Land Mines and Spatial Development *

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Abstract

According to UN reports land mines are uniquely savage in the history of modern warfare not only because of their appalling individual impact but also their social and economic destruction. As minefields often remain on the ground long after the cessation of hostilities they have an enduring legacy. Despite their importance for understanding post-conflict recovery and the billions of dollars spent on clearance, little research exists on the consequences of demining. This study focuses on Mozambique which was declared land mine free in the fall of 2015; 23 years after the end of the civil war that left the country contaminated with hundreds of thousands of explosive remnants of war across its territory. After documenting the spatial distribution of land mines and the timing of their removal across 1200 Mozambican districts, we exploit time variation in demining that appears to be largely non-coordinated, to assess its impact on local economic activity. The difference-in-difference specifications reveal significant positive impacts. We then apply a "market access" approach to examine the general equilibrium consequences of these interventions. We find strong positive aggregate effects of demining via the transportation network. Finally, to improve on identification we show that the market access – development nexus is also present for districts that were not directly affected by the placement of landmines. Our results highlight the importance of coordination among development actors in presence of strong spatial externalities.

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1 Introduction

Understanding the speed of economic recovery of conflict-ridden regions occupies an increasing part of the agenda among economists and political scientists. And of course it is of vital importance to understand why some countries manage to recover quickly after civil wars, while recovery is sluggish and slow in other cases. A weak recovery after a peace accord may push the country back into violence, giving rise to a vicious circle of poverty and conflict.

Naturally the consequences of conflict are multifaceted and permeate many different attributes of a society ranging from the loss of lives, the destruction of physical capital and infrastructure, distrust and decline of social capital, and deterioration of institutional capacity. Nevertheless, one aspect of wars, especially civil wars, that has been deemed particularly detrimental for the recovery of war-torn communities is the legacy of landmines and other unexploded ordnances (UXOs).[1] Its importance can be seen in the numerous NGO's, government agencies, donors and commercial partners that engage in mine-related activities, like the clearance of minefields, providing orthopedic and physiological assistance to victims, assisting in community building. There are 14 agencies under the auspices of the UN mine-action team, which as of 2008 was active in 43 countries. Land mines have been used extensively in many civil wars, mostly because they are very cheap and quite effective[2]; they have been coined as "*the weapon of the poor*" as they cost as little as one dollar (and can even by manufactured by militias at an even lower cost). As a result of it, unexploded land mines pose a serious and on-going threat to civilians across many parts of the developing world long after the cessation of the hostilities. According to Graça Machel, an expert of the UN Secretary-General on the "Impact of Armed Conflict on Children" and former minister of education of Mozambique "*Land-mines are uniquely savage in the history of modern conventional warfare not only because of their appalling individual impact, but also their long-term social and economic destruction*" (UN General Assembly Resolution 48/157, 1996). Despite the salience of this topic within the international community, academic work assessing the impact of landmines and their clearance on regional development is missing. This is puzzling as land mines and UXOs are a serious threat in more than 50 countries, most importantly in Angola, Afganistan, Cambodia, Bosnia, Somalia, Sudan, but also in frontier/developing economies, such as Colombia, El Salvador, Nicaragua, and Myanmar (Landmine Monitor 2015); and while there was a downward trend on the use of landmines, the 2015 Landmine Monitor identifies an increase of antipersonnel mines or victim-activated improvised explosive devices over the past years, among other places, in Syria, Iraq, Yemen, and Ukraine.

[1] Land mines are containers of explosive material with detonating systems that are triggered by contact with a person or vehicle. They are designed to incapacitate that person or vehicle through damage caused by an explosive blast, fragments, (or, in the case of some antitank mines, a jet of molten metal). They are generally buried within $15cm$ of the earth's surface, or laid above ground.

[2] Land mines have also been used extensively in international wars, such as WWI and WWII. Yet their effect after the war ending is typically small or mild, as conventional armies keep records of minefields that allow for their clearing. Moreover, typically in international wars, the armies do not use land mines to terrorize the local population and to block access to key facilities and infrastructure.

Our paper is an effort to shed light on both the local and economy-wide effects of land mines on spatial development. We focus on Mozambique, a country that after 25 years of warfare (initially fighting for independence from Portugal and subsequently entering a disastrous civil war), was not only almost totally destroyed in $1992-1994$, but approximately one million land mines and thousands of UXOs were scattered around the country. Though there were many back and forth, with significant support from international agencies and governments and the strength of the Mozambican people, the country was recently (in September 2015) declared to be free of the "threat" of land mines. In this study, we explore the economic consequences of demining efforts for both the affected districts and to the Mozambican economy as a whole.

Mozambique's experience with land mines starts with the war of independence $(1964-1974)$. Portugal planted large minefields in the border with Tanzania to prevent the fighters of the Front for Liberation of Mozambique (FRELIMO) to enter the country and rearm. The colonizers also installed mines in key infrastructure projects so as to protect them from the insurgents. At the same time, FRELIMO also used land mines that appeared quite effective in demoralizing the colonial army and create chaos in the countryside. Sadly things became worse after independence (in 1975), as soon afterwards Mozambique suffered one of the most prolonged (lasting till 1992) and devastating civil wars since the end of the Second World War.[3] What makes Mozambique a particularly important (though sad) case study is that both fighting sides, the Front for Liberation of Mozambique (FRELIMO) that was now controlling the government and was backed by the Soviet Union and other socialist countries- and the Mozambique Resistance Movement (RENAMO) – which was heavily supported by Rhodesia and South Africa's apartheid regime - relied heavily on the use of land mines.

Many tactics, including the random deployment of mines and the deliberate targeting of civilian populations, were in direct violation of international law (Human Rights Watch, Africa Watch (1992), Vines (1996)). In the overwhelming majority of cases the plotting of mines was not mapped imposing a tremendous obstacle to recovery. Since the transition to democracy in 1994, the national government with the help of international donors has tried to de-mine the country; yet given the chaotic conditions, the large country size, the low levels of road and railroad infrastructure (that was totally destroyed), and lack of coordination progress had been sluggish especially during the first decade. Moreover, there has been significant heterogeneity on the timing and success of demining activities, which are largely unrelated to economic fundamentals or political considerations (e.g., massive floods in 2000 and 2001 slowed down demining operations in the southern and central provinces). This slow pace becomes less perplexing when viewed in light of the fact that the absence of records indicating the location of mines exponentially increased the surveying and verification costs. Demining was especially challenging as the problem of land mines in Mozambique was one of "extensive" rather than "intensive" margin, many areas and districts were affected

[3] As we discuss below the costs of the civil war were tremendous and the numbers are flabbergasting. 100-200 thousand people dying from the war, 1 million dying from starvation, 1.5-2 million refugees in nearby countries, 3 million internally displaced people, tens of thousands of orphaned children, and tens of thousands of amputees from land mines.

by a relatively small number of mines that were placed either close to any type of infrastructure (roads, rail tracks, energy stations, pylons, schools, government buildings) or close to villages so as to terrorize the local population (Halo Trust (1994), Corps (2001), for Humanitarian Dimining (2013)). Hence, till recently a significant fraction of the country has been de facto cut from the transportation system. For example, the first detailed land mine impact survey, conducted in 2001 period suggested that almost all 128 districts in all 10 provinces (both rural and urban) were directly affected by land mines. And subsequent surveys in 2007 also revealed that the problem was still present, in spite of sizable progress during the period $1999 - 2007$; new mined areas were found and mines and UXOs were detected in areas that were cleared.

Besides the sizable direct death toll and injuries, land mines hinder development via numerous channels. First, land mines (or even suspicions on land mines) impede trade within and across regions by fragmenting markets. The ensuing isolation of the communities circumscribed by minefield exacerbates poverty and underdevelopment. Second, land mines prevent the repatriation of refugees and internally displaced people, and hamper the delivery of humanitarian aid. Third, land mines limit human capital accumulation by preventing school attendance and blocking access to health clinics. Fourth, there are large physiological and psychological costs to those injured and handicapped. The costs associated with the chronic treatment of individuals injured by land mines are sizable and constitute a continuing financial toll to the fragile health system of underdeveloped and developing countries. Fifth, land mines limit agriculture production, a key consideration in subsistence farming communities. By restricting access to farmland land mines have also contributed to food shortages and (small scale) famines, that were commonplace during the civil war. Sixth, land mines have non-negligible environmental consequences, as mines kill wildlife and cattle and destroy forests.

Results Preview First, we present the self-collected and cross-validated data on demining activities and describe the spatial distribution of land mines at the end of the civil war in 1992. We then examine the correlates of the distribution of land mines in an effort to uncover the strategic and non-strategic factors influencing land mine placement. We also examine the role of end-of-war and at-independence factors in explaining the timing of land mine clearance. In line with the surveys and historical narrative, we find that the timing of land mine and UXO removal is unrelated to geographic, location, and economic characteristics.

Second, we examine the local effects of demining on economic activity and urbanization, as reflected in satellite imagery data on light density at night, employing simple difference-in-difference specifications that compare luminosity in the group of affected by land mines and UXOs districts to those that did not before and after the demining. These empirical models show that regional development/urbanization increases modestly after the removal of land mines compared to the level of development in affected by land mine regions that have not been cleared yet and/or districts that have not been directed affected by

land mines.

Third, employing recently developed techniques in urban economics and quantitative trade literature, we examine the economy-wide implications of land mine removals. This is crucial as there may be general equilibrium effects from the removal of land mines in one district to others. Accounting for spillovers and estimating the economy-wide effects of land mine clearance is also key for policy, as the interest is typically on the aggregate impact. We combine the evolution of land mine clearance with the transportation network (roads, railroads and rivers) and building on Donaldson and Hornbeck (2016) we apply a "market access" approach that quantifies the aggregate effects of land mines (and their subsequent removals) on spatial development. This method, which is derived from general equilibrium trade theory of within-country cross-regional trade(e.g., Eaton and Kortum (2002), Arkolakis, Costinot, and Rodriguez-Clare (2012)) under flexible and widely-used assumptions, is well-suited to our research inquiry, as it allows us to shed light both on the direct and the indirect effects (stemming from changes in the network structure) of land mine clearance and opening of roads and railroads on economic activity. The "market access" estimates reveal an economically large and statistically precise impact of land mines removal on aggregate economic development, that works on top of any direct local effect.

Fourth, we provide two additional results in an effort to push on causation and account for endogeneity. As a starting point, we associate changes in luminosity to changes in "market access" coming from land mines cleared outside a buffer zone of 50 or even 100 kilometers; this minimizes concerns that NGOs and local agencies target districts those with high economic potential (something that does not seem to be the case). Our estimates retain economic and statistical significance. Perhaps more importantly, we then report results linking changes in regional development and changes in market access in the set of Mozambican regions without any minefield and UXO contamination at the end of the civil war. For these districts, changes in market access stem solely from land-mine clearance in other regions. The correlation between regional development and market access is quite strong and the estimates are quantitatively similar to those derived in the full sample.

1.1 Related Literature

Our paper connects four strands of the literature that have so far developed largely in parallel. In some sense part of our contribution is to bring together these fruitful strands of research.

Civil Conflict and Development First, our work is related to the voluminous body of research examining the origins and consequences of civil wars (see Blattman and Miguel (2010) for a thorough overview). Due to endogeneity issues in identifying the conflict-development nexus, the literature has mostly examined the correlates and deep determinants of civil conflict[4]. Studies using cross-country re-

[4]The literature is simply too large to summarize here. See, among others, Miguel, Satyanath, and Sergenti (2004), Buhaug and Rod (2006), Michalopoulos and Papaioannou (2016b), Cervellati, Sunde, and Valmori (2011), Fearon and Laitin (2003), Hegre and Sambanis (2006), Esteban, Mayoral, and Ray (2012), Montalvo and Reynal-Querol (2005), Spolaore and Wacziarg

gression methods and cases (e.g., Collier and Hoeffler (2007), Collier and Sambanis (2005)) show that civil wars slow down economic activity; yet typically growth resumes after the end of conflict, though there is considerable heterogeneity on the strength and timing of the recovery. From a theoretical standpoint, recovery is ambiguous; in the canonical neoclassical growth model, economic activity rebounds quickly and the recovery is timely and strong, if the war has mostly destroyed capital (as in our case). Yet, in absence of external interventions recovery is absent or sluggish in "poverty trap" models that are commonly used/assumed in development policy circles (e.g., Sachs (2005), Banerjee and Duflo (2011)). Of most relevance to our work are the innovative studies of Miguel and Roland (2011) and Lin (2015), who (while not studying the role and legacy of land mines) assess the long-run effects of the bombing of Vietnam and Cambodia by US Air Force between $1965 - 1973$, respectively.[5] Our work is also linked to a nascent literature in political science and development economics examining strategies for integrating ex-combatants (e.g., Blattman and Annan (2016)) and analyzing the impact of other than land mines, consequneces of conflict, such as child soldiering (Beber and Blattman (2013), Blattman and Annan (2013)). We complement these studies by exploring the consequences of demining on regional development and shedding light on the benefits of integrating the minefield-contaminated regions into larger markets.

We contribute to this body of research by studying a so-far neglected by academic research but crucial in practice aspect of civil wars, the use of land mines that may affect economic activity long after the end of warfare. Our results show that land mines can have long-lasting negative effects on economic activity even decades after the ending of conflict and the restoration of democracy. Our paper brings into this body of research a recently developed in international trade litearture method that allows estimating not only the local effects of land mines and their removal, but also the aggregate economy-wide effects that take into account spillovers. Methodologically this is important, as most within-country works that exploit regional variation employ a "control"-"treatment" approach that requires the absence of interdependencies between the two sets of regions; this is a strong assumption as conflict and removing land mines most likely do affect population dynamics and relocation.[6] Our results show that this appears crucial not only in theory, but also in practice. "Market access" general equilibrium effects are quantitatively large in our setting and tend to dominate local impacts.

(2015), and Wimmer, Cederman, and Min (2009).

[5] Miguel and Roland (2011) find that poverty and consumption in heavily-bombed areas in Vietnam are quite similar with non-bombed or lightly-bombed areas. Likewise Lin (2015) shows that the average effect of bombing Cambodia on agricultural productivity is negative but small and statistically insignificant; yet bombing had sizable negative effects on areas with fertile soft soil. Davis and Weinstein (2002) also document a quick recovery in population of Japanese cities after the bombardment of Japan by Allied Forces during the latest stage of WWII.

[6] Exploiting the infrastructure network structure of Mexico, Dell (2015), for example, shows significant spillovers of drug-related violence and trafficking in Mexico when policing increases in some municipalities. Employing spatial econometric techniques, Harari and La Ferrara (2014) show sizable spillovers between climate shocks and conflict. Michalopoulos and Papaioannou (2016b) provide reduced-form estimates showing that conflict in Africa spreads from partitioned by the national border ethnic homelands to nearby ethnic regions.

Aggregate Effects of Infrastructure Second, methodologically our paper relates to recent works in trade and urban economics that apply the insights of general equilibrium trade theory to study the aggregate effects of railroad or/and road infrastructure on the density of economic activity (see Donaldson (2015) for an eloquent overview).[7] Many empirical studies have examined the effects of roads-railroads on local economic activity and urbanization employing difference-in-difference specifications that compare various outcomes in regions that were affected by such investment and those that did not (typically exploiting some quasi-experimental variation on the location of the network). For example, Baum-Snow (2007) and Michaels (2008) study the impact of highway construction in the US on urbanization and manufacturing, documenting non-negligible impacts. Banerjee, Duflo, and Qian (2012) estimates the impact of railroads in China finding that population moved in cities close to railroads, but income per capita increased only modestly. Donaldson (forthcoming) examines the impact of the large colonial railroad network in India from 1853 till 1930 using data on agricultural production across 235 (large) Indian districts. Employing difference-in-difference models he estimates an average treatment effect on agricultural incomes for regions that were directly crossed by the railroad of approximately 15%.

Yet, these (and similar) studies can only estimate the local impact of infrastructure and only if spatial externalities are absent or small.[8] Yet, spatial spillovers are likely to be strong, due to factor mobility and hard-to-account-for general equilibrium effects that are way stronger within countries as compared to cross-country comparisons (Donaldson (2015));[9] and from a policy standpoint it is important to know the aggregate economy-wide impact of such interventions. In an important paper, Donaldson and Hornbeck (2016) adopt the general equilibrium intra-region trade Ricardian model of Eaton and Kortum (2002) to derive an expression linking changes to regional welfare (income) into changes into a district's market access, that reflects its proximity to all other markets in a country, appropriately discounted by their effective distance that reflects transportation/trade costs.[10] They then examine the impact of the expansion of US railways in the end of 19th century on aggregate economy activity, comparing their estimates to Fogel's influential ("social savings") work (Fogel (1964), Fogel (1962)). Donaldson and Hornbeck (2016) document that aggregate effects are considerably larger than local effects, indicating sizable positive indirect effects due to higher "market access".[11] Alder (2015) applies the "market access" approach to assess the impact of a large Indian highway project that aimed at improving connections between the large economic

[7] Redding and Turner (2015) summarize works on the consequences of transportation infrastructure. Costinot and Rodriguez-Clare (2014) provide thorough overview of recent empirical works estimating "gravity" equations across and within countries within the theoretical framework of general equilibrium trade models.

[8] Some authors estimate spatial lag models to approximate spillovers in nearby regions. Moreover, some researchers aggregate the data at a higher level of aggregation (states, provinces) so as to account for externalities.

[9] Following Rubin (1980), the assumption that there should be no interactions and spillovers between the "treatment" and the "control" regions is often referred to as the "stable unit treatment value assumption" (Donaldson (2015)).

[10] Donaldson (forthcoming) employs a similar approach to approximate the aggregate impact of colonial railroads in India; since his unit of analysis is quite large (253 districts) accounting for externalities, the aggregate effects are quite similar to the local estimates.

[11] Using a richer dataset covering 6 decades, more refined data, and an improved method to estimate bilateral trade costs, Perez-Cervantes (2014) estimates even larger aggregate effects of railroad expansion in the range of 9% of GDP (as compared to the 6.3% estimate of Donaldson and Hornbeck (2016)).

centers (Mumbai, Delhi, Chennai, and Calcutta). Proxying economic activity using satellite images on light density at night (as we do), Alder (2015) estimates that aggregate economic activity was approximately 3.5% higher in 2009 than it would have been in the absence of the improved road network.

Our work employs the "market access" approach to study a quite different research question than the ones asked by the trade, economic geography, and urban economic literature. We use the "market approach" to study a so far understudied issue, the aggregate impact of removing land mines and other war remnants from a country after the termination of warfare. By employing the "market access" approach, we can thus shed light on some important policy questions. What are the aggregate, as opposed to purely local, effects of removing land mines? How shall NGOs, international organizations and government agencies design the clearance of the minefields? The general-equilibirum market access approach shows that there are sizable externalities and hence land mine clearance have non-negligible aggregate effects. Moreover, our results point out that development agencies should take into account the infrastructure network structure when they prioritize their actions.

Infrastructure on African Urbanization and Development Third, our paper relates to works examining the role of mostly colonial investments in key infrastructure, mostly roads and railroads, on African development (see Ayogu (2007) for an overview of the interlinks between infrastructure and African development).[12] Using colonial data from French West Africa, Huillery (2009) shows that colonial infrastructure investment correlates significantly with current infrastructure; since colonizers did not invest much on infrastructure these results point out to the negative long-run effects of colonization. Chaves, Engerman, and Robinson (2014) present aggregate statistics from British colonies in West Africa (Golden Coast, Sierra Leone, and Nigeria) showing very high social returns (exceeding 50% yearly return in all colonies) and considerable social savings (around 5% of local GDP) to railroad construction. Jedwab, Kerby, and Moradi (2016) study the impact of colonial railroads in Kenya (connecting the port of Mombasa to Lake Victoria in Uganda) on subsequent urbanization and spatial development; they show that the railroad crucially affected the density of population and economic activity, as European and Asian settlers settled in cities close to the railroad; cities and towns near the railroads are still more developed, as compared to other similar cities, even though many Europeans left in the 1960s and even though due to under-investment, the railroads declined from the 1960*s* to 1980*s*. Focusing on Ghana, Jedwab and Moradi (2015) show similar patterns on the impact of colonial railroad on urbanization, city development and agricultural productivity (e.g., cocoa production). Importantly, Jedwab and Moradi (2015) also show that the positive link between colonial railroads and contemporary spatial development extends to 39 Sub-Saharan African countries.[13]

[12] Wantchekon and Stanig (2015) show that transportation costs play a sizable role on African development. Using high-resolution data they show that soil quality correlates positively with poverty and costly (low quality) infrastructure.

[13] Since a considerable fraction of the aggregate "market access" effects of removal of land mines in Mozambique come by connecting districts to the three main ports of Maputo, Beira, and Nampula, our paper is also related to recent studies examining the impacts of ports on African development (e.g., Sequeira (2015), Djankov and Sequeira (2014)).

Our paper differs from these works as it studies the role of land mines and their interactive effects with the infrastructure system after colonization. Moreover, we try to account for spatial spillovers and general equilibrium effects, moving therefore beyond a "control"-"treatment" approach. In this regard our paper is mostly related to the parallel study of Jedwab and Storeygard (2015) who also employ a "market access" approach to study the role of road construction on urbanization in Sub-Saharan Africa during post-independence ($1960 - 2010$).

African Political Economy Fourth, our work fits into the broad recent agenda that aims to uncover the origins of African (under)-development. The literature has mostly focused on the impact of colonization (via institutions, Acemoglu, Johnson, and Robinson (2001), early human capital, Easterly and Levine (2015) and Wantchekon, Klasnja, and Novta (2015), and infrastructureHuillery (2009)) or other large critical events, such as the Scramble for Africa (e.g., Michalopoulos and Papaioannou (2016a), Alesina, Easterly, and Matuszeski (2011)), the slave trades (Nunn (2008), Nunn and Wantchekon (2011)), and the type (urban protests versus rural insurgencies) of anti-colonial independence movements (e.g., Wantchekon and Garcia-Ponce (2014)).[14] We focus instead on a key post-independence event, the legacy of a devastating almost two-decade long civil war that starts shortly after independence and at its ending (besides the massive catastrophe) leaves the country contaminated with more than 1 million land mines that took the country more than twenty years to clear.

1.2 Paper Structure

The paper is structured as follows. In the next section we provide an overview of the history of the war of independence, the civil war and the use of land mines. We also discuss the difficulties of Mozambique in detecting mine fields and removing. In Section 3 we present and discuss the data on the distribution of land mines and other war remnants at the end of the civil war and the subsequent efforts to remove land mines. We also present the data on roads, railroads, and other infrastructure and the proxies of local development. Section 4 reports a preliminary analysis of the correlates of land mine usage and their subsequent removal. In Section 5 we report "difference-in-difference" specifications that compare the evolution of development in districts affected by land mines before and after the clearance to the group of districts that were not directly affected by the war and the placement of land mines. Section 6 reports the baseline market access specifications that quantify the economy-wide effects of land mine clearance. In Section 7 we push on causation we exploring how changes in the market access shape regional development across districts that were not directly affected by the placement of land mines (and hence were never demined). We also reports estimates with the market access method ignoring land mine removals in proximate districts. In section 7 we summarize our findings and discuss directions for future research.

[14] Michalopoulos and Papaioannou (2016a) summarize the burgeoning literature on the historical legacies of African development, while Nunn (2014) reviews works, quantifying the long-run effects of various historical episodes.

2 Historical Background

This section provides a detailed account of the use of landmines during the civil war and the subsequent efforts to remove them along with other explosive war remnants, a process that lasted more than twenty years (1993 – 2015).

2.1 Mozambique at the End of the Civil War

Mozambique experienced one of the most devastating civil wars since WWII that lasts from 1977 till 1992. Adding the war of independence against Portugal (1964 – 1974) and the turmoil years of independence in 1975, implies that the country was in war for roughly three decades. Besides its brutality, a key characteistic of the conflict is the extenive use of land mines by all fighting parties in both wars (Portugal, FRELIMO, RENAMO and the armies of neighboring countries). Rebels, militias, and government troops scattred land mines, mostly to seal borders, block access to infrastructure, and to terrorize civilians.[15]

Human Rights Watch summarizes the conditions on the ground at the end of the civil war in 1992 as follows: "*Most of the country's economic infrastructure is destroyed or inoperable, and much of the population is dependent on a massive international aid program. Hundreds of thousands of people are refugees in neighboring countries or displaced inside Mozambique. Many rural areas have been reduced to a stone age condition, without trade or modern manufactured goods, education or health services, and suffering from constant insecurity. Mozambique needs to be built almost from scratch.*"

2.2 The Problem of Land Mines

In this backdrop economic recovery was challenging, not only because of the total collapse of economic activity, but because land mines, UXOs (unexploded ordnance, such as rockets, grenades, and mortar bombs) and SAA (small arms ammunition, such as rifle and pistol bullets) were scattered throughout the country. According to all reports, the warring parties FRELIMO and RENAMO used mines extensively and in an ad-hoc manner during the civil war; besides blocking borders and access to roads, railways, and electricity RENAMO (and to a lesser extent FRELIMO) used land mines to terrorize civilians.[16] Land mines and unexploded ordnance posed massive problems and interacted crucially with the other devastating consequences of the civil war. Mozambican refugees in neighboring countries (approximatley 1.5-2.0 million) and internally displaced people (ruoghly 3 million) who were forced to leave their homes could not return, as they did not know whether the roads were safe or whether their fields were mined. The mine assessment reports revealed that mines were placed around almost all key roads and rail tracks, so people were

[15] In the Appendix we provide an overview of the historical background regarding the war of independence (1964 – 1974) and the ensuing civil war (1977 – 1992). We also discuss the strategic objectives of the parties and the use of land mines during each stage of the war.

[16] The use of land mines by all parties engaged in the war of independence and the civil war is corroborated by the origin of these land mines. They come from many different countries, including Portugal, Russia, USA, Britain, Czechoslovakia, Hungary, Italy, South Africa, Belgium, France and China.

rationally unwilling to return to their homelands. Key infrastructure like electricity pylons, dams, power stations, were also heavily contaminated. A country with one of the most advanced hydroelectric dams in the world that was meant to provide energy also to neighbouring counries was without electricity. At the local level, mines had been planted around schools, police stations, and other government buildings, which were typically used as local rebel headquarters. While there is no reliable data, the various early reports reveal that there were hundreds of accidents with deaths and injuries (some estimates put the death toll from land mines to $30,000$). Recognizing this challenge the General Peace Accord of 1992 in its Protocol VI required that the two parties "*organize and implement mine-clearing operations*" and provide assurances that they will not "*prevent mine-clearing operations.*"

A preliminary back-of-the-envelope UN assessment was that the country was covered by 2 million land mines. The first national plan for mine clearance was drafted in January 1993, but was only approved by FRELIMO and RENAMO at the end of the year, as the two parties were quarreling over the wording of the mandate and on who will be responsible for the actual demining.[17] At that time, the primary objective of demining was to clear the major roads, so as to allow for the delivery of humanitarian relief and the functioning of UN missions. But, even after the agreement, progress was slow, both because of chaotic conditions, lingering mistrust between RENAMO and FRELIMO, UN bureaucratic frictions, and virtual absence of coordination. Even the typically diplomatic UN Security Council in September 1994 "*expressed concern with the limited progress made so far*".[18]

The most comprehensive description of the situation during the transition period comes from HALO Trust' 1994 survey conducted for the UNOHAC (United Nations Office for Humanitarian Assistance Coordination). The key findings were. First, the problem was mostly on the extensive -rather than the intensive- margin, as the "*use of landmines in Mozambique is characterized by a highly dispersed pattern*". The report suggested a "*figure of hundreds of thousands [mines] is probable*" (Halo Trust (1994)).[19] While this report was incomplete (as many parts of the country were still inaccessible) and only partially identified land-mine-affected areas, subsequent more-in-depth reports confirmed this initial assessment. Besides some concentrated large minefields along the borders, land mines were spread throughout the country. The survey identified 981 contaminated sites though the problem was more acute, mostly in the South and the Center. Second, in line with people's initial fears, infrastructure was literally inaccessible, as in the Southern and Central provinces "*all dams, railway lines, electricity substations and pylon lines should*

[17] For example, RENAMO wanted itself to demine the Macossa-Maringue-Canxixe road to protect its headquarters in Maringue. And FRELIMO wanted to start clearing strategic areas close to their opponents' bases. Actually there are reports that some mining was still taking place during 1993! (Roberts and Williams (1995))

[18] The basic operations during 1993 and 1994 were carried by: (1) The Norwegian People's Aid which cleared roads and rail tracks in Tete, Zambezia and Sofala in an effort to allow the return of refugees from Malawi and Zimbabwe. (2) The Halo Trust in Zambezia enabling the return of the more than one million refugees from Malawi. (3) A consortium of private contractors (Lonrho, Royal Ordnance, and Mechem) cleared some key roads in Sofala and Manica Province. (4) UNOMOZ did also some clearing, though its efforts was mostly on training. Approximately $2,800$ kilometers of roads were cleared and $1,440\ km^2$ (Roberts and Williams (1995)).

[19] A subsequent 1995 report to the UN Secretary General revised this number to one million.

be assumed to be mined" and a similar (though perhaps slightly better) assessment carries also for the Northern districts. Third, the survey rightly pointed out that the actual number of land mines is "*not of great importance*", as "*what matters is the number of areas which the total population believe to be mined and therefore do not enter.*" This problem was especially pronounced as RENAMO fighters would often tell the local community that their village or farms were mined, while in practice they were not (or they had thrown a handful of land mines so as the locals would believe that their area was mined). For example, eight mines that were eventually cleared in 1996 were preventing 20,000 people of the entire Mahniça valley (in the Maputo province) from returning to their villages.[20,21] Fourth, UXOs posed also a key challenge, as they were also spread all around the country and turned out to be very costly, especially for children. Moreover due to rainfall and landslides, UXOs will blend with mud and dirt and become extremely dangerous.

2.3 Land Mine Removal[22]

2.3.1 Phase 1. (1995 – 1999)

The initial phase of demining starts with the democratic transition in 1994. Challenges remained as there was very little work done since the signing of the Peace agreement. The focus on emergency-oriented objectives "*resulted in a failure to recognizes the need for long-term demining in the country. In addition, little attention was placed on the needs for comprehensive data gathering and the establishment of sustainable indigenous capacities.*"

Based on the 1992 Peace Accord, UN soldiers and workers had to work together with national authorities to coordinate mine clearance efforts. However, the UN was not adequately prepared for this (GICHD (2005)). And the coordination and administrative structures of the government were weak and ineffective. The United Nations wanted to establish a mine action unit of its own, but donors were skeptical and wanted to proceed with specialized NGOs. Therefore, during the first years, the humanitarian operators were left at their own, with no overall direction.

A National Demining Commission (CND) was set up in 1995 that aimed coordinating the various parties. Yet CND did not meet formally until a year later and it had virtually no capacity. Political interference, poor staffing, lack of technical knowledge, and limited funding prevented the coordination

[20] Another example showing that focusing on the number of mines is misleading comes from the Northern Provinces. While the Cabo Delgado had the highest number of land mines of all Northern Provinces, almost all of them were in large minefields straddling the border with Tanzania; besides these minefields few areas were affected. In contrast, while the number of mines found in Zambezia was relatively low; the mines were widely spread across farms and infrastructure and as such it was extremely to detect and remove massively affecting the local communities.

[21] Another illustrative example is provided by the Human Rights Watch report of 1997. "*In some cases the actual number of mines proves to be irrelevant. The very threat of mines, especially antipersonnel mines, can depopulate an area or close a road network. During an Norwegian Peoples Aid mine clearance operation in Maputo province a team was sent in 1994 to clear the village of Mapulenge, which had been the center of a community of about 10,000 people. It had been deserted for some four years because it was locally believed to be heavily mined. After three months of work, the clearance team reported finding four mines; these, and the rumor of many more, were sufficient to depopulate the entire area.*"

[22] for Humanitarian Dimining (2013) provides a synopsis of land mine clearance operations in Mozambique.

of mine clearance efforts and other necessary interventions. CND was (rightly) considered a failure and subsequently it was abolished. Effectively demining operations emerged with three geographically distinct "humanitarian" programmesGICHD (2005).[23]

- The Halo Trust (with funding from the British Overseas Development Administration, as well as from Japan and the US) was operating in the Northern Provinces. Operations started in 1994 in Zambezia (with UK funding), in 1995 in Niassa (with funding from the Irish Government), in 1996 in Cabo Delgado (with financial backing from the Swiss government), and in 1997 in Nampula (with Dutch and US financial assistance). From our reading, it seems that in these provinces demining and removal of UXOs was more efficient than in other areas. Moreover, the problem was not that severe in the three Northern provinces, though Zambezia was heavily mined. In 1999 Halo Trust was employing close to 200 deminers and supervisors.
- The Norwegian People's Aid (NPA) started demining programmes in the central regions of Sofala, Manica and Tete; since 1998 they were assisted by Handicap International (HI), though this NGO mostly implemented victim assistance programs in Inhambane (and subsequently in Sofala). In 1999, NPA was employing close to 500 local deminers assisted by a dozen or so foreign experts.
- The UN established the Accelerated demining program (ADP) in 1995 and together with many small operators were deployed in the Southern provinces of Maputo, Gaza, and Inhambane. ADPs was quite slow in clearing affected sites; and in the initial stage it mostly focused on training. Yet by the end of 1998, ADP looked properly staffed and funded and ready to carry many operations (employing 10 platoons of 50 deminers each).

The first phase can be characterized as a preparatory one (GICHD (2005) labels it as a phase of "consolidation"); the country established centers for training deminers, some demining operators started conducting thorough technical reports, and few proceeded with demining operations. There was not much progress on actual demining though[24] and the government and NGOs have a fragmented at best picture of the problems. According to director of Mozambique's mine clearance operations in 1997: "*First, we must have a clear idea of what the landmine situation in Mozambique is. We are in the dark about that, and without a sound knowledge of the situation, it is impossible to define a strategy, let alone determine the cost and resources needed for clearance operations*". (Human Rights Watch (1997)) In the meantime other

[23] The location of operations of the various NGOs and operators was coincidental. NPA focused on the central Provinces, locating itself in Tete, as it was running already a development programme during the civil war. Likewise, Handicap International's presence in the central provinces dates back to 1986, when they were providing orthopedic assistance, physiotherapy, and rehabilitation to land mine victims. UN ADP focused on the Southern Provinces around Maputo, because this is where the initial UN mission located, as security concerns were not that high in the North.

[24] Data on demining during the first stage are incomplete, poor and in some instances conflicting. The official data -that we use so far- record very limited clearance of roads and farmland. Yet going over the various reports, it seems that things were a bit better, especially in the Northern Province. The LandMine Monitor, for example, estimates that approximately 200 km^2 were cleared.

related projects on raising awareness, assisting the wounded, and improving health facilities proceeded. The number of deaths and injuries from land mines and UXOs fell considerably from 1992 – 1994 until 1999.[25]

2.3.2 Phase 2. (1999 – 2006)

The second phase starts with the establishment of the National Demining Institute (IND) in 1999, that replaced the National Demining Commission. The IND had much more autonomy and could bypass cumbersome procedures and red tape. IND established two provincial offices (on top of the headquarters in Maputo), one in Nampula in the North and the other in Manica in the Centre to coordinate with Halo Trust and NPA, respectively. Donor funding increased (from approximately 5 – 8 million in 1993 – 1996) to more than 14 million during 1999 – 2004. The IND started coordinating the demining efforts and it is no coincidence that land mine clearance accelerates in 1999 – 2001 (GICHD (2005)).

Sadly when land mine clearance operations seemed to have been gaining momentum, Mozambique experienced devastating floods in 2000 (Cyclone Eline in late February 2000 and Cyclone Hudah in mid-April 2000), in the Southern provinces of Gaza, Maputo and Inhambane, which killed about 600, displaced more than 200,000 and affected the lives of about two million people. A major flood also occurred in 2001 this time hitting the central provinces. This was a major setback, as floods move land mines and UXOs from their original positions and made their detection (from both trained animals and specialized equipment) extremely hard.

Authorities responded with a two-step strategy. First, with financial support from the Canadian government, the IND commissioned the Canadian International Demining Corps (CIDC) and Paul F. Wilkinson & Associates to execute a thorough county-wide survey. The purpose of the Mozambique's Landmine Impact Survey (LIS) was "*to collect, record and analyze information on the location of known or suspected mined areas throughout the country, and to provide an overview of their social and economic impacts as perceived by the residents of landmine-affected communities.*" The survey pointed out that landmines affected all 10 provinces and almost all admin-2 units, 123 out of 128 districts. LIS recorded 1,374 areas suspected to contain anti-personnel mines totalling roughly 560,000,000 square meters. The survey also estimated that approximately 1.5 million people (roughly 9.0% of Mozambique's population) lived in 791 identified mine-affected communities. The share of population under threat from land mines more than doubles if one was to include people residing in areas modestly contaminated by land mines and UXOs. While it has since become recognized that the LIS had major flaws[26], it was the most comprehensive

[25] A recent report by Handicap International (2014) reproduces an estimate of the US Department of State that the number of victims from land mines during this period (1992 – 1998) was between 10,000 – 30,000, though other surveys present significantly smaller estimates.

[26] Mozambique, Republic of (2008) summarizes the key challenges as follows: "The large size of Mozambique and the absence of a functional road network in much of it, extensive flooding in parts of the country in 2001, the widespread distribution of mine affected communities, the absence of comprehensive and accurate national gazetteer (i.e., official listing of communities and their geographic coordinates), the lack of accurate maps and an appropriate scale, the impossibility of applying in its entirety the SAC protocol for false-negative sampling, and, the nature, availability and quality of expert opinion."

dataset available at that point and provided a road map for the land mine clearance operations. Second, with the LIS serving as an input, in late 2001 the IND issued Mozambique's first five-year strategy for mine action (the National Mine Action Plan $2002-2006$).

However, in the middle of the 2000′s the Mine Action Program underwent a crisis. Since the anti-personnel mine convention was adopted in 1999, a program called "Adopt a Minefield" (AAM) was created to engage American civil society and get funding for mine clearing procedures. In 2003 and 2004 a scandal erupted around the AAM funds. In response some operators (especially the "smaller" ones) announced plans for closure (The German NGO "Menschen Gegen Minen", which had arrived in 2000, left in 2003). Additionally, the UNDP (United Nations Development) Capacity Building Project in IND ended in 2005, leaving the best trained local staff unpaid. Around the same years, ADP was discontinued in 2005 and NPA left in 2006 (GICHD, 2012). The scandal, the perception that the mine problem was not as bad as previously thought, contributed to the sizable decline in international donor support from about 20 million in 2002 to 5 million in 2007.

In an effort to overcome these difficulties,[27] the IND commissioned two reports to HALO Trust, Mine Impact Free (MIFD) survey covering the Northern Provinces of its operations (Halo Trust (2007a)) and a baseline assessment of the remaining 6 Provinces, based on existing records (Halo Trust (2007b)). Together with the reports of HI in 2007 and the NPA Task impact assessment in 2006, the Halo Trust surveys depict the situation in the end of 2006 and early 2007, giving for first time since the beginning of the demining efforts an accurate picture of what is the situation on the ground. The surveys revealed that there were three times as many mines in Mozambique than previously thought, with more than 500 new mine-contaminated areas identified. The problem was far from being solved.

- The three Northern Provinces and Zambezia were officially declared land mine free (defined as absence of any known mines or absence of cases of suspected and not verified areas of land mines) (Halo Trust (2007a)).[28] During its operations there, HALO personnel have completed the clearance of 552 suspect mined areas and 1,604 explosive ordnance disposal (EOD). Halo Trust cleared 234 kilometers of road and $10,454,249m^2$ meters of minefields, destroying 99,167 anti-personnel mines, 1,620 anti-vehicle mines, and 22,329 items of unexploded ordnance.[29]

During the course of the survey, teams attempted to visit 1,973 communities over a 14 month period, interviewing approximately 14,000 persons.

[27] GICHD (2005) writes "*although performing far better than the former NMCC/CND, IND has as yet been unable to establish fully adequate coordination to ensure the activities of the humanitarian operators are consistent with an overall national plan for mine action. In part this is because operators saw the LIS as flawed and largely ignored its findings or the priorities identified by IND on the basis of LIS data.*"

[28] As the report states, "*That is not to say that there are no more mines remaining. Unfortunately the manner in which the war was conducted means that mines may remain in isolation which nobody alive knows anything about, and their presence will go undetected until such time that they explode or are uncovered. But nevertheless there are no more areas left to demine, nobody in the north of the country can point at an area and say 'I think there are mines there*".

[29] Halo Trust's report for the 4 provinces of its operations in 2007 covered 6,395 communities and 401,007 people interviewed. During the survey, 74 new suspect areas were identified and cleared, 176 mines were found and destroyed.

- In spite of some progress, the issue of land mines was pressing for the central and southern provinces.[30] The new surveys identified previously undocumented hazardous areas, including the Cahora Bassa dam, the Chicamba dam, some power lines in Sofala and new sites on the border with Zimbabwe.

2.3.3 Phase 3. (2007 – 2015)

The final phase of demining starts with the second governmental land mine removal plan (the Mine Action Plan 2008 – 2014) and the subsequent request of the Mozambican government for an extension for completing the destruction of anti-personnel mines by 2008 (Mozambique, Republic of (2008)). This plan was based on the findings of the 2007 Halo Trust reports. Learning from past experience, the final phase proceeded well, this time with some coordination. HALO Trust moved to the provinces of Maputo in the south and to Manica and Tete in the center. APOPO, a Belgian-Tanzanian NGO experimenting the use of rats as a cheap and efficient technology for demining, was asked by IND to start clearance in the Gaza province, after its successful testing started in the Manica province in 2004. Finally, IND asked HI to move beyond its original Inhambane province and start demining in Sofala and Manica. As it is clear, this new geographical distribution of NGO's was at least partially coordinated by IND (GICHD (2005)). At the same time donors returned as the reports showed that the problem was still acute. Foreign assistance for land mine clearance increased four-fold.

The 2008 – 2014 Plan, on top of the strict demining operations, included mine risk education and victim assistance. Overall the last phase is characterized by increased efficiency, was supported by more precise and technical surveys helping the demining operations. Formal verification, as well as a district-by-district approach were followed, facilitating planning and monitoring. The last plan's timeline was quite closely respected, and on September, 2015 all Mozambique districts were declared mine free.

3 Data

Our data come from diverse sources. The geographical unit of our analysis is the $4th$ level administrative division of Mozambique (districts from now on).[31] Information on district boundaries is derived from the digitized map of Mozambique in 2007, as released by the National Institute of Statistics. Our sample comprises of 1,224 districts[32]. In terms of size, Mozambican districts are comparable to French municipalities (“cantons“).

[30] Halo Trust identified 651 previously unknown hazardous areas in Tete, Manica and Sofala.

[31] Mozambique is divided into 10 provinces and the citade of Maputo, the capital (admin unit 1). The 11 Prrovinces are divided into 128 districts (admin unit 2). These districts are in turn divided into 405 postos (admin unit 3).

[32] For each of the 6 largest cities in the country we aggregate the respective constituent neighborhoods. Hence, Maputo, Matola, Beira, Chimoio, Nampula and Nacala (they are those with more than 200,000 inhabitants) are treated as unique districts.

3.1 Land Mine Data

The crucial piece of information are the data on mine and UXO clearance activities, collected by the National Institute of Demining (IND). This dataset lists at a disaggregated level the universe of land mine and Unexploded Ordnances (UXOs) removal operations by the main NGOs, governmental agencies, private contractors, and the Mozambican government.[33] The data starts in 1998 and goes till October 2015, when the country was officially declared land mine free. Information is at the intervention ("threat") level. This means that each entry is disaggregated at the level of latitude and longitude for each single intervention. We have details on the operators (e.g., Halo Trust, Handicap International, Ronco, APOPO), the type of threat (large minefield, mines in key infrastructure, UXOs), and for most threats an approximation of the size of the affected area.[34] The data is available at a yearly frequency, though coverage is suspiciously higher/lower in some years.[35] Coverage quality and accuracy of reporting of the demining activities improves only after 1997, then improves even more after the LIS report (2001-2002) and it becomes fairly precise for the interventions that took place after $2007-8$, under the second five-year mine action plan (Mozambique, Republic of (2008)). The data allows distinguishing between two main threat categories: minefields (either small or large) and UXOs.

The data is far from being perfect and as such we have undertaken a huge effort to add missing information, correct inconsistencies, and improve coverage. We have also tried to cross-validate *all* entries. In this regard we have gone over dozens of reports, surveys, and impact assessments (approximately 50 so far); and we have liaising with the National Institute of Demining so as to go over the original data records and the archives. To investigate the comprehensiveness of the IND data, we have tried to validate its content acquiring the original reports directly from the individual operators i.e., the main NGOs and international organizations. For example, we got the data from the Handicap International (HI) report of 2008. HI reports its land mine clearance operations in Southern Provinces. Reassuringly for this case at least, the IND data encompass all interventions contained in the HI report. Likewise we have overlaid the maps in the Halo Trust 2007 report on clearance of the Northern Provinces with the IND data so as to examine whether data was missing. We also used information from a detailed report of RONCO Consulting Corporation (1996), a private consulting firm that on behalf of USAID demined roads in Sofala and Zambezi Provinces in $1994-1995$.

Along with reports from relevant actors, we used the main surveys aimed at identifying land mine affected areas. Specifically:

- We checked the early Halo Trust Report that identified 981 potentially affected areas (Halo Trust

[33] In the Appendix we list the main (28) operators and their respective shares in the clearance project.

[34] Typical entry in the data looks as follows: a minefield covering an area of 18893 square meters was cleread by Halo Trust on a civil war battle trench nearby Matsinho village in Manica province in 2015.

[35] From correspondence with the officials of the National Institute of Demining, it seems that some years record information of operations in a couple of previous years. This issue seems to be particularly important for $1999-2000$, as during this period the archives strored at the National Demining Commission (CND) were transferred to the newly established National Demining Institute (IND).

(1994)). Yet, given the challenges on the ground and the chaotic conditions, this survey was coarse and did not cover all the country, as many parts were unreachable.

- We also procured the 2000 − 2001 Landmine Impact Survey carried out by the Canadian International Demining Corps (Corps (2001)). This Survey reports as contaminated 123 out of the 128 districts. Yet this report seemed to be also quite inaccurate, partly because the large-scale floods of 2000 − 2001 moved land mines and UXOs and made it very hard (if not impossible) for land mine detecting experts to identify the exact location of the minefields.

- The 2007 Halo Trust report covering all centre-South Provinces (Tete, Manica, Sofala, Inhambane, Gaza and Maputo) and the complementary 2004 − 2007 survey of Halo Trust in the remaining Centre-North Provinces (Zambézia, Nampula, Niassa and Cabo Delgado) of its initial operations (Halo Trust (2007a)). These are the most detailed and by far the most accurate surveys; they provide a comprehensive description of demining activities up to that point in time and record the remaining land mine affected areas. These surveys also give information on areas that were suspected by the locals to be contaminated by land mines, but were found to be clear upon examination. The IND dataset contains most (though not all) of the interventions that are listed in the last two surveys.

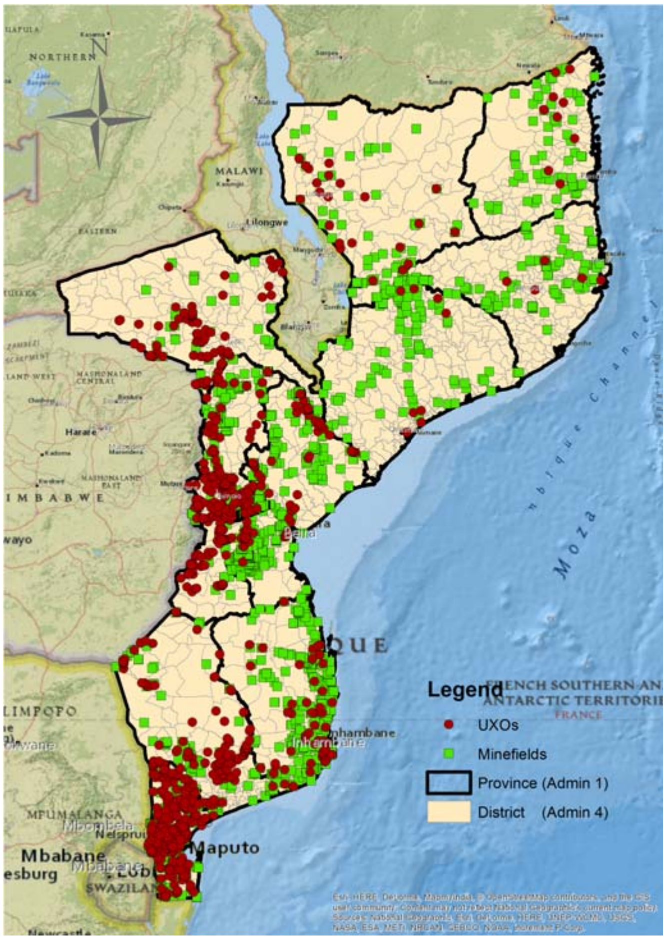


Figure **1a** : Minefields and UXOs - Intervention level

Figure 1*a* shows the spatial distribution of land mines and UXOs in 1992. To construct this map we pull together the interventions listed in the IND yearly database to reconstruct the universe of actual threats in Mozambique at the end of the Civil War. Since from the reports and interviews, it seems that suspected for land mines areas were also inaccessible by locals and hence affected local economic activity, in Figure 1*b* we plot "cancelled" areas, as identified in the LIS (2001) and Halo Trust (2007a,b) surveys; there are "suspected for land mine threats" that were investigated by NGOs and private contractors and then declared as land mine free.

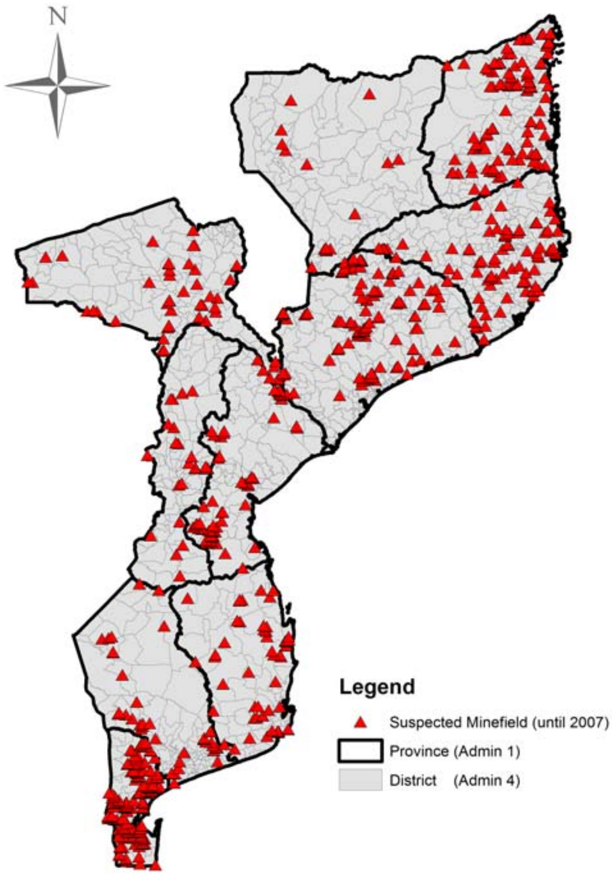


Figure **1b** : Suspected but Eventually Declared Land Mine Free Areas

3.2 Infrastructure

We collected information on the transportation network in Mozambique including (primary, secondary, and tertiary) roads, railways and navigable rivers.

Information on the road network was kindly provided by the National Road Administration (ANE), which produced a detailed geo-referenced database of the Mozambican roads for 2011.[36] For each road segment we have information for its type (primary, secondary and tertiary road), the conditions (paved,

[36] We recently accessed digitized data on the road network in 2004; and we are in the process of digitizing the transportation network (railways and roads) in 1973.

unpaved or trail) and quality (good, fair, bad). For example, the national road (N1) connecting the 2434 km between Maputo and Pemba in northern Cabo Delgado province is classified as a paved primary road and in overall good conditions. Yet, not all primary road are paved. The primary road connecting the 700 km between the city of Nampula and the city of Lichinga (Niassa province) near Lake Malawi is unpaved and in poor condition. Overall, around 14% of primary roads are both unpaved and in bad conditions. The percentage of unpaved and in bad conditions roads increases to 30% for secondary roads and 37% for tertiary roads. And 50% of trails connecting villages to the main roads are both unpaved and in poor conditions.

Data for the railways network come from the Ministry of Transport and Communication. For each of the rail corridors, we were able to identify the name of the lines and the length of each segment. There are three main railways, all connecting the coastal areas in the Indian Ocean with inland: the Northern line linking Nacala to Malawi; the central line connecting Beira to Zimbabwe; and the Southern route from Maputo to South Africa. As it is clear from Figure 2 below, a peculiar feature of the Mozambican railways network intimately connected to each colonial experience is the absence of any connectivity among these three main corridors. [37]

We also collected data on navigable rivers from the Ministry of Transportation (and we are in the process of getting data on port cities). We count 12 navigable rivers in Mozambique.[38] With the exception of the Zambezi river, Mozambican navigable rivers do not allow large or medium boat to sail. In terms of transportation route, rivers are far less exploited than road and rail.

[37] This is because during colonization (1890 – 1950) Mozambique was effectively split into three/four parts, with the Portuguese directly controlling only the South and the center and Northern areas passed via concessions to private British, Portuguese, French and German controlled companies (the Mozambique company was controlling the center, the Zambezi company was controlling the center-west, and the Niasa company controlling the North). The Beira-Harare (Salisbury) railway was built by the British South Africa Company to connect Rhodesia to the Indian Ocean in 1898 – 1900. While this railway helped the development of Beira and allowed for the establishment of commercial farming along its trains in Manica, it was almost exclusively used for Rhodesia. Newitt (1999) reports that as of 1909 only 4% of railway's receipts was from Mozambique traffic.

The Southern Maputo - South Africa connecting rail was built at the late 19th century aiming to connect mining areas in the Rand to the coast. The Portuguese expanded it in 1905 – 1914 connecting Maputo with the Swazi borders and the sugar-growing Incomati regions. This led to some industrialization and increased agricultural output.

The Northern Sena line was built later (completed in 1922) and was much shorter than the initial plans that aimed connecting Nacala and Nampula to Nyasaland (Malawi).

[38] AmoBuzi,Chire, Incomati, Limpopo, Lugela, Lurio, Messalo, Pungue, Rovuma, Save, Tembe, Zambese

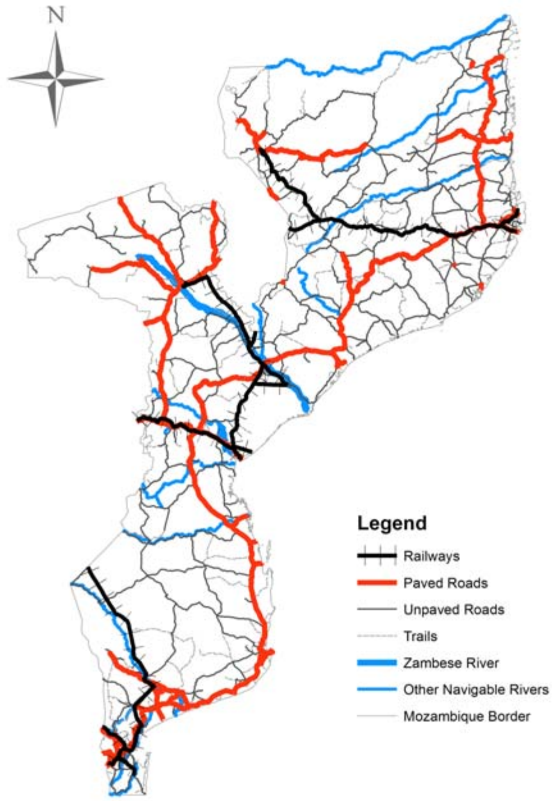


Figure **2** : Infrastructure Network

3.3 Development Proxies

We proxy regional development using satellite image data on lights emission, as reported by the Defense Meteorological Satellite Program's Operational Linescan System that reports images of the earth at night (from 20 : 30 till 22 : 00).[39] The six-bit number that ranges from 0 to 63 is available approximately at every square kilometer since 1992. This approach follows Henderson, Storeygard, and Weil (2012)(see also Elvidge, Baugh, Kihn, Kroehl, and Davis (1997)and Doll, Muller, and Morley (2006)) and subsequent works (e.g., Chen and Nordhaus (2011), Alesina, Michalopoulos, and Papaioannou (2016), Michalopoulos and Papaioannou (2013), Michalopoulos and Papaioannou (2014), Pinkovskiy (2013), Pinkovskiy and Sala-i-Martin (2016), **?**), who have used luminosity to proxy regional development in under-developed countries where output/income data are unavailable. In the Appendix we report plots and simple regression analysis results showing that luminosity correlates strongly with survey data on household wealth and access to public goods (from the Demographic and Health Surveys) across many Sub-Saharan African countries in the past thirty years. We also report scatters using DHS Mozambique data in the late 2000 showing a robust strong association between luminosity and DHS composite wealth index.

[39] We are currently processing and cleaning individual level data from the agricultural surveys and the census in order to extend the analysis along these dimensions.

The use of satellite night light data for Mozambique is appealing given the situation of the country at the end of the civil war. According to the Penn World Tables, Mozambique was the third poorest country in the world in 1992 − 1994 out of 167 countries. The real GDP per capita at country level was around 390 US dollar for the relevant period. To get an idea of the magnitude of under-development according to the MODIS dataset in 2013 the median district in Mozambique had 89% of its territory covered by either savannahs or forests. Figure 3*a* and Figure 3*b* maps the distribution of lit districts in 1992 and 2013, which is the last year available. As of 1992, only 11% of the districts had some detectable luminosity. This percentage increases to 36% in 2013.

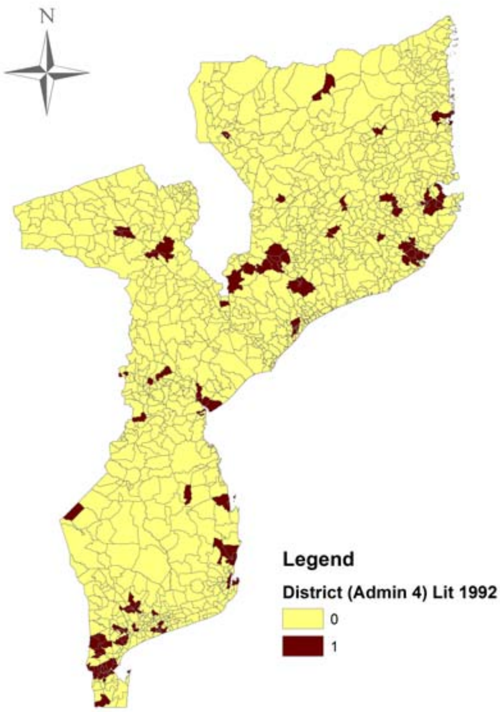


Figure **3a** : Luminosity **1992**

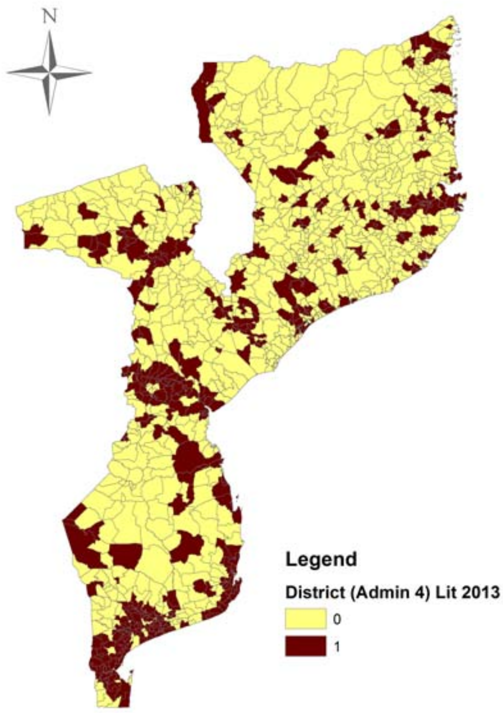


Figure **3b** : Luminosity **2013**

3.4 Other Data

To proxy development during the pre-independence period, we use data on population density for 1960 from the UNEP GRID (2004). Given the high reliance of the country on agriculture and the low levels of industrialization, using population density is perhaps not farfetched.[40] We also use data on various geographical features, such as elevation, soil quality (suitability) for agriculture, malaria stability, etc.[41]

[40] Yet, the data is noisy and perhaps have non-negligible measurement error. We are thus currently processing and digitizing the Censi of 1970 and 1980.

[41] We derive elevation from the NOAA raster; we construct a measure of land suitability for agriculture from Michalopoulos (2012); and, to proxy for the potential exposure to malaria, we employ the Malaria Stability Index from Kiszewski, Mellinger, Spielman, Malaney, Sachs, and Sachs (2004).

We also got data on conflict during the civil war from Domingues (2011)and Robinson (2006).[42]

Table 1 gives summary statistics for all variables at the district level, our unit of analysis.

4 On the Spatial Distribution of Land Mines at the End of the Civil War and Subsequent Land Mine Clearance

4.1 Distribution of Land Mines in 1992/1994

Our dataset records more than 3,800 locations with land mines or/and explosive remnants that at the end of the Civil War in 1992. Roughly 70% are mines (2,605); whereas UXOs account for the remaining 30% (1,251). In term of size, the area of the median minefield in our sample is 2,500 square meters. Yet there is considerable heterogeneity, as minefields in borders are typically large while planted near infrastructure and scattered mines do not take much area.

Figure 4*a* portraits several histograms plotting the distribution of minefields and UXOs over distances from several locations. To facilitate the interpretation of the graphs, we report histograms with comparable distance intervals (on the horizontal axis) and the corresponding percentage in bars. Each graph gives the percentage of threats within the four distance bandwidths: less than 1 km; between 1 and 10 km; between 10 and 100 km; more than 100 km. The first four histograms show the distribution of minefields and UXOs with respect to distance from the border of Malawi, Tanzania, South Africa and Zimbabwe, respectively. In line with the historical account, 12% of land mines are found within 50km from the South African border. Regarding distance from Zimbabwe, 4% of both land mines and UXOs are in a radius of 50km from the border.[43] 4% of threats are found within 50km from the Malawi.[44] And 0.5% of minefields are found within 50km from the border with Tanzania.[45] The third block of the graph reports distance from railroads and roads. More than 30% of the total number of treats are found in a radius of 10 km from the railroad. Focusing on 1km distance from railroads, we find 7% of threats. The correlation with roads is also strong. 32% of minefields and UXOs are found within 1 km from the closest road (and the percentage increases up to 73% if we consider a radius of 10 km).[46] Proximity to navigable rivers does not seem to be a strong predictor of mines. As the last graph shows, 19% of landmines were placed within a radius of 10 km from a violent event of the Civil War.[47]

[42] The format resembles the one of ACLED (Raleigh, Linke, and Dowd (2014)) or UCDP-GED dataset (Sundberg, Lindgren, and Padskocimaite (2010), Sundberg and Melander (2013)) and make the distinction between battles involving the warring parties and one-sided violence (e.g. repression against civilians) perpetrated by both parties. We combine data on both types of violence to derive a measure of the overall incidence of conflict at the district level.

[43] For example a large minefield of 300000 m^2 was cleared nearby Machaze, very close to the border with Zimbabwe.

[44] For example, near Mitucue village, Niassa Province, a large minefield of 200000 m^2 was cleared by Halo Trust in 2001.

[45] In spite of the small number, these are very large minefields. In 2004 and 2005, Halo Trust cleared several large minefields threatening Nangade (560000 m^2) and Chapa (600000 m^2) villages.

[46] Note that as shown in Figure 3, railways almost always coincide, or they are very close, to roads.

[47] The current version of the Civil War data we are using seems not to be representative of the whole war. We in the process of increasing the data coverage.

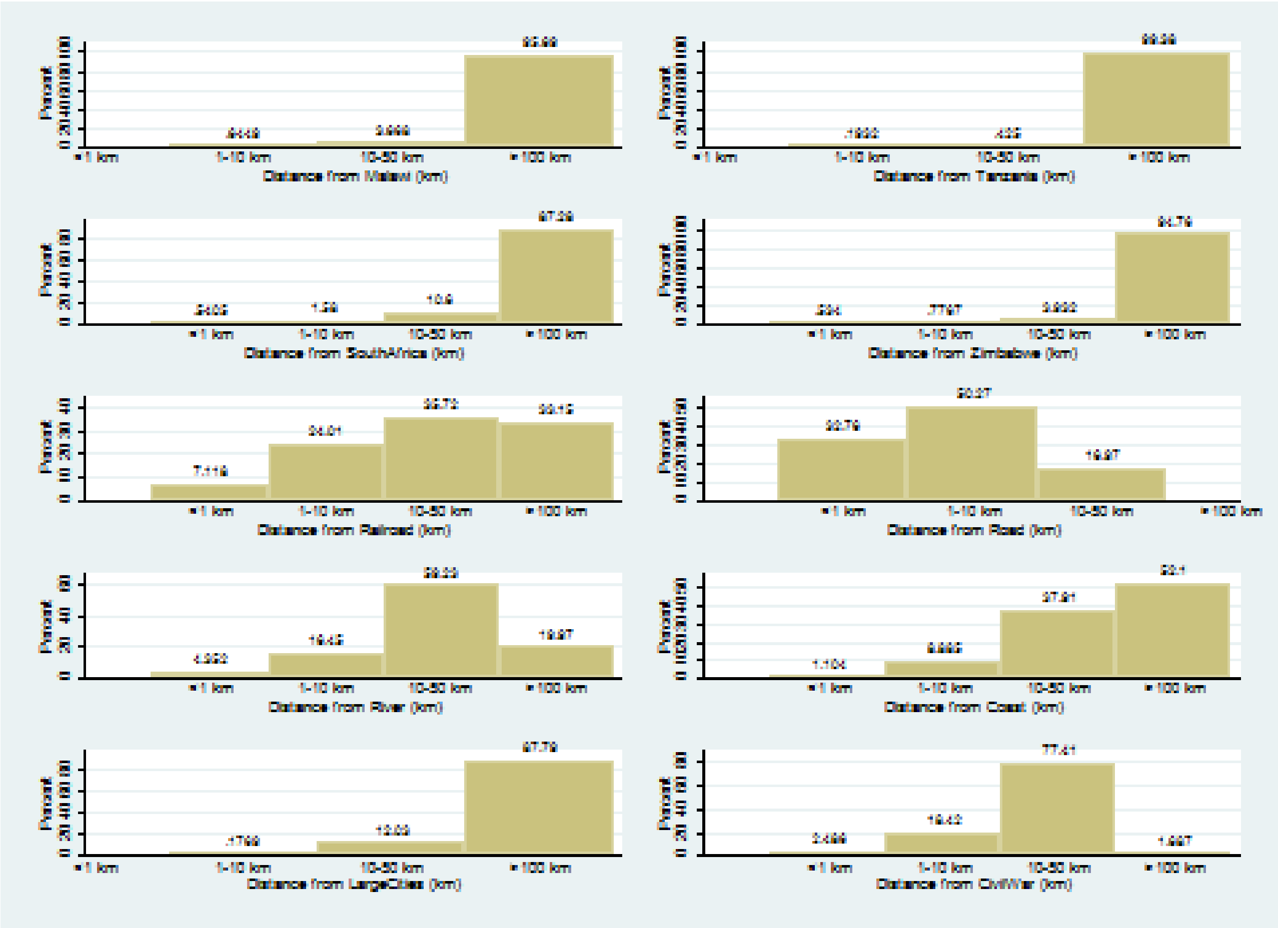


Figure 4a : **Distribution of Land Mines across Districts**

In Figure 4*b* we tabulate land mine and UXO threats by the key type, as revealed in our reading of the planting of land mines during the war of independence and the subsequent civil war. We distinguish between three main categories and a residual. In particular the pie chart plots[48]: (*i*) the number (percentage) of land mines related to blocking or destroying network infrastructure. These are defined as mines within one kilometer of main roads and rail tracks. (*ii*) 1420 and 78 threats are close to roads and railroads (in total 39% of the total number of threats); (*ii*) 153 of mostly UXOs and land mines are close (5 kilometers or less) to major civil war events (4%); (*iii*) 592 threats (typically large minefields) are within 50 kilometers from the borders (15%); and (*iv*) 1613 threats are neither close to the border nor close to roads-railroads nor close to main civil war locations. The latter category reflects mines used for non-strategic and unrelated to the war operations, such as terrorizing the local population, isolating communal and other villages, and preventing peasants from accessing their land and small farms.

[48] For expositional clarity we report a pie chart with mutually exclusive categories of land mine usage, though clearly there is some overlap (land mines that are both near the border and near a main road and near a major civil war event). The pecking order of the categorization is: railroad road, civil war incidents, and borders.

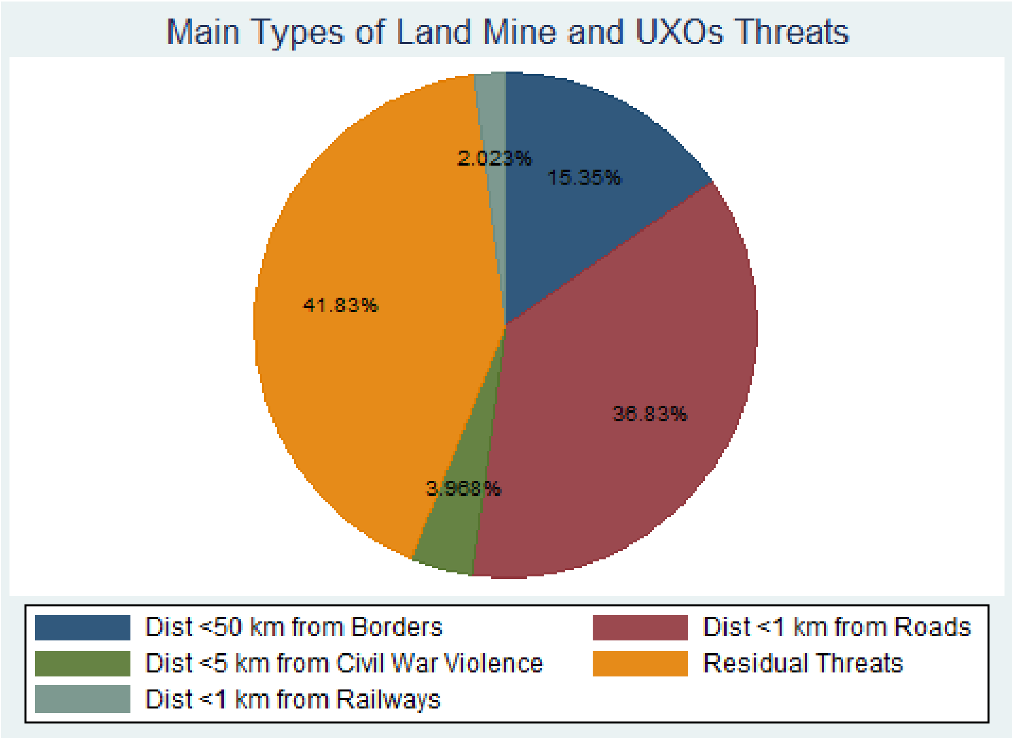


Figure 4b : Distribution of Land Mines by Type

Figure 5 illustrates the spatial distribution of minefields and UXOs at the district level, the unit of our analysis. Out of the 1,224 districts, 582 were affected by at least one minefield or UXOs (48%). The cross-district mean is above 3 threats with a standard deviation of 11. Focusing on the 582 mined districts, the mean (median) is 6,6 (3) with a standard deviation of 15. All provinces are affected by the presence of land mines and UXOs though intensity differs. The most contaminated provinces are Sofala (672), Manica (527), Maputo (433) and Inhambane (430). These were the areas that RENAMOs operations concentrated in the brutal phases of the 1980s. Conversely, the least affected provinces are Cabo Delgado (83) and Tete (54); in these areas mines were mostly planted across the border with Tanzania (by Portuguese forces during the war of independence) and the border with Zimbabwe (by both parties). There are numerous explosive remnants of war in districts along the Beira corridor on the Sofala and Manica provinces. In the South, threats are mostly present at the border with South Africa and in proximate to Matola and Maputo areas: in Sofala, minefields and UXOs are along the Beira (rail and road) corridor and along the Zambezi river. There is also considerable variation within provinces. For example, in Nampula the hot spots are found nearby the national road connecting Nampula to Pemba and on the corridor linking the port of Nacala to Lichinga. In Manica, threats are concentrated between Chimoio city and the border with Zimbabwe. In the Southern provinces, minefields and UXOs are spread over the borders and on the routes connecting the city of Xai-Xai (Gaza province), Inhambane (Inhambane province) Maputo and Matola (Maputo province).

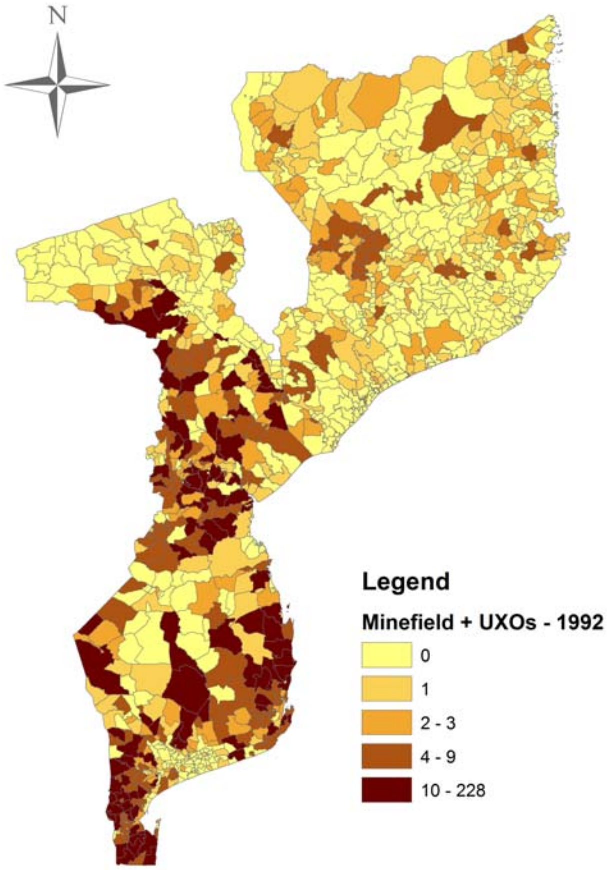


Figure 5 : **Land Mine Affected Districts**

4.2 Correlates of Minefields

As a preliminary step, we investigated the correlates of minefields and UXOs across districts; this allows getting a more precise understanding of the factors that shaped their usage during the independence and the civil war. We run simple probit (and negative binomial) specifications (with maximum likelihood) associating the likelihood (and the number of minefields/UXOs) across districts with various geographic-locational characteristics and development proxies. The specification reads:

$$\begin{aligned} Threat_{i,p} &= \exp(a + \beta_0 Area + \beta_1 Geo_{i,p} + \beta_2 Border_{i,p} + \beta_3 CW_{i,p} \\ &\quad + \beta_4 BigCity_{i,p} + \beta_5 Transport_{i,p} + \beta_6 Lit_{i,p} + \beta_7 PopDens_{1960,i,p} + \varepsilon_{i,p}) \end{aligned} \quad (1)$$

In the probit specification $Threat_{i,p}$ is an indicator that takes the value one if at least one explosive remnant of war was present in district i in province p at the end of the civil war; in the negative binomial specification the dependent variable is the number of UXOs and minefields.[49] *Area* denotes log land area

[49] Specification tests reject the mean-variance equality of the dependent variable and this is why we opt for the Negative

that accounts for scale effects. *Geo* is a vector of geographical characteristics (namely (log) land suitability for agriculture, (log) elevation, (log) malaria stability); *Border* is a vector of (log) distance terms to the borders of Malawi, Tanzania, South Africa and Zimbabwe, respectively, from the district's centroid; *CW* is a variable capturing (log) distance to the closest civil war's violent event; *Big City* is a variable reflecting the (log) distance to the closest major urban center (Beira, Nampula, Maputo); *Transport* is a vector of (log) distances to the closest navigable river, railroads and roads; *Lit* is an indicator that identifies lit districts in 1992; and *PopDens*1960 denotes (log) population density based on the earliest post-independence census.

Table 2*a* reports the probit estimates, while Table 2*b* gives the corresponding NB estimates (across 1213 districts).[50]. Standard errors are clustered at the province level. All specifications include log of land area; as expected, the coefficient is positive and highly significant across all permutations.

In column (1) we introduce the distance terms from the borders of the four neighboring countries. Distance to South Africa is negative and significantly related to the presence of a threat, reflecting mostly the minefields of the SADF and RENAMO in the second phase of the civil war, when the apartheid government in South Africa was trying to suffocate Mozambique. This applies to both the probit and the NB specifications. Distance to Zimbabwe also enters with a significant estimate capturing the minefields set up by FRELIMO, RENAMO, ZANLA and the Rhodesian army during the initial phase of the war. In column (2) we include geographical controls. Overall the presence of minefields and UXOs does not seem to be related to inherent agricultural productivity and elevation. In column (3) we add log distance to the closest large city. Distance to the largest urban centers does not predict the placement of mines or the presence of UXOs. This applies both to the extensive margin estimates (in Table 2*a*) and the joint extensive-intensive margin NB estimates (in Table 2*b*).

In column (4), we check whether proximity to violent events during the civil war predicts the incidence of threats. Although the civil war data is incomplete and thus the estimates are attenuated, being close to a civil war event increase both the likelihood of threats and the intensity of land mines. Proximity to civil conflict battles and violence against civilians events is particularly strong with the presence of UXOs, while the correlation with mines is less strong. In column (5) we examine whether proximity to the transportation network affects the likelihood of mines and UXOs. Distance to roads and, to a lesser extent, distance from railroads are increasing the probability (and intensity) of having at least one threat. And they also affect the intensity of land mines. In column (6) we examine whether development in 1992, as proxied by night lights, correlates with land mines; this does not seem to the case (in both probit and NB specifications). In column (7) we examine the role of log population density. The coefficient is positive, but statistically indistinguishable from zero. In column (8) we add all explanatory variables. Previous patterns persist. Notice however that both elevation and agricultural suitability are now significant. Moreover, the population density in the first census in the post-independence period enters now positive and significant.

Binomial, as compared to the Poisson model.

[50]Compared to the universe of districts, 11 are missing because of the coarse resolution of the population density raster.

The results are similar when we estimate linear probability or OLS estimates; the same applied when we also add province fixed effects to account for potential differential reporting by demining operators, heterogeneity on the intensity of conflict and land mine usage, and unobserved heterogeneity.

The regression analysis is in line with the historical narrative of conflict during the war of independence and the civil war, as well as the various reports on demining operations. Mines were plotted near the borders to prevent the movement and rearmament of rebels; they were also placed near roads and railroads (as well as dams and electricity pylons); and land mines and UXOs are also found in areas with civil war violence and battles. Yet, and as Figure $4b$ illustrates, a large part of the variation (around $40\% - 50\%$) on the distribution of land mines is unrelated to these features. Sadly, this residual variation reflects one of the most devastating episodes of "terror" since the end of WWII.

4.3 Removal of Land Mines Over Time

As outlined above, the process of demining has gone through three phases. Demining operations were carried out by different operators in different areas. Figures $6a$ and $6b$ portray the distribution of land mines in 2001 and 2007 reflecting the evolution of the demining process across districts at the beginning of the first and the second five-year mine action plan ($2002 - 2006$ and $2008 - 2012$). Combined with Figure 5 which shows the initial extent of mine contamination in 1992 and the fact that in 2015 the country was declared land mines free, these two snapshots of mine contamination reveal the uneven pace of mine clearance during the 23 years after the end of the civil war (at the district level). From 1994 to 1999, the operators mostly concentrated their efforts on cataloguing the extent of the problem. And while demining efforts seem to accelerate in $1999 - 2000$ the floods of 2000 and 2001 (that affected all provinces but the north) slowed down the process. So demining resumes in the Center and the South after 2001. From 2001 to 2007, Halo Trust almost completes the demining activities in the North and demining intensifies in the Centre-South.

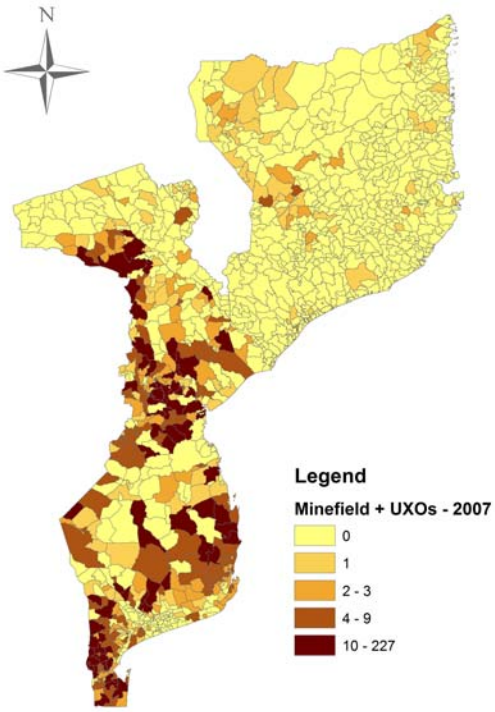


Figure $6a$ – 2001

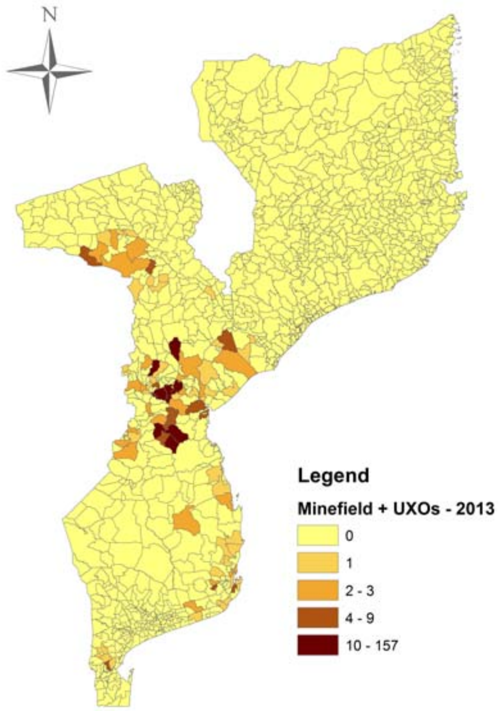


Figure $6b$ – 2007

Given the spatial and temporal heterogeneity of the demining process, one may naturally wonder whether there are systematic elements in this pattern. It is important examining this issue as in principle there is a concern that the country's authorities prioritized some areas with growth potential. To examine we estimate variants to regression equation (1), associating the timing of the initial (and final) intervention in each district to the geographic, development, and locational features. The dependent variable denotes the number of years until first intervention takes place from 1992. The variable ranges from 6 (first intervention in 1998) to 23 (first intervention in 2015).[51] The set of independent variables and the structure of the columns mimics the layout of Table 2. Finding a significant predictor among these time invariant district-level characteristics and the timing of the first intervention could provide hints on the considerations driving temporal variation in the demining decisions.

Table 3a reports OLS estimates. To account for heterogeneity on the demining operators (e.g., Halo Trust in the North, NPA in the Centre) and the massive floods, we also report specifications with province fixed effects (Table 3b). Each specification includes a control for the log area of each district. Column (1) introduces the vector of distance to the borders terms. Interestingly, neither distance to South Africa or Zimbabwe seems to be related to the timing of first intervention. Distance to Tanzania (Malawi) decreases (increases) the number of years since first intervention. These two results are in line with the

[51] Applying a logarithmic transformation does not affect the results. We also experiment with Ordered Logit and Ordered Probit ML specifications that are more suited for count data. All these perturbations deliver similar patterns (see the Appendix).

Halo Trust operations in the northern provinces of the country that started earlier and where not affected by the floods of $2000-2001$. Distance to the closest big city is not systematically linked to the timing of clearance, assuaging concerns that demining operations were prioritized in these potentially high-growth potential districts close to the main ports (column (3)). And clearance is not related to the initial level of development, as captured by the dummy variable identifying lit districts at the end of the war (column (6)). The only robust correlate of the timing of clearance is proximity to roads, a result in line with the reports and operators effort to free roads so as to allow the delivery of humanitarian aid and people's return to their home. In column (7) we add all covariates, finding similar patterns.

Two important implications emerge from the results in Tables $3a-b$ that are consistent with the historical narrative. First, the timing of interventions is not related to various proxies of (relative) economic well-being not is related to proximity to the main economic hubs of Maputo, Beira, and Nampula. Second, only distance to roads seems to be related to the timing of interventions. Thus, the model-fit is poor; the overall R^2 when we include all covariates is 0.18 and most of it stems from the district area size, while in the province fixed-effects specifications the R^2 net of the province constants is around 0.02.

5 Land Mines and Local Development

5.1 Panel Fixed-Effect Estimates

Is it the case that land-mine-clearing operations unlocked the growth potential of the affected regions? To address this question, we implement a district fixed effects strategy that looks at the coevolution of luminosity and demining interventions netting out district-specific time-invariant characteristics as well as general trends. The difference-in-difference empirical specifications takes the following form

$$y_{i,t} = \mu_i + \mu_t + \beta Threat_{i,t} + \eta_{i,t} \tag{2}$$

where $y_{i,t}$ reflects economic activity in district i captured by the light density at night in year t. $Threat_{i,t}$ corresponds to the number of landmine and UXO threats in district i in each period. Following the various phases of demining activities (discussed in Section 2) we examine district-level economic activity and land mines every 7 years starting in 1992. The second period is 1999, where up to this point little and non-coordinated clearance has taken place. The third year/period is 2006, when the Northern provinces are cleared and when demining efforts in the Southern and Central provinces accelerate with the second (and final) five-year mine action plan that is also supported with considerable funding from the international community. The fourth year/period is 2013, the last year with available data on luminosity.[52]

μ_i and μ_t denote district and time fixed-effects, respectively. So variation in $Threat_{i,t}$ for each district comes from demining activities that take place in-between the three periods, netting out also

[52] To be sure demining activities end in 2015, but we are currently constrained to use as terminal year that of 2013 because this is the last year for which we have information on luminosity.

general trends, something key as luminosity increases and land mine threats fall throughout the country.[53]

The distribution of luminosity across districts is not normal with a large fraction of districts where no light can be detected from the satellites. To account for the highly non-linear nature of the dependent variable, we apply two transformation. First, we focus on the extensive margin of luminosity using as a dependent variable a dummy variable that equals one if the district is lit and zero otherwise. Given Mozambique's state of underdevelopment where as of 2013, 89% of the overall country was covered by savannah, treating light density as an indicator variable is appealing as it allows us to detect any small variation in the economic landscape over time. Second, in an attempt to utilize both the intensive and the extensive margin of luminosity, we use as dependent variable the log of light density augmented by a small number.[54] The same considerations applies to the distribution of both minefields and UXOs, as there are many (631) districts without any mine or UXO threat and some districts with hundreds of mines. We thus use a logarithmic transformation of the number of threats adding one.

Before we report the results it is important to stress that even if the removal of land mine and UXO threats was random, the coefficient on the difference-in-difference specification (equation (2)) will not identify the causal effect of demining if there are spillovers across districts; spatial externalities cannot be ruled out in such a within-country framework as population may move and there may be significant relocation of economic activity. [We return to this issue in the next Section, where we will apply an empirical approach that allows estimating aggregate economy-wide effects of demining in the presence of spillovers].

Table 4 present the results of the panel fixed-effects estimation. Standard errors are clustered at the province level. In column (1) we account for both district and year fixed effects. The coefficient on the land mine and UXOs is negative and significant, implying that demining has a positive effect on local economic activity. An increase of one standard deviation in demining augments the log of average luminosity by 0.43 (standardized "beta" coefficient 0.10). In column (2), we augment the benchmark regression with province-year specific trends. In spite of this highly demanding specification, the coefficient on $Threat_{i,t}$ remains statistically significant at standard confidence levels, though it somewhat falls. In column (3) we check for heterogeneity in the type of threats allowing for a different coefficient for land mines and UXO. Both coefficients are negative and statistically significant. The respective magnitudes seem to suggest that, if anything, the clearance of UXOs are more influential compared to minefield removal. This difference in magnitudes between land mines and UXOs can be interpreted in a rational expectations framework. UXOs are by definition visible threats to individuals, whereas land mines are not (though due to weather and soil conditions it may become hard for locals to distinguish them).[55] Column (4) replaces the year

[53] Results are similar if instead of $Threat_{i,t}$ we transform the independent variable of interest to take the value of 1 if any land mine clearance has taken place in the the district in the respective year and 0 otherwise.

[54] We take the logarithm of lights and we add the half of its minimum positive value in the data. This turns out to be equal to $\ln(0.0001 + light)$.

[55] The cross-districts correlation between the number of minefields and the number of UXOs is .22. Given the nature of UXOs, we expect them to be correlated with the incidence of civil conflict; while such a link should be less strong for minefields.

constants with province-year fixed effect. Doing so decreases the economic and statistical significance of the variables of interest. Note that in presence of strong spatial externalities in landmine clearance, that is to the extent that neighboring districts also benefit from landmine removal in a given district, one would expect the influence of demining efforts to be harder to detect across spatially proximate units (which is what we do when we add province-years in our specifications). We return to this point below, where we employ a "market access" approach to shed light on the extent of externalities and general equilibrium effects of local demining. In columns (5)-(8) we repeat the analysis using as a dependent variable the lit indicator. Results are in line with those obtained with average luminosity.

5.2 Long-Run Differences $(1992 - 2013)$

The previous results highlight the positive impact of the removal of UXOs and minefields on local development controlling for unobservable time-invariant district features. One possible concern with our estimation strategy is that we do not take into account initial conditions across districts. It might well be the case that districts with higher initial levels of development were the ones that would have grown faster even in absence of demining. Moreover, controlling for the level development at the end of the civil war allows us to check for the presence of convergence across districts. We thus estimate the following long-run difference specification (that is simply a variant of (2)):

$$\Delta y_{i,2013-1992} = a + \beta \Delta Threat_{i,2013-1992} + X'_{i,1992}\Phi + \Delta\eta_{i,2013-1992}. \quad (3)$$

$\Delta y_{i,2013-1992}$ is the long-run change of luminosity in district i between 1992 and 2013; $\Delta Threat_{i,2013-1992}$ is the long-run change in the number of UXOs and minefields due to demining activities. $X'_{i,1992}$ is a vector of initial characteristics, including luminosity in 1992, population density in 1960 and the total number of civil war events (both battles and repression towards civilian) in district i.

Results are reported in Table 5.[56] Columns (1) to (4) give results using changes in the log of average luminosity, while columns (5) to (8) return the estimates for the model with changes in the lit indicator.[57] The first column reports a specification adding the long-run change in the number of threats only. The coefficient on demining activities is highly significant with a decrease in the number of UXOs and minefields associated with an increase in the long-run change in luminosity. An one standard deviation fall in the number of land mines and UXOs increases log luminosity by 0.65. In column (2) we control for the level of development in 1992 (as proxied by luminosity) and in 1960 (population density). The magnitude of β coefficient is not affected much by the inclusion of these proxies of early development. The sign of the luminosity coefficient is negative suggesting convergence across districts. In column (3) we control for civil

Indeed, the correlation between civil war events and UXOs is .0.15 at the district level; while the respective correlation for minefields is 0.01.

[56] In the Appendix we report results when we employ as the main independent variable of interest $\log(0.01 + (Threat/LandArea(km^2))$. Results are similar to those shown in Table 5.

[57] The latter takes three distinct values. Namely, -1 for those districts that were lit in 1992 and unlit in 2013, 0 for districts whose classification as lit or unlit did not change, and 1 for those districts which were unlit in 1992 and lit in 2013.

war battles and violent events against the civilian population. The measure for civil war severity does not seem to be related to the change in luminosity; and conditioning on district-level civil war intensity does not affect the estimate on changes in land mines and UXO threats. In column (4), we control for all three initial characteristics; the coefficient on the log change in cleared threats retains its economic and statistical significance. Column (5)-(8) report otherwise similar specifications with change in the extensive margin of luminosity in the LHS. The pattern is similar. There is a strong and significant relationship between clearing land mine and UXO threats and the likelihood that a district will be lit in 2013.

5.3 Heterogeneity

So demining activities foster regional district-level development. Yet, in the previous sections we restricted our attention to the overall consequences of demining without attempting to disentangle the relative importance of demining depending on the original placement of these explosive remnants of war. The historical account reviewed in section 2 highlights, for example, that such threats were frequently found along the transportation network (roads, railways and navigable rivers) limiting, or shutting down the access to the affected districts. To evaluate the differential importance of land mine clearing depending on the initial location (type) of land mines removed, we re-run the long-run difference specifications adding separate indicators for demining activities on the transportation infrastructure. To facilitate comparisons we focus on the extensive margin of demining, i.e., we construct an indicator equal to one if at least one threat is present in 1992 and zero otherwise. The land mine and UXO threat indicators will go to zero in 2013 if the district was cleared from all minefields and UXOs. We generated also a set of indicator variables taking the value of one if at least one threat was in a radius of 500 meters from a railway, a navigable river and a road in 1992 and zero otherwise. We further divided roads into paved, unpaved and trails to investigate the relative importance of each category. If the specific type of land mines and UXOs were cleared as of 2013, the corresponding indicator variable switches to zero.

Table 6 reports the results. Column (1) presents results from a specification with long-run changes in the presence of mines where we also add the long-run changes in the presence of threats along the transportation network of the district. Strikingly, both the long-run changes in the dummy for affected paved roads and railways are highly significant and negatively correlated with the long run change in luminosity. This implies that clearing the main transportation routes has a positive impact on the evolution of economic activity independently of any positive effect coming from the removal of landmines that were not affecting the transportation network. In terms of magnitudes the effects are sizable. Once we introduce the mines impacting the transportation network, the magnitude of the "general" threats dummy falls by more than 50% (result not shown). The effect of removing either land mines and UXOs from paved roads and railroads are strong. Additionally, among the elements of the network, only paved roads and railways are significant predictors of the evolution of light density at night. In column (2), we add the controls on the initial level of development and civil war intensity. Results are largely unaffected by the introduction

of these initial conditions. In absolute value the impact of clearing all paved roads in a district is similar, in terms of magnitude, to the one of being already lit in 1992.[58] Columns (3) and (4) reports the results for the specification with changes in being lit as dependent variable. The pattern is similar both in terms of magnitude and significance.

6 Land Mines and Aggregate Development. A "Market Access" Approach

This section reports the results of the "market access" approach that uncovers the general equilibrium impact of demining on development via the improved access to the transportation network. We start discussing the theoretical foundations of the empirical specification. We then lay down the details in the construction of the market access that requires calculating bilateral transportation costs across all districts. We then report the baseline results.

6.1 Theoretical Foundations[59]

Our empirical framework follows Donaldson and Hornbeck (2016) and other recent works (e.g., Donaldson (forthcoming), Alder (2015), Perez-Cervantes (2014)), that building on Eaton and Kortum (2002) develop Ricardian spatial general equilibrium models of inter-district trade and spatial development.[60] These models yield a "gravity equation" in which bilateral trade across districts o (origin) and d (destination) in a given country is a function of district specific terms capturing size, productivity, demand, population ($A_o(X,\tau)$ and $B_d(X,\tau)$) and bilateral costs ($\tau_{o,d} \geqq 1$).

$$\ln X_{o,d} = A_o(X,\tau) + B_d(X,\tau) - \theta\tau_{o,d}.$$

$X_{o,d}$ denotes the value of total bilateral trade from origin to destination district. θ is the "trade elasticity" that reflects (under symmetry) the common-to-all-district pairs sensitivity of trade flows to trade (transportation) costs. The above gravity equation can be derived from a broad class of theoretical models.

- Perfect competition Ricardian models of comparative advantage (with or without labour mobility) in the spirit of Eaton and Kortum (2002), where a region's productivity for a given good (variety) is drawn from Frechét distribution with parameter θ (smaller values denote higher heterogeneity and stronger comparative advantage).

[58] The standardized beta coefficient for paved road demining is 0.20 and the one for lit in 1992 is 0.27.

[59] Donaldson (2015) provides an eloquent review of this body of research and our discussion follows his synthesis. Costinot and Rodriguez-Clare (2014) provide an overview of recent quantitative works on trade across and within countries.

[60] Costinot and Rodriguez-Clare (2014), Allen and Arkolakis (2014) and Arkolakis, Costinot, and Rodriguez-Clare (2012) extend this analysis to other setups, such as the Melitz (2003) model of firm-level heterogeneity.

- Of good differentiation by region (Anderson (1979) and Anderson and Wincoop (2003)) and love-for-variety (Dixit-Stiglitz) preferences over differentiated by origin goods. In these models the "trade elasticity" θ is one minus the elasticity of substitution across goods/varieties.

- Monopolistic competition models with firm heterogeneity and fixed costs in production, like Melitz (2003) or Eaton, Kortum, and Kramarz (2011) or Chaney (2008), where θ is the parameter of the Pareto distribution shaping firm productivity (lower values implying higher heterogeneity).

Under some (widely-employed) generic assumptions (e.g., homothetic preferences, symmetry, balanced trade, costs of trade are paid at the destination district), one can derive from these models a neat reduced-form relationship linking aggregate changes in welfare (income) to improvements in a district's "market access" (Arkolakis, Costinot, and Rodriguez-Clare (2012)). The derived expression reflects district's connectivity via the transportation system (railroads, primary paved roads, non-paved roads, navigable rivers) to all other districts; "market access" is a function of location (district-specific) characteristics and its "distance" to all other districts, weighted by their market size. As shown by Donaldson and Hornbeck (2016) in the context of a Ricardian model of trade across districts with labour mobility (see also Allen and Arkolakis (2014)) a district's "market access" can be expressed as:

$$FMA_o = \sum_{d=1}^{D} \tau_{o,d}^{-\theta} CMA_d^{-1} Y_d$$

The market access for firms (producers) in origin district o is the sum of its "proximity" (captured by the transportation costs $\tau_{o,d}$) to all other (destination) districts d, scaled by their income (Y_d) and consumer's market access (CMA_d^C). Alternatively, market access for a given district is the sum of the income of all other districts (which are potential trading partners), effectively discounted by bilateral trade costs and by the destination's district market access. Consumers' and producers' market access are related ($FMA_o = \delta CMA_o$) as they both fall in trade costs and increase in district's proximity to large markets (the "gravity equation"). Hence, under a given parameterization of the "trade elasticity" θ, one can approximate a region's market access with the following expression:

$$MA_o \approx \sum_{d=1}^{D} \tau_{o,d}^{-\theta} N_d(Y_d) \tag{4}$$

where N_d and Y_d reflect total population and total output of all but the origin district (see Donaldson and Hornbeck (2016) and Alder (2015)).

Therefore, in our context calculating market access requires picking a value of θ and estimating bilateral costs across all district-pairs in Mozambique. Below we discuss the components used in the construction of the market access index, namely the bilateral costs and the trade elasticity.

6.2 Market Access across Mozambican Districts

6.2.1 Bilateral Transportation Costs

The creation of our network involves three steps. The first one consists of collecting the main components of the network: roads, rails and navigable rivers. We allow for heterogeneity in the maximum speed of the road network based on the following classification: paved road, unpaved road, and trails. Second, we need to link all districts to the network. We conduct the analysis using district centroids and we connect every centroid to the closest paved road, unpaved road, railway and navigable rivers.[61] We then calculate the travel cost for each pair of districts. Moreover, we allow for the possibility of straight line connection between centroids in a radius of 300 km. We force each centroid connection to take place only inside the borders of Mozambique. Third, in our calculation we impose different cost parameters for each route. The most efficient technology in our network is the railway. We normalize the cost of railways to 1. Regarding roads, we differentiate between paved and unpaved. We impose a (relative) cost of paved roads of 2 and for unpaved road a (relative) cost of 4.[62] A further classification for the road network involves trails typically connecting paved roads to villages and small towns; even today trails are in very poor conditions and as such we assign a relative cost of 10. We also allow for commuting by walking (using centroid-to-centroid connections) setting a relative cost of 20. The last component of the network are the navigable rivers, which play a tiny -if any role- on local trade. For this reason we assign a relative cost of 15 to the river segments of the network.[63]

Using the constructed network we compute the lowest-cost route between every pair of district centroids, using Dijkstra's algorithm to solve for the optimal route between any two points in the network (This process is similar to the one employed by Google in its Google Maps tool). We compute the shortest path routes in the end of the war in 1992, when many parts of the country were blocked by land mines, and in 2013, the last year with available data on luminosity that approximately coincides with the clearance of all known explosive remnants or war. Time variation in transportation costs (travel time) comes solely from the demining activities that allow access to railroads, paved and unpaved roads, and navigable rivers and walking. In the first year (1993), we overlay the entire distribution of land mine and UXO threats on the network. We assume that each threat within 500 meters of a road/railroad and navigable river is blocking access to the respective segment. This way we force the algorithm to ignore all mined routes in the derivation of the shortest path. In the calculation of the bilateral minimum distances for 2013 we "take out" all mines and UXO sites that were cleared as of this year.

[61] We automate this procedure in GIS to avoid any manual procedure or alteration of the network.

[62] 60% of roads are paved and 40% are classified as unpaved.

[63] We do not allow for maritime transportation. Data from Mozambican ports and historical evidence highlight the scarce importance of connection among ports in the country.

Another possible route that we do not consider in this draft regards navigable lakes. This might be relevant for district around lake Niassa/Malawi in the North-West. We are in the process of collecting data for on lake ports in these areas and plan to allow for such connections in the next draft.

6.2.2 Parameterization of the trade elasticity

To estimate a district's market access, we need to weight bilateral trade costs using a parameter value of the trade elasticity (θ). The literature has produced a wide range of estimates (from 2 to 10) depending on the context (sample of countries, type of trade, manufacturing, agriculture, etc.). For our baseline estimates, we follow Donaldson (forthcoming) and use a value of 3.88. His estimate looks appropriate, as he derives it using data across 17 agricultural goods in India in 1900, when (as Mozambique) the Indian economy was practicing subsistence agriculture (standard deviation of 1.2). This estimate is close to the average value of 4 (range $2.79 - 4.46$) that Simonovska and Waugh (2014a,b) produce. For robustness we also experiment with a lower value of 2.6 and a higher value of 5 (that correspond to the range of estimates in these works). The results are not sensitive to the exact parameterization of the strength of comparative advantage.

6.3 Market Access Measures

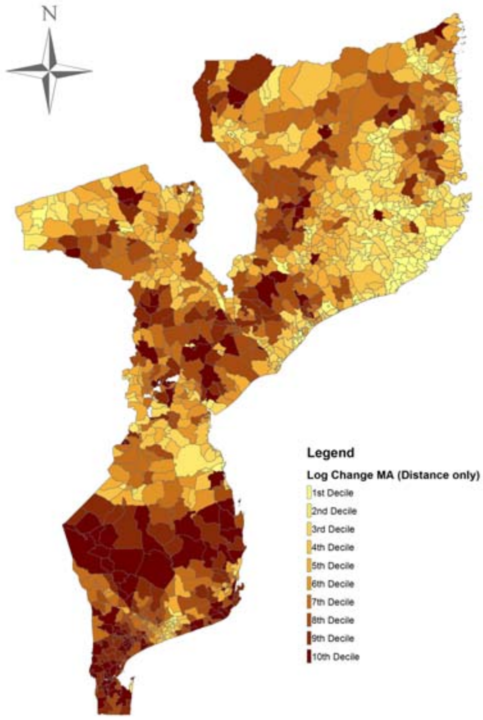
Having estimated bilateral transportation costs across districts and given the baseline parameterization of the trade elasticity, we construct two alternative measures of market access.

First, we ignore aggregate demand effects (captured in total population or income in (4)) and calculate market access using only bilateral transportation costs; so, this measure captures a district's connectivity to all other districts taking the shortest path, adjusted by the means and quality of transportation routes that have not been rendered inaccessible by land mines and UXOs. By not taking into account market size, this proxy of market access isolates the impact of land mine clearance from that of demand; this is useful, as population and output are endogenously determined, perhaps even moving in opposite directions due to spillovers. So, in some sense this measure captures a district's centrality in the Mozambican network.

Second, we estimate market access proxying aggregate demand (total output) in the destination districts with the sum of lights, Y_d. This approach is similar to Alder (2015), who also uses satellite images on light density at night to proxy local output in Indian districts. This approach is also conceptually similar to the robustness analysis in Donaldson and Hornbeck (2016), who use total property value across US counties.[64]

Since in our empirical specifications we examine the role of changes in market access, Figures $7a - b$ plot changes in the two market access measures over the period $1992 - 2013$. As can be seen there is considerable heterogeneity in changes in market access across the country. There seems to be no clear pattern, as land mines and UXOs are not removed in a coordinated and strategic manner.

[64] We will explore a third "market access" variant using total population to proxy district-level demand (Donaldson and Hornbeck (2016)). We have managed to get data from the last colonial census and the first-post-independence census of 1980. We are in the process of cleaning and digitizing the data and we are confident that we will be able to use them in the next draft.



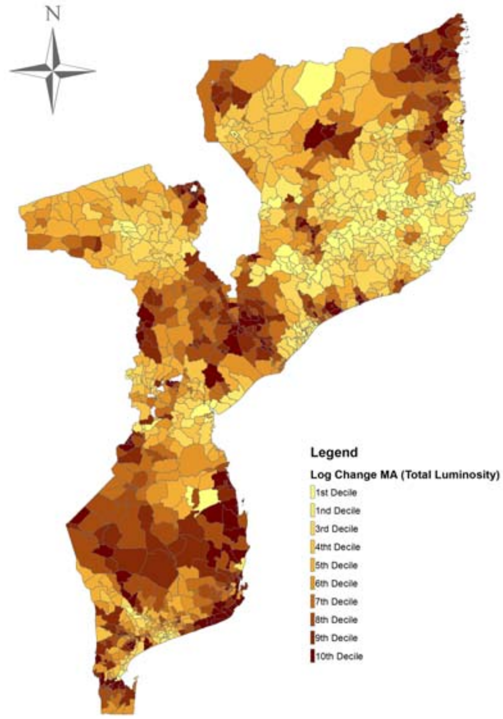


Figure $7a$ **: Change in Log Market Access 1** **Figure 7b : Change in Log Market Access 2**

6.4 Results

Empirical Specification Having constructed the two market access measures, we proceed to estimating the "reduced-form" association between regional development and market access. The specification reads:

$$\Delta Y_{d,2013-1992} = \lambda \Delta \ln(MA_d) + \zeta X'_{d,1992} + \varepsilon_d.$$

The dependent variable is the change in luminosity over the period $2013 - 1992$. $\Delta \ln(MA_d)$ is the change in district's "market access". $X'_{d,1992}$ is a vector of initial characteristics in district d in 1992 that may affect changes in market access and development.[65] Estimation is performed across the full sample of 1204 admin-4 districts.[66]

[65] We estimate the specification in differences rather than in levels with district fixed effects. While the unconditional specifications yield identical estimates with the two methods, specifying the model in differences allows for further controlling for heterogeneity in initial conditions.

[66] Due to the structure of the network, we lose 5 districts that are small islands. Moreover, in 1992 we have 12 district centroids falling within the buffer of 500 meters of a minefield or UXO, thus becoming entirely isolated from the network. When we control for population density in 1960, we lose an additional 8 districts due to the coarseness of the underlying raster.

Baseline Estimates Table 7 gives the results.[67] As in the difference-in-difference specifications we use two transformations of luminosity, the change in the log of average luminosity (in columns (1)-(4)) and the change in the lit dummy between 1992 and 2013 (in columns (5)-(8)). We use two measures of market access, one that solely exploits changes stemming from removal of land mines and UXOs (reported in the odd-numbered columns) and one that adjusts for the other district's income using total lights (in the even-numbered columns).

The elasticity of market access - luminosity in (1) and (2) is positive and highly significant, suggesting that luminosity increased considerably more in districts that experienced a larger increase in market access due to the removal of land mines and UXOs. The specification in (2) where we use the theory-based measure of market access that takes into account total demand effects in the destination districts discounted by transportation costs implies that a 10% increase in the market access increases average luminosity by around 4%. The pattern is similar with changes in the lit indicator in (5) and (6). A 10% increase in market access increases the likelihood that the district will become lit by approximately $0.4\% - 0.7\%$.

As the specification is in differences, concerns that the estimates capture the impact of time-invariant district-level characteristics are attenuated. Yet one may be concerned that there is still unobserved heterogeneity and that perhaps initial (at the end of civil war and during the transition) factors have shaped the process of demining and subsequent regional development. To assuage these concerns in columns (3), (4), (7) and (8) we control for initial district-level characteristics, reflecting the intensity of the civil war and initial levels of development and urbanization. And, we also account for the 1992 log level of market access.

By adding these controls, we net out any effect of initial conditions on the subsequent changes in development at the district level. Conditioning on initial differences improves the fit of the model (R^2 increases considerably), as changes in luminosity are related to initial urbanization;[68] yet this has no effect on the luminosity-market access elasticity that retains its economic and statistical significance. The luminosity-market access elasticity in (4) is 0.30, quite similar to the one reported by Alder (2015), who also uses luminosity to proxy for district-level development in India (range $0.20 - 0.40$). And the estimate in (8) implies that a 10% increase in market access increases the likelihood that the district will be lit by approximately 1%.

Changes in Market Access and Changes in Luminosity; Graphical Illustration To enable the interpretation and visualization of the regression estimates we did the following. First, we split the districts into four groups based on changes in the lit indicator: *i*) districts that were lit in 1992 but no light was detectable from the satellites in 2013 (in total 18 districts); *ii*) districts that were unlit both in 1992

[67] Table 7*b* in the Appendix reports the results of the estimation of the same specification as Table 7 controlling for province fixed effect.

[68] Log population density enters with a significantly positive coefficient, implying agglomeration effects, a common across many African countries patterns. The 1992 log level of luminosity enters with a negative estimate, pointing out to a pattern of regional convergence.

and in 2013 (770 districts); *iii*) districts that were unlit in 1992 and became lit by 2013 (328 observations); and *iv*) districts that have been lit both in 1992 and 2013 (108 districts). We then estimate the average increase in market access for each group of districts. And we also estimate the mean values of the initial log level of market access.

Figure 8 depicts the "market access" pattern for all four groups of districts. The top panel plots changes in the market access (reflecting only changes in bilateral minimum distances via improvements in the transportation network due to mine and UXO clearance). The bottom panel shows the initial log level of market access in 1992.[69] Those districts that were lit at the end of the civil war and in 2013 where the ones that experienced the largest positive change in market access (approx. 110%); these districts had on average a somewhat larger market access in 1992, yet as can be seen from the bottom part of the Figure initial differences in market access across the four categories were small. The other three categories had comparable initial levels of market access in 1992; yet they experienced different development paths post transition. Let us compare the 1098 districts that were unlit at the end of the civil war. The increase in "market access" for those districts that start unlit in 1992 and are lit in 2013 is almost twice as large as the respective change in market access among districts that were also unlit in 1992 but remained unlit also during the next two decades. Let us now turn to districts that looked -relatively speaking- better off in 1992, as there was some light emission but are unlit in 2013. In line with the results in Table 7, these districts experienced the smallest increase in market access in Mozambique over 1992 − 2013; so while overall luminosity and development increased during this period, the satellites in 2013 did not detect any light emission.

[69] The correlation of the change in the log of market access during 1992 − 2013 with the initial log market access in 1992 is −0.256 when we use the measure that is solely driven by changes in transportation costs and −0.53 when we use the market access measure that also takes into account total luminosity. The negative correlation is intuitive. Districts which to start with had fewer impediments in their access to other districts gained relatively less from the demining process.

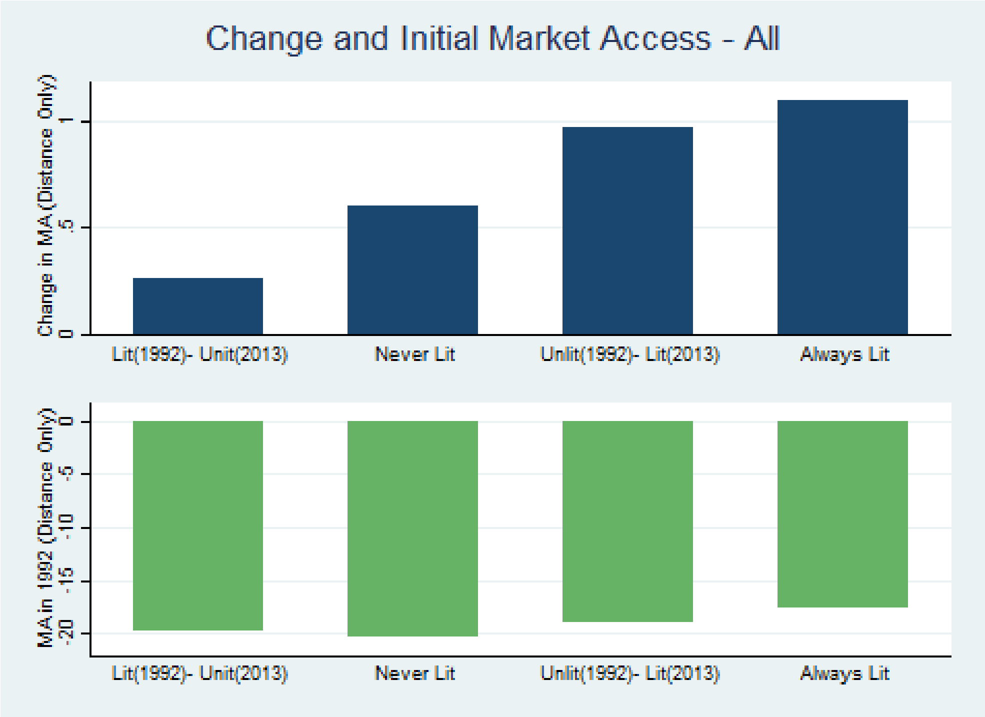


Figure 8: **Changes in Market Access**

Market Access and Local Effects of Demining Operations Estimating the general equilibrium impact by taking into account the transportation network reveals a strong impact of land mines and UXOs clearance. In theory the market access specifications capture both the local effect of demining and externalities from demining in all other districts. Yet it is interesting to break down the magnitude of the effect into its constituent components, namely the part that is due to demining in one's district and the part that reflects the spillovers of demining in other districts. We augment the market access specification (equation (1)) with indicators capturing the local (at the district level) effects of demining; in particular, we add dummy variables that identify the removal of land mines and UXOs that block paved roads, unpaved roads, trails, railways and navigable rivers at the district level (using as before a 500 meters buffer of threats around these features). [The direct effects of these variables are absorbed since the specification is in differences].[70]

Table 8 reports the results with both proxies of market access and both transformations of luminosity. There is clear-cut evidence for positive effects of demining; the removal of land mines that were blocking access to paved roads and rail tracks are associated with significant increases in district-level luminosity. In contrast, the clearing of threats near navigable rivers, unpaved roads, and trails are rarely significantly related to increases in luminosity. These results suggest that the clearance of land mines and UXOs

[70] We thus end up using a set of indicator taking the value 1 in 1992 if at least one threat was found in a buffer of 500 meters from a paved or unpaved road, trail, river of railways and zero otherwise. As before, these indicators become 0 in 2013 if all such threats in the district have been removed.

interacts crucially with the main road and infrastructure network. The coefficient on the market access is also statistically significant and quite similar to the baseline estimates (in Table 7), implying that there are also sizable spillovers from demining activities that free roads and railroads in other districts. The joint significance of the market access measures and of the local demining that free up previously inaccessible paved roads and railroads suggests a complementarity between the local and the general equilibrium effects.

7 Market Access and Spatial Development. Accounting for Endogeneity

The estimates reveal a strong positive effect of demining activities both at the local and the aggregate level. The market access approach shows how the effect of demining propagates through the network, facilitating economic interactions among districts and hence fostering economic activity. A natural concern with the analysis is that mine placement and the rate of demining took place in districts with high growth potential that would have grown faster even in absence of land mine clearance efforts. We regard this possibility as unlikely for many reasons. First, the use of land mines during the civil war had a significant non-strategic component, as besides blocking infrastructure and border crossings, mines were extensively used to terrorize civilians (see the Appendix for an overview of land mine usage during the civil war). In line with this, a great fraction of the distribution of mines across districts cannot be explained by location characteristics, pre-war urbanization and regional development in the early 1990*s* (Table 2 and Figure 4*b*). Second -as highlighted in Section 2- the process of demining was far from being centralized and the priorities on what to demine changed over time. And the significant floods of $2000-2001$ changed the distribution of land mines and UXOs rendering the efforts to detect and remove those threats far more costly than previously anticipated. In line with this, the timing of land mine and UXO removal operations (Table 3) is not related to end-of-war or location-specific characteristics. Third, there is great uncertainty on the location of land mines and thus demining activities cannot be perfectly planned. For example all country-wide surveys (Halo Trust in 1994, LIS in 2001, Halo Trust in 2007) had non-negligible type I and type II error, complicating removal operations.

However, one cannot fully rule out the possibility that demining operators or IND after 1999 prioritized districts with strong growth potential. In this case, the baseline estimates will be amplified (biased upwards) due to (reverse) causation (regional development affecting market access rather than the other way around). We thus implemented two complementary approaches in an effort to identify the one-way impact of (changes in) market access due to the removal of land mines and their interaction with the railway-road network and (changes in) regional development.

7.1 Identification Strategy 1

Our first identification approach is based on the idea that the market access of a particular district is affected not only by the removal of land mines and UXOs in the district itself or even in nearby districts,

but also in far away districts. We re-calculated districts' market access in 1992 and in 2013 excluding from the estimation districts that are within 50 kilometers from the district's borders (or approximately 100 kilometers from the centroid of each district) and repeated estimation. Eliminating the local effect from closest neighbors has the benefit of netting out any local reallocation of population or/and economic activity. The alternative market access measure allows us to better isolate the network spillover effects (that are not driven by local characteristics).[71]

Table 9 reports the results. Panel A reports OLS estimates associating changes in log luminosity and changes in the lit indicator on changes in market access, driven by land mine and UXO removals outside a 50-kilometer buffer of a district's boundaries. The coefficient on market access retains significance, further assuaging concerns that the baseline estimates (in Tables $7-8$) reflect demining taking place in districts with (hard-to-observe) good prospects. This applies with both transformations of luminosity and measures of market access. The coefficient in columns (5)-(8) imply that a 10% increase in market access raises the likelihood that a district will be lit by approximately $0.5\% - 1.2\%$. Panel B reports 2sls estimates, instrumenting the baseline market access measures (that reflect changes in connectivity across all districts) with the alternative "market access" measures that exclude from the calculation demining of nearby districts. The first-stage fit is strong. The 2sls coefficients are highly significant in all perturbations; these estimates imply that the component of a district's change in market access that is driven from land mine removal operations outside a radius of 50 kilometers is a significant correlate of changes in luminosity. Moreover, the 2sls estimates are moderately larger than the analogous OLS specifications (in Table 8).

7.2 Identification Strategy 2

Our second identification strategy focuses on the subset of districts that no land mines or UXOs were placed during the civil war. So, in these districts no demining operations were carried out and thus concerns of demining targeting towards high-growth-potential areas are not warranted.

Table 10 reports the results when we restrict estimation to the sample of 634 districts that were never directly affected by land mines or UXOs. Columns (1) to (4) employ the changes in the log of average luminosity as the dependent variable, while in columns (5) to (8) we use the change in the lit indicator to proxy for district-level development over time. Due to the drop in the sample size, the estimates are somewhat less precise, yet they retain economic and statistical significance. Changes in market access due to demining have beneficial repercussions in the sample of districts where demining activities never took place. Estimated coefficients become larger when we control for initial conditions. We take this as evidence that the effect of market access on the evolution of local activity goes beyond the mere effect of local demining. The existence of such relationship in the sample of districts where land mines and UXOs were absent seems to suggest strong general equilibrium effects of demining activities on spatial

[71] Donaldson and Hornbeck (2016) and Jedwab and Storeygard (2015) also perform a similar identification strategy in an effort to account for potential endogeneity on the location of railroads and roads.

development, driven by the evolving accessibility of the transportation network.

7.3 Conclusion

While the motto of the United Nations, many specialized NGO's and donor governments is that "*land mines keep poor people poor, decades after the conflict*" (see The Guardian's Poverty Matters Blog, July 6 2012), there is little econometric work quantifying the impact of land mines and their clearance on regional economic performance. Understanding the impact of land mines on economic activity is crucial, as a slow recovery after a long-lasting conflict due to the wide spread of land mines, may push the society into a vicious cycle of poverty and conflict.

Surprisingly there is little work in economics, employing formal econometric techniques assessing the legacy of land mines on economic activity. Our paper tries to shed some light on these issues by examining impact of land mine clearance on both the affected and potentially non-directly affected communities, that however may experience negative spillover effects. We focus on Mozambique, a country that was severely affected by the placement of landmines by all warring parties during the war of independence (1964 – 1975) and especially during the subsequent civil war (1977 – 1992). Our findings suggest that demining has both local and aggregate effects. Regarding the local consequences we employ a difference-in-difference framework where we leverage the variation in the timing of the clearance across contaminated districts. Although there do not seem to be pre-existing trends in economic activity as captured by light density among the soon-to-be cleared districts, upon demining there is a clear change in the trend for the cleared ones. One of the notable features of landmines is that by crippling down the transportation network they increase market fragmentation and isolation of the communities. This implies that the presence of landmines and their subsequent removal will indirectly affect districts that did not have any direct exposure to explosive remnants of war. In order to properly quantify this general equilibrium effect of land mine clearance we employ the market access approach (a recent development in the trade and urban literature) which takes into account how the removal of landmines increases differentially market potential for all parties depending on their initial location in the transportation network (Donaldson and Hornbeck (2016)). The removal of landmines increased market access for an average district by 76%. Naturally, those that had at least one minefield in their territory benefited more enjoying an increase of roughly 118% but also those districts with zero initial exposure to minefields saw their market potential increase by 38% by the time Mozambique was declared land mine free. Changes in market potential for both sample has a large impact on changes in luminosity across time.

Establishing the beneficial role of demining efforts on the local and global economy of Mozambique is a first step towards assessing the economic impact of land mines and demining operations. These findings are important, since minefield contamination is an ongoing concern for several countries. The Landmine Monitor 2015, for example, provides a global overview of the current land mine situation. In 2014, 3,678 casualties due to explosive remnants of war were identified in 58 countries. The vast majority

of recorded were civilians (80%) with children accounting for 39% of all civilian casualties. Although the use of landmines has subsided significantly since 1997 when the Mine Ban Treaty was put in place (currently 162 countries are members of this treaty) during the last year the Monitor has confirmed new use of antipersonnel mines by the government forces of Myanmar, North Korea, and Syria and by non-state actors in Afghanistan, Colombia, Iraq, Libya, Myanmar, Pakistan, Syria, Tunisia, Ukraine, and Yemen. Moreover, the problem of land mines is still important in several conflict-prone countries. As of 2015 massive antipersonnel mine contamination of more than 100 km^2, is believed to exist in Afghanistan, Angola, Azerbaijan, Bosnia and Herzegovina, Cambodia, Chad, Croatia, Iraq, Thailand, and Turkey, and Western Sahara.

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Main Tables

Table 1. Summary statistics: Land Mines Sample

Variable	N	Mean	SD	Min	p25	p50	p75	Max
			Minefield and UXOs Affected Districts					
Elevation (meters)	582	339.11	350.211	0	45.06128	227.0709	542.7656	1716.991
Suitability of Agriculture	582	.4729592	.1880112	.088168	.362	.4479429	.5918888	.9603358
Malaria Ecology	582	10.98707	3.511599	0	9.601864	10.82852	13.41984	19.18703
Distance South Africa Border	582	.6268148	.4404226	.0044679	.2759026	.561645	.9989504	1585.569
Distance Zimbabwe Border	582	.3568384	.2486009	.0027126	.1469523	.3452576	.4666969	1019.269
Distance Malawi Border	582	.4323197	.3128483	.0024827	.15698	.3559757	.7266181	1104.186
Distance Tanzania Border	582	.8232044	.4832114	.0098356	.4137519	.7446681	1.325.443	1703.351
Distance Closest Big City	582	.2429436	.1366804	.0080111	.1397033	.2301036	.3383509	.6546202
Distance Civil War's Violent Event	582	.0379065	.0397604	.0003296	.0136304	.0258959	.0496278	.271094
Distance From Closest River	582	.0588002	.0559646	.0000404	.0157584	.0379858	.0866782	.2352607
Distance From Closest Road	582	.0062588	.0071656	5.72e-06	.0014243	.0040208	.0083515	.0563127
Distance From Closest Rail	582	.0960331	.0916889	.0001081	.0203016	.0642004	.1554489	.4101087
Population Density, 1960	582	-5.56543	1.326577	2.223579	3.147586	6.532299		
Lit (dummy) 1992	582	.1099656	.313116	0	0	0	0	1
Luminosity 1992	582	.1455037	13.14466	0	0	0	0	25.12889
Lit (dummy) 2013	582	.4587629	.4987252	0	0	0	1 1	
Luminosity 2013	582	.9714751	3.90746	0	0	0	.1832566	43.30119
Log - Market Access, only distance 1992	570	-20.09641	2.16584	-24.86193	-21.64691	-20.33321	-18.7177	-13.83967
Log - Market Access, Light Sum 1992	570	-15.87114	3.035858	-20.87127	-18.22517	-16.46334	-13.87649	-5.649086
Log - Market Access, only distance 2013	570	-18.90902	2.304482	-24.18185	-20.5385	-19.16161	-17.45657	-11.10988
Log - Market Access, Light Sum 2013	570	-11.69575	2.786992	-17.99229	-13.78564	-12.09655	-10.03084	-3.174424
			Minefield and UXOs Free Districts					
Elevation (meters)	631	339.1131	350.211	0	45.06128	227.0709	542.7656	1716.991
Suitability of Agriculture	631	.4951795	.1897898	.095	.3775362	.454382	.5910265	.968
Malaria Ecology	631	1.157.358	4.471.024	0	986.225	1216.121	1.516.187	1.926.046
Distance South Africa Border	631	.8676139	.4004565	.0106707	.6898302	.9149835	1161.586	1623.882
Distance Zimbabwe Border	631	.471547	.2545982	.0032399	.2817499	.4425334	.6844802	104.802
Distance Malawi Border	631	.3438366	.2580511	.0026649	.1481733	.2984484	.4850788	1059.338
Distance Tanzania Border	631	.6030163	.4064376	.0081197	.3434825	.5033189	.6918822	1654.948
Distance Closest Big City	631	.264161	.1518038	.0069848	.1527091	.2311447	.3384522	.7095319
Distance Civil War's Violent Event	631	.0468044	.0415339	.0001078	.0209589	.0350955	.0603915	.2954091
Distance From Closest River	631	.0773043	.0683214	.0001973	.0222792	.0556165	.115247	.2796952
Distance From Closest Road	631	.0071189	.0074357	1.89e-06	.0018165	.0045414	.0102111	.0507857
Distance From Closest Rail	631	.113592	.0874147	.0001458	.0458024	.0982706	.1570172	.4350792
Population Density, 1960	631	2.305866	1.745658	-4.879128	1.320395	2.506766	3.59476	6.821889
Lit (dummy), 1992	631	.0982567	.2978976	0	0	0	0	1
Luminosity 1992	631	.1599068	10.86611	0	0	0	0	15,54277
Lit (dummy), 2013	631	.2632399	.4407349	0	0	0	1	1
Luminosity 2013	631	1.05697	4.417913	0	0	0	.0045321	50.85537
Log - Market Access, only distance 1992	631	-19.31364	2.262788	-24.63466	-20.77369	-19.43407	-17.86877	-10.00423
Log - Market Access, Light Sum 1992	631	-15.34028	3.184742	-21.07344	-17.83752	-15.89857	-13.22016	-4.245724
Log - Market Access, only distance 2013	631	-18.93682	2.185371	-24.15644	-20.41326	-19.17256	-17.57982	-10.0041
Log - Market Access, Light Sum 2013	631	-12.22764	2.59657	-18.08105	-14.09695	-12.58932	-10.65123	-2.554054

The table reports summary statistics at the district level for the key variables employed in the empirical analysis. Panel A gives summary statistics in the group of districts with at least one land mine or UXO threat. Panel B gives summary statistics in the group of districts with no land mine of UXO threats.

Table 2a: Cross-District Correlates of Land Mines and UXOs - Probit ML

Dependent Variable	Minefields and UXOs Threat (dummy)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log - Distance South Africa Border	-0.191***							-0.202***
	(0.073)							(0.048)
Log - Distance Zimbabwe Border	-0.079*							-0.110**
	(0.047)							(0.044)
Log - Distance Malawi Border	0.019							0.057
	(0.043)							(0.054)
Log - Distance Tanzania Border	-0.069							-0.164*
	(0.068)							(0.086)
Log - Elevation		0.004						0.027***
		(0.014)						(0.008)
Log - Suitability of Agriculture		-0.053						-0.065**
		(0.067)						(0.030)
Log - Malaria Ecology		0.003						0.016
		(0.019)						(0.014)
Log - Distance Closest Big City			-0.091					-0.012
			(0.105)					(0.116)
Log - Distance Civil War's Violent Event				-0.205***				-0.124***
				(0.072)				(0.047)
Log - Distance Closest Navigable River					-0.069			0.010
					(0.058)			(0.044)
Log - Distance Closest Road in 2011					-0.231***			-0.235***
					(0.074)			(0.062)
Log - Distance Closest Railroad					-0.084*			-0.053
					(0.048)			(0.043)
Lit in 1992 (dummy)						0.103		-0.067
						(0.085)		(0.054)
Log - Population Density, 1960							0.023	0.042***
							(0.014)	(0.012)
Land Area (log)	0.098***	0.078***	0.093***	0.121***	0.128***	0.088***	0.100***	0.156***
	(0.013)	(0.016)	(0.018)	(0.021)	(0.024)	(0.020)	(0.022)	(0.017)
Observations	1,213	1,213	1,213	1,213	1,213	1,213	1,213	1,213
Province FE	N	N	N	N	N	N	N	N
Log Likelihood	-744.9	-812.4	-805.8	-778.2	-771.1	-811.5	-811.4	-700.5
Pseudo R-squared	0.113	0.0326	0.0405	0.0734	0.0818	0.0337	0.0338	0.166

The table reports probit maximum likelihood (ML) estimates (marginal effects estimated at the mean of the independent variables) associating land mine and UXOs (unexploded ordnance) at the district level with location, geography, and other district characteristics. In all specifications the dependent variable is an indicator variable that takes on the value of one if a land mine or UXO was found during the land mine removal operations at the district and zero otherwise. Below the estimates, the table gives standard errors clustered at the province level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 2b: Cross-District Correlates of Land Mines and UXOs - Negative Binomial ML

Dependent Variable	Number of Minefields and UXOs Threats (count)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log - Distance South Africa Border	-0.596**							-0.541***
	(0.232)							(0.204)
Log - Distance Zimbabwe Border	-0.583***							-0.683***
	(0.160)							(0.118)
Log - Distance Malawi Border	0.0944							0.248
	(0.181)							(0.242)
Log - Distance Tanzania Border	0.224							-0.0163
	(0.319)							(0.269)
Log - Elevation		-0.106						0.0446
		(0.125)						(0.0362)
Log - Suitability of Agriculture		0.278						-0.0837
		(0.356)						(0.112)
Log - Malaria Ecology		0.0446						0.170***
		(0.127)						(0.0583)
Log - Distance Closest Big City			-0.864**					-0.0444
			(0.388)					(0.495)
Log - Distance Civil War's Violent Event				-1.107***				-0.107
				(0.203)				(0.108)
Log - Distance Closest Navigable River					-0.160			0.0240
					(0.372)			(0.185)
Log - Distance Closest Road in 2011					-0.850***			-0.756***
					(0.235)			(0.163)
Log - Distance Closest Railroad					-0.475*			-0.282
					(0.275)			(0.196)
Lit in 1992 (dummy)						0.614		-0.203
						(0.487)		(0.196)
Log - Population Density, 1960							0.138	0.183***
							(0.0871)	(0.0472)
Land Area (log)	0.519***	0.493***	0.529***	0.678***	0.621***	0.475***	0.517***	0.672***
	(0.0447)	(0.0642)	(0.0799)	(0.0849)	(0.0977)	(0.0791)	(0.0805)	(0.0511)
Province FE	N	N	N	N	N	N	N	N
Observations	1,213	1,213	1,213	1,213	1,213	1,213	1,213	1,213
Log Likelihood	-2171	-2321	-2282	-2272	-2272	-2322	-2323	-2132

The table reports negative binomial likelihood (ML) estimates associating land mine and UXOs (unexploded ordnance) at the district level with location, geography, and other district characteristics. In all specifications the dependent variable is an indicator variable that takes on the value of one if a land mine or UXO was found during the land mine removal operations at the district and zero otherwise. Below the estimates, the table gives standard errors clustered at the province level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 3: Cross-District Correlates of the Timing of Land Mine and UXO Removal Operations

Dependent Variable	Number of Years until First Intervention							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log - Distance South Africa Border	0.034							0.092
	(0.349)							(0.365)
Log - Distance Zimbabwe Border	-0.666							-0.699
	(0.412)							(0.404)
Log - Distance Malawi Border	0.796**							0.962***
	(0.271)							(0.256)
Log - Distance Tanzania Border	-0.821**							-0.729
	(0.272)							(0.432)
Log - Elevation		0.038						0.036
		(0.179)						(0.170)
Log - Suitability of Agriculture		-0.805						-0.376
		(0.519)						(0.497)
Log - Malaria Ecology		-0.039						0.008
		(0.218)						(0.216)
Log - Distance Closest Big City			-0.055					0.073
			(0.531)					(0.538)
Log - Distance Civil War's Violent Event				0.462				0.498
				(0.349)				(0.406)
Log - Distance Closest Navigable River					0.190			0.341*
					(0.218)			(0.186)
Log - Distance Closest Road in 2011					0.757			0.621
					(0.478)			(0.514)
Log - Distance Closest Railroad					-0.002			-0.386*
					(0.211)			(0.181)
Lit in 1992 (dummy)						0.325		0.435
						(0.565)		(0.574)
Log - Population Density, 1960							-0.059	0.042
							(0.107)	(0.119)
Land Area (log)	-0.441*	-0.406**	-0.351	-0.432*	-0.467	-0.346	-0.394*	-0.576*
	(0.215)	(0.167)	(0.201)	(0.219)	(0.257)	(0.189)	(0.198)	(0.260)
Observations	582	582	582	582	582	582	582	582
Adjusted R-squared	0.233	0.224	0.221	0.223	0.222	0.221	0.221	0.231
Province FE	Y	Y	Y	Y	Y	Y	Y	Y

The table reports OLS estimates associating the number of year between 1992 and first intervention at the district level with location, geography, and other district characteristics. In all specifications the dependent variable is an indicator variable that takes on the value of one if a land mine or UXO was found during the land mine removal operations at the district and zero otherwise. Below the estimates, the table gives standard errors clustered at the province level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 4: Demining and Local Development. Panel Fixed-Effects Estimates

Dependent Variable	Log Average Luminosity				Lit (dummy)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log - Number of All (Minefields+Bombs)	-0.153***	-0.108***			-0.015***	-0.013***		
	(0.027)	(0.029)			(0.003)	(0.003)		
Log - Number of Minefields			-0.294***	-0.059			-0.029***	-0.008
			(0.053)	(0.038)			(0.006)	(0.005)
Log - Number of Bombs			-0.421***	-0.150			-0.038***	-0.018*
			(0.067)	(0.090)			(0.010)	(0.009)
Number of Districts	1,224	1,224	1,224	1,224	1,224	1,224	1,224	1,224
District FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Year x Province Trend	N	Y	N	Y	N	Y	N	Y
Observations	4,896	4,896	4,896	4,896	4,896	4,896	4,896	4,896
R-squared	0.178	0.218	0.101	0.219	0.139	0.174	0.079	0.175

The table reports FE estimates associating the log of average luminosity with number of minefields and UXOs at district level. In all specifications we control for district FE and Year FE. Below the estimates, the table gives standard errors clustered at the province level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 5: Demining and Local Development. Long-Run Differences (2013-1992) Specifications

Dependent Variable	Δ Log Average Luminosity				ΔLit (dummy)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Log - Number of All (Minefields+Bombs)	-0.239***	-0.278***	-0.222***	-0.256***	-0.025***	-0.029***	-0.024***	-0.028***
	(0.061)	(0.058)	(0.060)	(0.061)	(0.005)	(0.005)	(0.005)	(0.005)
Log - Light Density, 1992		-0.382***		-0.424***				
		(0.048)		(0.045)				
Log - Population Density, 1960		0.997***		0.987***		0.085***		0.084***
		(0.161)		(0.167)		(0.012)		(0.012)
Number of Civil War Violent Events, 1992			0.304	0.406*			0.018	0.031*
			(0.194)	(0.188)			(0.016)	(0.016)
Lit (dummy), 1992						-0.569***		-0.593***
						(0.043)		(0.039)
Observations	1,216	1,216	1,216	1,216	1,216	1,216	1,216	1,216
R-squared	0.020	0.159	0.029	0.174	0.022	0.191	0.026	0.200

The table reports OLS estimates of the long-run change 2013-1992 of the log of average luminosity (or lit indicator) with change in the number of minefields and UXOs at district level. Below the estimates, the table gives standard errors clustered at the province level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 6: Demining, Network Interactions and Local Development. Long-Run Differences (2013-1992) Specifications

Dependent Variable	Δ Log Average Luminosity		ΔLit (dummy)	
	(1)	(2)	(3)	(4)
Δ Threats (dummy)	-0.565*	-0.672***	-0.082**	-0.085***
	(0.264)	(0.179)	(0.026)	(0.019)
Δ Threat on Paved Road (Dummy)	-3.615***	-2.916***	-0.292***	-0.244***
	(0.659)	(0.553)	(0.061)	(0.054)
Δ Threat on Unpaved Road (Dummy)	0.450	0.345	0.049	0.041
	(0.399)	(0.370)	(0.043)	(0.041)
Δ Threat on River (Dummy)	-0.660	-0.711	-0.047	-0.084
	(0.543)	(0.600)	(0.053)	(0.055)
Δ Threat on Railways (Dummy)	-2.501***	-2.246***	-0.193***	-0.191***
	(0.710)	(0.564)	(0.050)	(0.038)
Δ Threat on Trails (Dummy)	-0.210	-0.309	-0.020	-0.049
	(0.766)	(0.680)	(0.070)	(0.067)
Log - Light Density, 1992		-0.439***		
		(0.049)		
Log - Population Density, 1960		0.821***		0.069***
		(0.117)		(0.009)
Number of Civil War Violent Events, 1992		0.348		0.026
		(0.214)		(0.018)
Lit (dummy), 1992				-0.606***
				(0.043)
Observations	1,216	1,216	1,216	1,216
R-squared	0.101	0.223	0.073	0.234

The table reports OLS estimates of the long-run change 2013-1992 of the log of average luminosity (or lit indicator) with change in the number of minefields and UXOs at district level. Below the estimates, the table gives standard errors clustered at the province level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 7: Market Access and Regional Development.
Long-Run Difference Specifications, 2013-1992 at the District Level

Dependent Variable	Δ Log Average Luminosity				ΔLit (dummy)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Log - Market Access, only distance	0.832***		0.842***		0.068***		0.111***	
	(0.140)		(0.118)		(0.014)		(0.011)	
Δ Log - Market Access, Light Sum		0.409***		0.280***		0.042***		0.086***
		(0.074)		(0.067)		(0.007)		(0.007)
Log - Market Access, only distance 1992			0.753***				0.058***	
			(0.070)				(0.007)	
Log - Market Access, Light Sum 1992				0.834***				0.072***
				(0.056)				(0.005)
Number of Civil War Violent Events, 1992			0.379***	0.410***			0.028**	0.028**
			(0.146)	(0.152)			(0.011)	(0.012)
Log - Light Density, 1992			-0.444***	-0.395***				
			(0.039)	(0.037)				
Lit (dummy), 1992							-0.664***	-0.683***
							(0.037)	(0.037)
Log - Population Density, 1960			0.976***	0.941***			0.039***	0.018**
			(0.073)	(0.074)			(0.008)	(0.008)
Province FE	N	N	N	N	N	N	N	N
Observations	1,204	1,204	1,196	1,196	1,204	1,204	1,196	1,196
Adjusted R-squared	0.032	0.031	0.185	0.166	0.021	0.032	0.244	0.288

The table reports OLS estimates of the long-run change 2013-1992 of the log of average luminosity (or lit indicator) with change in the market access computed as distance only as well as weighted by total lights at district level. Below the estimates, the table gives robust standard errors. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 8: Local Demining, Market Access and Regional Development.
Long-Run Difference Specifications, 2013-1992 at the District Level

	Log Luminosity				Lit (dummy)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log - Market Access, only distance	0.333**		0.998***		0.027*		0.082***	
	(0.154)		(0.142)		(0.016)		(0.013)	
Log - Market Access, Light Sum		0.276***		0.815***		0.032***		0.074***
		(0.077)		(0.091)		(0.008)		(0.009)
Threat on Paved Road (Dummy)	-3.415***	-3.311***	-1.798***	-1.685***	-0.287***	-0.262***	-0.165***	-0.142***
	(0.479)	(0.462)	(0.459)	(0.442)	(0.047)	(0.046)	(0.044)	(0.041)
Threat on Unpaved Road (Dummy)	0.414	0.511*	0.538*	0.270	0.035	0.052*	0.054*	0.033
	(0.302)	(0.301)	(0.280)	(0.282)	(0.031)	(0.031)	(0.029)	(0.028)
Threat on Railways (Dummy)	-2.345***	-2.542***	-1.165**	-0.657	-0.186***	-0.205***	-0.109**	-0.056
	(0.558)	(0.564)	(0.517)	(0.522)	(0.057)	(0.057)	(0.051)	(0.051)
Threat on Trails (Dummy)	-0.079	-0.167	-0.689	-0.493	-0.013	-0.017	-0.081*	-0.068
	(0.530)	(0.519)	(0.465)	(0.443)	(0.056)	(0.054)	(0.048)	(0.046)
Threat on River (Dummy)	-0.595	-0.798	-0.484	-0.281	-0.042	-0.057	-0.056	-0.040
	(0.663)	(0.667)	(0.536)	(0.527)	(0.070)	(0.070)	(0.056)	(0.054)
Province FE	N	N	N	N	N	N	N	N
Observations	1,204	1,204	1,196	1,196	1,204	1,204	1,196	1,196
Adjusted R-squared	0.095	0.104	0.277	0.303	0.062	0.077	0.255	0.296
Level 1992	N	N	Y	Y	N	N	Y	Y

The table reports OLS estimates of the long-run change 2013-1992 of the log of average luminosity (or lit indicator) with change in the market access computed as distance only as well as weighted by total lights at district level. Below the estimates, the table gives robust standard errors. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 9: Market Access: Excluding Neighbors (50km)

	Panel A: OLS estimation							
Dependent Variable	Δ Log Average Luminosity				ΔLit (dummy)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Log - Market Access, only distance (50km)	1.192***		1.391***		0.098***		0.120***	
	(0.112)		(0.116)		(0.011)		(0.011)	
Δ Log - Market Access, Light Sum (50km)		0.673***		1.026***		0.053***		0.089***
		(0.082)		(0.091)		(0.008)		(0.009)
Adjusted R-squared	0.099	0.059	0.249	0.246	0.065	0.036	0.244	0.243
	Panel B: IV Estimates							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Log - Market Access, only distance	2.105***		2.006***		0.172***		0.178***	
	(0.237)		(0.188)		(0.023)		(0.019)	
Δ Log - Market Access, Light Sum		1.022***		1.157***		0.081***		0.100***
		(0.135)		(0.120)		(0.013)		(0.012)
F-Stat	260.62	395.39	334.62	784.85	260.62	395.39	332.68	787.92
Initial Level 1992	N	N	Y	Y	N	N	Y	Y
Observations	1,204	1,204	1,196	1,196	1,204	1,204	1,196	1,196

Panel A of the table reports OLS estimates of the long-run change 2013-1992 of the log of average luminosity (or lit indicator) with change in the market access computed as distance only as well as weighted by total lights excluding neighbors district in a radius of 50 km. Panel B reports the second stage of the IV estimates of the first-difference baseline model. The instrument is the market access measures excluding neighbors in a radius of 50 km. Below the estimates, the table gives robust standard errors. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 10: Market Access and Development across Districts without Land Mines and UXOs

Dependent Variable	Δ Log Average Luminosity				ΔLit (dummy)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Log - Market Access, only distance	1.196***		2.089***		0.122***		0.186***	
	(0.447)		(0.367)		(0.040)		(0.034)	
Δ Log - Market Access, Light Sum		0.189*		0.907***		0.026**		0.080***
		(0.111)		(0.125)		(0.011)		(0.012)
Initial Level 1992	N	N	Y	Y	N	N	Y	Y
Observations	634	634	626	626	634	634	626	626
Adjusted R-squared	0.015	0.004	0.298	0.346	0.017	0.010	0.301	0.349

The table reports OLS estimates of the long-run change 2013-1992 of the log of average luminosity (or lit indicator) with change in the market access computed as distance only as well as weighted by total lights at district level. The sample is composed by those districts that were not affected by land mines and UXOs in 1992. Below the estimates, the table gives robust standard errors. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.