10*(2), 417–450.

Malamud, O. and A. K. Wozniak (2010). The impact of college education on geographic mobility: Identifying education using multiple components of vietnam draft risk. nber working paper no. 16463. *National Bureau of Economic Research*.

Mansour, H. and D. I. Rees (2012). Armed conflict and birth weight: Evidence from the al-aqsa intifada. *Journal of Development Economics 99*(1), 190–199.

Manuelli, R. E. and A. Seshadri (2007). Human capital and the wealth of nations.

Miguel, E. and M. Kremer (2004). Worms: identifying impacts on education and health in the presence of treatment externalities. *Econometrica 72*(1), 159–217.

Millán, J. A. (2014). Crime and labour market, choice under uncertainty model and an application for colombian cities. *University College London mimeo*.

Mincer, J. A. (1974). Schooling, experience, and earnings. *NBER Books*.

MoEYS (2005). Education strategic plan 2006-2010.

MoEYS (various). *Cambodia Ministry of Education and Sports Annual Report*.

Mustard, C. A., S. Derksen, J.-M. Berthelot, M. Wolfson, and L. L. Roos (1997). Age-specific education and income gradients in morbidity and mortality in a canadian province. *Social science & medicine 45*(3), 383–397.

Myers, D. G. (2001). Do we fear the right things. *APS Observer 14*(3), 31.

Oreopoulos, P. and K. G. Salvanes (2011). Priceless: The nonpecuniary benefits of schooling. *The Journal of Economic Perspectives*, 159–184.

Oster, E., I. Shoulson, and E. Dorsey (2013). Limited life expectancy, human capital and health investments. *The American Economic Review 103*(5), 1977–2002.

Roberts, W. C. (2011). *Landmines in Cambodia: Past, Present, and Future.* Cambria Press.

Rodriguez, C. and F. Sánchez (2009). Armed conflict exposure, human capital investments and child labor: Evidence from colombia. *Human Capital Investments and Child Labor: Evidence from Colombia (February 20, 2009).*

Shemyakina, O. (2011). The effect of armed conflict on accumulation of schooling: Results from tajikistan. *Journal of Development Economics 95*(2), 186–200.

Slovic, P. (1987). Perception of risk. *Science 236*(4799), 280–285.

Slovic, P., B. Fischhoff, and S. Lichtenstein (1982). Why study risk perception? *Risk analysis 2*(2), 83–93.

Soares, R. R. (2005). Mortality reductions, educational attainment, and fertility choice. *American Economic Review*, 580–601.

Stoler, A. and D. Meltzer (2013). Mortality and morbidity risks and economic behavior. *Health economics 22*(2), 132–143.

Strauss, J. and D. Thomas (1995). Human resources: Empirical modeling of household and family decisions. *Handbook of development economics 3*, 1883–2023.

Strulik, H. and S. Vollmer (2013). Long-run trends of human aging and longevity. *Journal of Population Economics 26*(4), 1303–1323.

Weitz, E. D. (2009). *A century of genocide: Utopias of race and nation.* Princeton University Press.

Willis, R. J. (1987). Wage determinants: A survey and reinterpretation of human capital earnings functions. *Handbook of Labor Economics 1*, 525–602.

WorldBank (2008). Cambodia statistics.

Wozniak, A. (2010). Are college graduates more responsive to distant labor market opportunities? *Journal of Human Resources 45*(4), 944–970.

Figures

Figure 1: National level of landmine clearance productivity: 2000-2008

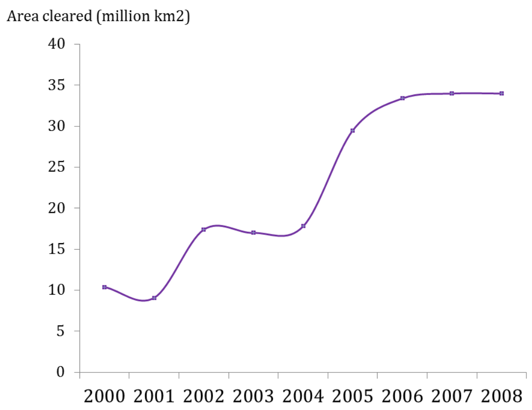


Figure 2: National level of landmine casualty rate: 2000-2008

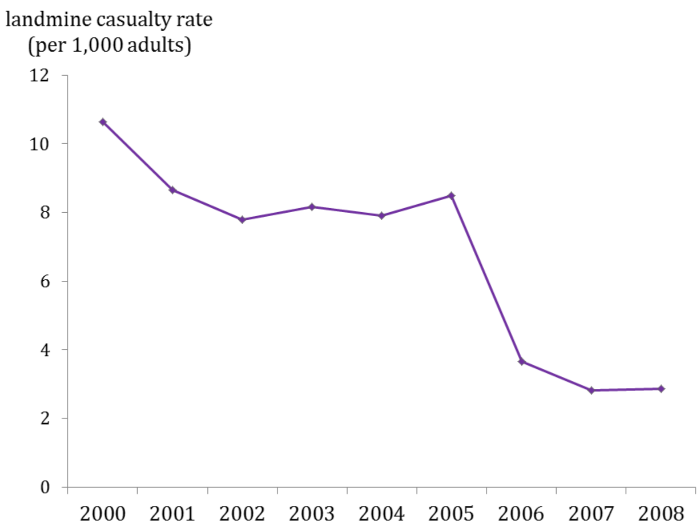


Figure 3: Spatial distribution of landmines productivity and landmine casualty rate: before and after 2005

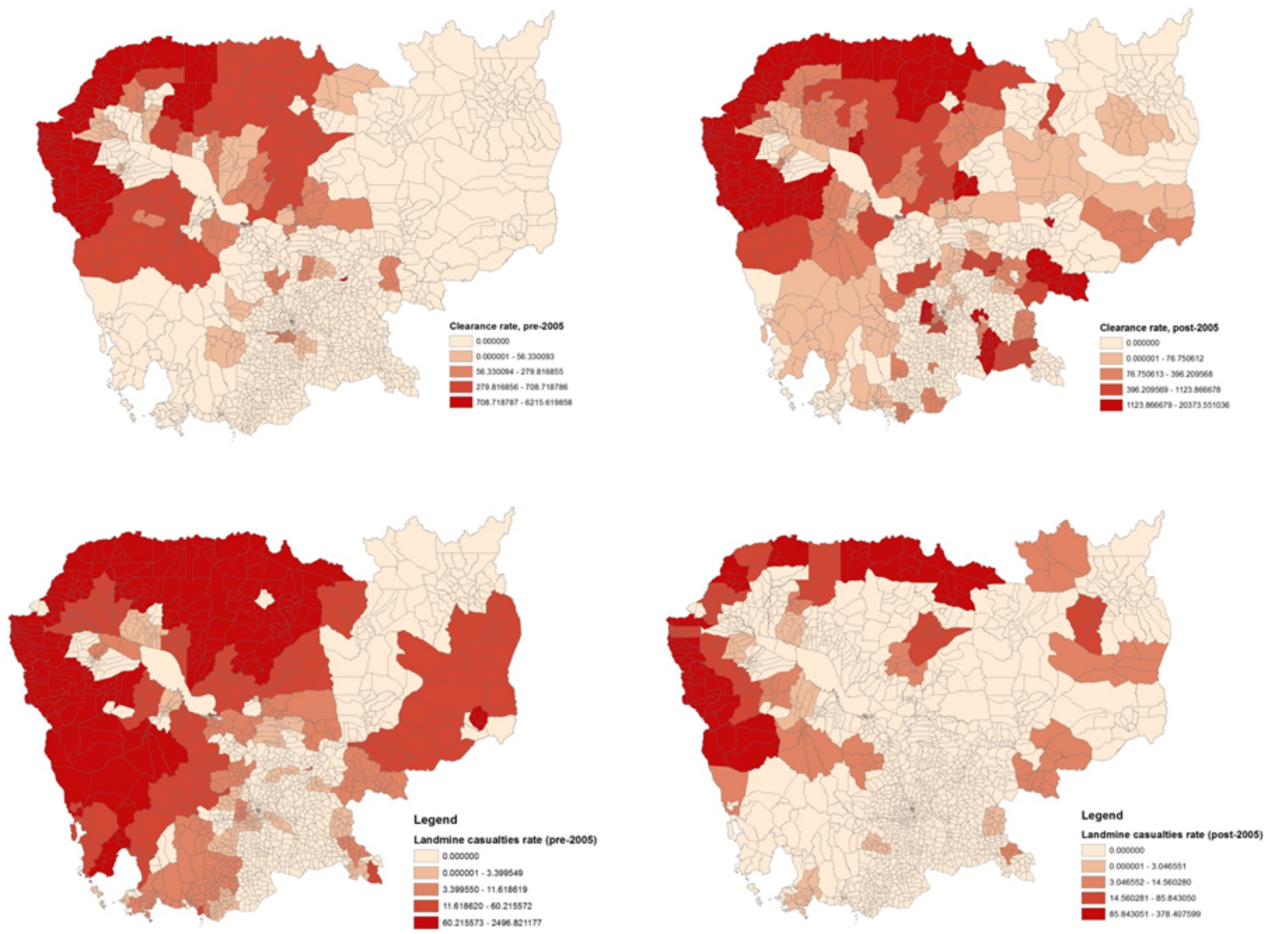


Figure 4: Trends of landmines productivity and landmine casualty rate by average intensity of landmine casualty rates in 2001-2004

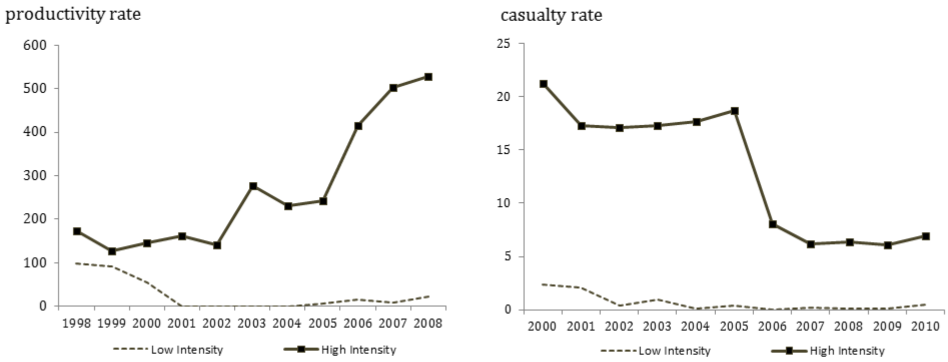


Figure 5: Average number of schools by average intensity of landmine casualty rates in 2001-2004 (province-level)

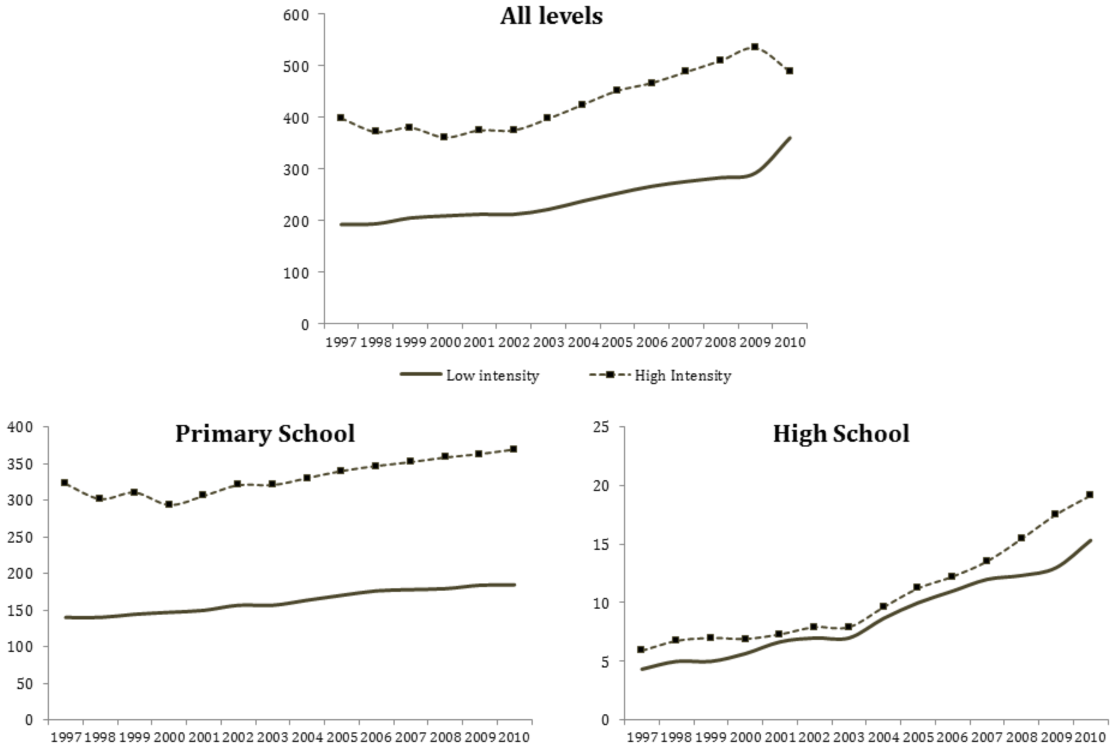


Figure 6: School attendance characteristics by average intensity of landmine casualty rate in 2001-2004 (province-level)

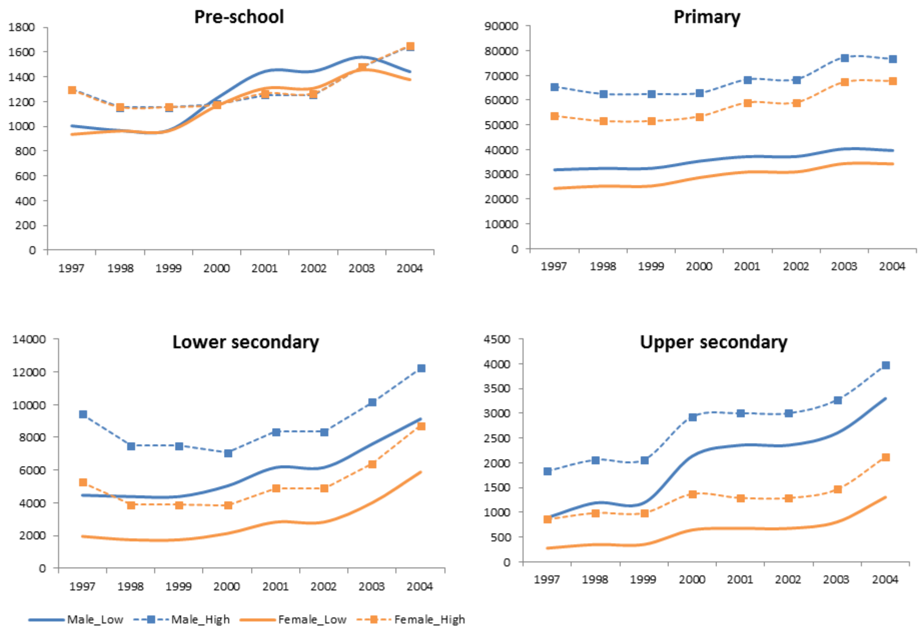


Figure 7: Poverty rate by intensity of landmine clearance productivity in 2005-2007

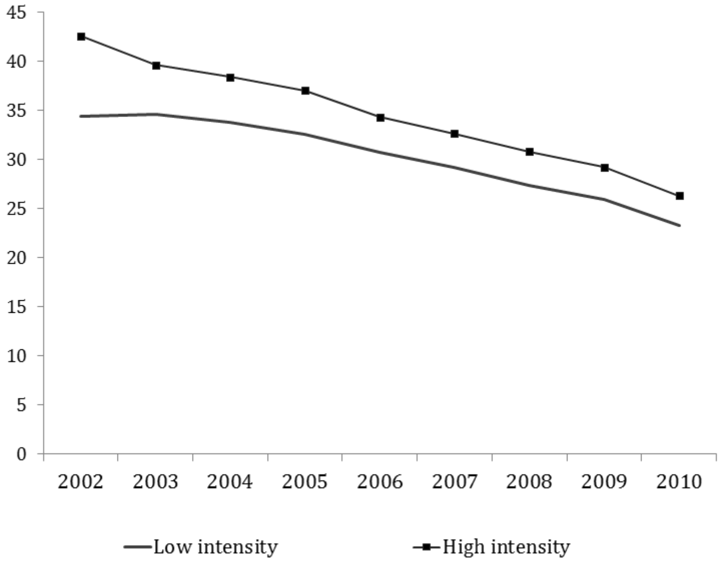


Figure 8: Age-gender specific mortality rates at province level, by intensity of clearance productivity in 2005-2007

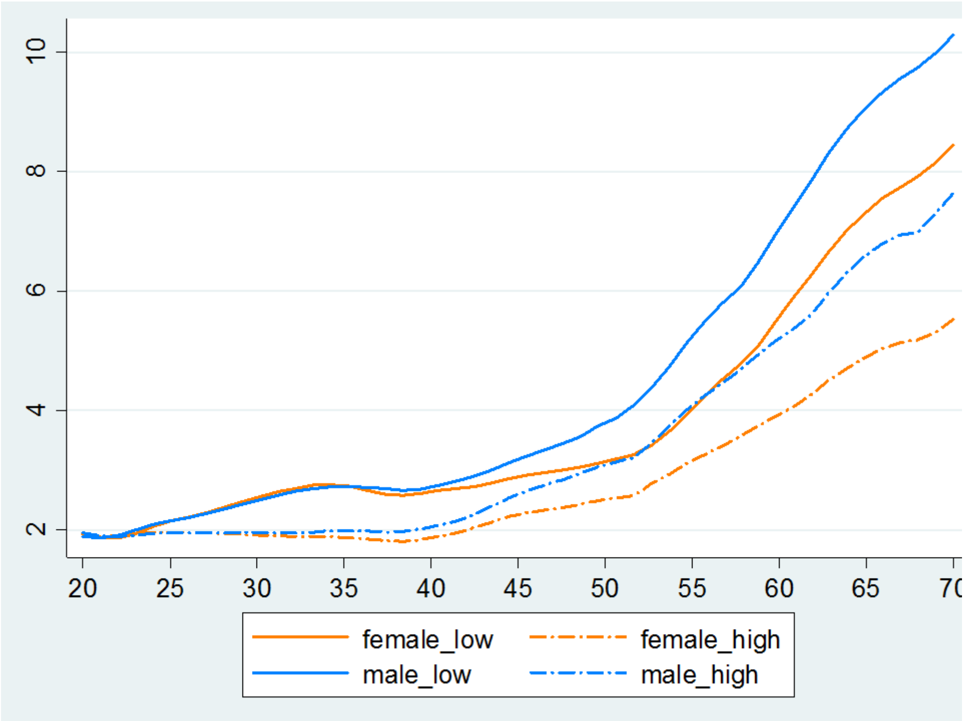


Figure 9: Causes of death in Cambodia (national average)

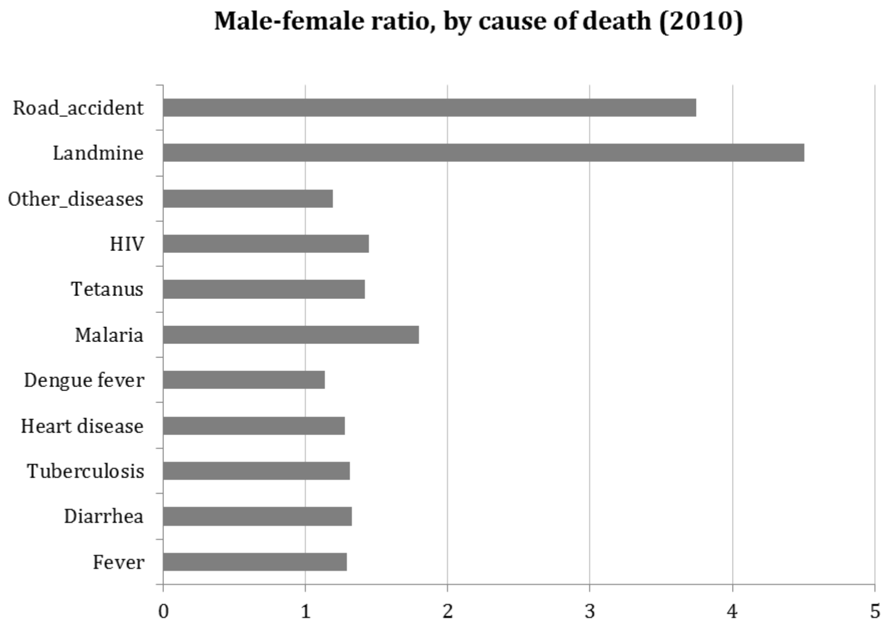


Figure 10: Causes of death in Cambodia (national average)

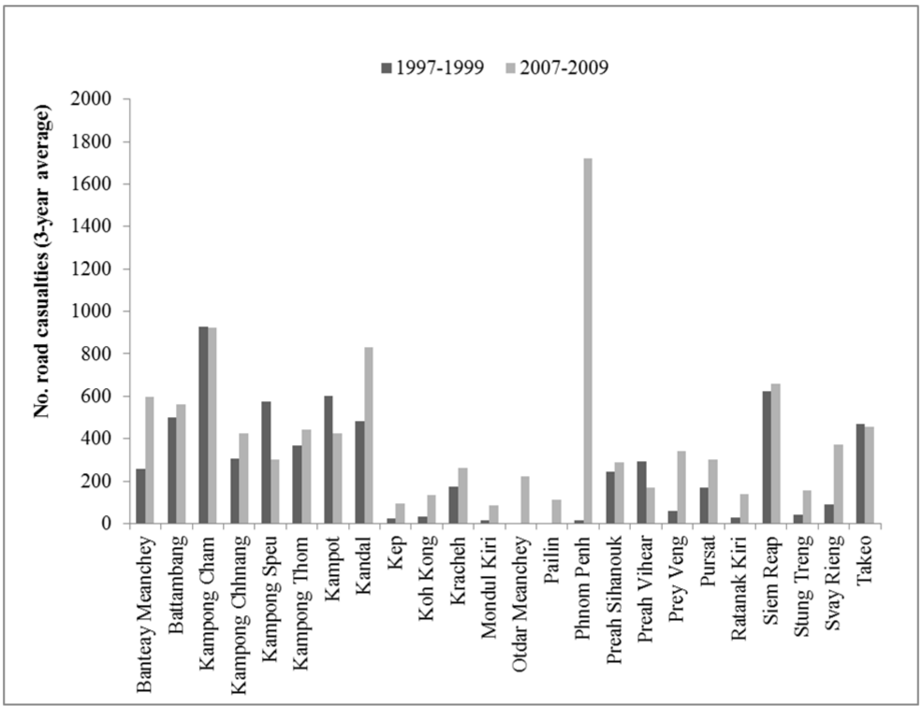
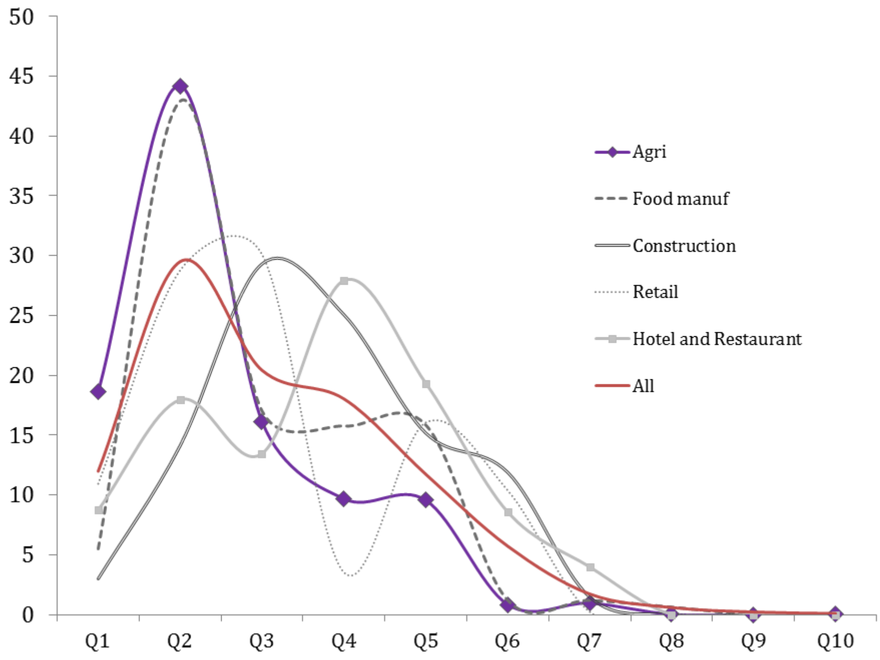


Figure 11: Wage distribution by decile in 2001 (national average)



Tables

Table 1: Share of landmine casualties to total mortality (province average) by age and gender, 2008

Age:	Under 0	0-5	0-14	15-40
Panel A: Males				
2005	22.28	9.00	6.45	17.40
2006	9.8	3.77	2.56	6.41
2007	6.54	2.54	1.77	4.59
2008	4.98	1.94	1.35	3.34
2009	4.82	1.80	1.22	3.09
2010	6.9	2.79	1.96	5.4
2011	6.58	2.52	1.66	4.31
Panel B: Females				
2005	1.80	0.68	0.46	1.23
2006	0.88	0.33	0.23	0.57
2007	0.33	0.11	0.07	0.15
2008	1.37	0.42	0.27	0.91
2009	0.56	0.23	0.16	0.04
2010	2.98	1.34	1.04	2.63
2011	0.30	0.11	0.06	0.14

Source: CMAA. The numbers indicate percentage share among different age groups with each calendar year, for males (Panel A) and females (Panel B)

Table 2: Province-average number of landmine casualties, by age group and gender

	Age 0-15		Age 15-40	
	Male	Female	Male	Female
2005	1	0	17.8	3.6
2006	1	2	11.1	2.4
2007	3.5	1	8.7	4.0
2008	2	0	8.0	2.6
2009	1	3	8.1	2.3
2010	3	1.5	7.2	4.5
2011	1	1	9	3.0

Notes: the data on landmine casualties come from CMAA database. The numbers above are the total number of reported landmine casualties the province level between 2005-2011 in Cambodia.

Table 3: Summary statistics by intensity of landmine casualties (1998)

	Low Intensity		High Intensity	
	Male	Female	Male	Female
Educational characteristics in 1998				
Primary (age 6-15)	0.63	0.60	0.83	0.84
Secondary (age 12-20)	0.26	0.20	0.47	0.46
Literacy (age 6-15)	0.59	0.57	0.84	0.85
Literacy (age 12-20)	0.84	0.77	0.93	0.92
School attendance (age 6-14)	0.78	0.77	0.77	0.76
School attendance (age 15-17)	0.62	0.58	0.59	0.55
Other characteristics in 1998				
Rural(%)	0.82		0.87	
With electricity(%)	0.17		0.14	
With piped water(%)	0.09		0.04	
With toilets(%)	0.17		0.13	
Home ownership(%)	0.92		0.93	
Female as household head(%)	0.25		0.25	
No. health centres per commune	0.5		0.5	
Poverty rate (%)	34.15		38.17	
Landmine mortality rate	14.52		169.84	
Annual landmine clearance rate(km^2)	0.85		355.0	

Notes: Data are derived from various sources (IPUMS 1998, 2008; Cambodia Commune Database 2006; Seila-CARERE2 1998; CMAA 2010). Low intensity districts are defined as the districts with the rate of landmine casualty (per 1000 adults) below the 45^{th} percentile in the years 2002-2004. High intensity districts are those with the casualty rate above the 65^{th} percentile.

Table 4: District-level summary statistics by the intensity of landmine clearance operation productivity in the years 2005-2007

Characteristics	High Productivity	Low Productivity	P-value
Male illiteracy (age 36-45)	47.8	53.7	0.54
Female illiteracy (age 36-45)	57.4	59.6	0.96
Male illiteracy (age 46-60)	49.0	53.8	0.62
Female illiteracy (age 46-60)	60.4	64.6	0.68
No. all schools	0.6	0.5	0.23
No. primary schools	3.0	3.7	0.08
No. lower-secondary schools	0.6	0.7	0.36
No. upper-secondary schools	0.2	0.2	0.98
No. health clinics	0.3	0.3	0.73
Child mortality rate	160	171	76
Maternal mortality rate	0.8	0.7	0.60
Poverty rate (%)	30.83	27.35	0.04
No. large-size markets	0.1	0.1	0.40
No. small-size markets	0.4	0.4	0.47

Notes. Data are derived from various sources (Cambodia Commune Database 2006; Seila-CARERE2 1998; CMAA 2010). Illiteracy variables are the percentage per population of a given age-gender group. Number of school (total and by each level) are the number at district level, child mortality rate is under-five year mortality per 1,000 live births, maternal mortality rate is per 100,000 birth. The P-values are obtained from a t-test from the null hypothesis that there is no difference between the districts from high and low clearance productivity. Low productivity districts are defined as the districts receiving the aggregate landmine clearance operation (per km^2) during the years 2005-2007 below the 45^{th} percentile. High productivity districts are those with the landmine clearance operation rate above the 65^{th} percentile.

Table 5: DDD at district level using the 1998 and 2008 census

	(I)	(II)	(III)	(IV)
Panel A: primary school (age 6-15 in 1998 and 2008)				
$Mine * Male$	-0.061***	-0.054***	-0.045***	-0.045***
	[0.011]	[0.014]	[0.014]	[0.014]
Additional controls				
Rice income	N	Y	Y	Y
Poverty rate	N	N	Y	Y
Health conditions	N	N	N	Y
R-Sq	0.0929	0.0933	0.0934	0.0934
Obs	620497	620497	620497	620497
Panel B: secondary school (age 12-20 in 1998 and 2008)				
$Mine * Male$	-0.042***	-0.056***	-0.056***	-0.061***
	[0.009]	[0.008]	[0.008]	[0.009]
Additional controls:				
Rice income	N	Y	Y	Y
Poverty rate	N	N	Y	Y
Health conditions	N	N	N	Y
R-Sq	0.1114	0.125	0.125	0.1269
Obs	518638	518638	518638	518638

Notes: Dependent variable is the probability of having at least a primary school education for Panel A and the probability of having at least secondary school for Panel B. Each cell reports the coefficient from each separate regression. *Mine* is landmine casualty rate per 1,000 prime age adult population in a district of interest. In Panel A, the cohorts of interest aged 6-25 years old in IPUMS 2008. Panel B, the cohorts of interest aged 12-30 years old in IPUMS 2008. All regressions include district-age cohort, age cohort-gender, district-gender and age fixed effect. Robust standard errors clustered at province level are reported in square brackets.* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6: DDD at district level using two groups of age cohorts in the 2008 census

	(I)	(II)	(III)	(IV)
Panel A: primary school (age 6-15 and 16-25 in 2008)				
$Mine * Male$	-0.015***	-0.012**	-0.012**	-0.010**
	[.007]	[.007]	[.007]	[.007]
Additional controls:				
Rice income	N	Y	Y	Y
Poverty rate	N	N	Y	Y
Health conditions	N	N	N	Y
R-Sq	0.0275	0.1668	0.1668	0.1668
Obs	567350	567350	567350	567350
Panel B: secondary school (age 12-20 and 22-30 in 2008)				
$Mine * Male$	-0.031***	-0.033***	-0.032***	-0.035***
	[0.009]	[0.008]	[0.008]	[0.01]
Additional controls:				
Rice income	N	Y	Y	Y
Poverty rate	N	N	Y	Y
Health conditions	N	N	N	Y
R-Sq	0.133	0.1246	0.1246	0.1253
Obs	359992	359992	359992	359992

Notes: Dependent variable is the probability of having at least a primary school education for age 6-15. Dependent variable is the probability of having at least a secondary school education for age 12-20. Each cell reports the coefficient from each separate regression. $Mine$ is landmine casualty rate per 1,000 prime age adult population in a district of interest. The cohorts of interest aged 6-15 years old in IPUMS 2008 and similarly in IPUMS 1998. Similarly, they are aged 12-20 for Panel B. All regressions include district-year, year-gender and district-gender fixed effects. Robust standard errors clustered at province level are reported in square brackets.* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 7: DDD at district level using gender-specific rate, with the 1998 and 2008 census

	(I)	(II)	(III)	(IV)
Panel A: primary school (age 6-15 in 1998 and 2008)				
$Mine_G$	-0.046***	-0.042***	-0.042***	-0.043***
	[0.009]	[0.009]	[0.009]	[0.009]
Additional controls:				
Rice income	N	Y	Y	Y
Poverty rate	N	N	Y	Y
Health conditions	N	N	N	Y
R-Sq	0.0943	0.0947	0.0947	0.0947
Obs	621066	621066	621066	621066
Panel B: secondary school (age 12-20 in 1998 and 2008)				
$Mine_G$	-0.029***	-0.029***	-0.029***	-0.031***
	[0.007]	[0.005]	[0.005]	[0.005]
Additional controls:				
Rice income	N	Y	Y	Y
Poverty rate	N	N	Y	Y
Health conditions	N	N	N	Y
R-Sq	0.1119	0.1247	0.1247	0.1266
Obs	518638	518638	518638	518638

Notes: Dependent variable is the probability of having at least a primary school education for Panel A and the probability of having at least secondary school for Panel B. Each cell reports the coefficient from each separate regression. $Mine_G$ is gender-specific landmine casualty rate per 1,000 prime age adult population in a district of interest. In Panel A, the cohorts of interest aged 6-25 years old in IPUMS 2008. Panel B, the cohorts of interest aged 12-30 years old in IPUMS 2008. All regressions include district-age cohort, age cohort-gender, district-gender and age fixed effect. Robust standard errors clustered at province level are reported in square brackets.* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 8: 2SLS with neighbouring provinces' stock of *dangerous* areas as instruments, 1998 and 2008 census

	Primary School Age 6-15			Secondary School Age 12-20		
	Mine	Prob(Primary)		*Mine*	Prob(Secondary)	
First-stage						
$NeighDangerland * Male$	2.326**			2.234***		
	[0.06]			[0.035]		
Second-stage						
$MineHat * Male$		-0.099**	-0.055**		-0.087**	-0.136*
		[0.002]	[0.002]		[0.007]	[0.017]
Additional controls:						
Rice income	N	N	Y	N	N	Y
Poverty rate	N	N	Y	N	N	Y
Health conditions	N	N	Y	N	N	Y
F-test (only excluded)	20.75			20.50		
R-Sq	0.7633	0.092	0.093	0.728	0.111	0.126
Obs	621066	621066	621066	567350	567350	567350

Notes: Each cell reports the coefficient from each separate regression. For the main regression, dependent variable is the probability of having at least a primary school education. In the first stage, the dependant variable is $Mine * Male$ is a given period. $NeighDangerland$ is averaged level of proportion of lands in neighbouring provinces that are not yet cleared by landmine operations per 1000 squared meters. $MineHat$ is predicted landmine casualty rate per 1,000 prime age adult population in a province of interest from the first stage. In the second stage, the dependent variable is probability of having a qualification of interests (primary school, secondary school). The datasets used are from Cambodia IPUMS 1998 and 2008. Robust standard errors clustered at age cohort are reported in square brackets with * significant at 10%; ** significant at 5%; *** significant at 1%. F-statistic tests whether the instruments are jointly significant.

Table 9: 2SLS using gender-specific landmine casualty rates, 1998 and 2008 census

	Primary School Age 6-15			Secondary School Age 12-20		
	Mine	Prob(Primary)		*Mine*	Prob(Secondary)	
First-stage						
$NeighDangerland * Male$	2.59**			4.04***		
	[0.52]			[1.026]		
Second-stage						
$\widehat{Mine_G}$		-0.055***	-0.031***		-0.048***	-0.068***
		[0.01]	[0.01]		[0.01]	[0.007]
Additional controls:						
Rice income	N	N	Y	N	N	Y
Poverty rate	N	N	Y	N	N	Y
Health conditions	N	N	Y	N	N	Y
F-test (on the excluded)	19.15			19.12		
R-Sq	0.7029	0.0923	0.0931	0.639	0.1112	0.126
Obs	621066	621066	621066	567350	567350	567350

Notes: Each cell reports the coefficient from a separate regression. For the main regression, dependent variable is the probability of having at least a primary school education. In the first stage, the dependant variable is $Mine * Male$ is a given period. $NeighDangerland$ is averaged level of proportion of lands in neighbouring provinces that are not yet cleared by landmine operations per 1000 squared meters. $\widehat{Mine_G}$ is predicted gender-specific landmine casualty rate per 1,000 prime age adult population in a province of interest from the first stage. In the second stage, the dependent variable is probability of having a qualification of interests (primary school, secondary school). The datasets used are from Cambodia IPUMS 1998 and 2008. Robust standard errors clustered at age cohort are reported in square brackets with * significant at 10%; ** significant at 5%; *** significant at 1%. F-statistic tests whether the instruments are jointly significant.

Table 10: Health capital investments, using DDD with CDHS datasets

	BCG	Polio	Measles	Vitamin A
Panel A: age 1-5, DHS 2000 and 2010				
$Mine * Male$	-0.040*	-0.043*	-0.039**	-0.022
	[0.024]	[0.019]	[0.018]	[0.015]
R-Sq	0.173	0.111	0.107	0.569
Obs	15550	15559	15427	15371
Panel B: age 1-5, DHS 2000, 2005 and 2010				
$Mine * Male$	-0.093***	-0.082***	-0.062***	-0.037
	[0.025]	[0.018]	[0.021]	[0.020]
R-Sq	0.092	0.090	0.268	0.155
Obs	23067	23060	22849	22921

Notes: Dependent variables are the probability of the individual having received vaccination or micro-nutrition treatment by the observed age. Each cell reports the coefficient from a separate regression. $Mine$ is landmine casualty rate per 1,000 prime age adult population in a district of interest. The cohorts of interest aged 1-5 years old in each Cambodia DHS (2000, 2005 and 2010). All regressions include district-age cohort, age cohort-gender, district-gender and age fixed effect. Robust standard errors clustered at province level are reported in square brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 11: Probability of schooling and road accident mortality: DDD analysis

	Prob(Primary School)		Prob(Secondary School)	
	(I)	(II)	(III)	(IV)
Roadaccident ∗ Male	-0.106	-0.071	-0.148*	-0.13
	[0.13]	[0.11]	[0.084]	[0.19]
Additional controls				
No. motor vehicles	N	Y	N	Y
Rice income	N	Y	N	Y
Poverty rate	N	Y	N	Y
R-Sq	0.081	0.085	0.091	0.112
Obs	621066	621066	518638	518638

Notes: Roadaccident is road traffic casualty rate per 10,000 prime age adult population (aged 18-35) in a province of interest. Individuals of interest for the primary school outcome are 6-15 years old in 1998 and 2008. For secondary school outcomes, they aged 12-20 in 1998 and 2008. The datasets used are from Cambodia IPUMS 1998 and 2008. Robust standard errors are reported in square brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 12: Probability of schooling and road accident mortality: 2SLS analysis

	Primary School (age 6-15)			Secondary School (age 12-20)		
	Road Accident	Prob(Primary)		Road Accident	Prob(Secondary)	
First-stage						
$RoadNetworks * Male$	0.014**			0.015***		
	[0.0024]			[0.0025]		
Second-stage						
$AccidentHat * Male$		-0.178	-0.066		-0.271	-0.607
		[0.314]	[0.442]		[0.280]	[0.650]
Additional controls:						
No. motor vehicles	N	Y	Y	N	Y	Y
Rice income	N	N	Y	N	N	Y
Poverty rate	N	N	Y	N	N	Y
Health conditions	N	N	Y	N	N	Y
F-test (only excluded)	34.18			33.40		
R-Sq	0.746	0.087	0.091	0.755	0.090	0.069
Obs	651760	651760	651760	555999	555999	555999

Notes: Roadaccident is road traffic casualty rate per 10,000 prime age adult population (aged 18-35) in a province of interest. Individuals of interest for the primary school outcome are 6-15 years old in 1998 and 2008. For secondary school outcomes, they aged 12-20 in 1998 and 2008. *RoadNetworks* is the sum of distance (in 100 km) of major highways going through the neighbouring provinces in 1997 (*for control*) and 2007 (*for treated* cohorts). The datasets used are from Cambodia IPUMS 1998 and 2008. Robust standard errors are reported in square brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. F-statistic tests whether the instruments are jointly significant.

Table 13: 2SLS landmine casualty rates at province level), the 1998 and 2008 census

	Primary School (age 6-15)			Secondary School (age 12-20)		
	Mine	Prob(Primary)		*Mine*	Prob(Secondary)	
First-stage						
$NeighDangerland*Male$	2.203**			2.126***		
	[0.024]			[0.026]		
Second-stage						
$MineHat * Male$		-0.087**	-0.033**		-0.096**	-0.13*
		[0.002]	[0.002]		[0.005]	[0.014]
Additional controls:						
Rice income	N	N	Y	N	N	Y
Poverty rate	N	N	Y	N	N	Y
Health conditions	N	N	Y	N	N	Y
F-test (only excluded)	20.65			20.50		
R-Sq	0.353	0.085	0.090	0.348	0.088	0.109
Obs	621066	621066	621066	518637	518637	518637

Notes: Each cell reports the coefficient from a separate regression. For the main regression, dependent variable is the probability of having at least a primary school education. In the first stage, the dependant variable is $Mine * Male$ is a given period. $NeighDangerland$ is averaged level of proportion of lands in neighbouring provinces that are not yet cleared by landmine operations per 1000 squared meters. $MineHat$ is predicted landmine rate per 1,000 prime age adult population in a province of interest from the first stage. In the second stage, the dependent variable is probability of having a qualification of interests (primary school, secondary school). The datasets used are from Cambodia IPUMS 1998 and 2008. Robust standard errors clustered at age cohort are reported in square brackets with * significant at 10%; ** significant at 5%; *** significant at 1%. F-statistic tests whether the instruments are jointly significant.

Table 14: Landmine clearance and household wealth, using Cambodia DHS

	Household Wealth Index		Total Household Asset	
	(I)	(II)	(III)	(IV)
OLS repeated cross-section				
Clearance	-0.018		-0.046	
	[0.023]		[0.057]	
2SLS				
ClearanceHat		0.191		12.97
		[0.37]		[7.22]
R-Sq	0.3515	0.3475	0.3403	3343
Obs	41741	41741	41741	41741

Notes: The data used are CDHS 2000, 2005 and 2010. $Clearance_{L,Y}$ is 3-year average district-level landmine clearance area per total area in 1997-1999, 2001-2003, 2007-2009 for each corresponding Y. $ClearanceHat$ is the predicted clearance rate from the first stage where the instrument is $NeighbourClearance_{L,Y}$- the average rate of clearance of neighbouring provinces for the corresponding year. Robust standard errors clustered at province level are reported in square brackets * significant at 10%; ** significant at 5%; *** significant at 1%.

A Appendix

A.1 Data Sources

General Population Census: individual school attendance (1998, 2008); motor vehicle ownerships (1998, 2008)

Cambodia Mine Action and Victim Assistance Authority (CMAA)/ Cambodian Mine-UXO Victim Information System (CMVIS): landmine accidents (1979-2010); landmine casualties (1979-2010); landmine clearance productivity (1993-2010)

Cambodia Commune Database (1998-2010): population; literary; educational infrastructure; land allocation; economic activities; poverty rate; health statistics; rice harvest and yields; motor vehicle ownerships

Cambodia's National Health Statistics: road traffic fatalities at province level (1996-2005); annual health statistics

CMAA's Baseline Survey: landmine contamination by 2012 at commune level

Ministry of Agriculture, Forestry and Fisheries: annual rice price statistics at province level (1980-2010); annual rice yields at province level (1980-2010)

Cambodia Road Traffic and Victim Information System (RTAVIS): road traffic fatalities at province level (2004-2010); road accident incidents at province level (2004-2010)

Ministry of Public Health: road traffic fatalities at province level (1996-2010); health statistics at province level

Cambodia Land and Environment Atlas and Resource (CLEAR): road networks

Labour Force Surveys: wage and employment statistics (1998-2010)

A.2 A Simple Theoretical Framework

I present a simple framework to illustrate the role of mortality risk on optimal children schooling. The framework is built upon standard human capital investment theories. I adopt a simple two-period static model of paternalistic parents (Ben-Porath, 1967; **?**; Acemoglu and Autor, 2009). For now, the model assumes a perfect capital market [29] and no uncertainty.

Let a unitary household consists of a parent and a young child. The parent works and earns Y_1. He consumes C_1 for both him and the child in Period 1. The parent will decide

[29] Nevertheless, some borrowing constraints will be introduced later in order to reflect a more typical capital market in developing economies. With costs of schooling borne to the household become increasingly larger with a higher level of qualification, the role of financial constraints will become more determinant on the optimal level of household investments.

how much to invest in the child's schooling in this period. Let H_1 equals 1 when the parent decides to invest and zero otherwise. The total cost of schooling is θ_1, summing all official costs, for example school fee (F_1), and foregone costs. In the context of Cambodia, we can think of foregone costs is the child's earning from his labour market activities (W_C). At the end of Period 2, the parent dies and the child becomes a working adult. In this period, an educated adult earns W_E in the labour market whilst an uneducated adult receives W_U. In any case, she consumes C_2 in Period 2. The per-period utility take log-functions

Note that the unitary household discounts the future with the rate, ρ). To account for mortality risk, we add that the child faces a probability of not surviving to adulthood, m, at the end of Period 1 (Fortson, 2011). With a perfect capital market, the parent is able to borrow to invest, with the interest rate, r. The parent makes decision on the value of C_1, C_2 and H_1 so as to optimise the household lifetime utility given the budget constraint as the followings:

$$\max_{C_1,C_2,H_1} lnC_1 + exp(-(\rho + m))lnC_2 \tag{A.1}$$

subject to

$$C_1 + \frac{C_2}{1+r} = Y_1 - \theta_1 H_1 + [\frac{W_u}{1+r} + \frac{H_1(W_e - W_u)}{1+r}] \tag{A.2}$$

Under a perfect capital market, $1 + r$ is equivalent to $exp(-(\rho + m))$. The findings from the optimisation show that the parent will invest ($H_1 = 1$) only if $\theta_1 \leq ((W_e - W_u))/exp(-(\rho + m))$. This implies that a fall in mortality risk gives the parent more incentive to invest in the child's schooling. However, the effect gets more positive when the heterogeneous schooling premium ($W_e - W_u$) gets larger or when the costs on schooling falls.

Given the context of Cambodia, the assumption on perfect capital market may be far from true. To account for that, I introduce a borrowing constraint in which inter-temporal budget transfer is no longer possible (Acemoglu and Autor, 2009). Hence, the budget constraint of Period 1 and of Period 2 becomes the follows respectively:

$$C_1 - S_1 + \theta_1 H_1 \leq Y_1 \tag{A.3}$$

$$C_2 \leq W_u + (W_e - W_u)H_1 + (1 + r)S_1 \tag{A.4}$$

The parent compares between (i) the lifetime utility when they decide to invest in schooling and (ii) the lifetime utility when they do not invest. Denotes β as $exp(-(\rho+m))$, under imperfect capital market, H_1 is equal to one only if net utility gain from investment is strictly greater than net gain from not investing. This is equivalent to Equation (A.5) and subsequently Equation (A.6) below:

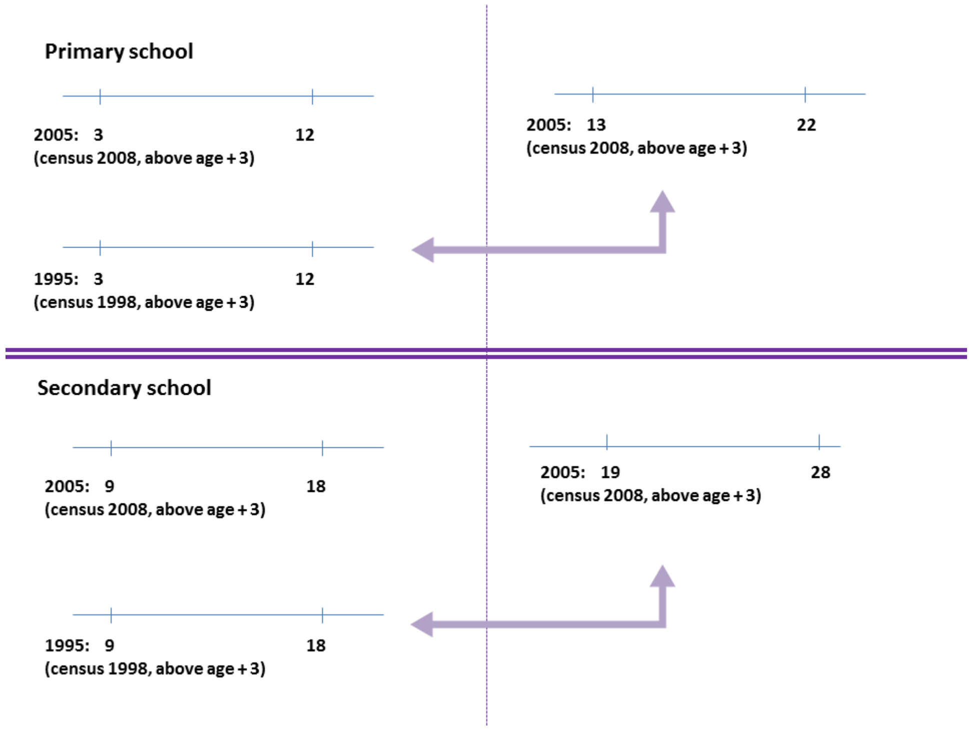
$$ln(Y_1 - \theta_1) + \beta ln(W_e) \geq ln(Y_1) - ln(W_u) \tag{A.5}$$

$$Y_1 \left(1 - \left[\frac{ln(W_e)}{ln(W_u)}\right]^{exp(-(\rho+m))}\right) \geq ln(\theta_1) \tag{A.6}$$

The inequality in Equation (A.6) shows that the effect of mortality risk on human capital investment remains negative under a credit constraint assumption. Compare to the perfect capital setting, in order to induce parents to invest, the magnitude of gains from human capital investment when facing with limited borrowing ability is required to be much larger *ceteris paribus*. A unit increase in m will pose a stronger negative response on the optimal investment decision under an imperfect capital market setting. Likewise, household's decision is more sensitive to a rise in costs of schooling in this context.

A.3 Supplementary Figures

Figure A.1: Definition of treated and control cohorts in the 1998 and 2008 census



Note: For each panel (primary school and secondary school panel), the top left figure indicates the treated cohorts from the 2008 census. The bottom left in each separate panel shows the age of the controlled cohorts from the 1998 census. The top right figures in each panel is the cohorts in the 2008 census that are the equivalent birth cohorts to the controlled group in the 1998 census. In each figure, the horizontal line outlines the actual ages of the cohorts of interest in a given calendar year. To link them to a related census year, three years need to be added to a given age.