CHAPTER 4

Does a Warming Climate Heat up the Small Arms Market?

Jeroen Klomp and Esmee de Bruin

Abstract

This study explores whether major droughts caused by a lack of rainfall or extraordinary evaporation affect the local small arms prices. The starting point of this relationship is that widespread evidence suggests that the negative societal consequences of climate change increase the likelihood of an armed conflict. However, it is possible that the parties that are involved in these climate change induced conflicts anticipate the higher conflict risk in the wake of a climatic event by strengthening their armed capabilities. As a result, the demand for small arms will increase in the aftermath of a climatic event. This increase in demand is, in turn, likely to be translated into higher local prices paid for small arms. The findings presented throughout this study support this idea but only for fragile countries, as these countries suffer more from weak governance and threats to national security.

Keywords: small arms prices; climate change; conflict

4.1 Introduction

The long-term consequences of climate change, such as rising sea levels, extreme weather events, and the increasing frequency and intensity of droughts, are identified as one of the major global security challenges of the twenty-first century (IPCC, 2023). Especially developing countries face increasing pressure on their societal structures due to climate change. Climate change is often seen as a factor that intensifies already existing tensions within or between societies and which could, if left unchecked, escalate into a widespread violent conflict. This urgency makes the possible relationship between climate change and armed conflict a popular topic on the agenda of academic scholars, policymakers, and politicians. In the past decade, a large and still growing body of research has tried to explain the nexus between climate change and the outbreak or duration of violent conflict (see, for instance, Buhaug, 2016; 2015, Buhaug et al., 2008; Hsiang et al., 2011; Hsiang et al., 2013, 2014; Adger et al., 2014; Bernauer et al., 2012; Gleditsch, 2012; Hendrix and Glaser, 2007; Klomp and Bulte, 2013; Meierding, 2013; Scheffran et al., 2012; Theisen et al., 2013; Zografos et al., 2014; Roche et al., 2020; Mach et al., 2019; Burke et al., 2009; Koubi, 2019; Mach et al., 2019). Despite the vast number of articles, the empirical literature still struggles with many conflicting empirical results. One explanation for this inconclusiveness is that the literature is still indecisively on the pathways underlying the empirical findings (Hsiang and Burke, 2014)[1]. The relationship between climate change and violent conflict is complicated and likely to be rather context-specific. It is recognised that underlying conditions, such as poor governance, poverty, severe resource competition, food insecurity, and water scarcity will magnify the climate impacts (Mach et al., 2020).

Because of the lack of consensus on the existence of a direct relationship, the field has shifted its focus by trying to reveal the underlying dynamics through which climate change may affect the risk of a violent conflict. One key element in this debate that is largely missing so far is whether climate change affects the armed capabilities of the conflict groups active in a country. The logic underlying this relationship is based on backward induction. The parties competing for power may see climate-induced events as a window of opportunity to gain more influence or achieve specific strategic goals. However, to take advantage of this opportunity, these parties must be ready and prepared. Thus, in the wake of these climatic events, parties may already anticipate the higher risk of conflict by strengthening their armed capabilities. In particular, climatic shocks may act as a learning mechanism. When these events occur more frequently, violent groups more easily recognise their opportunities and act accordingly. This is especially the case with droughts, as these shocks typically have a slow onset and the negative impact accumulates over a longer period. This leaves some time for the violent groups to prepare for an armed dispute or an attack on the ruling powers in the region or country.

Based on the existing evidence, the adverse consequences of climate change are typically associated with fueling civil conflicts rather than interstate conflicts. Apart from the government, the parties involved in civil conflicts usually have limited access to major conventional arms. Instead, in these kinds of conflicts, small arms and light weapons (SALWs) are predominantly used (Small Arms Survey 2005, Kopel et al., 2004; Lacina and Gleditsch, 2005; Greene and Marsh, 2011). The apparent easy access that all sorts of violent organisations have to SALWs is a major cause of the escalation of violence perceived in open conflict situations (Marsh, 2013; Bourne, 2007). According to the Small Arms Survey, SALWs are responsible for the death of more people than any other type of weapon (Small Arms Survey, 2018). In some conflicts, SALWs may produce up to 93% of casualties, as was the case in the Republic of Congo. Although the parties involved in a civil conflict differ along many dimensions, such as degree of organisation, number of members, financial resources, geographic reach, and motives, one thing they have all in common is that they need weapons to gain power, defend themselves against attacks of other adversary actors, or to achieve specific strategic goals. The armed capabilities are a visible signal of the intention of a group to resolve any dispute by force.

The question this study tries to answer is if the small arms demand increases in response to the expected security concerns of climate change shocks. One major complicating factor in measuring the demand for small arms is that most transfers occur on the black market. According to an estimate of the Small Arms Survey, more than 75% of the global total of all SALWs are outside the control of a state and subject to diversion. In practice, there are many ways in which the diversion of weapons might occur, including theft, smuggling, barter, military aid, and even through handouts to rebels or militias. In this way, arms are easily transferred from the legal to the illicit market (McDougal et al., 2019).

Despite this limitation, a large body of academic and policy literature has, in the last decade, tried to map the scale, structure, and geographic scope of the trafficking of weapons (Markowski et al., 2009, 2008; Killicoat, 2007; Karp, 2012; Brauer and Muggah, 2006; Brauer, 2013; Dreyfus et al., 2010; McDougal et al., 2014; McDougal et al., 2015). Recently, a more forensic-based method for detecting and quantifying illicit trade volumes has been proposed. This method entails analysing the small arms prices in response to certain events, shocks, or situations (McDougal et al., 2014; McDougal et al., 2019). Simplistically stated, if demand, licit supply, local production, and domestic flows amongst stocks could be perfectly controlled for in a given market and time period, negative and positive deviations from predicted prices would respectively indicate illicit imports to and exports from that market (see, for instance, Killicoat, 2007; Bhatia and Sedra, 2008; Florquin, 2014; McDougal et al., 2019).

In this research, we follow this approach to explore the price impact of climate change to make some inferences about the small arms demand in climate change-affected countries. More specifically, as the dependent variable in our panel model, we use the small arms price index reported in the Illicit Small Arms Prices (iSAP) dataset constructed by Marsh and McDougal (2017). The small arms price index is primarily based on the local prices for assault rifles. The climate change variable is based on the onset of severe droughts caused by a shortage of rainfall or extraordinary evaporation due to extreme temperatures. After testing for the sensitivity of the results, our main empirical findings indicate that droughts significantly increase the small arms demand in LDCs, especially in fragile countries.

The remainder of the chapter is structured as follows. Section 2 provides the theoretical foundation underlying the relationship between climate change and small arms demand. Section 3 describes the data used, while Section 4 explains the methodology applied. Section 5 shows our empirical results for the influence of climate change on the small arms demand. The final section offers the conclusions.

4.2 Theoretical Foundation

In an article published in the *New York Times*, Homer-Dixon (2007) argued that climate stress may well represent a challenge to international security just as dangerous as the arms race between rogue states. However, the question remains whether these risks are not intertwined, making the current arms races taking place in several countries around the globe partly fuelled by the adverse societal impact resulting from climate change. To theoretically underpin this idea, we follow the influential work of Most and Starr (1989), arguing that the onset of an armed conflict is the product of two concepts – the opportunity and willingness of conflict. These concepts describe the conditions that are necessary for events to escalate into a violent dispute (Most and Starr, 1989; Siverson and Starr, 1989). However, these two concepts also form the basis for linking climate risk factors to the behaviour of decision-makers to start a conflict. In particular, opportunity represents the total set of macro-level constraints and possibilities that are available within any environment. It captures the cause or motive of a conflict, in our case, climate shocks. In turn, willingness represents the choice processes that occur on the micro-level and is related to the intention of a decision maker, typically based on the calculation of cost and benefits. It is through willingness that decision-makers recognise opportunities and then translate those opportunities into alternatives that are weighed in some manner. In other words, opportunity is essentially the motivation for a violent conflict between states or groups, while willingness refers to the desire by states or groups to engage in violent conflict. To become involved in an armed conflict, parties must have both the opportunity and willingness to fight. Thus, opportunity and willingness should be viewed as jointly required conditions, and neither alone is sufficient (Most and Starr, 1989; Siverson and Starr, 1989).

Moreover, the theory on which this chapter is built is also related to the influential work of Hirschleifer, arguing that scarce resources may be invested either in production or predation of the production of others. In times of hardship, scarce resources might run more easily to the former (see, for instance, Hirschleifer, 2001). In this case, it would imply that after a climate shock, the resources are invested to strengthen the armed capacity.

In the literature so far, weather-related shocks and climate change are mainly linked with the opportunity of an armed conflict. Based on a brief review of the earlier studies, there are various theoretical pathways identified about how climate change influences this opportunity. First, climate change-induced shocks cause poverty and worsen livelihood conditions, making affected individuals more attracted to the selective benefits of rebel leaders for fighting. Second, deprivation and resource scarcity caused by adverse climate events might create grievances that spur violence. Third, adverse climate-related factors can force people to migrate and cause conflicts by creating struggles between hosts and newcomers over scarce resources or when newcomers alter local power relations. Fourth, weather-induced crop failures typically lead to food price hikes that ultimately might escalate into armed violence. Meanwhile, lower crop yields will mean that the same amount of food will require more land and water. In other words, it is a classic negative-sum game in which even trading water economically will require the predation of one's neighbours. Finally, the negative societal impact of climate change is strongly linked to exacerbating ethnic, political, and social divisions among the affected populace, leading to conflict (see, for instance, Burke et al., 2015; Buhaug and Uexkull, 2021; Koubi, 2019).

However, it is also possible that climate-related events also affect the willingness of armed groups to get involved or even start a civil conflict. This willingness is likely to be closely related to their ability. In particular, increasing the armed capabilities of rebel groups or other violent organisations such as militias might send out a powerful deterrence message to other domestic challengers, government troops, opposition groups, or even foreign powers by signaling the intent to resolve latent or future disputes through the use of armed force. In other words, arms purchases may be interpreted as a visible signal of the unwillingness of parties to comprise or settle in diplomatic ways. Potential challengers can observe these arms acquisitions and need to decide whether to initiate or get involved in a violent challenge.

Using deductive reasoning implies that when climate change would lead to a conflict, it may also strengthen the armed capacity as a means of readiness of the armed groups that are willing to participate in the conflict. The decision to strengthen the armed capabilities could be made in anticipation of a conflict, as parties might expect violent challenges by competing rebel groups or the domestic armed forces in the near future (Powell, 2013). Therefore, it is likely that the materialisation of the conflict risk depends both on the occurrence of an event that creates a fighting motive, such as the adverse societal impacts of climate change, and the willingness or ability of the violent parties to act on this fighting motive, such as the armed capabilities. Various studies claim the existence of a causal link between arms acquisitions and the onset or duration of armed conflicts (see, e.g. Craft and Smaldone, 2003). For example, Benson and Ramsay (2016) conclude that arms imports produce a law of conservation of violence. As one civil war ends, the resulting changes in the international market lead other war-torn countries' imports to increase, which in turn increases the number of casualties in ongoing civil wars.

Thus, based on these theoretical considerations, we argue that the chain of causality runs from opportunity (climatic shock) to willingness (increasing capabilities) and finally to the materialisation of the armed conflict risk. However, having a violent option available does not automatically mean that this final stage will be reached and the rebel groups are actually willing to use force. The basic premise is that conflicts do not arise over arms, as they arise first and foremost over certain contested issues (Fearon and Laitin, 2003; Collier and Hoeffler, 2004). For instance, the empirical results reported by Pamp et al. (2018) clearly show that while arms imports are not a genuine cause of armed conflicts, they significantly increase the probability of onset in countries where conditions are notoriously conducive to conflict. To deter competing groups from posing a violent challenge, armed groups are incentivised to gain a reputation for being resolute and thus willing to meet any challenge with force. If successful, just such a signal would already discourage challengers and make conflict less likely.

Meanwhile, there might be an interaction between the opportunity and willingness to get involved in an armed dispute due to climate change. For instance, because of a higher opportunity – more climate-related events – rebels might adjust their willingness. As a response, the rebel groups have the incentive to increase the acquisition of weaponry to increase their armed capacity after a climate shock, even when a conflict is not likely to occur. This suggests that climate change may work like a learning mechanism for the parties that are potentially involved in a conflict as it challenges the competencies of the government. The disruptions caused by climate events can create opportunities for rebel groups to exploit and amplify the existing grievances of marginalised communities. One of the key ways in which climate events can work as a learning device is by exposing the weaknesses of existing governance structures. In many countries, the government may be unable to respond effectively to the impacts of climate events, leaving communities vulnerable to further hardship and suffering. This can fuel anger and frustration toward the government and provide a rallying point for rebel groups seeking to overthrow it (Koubi, 2019; Burke et al., 2015). Climate change may provide an opportunity for rebel groups to fill the resulting power vacuum, providing them with a means of gaining support from local communities. Additionally, the chaos and confusion caused by climate events can also provide an opening for rebel groups to exploit and amplify existing social, economic, and political tensions (IPCC, 2007).

This learning effect is particularly present during a drought due to two reasons. First, droughts are slow-onset climatic disasters, providing the rebels and other government-challenging groups the opportunity to observe the disaster response of the government. It especially provides the opportunity for these violent groups to get better prepared in contrast to other sudden natural shocks, such as earthquakes or hurricanes. One element in this preparation phase is to strengthen the armed capabilities. Second, based on figures reported by EM-DAT, droughts are the natural hazard that affects the most people, both in terms of people killed, people affected, and economic damage (Guha-Sapir et al., 2020). This implies that droughts provide contemporary, visible, and distinct phenomena to analyse.

However, based on the earlier evidence in this area, it is expected that the impact of climate change on small arms trade is not the same among countries. In particular, climate change is expected to have a predominantly empirical effect on the arms demand in developing countries. The justification underlying this claim is based on two key arguments. First, more than 80% of the population identified to be vulnerable to climate change live in developing countries, especially in Africa, Asia, and Oceania (Guha-Sapir et al., 2020). This prevalence problem, in turn, in these countries is explained by a combination of three features that are most present in developing countries: a higher physical exposure in many areas to weather shocks (e.g. proximity to temperature thresholds), a higher economic vulnerability to climate events (e.g. heavier reliance on agriculture) and a lower adaptive capacity (i.e., a lower ability to deal with climate stress) (Loayza et al., 2012; Fomby et al., 2009; Noy, 2009).

Thus, based on these considerations, the hypothesis that will be tested in this study is given by:

H1*: Droughts increase the small arms demand in developing countries.*

4.3 Research Design

4.3.1 Dependent variable – Small arms prices

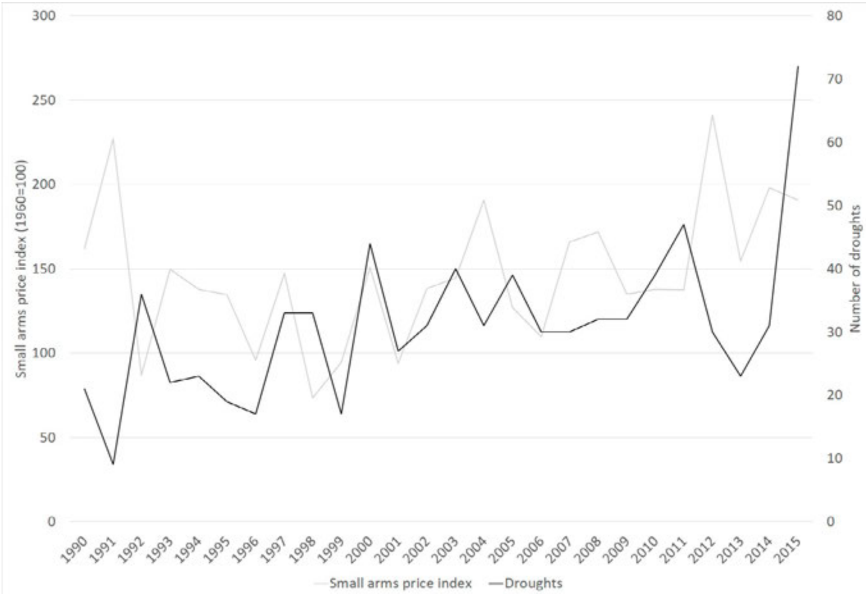
The global market for small arms and light weapons is massive and generates substantial profits for producers, brokers, distributors, and, not surprisingly, arms traffickers. In 2018, the global arms trade was estimated to exceed 100 billion US dollars (Small Arms Survey, 2018). This figure may even be short by a few hundred million US dollars, as the proliferation of small arms and light weapons is extremely difficult to track. The international market for small arms comprises a broad set of weaponry, including revolvers, self-loading pistols, rifles, carbines, heavy machine guns, grenade launchers, portable anti-aircraft weapons, recoilless rifles, anti-tank weapons, and their ammunition. It also includes missiles, grenades, landmines, various sizes of mortars, and other explosives (United Nations, 1997). Although the trade occurs globally, it is mainly concentrated in areas of armed interstate conflict, civil violence, and organised crime.

However, the fact that most of the SALW transactions occur on the black market creates a large limitation on doing cross-country research, as there are no reliable country estimates on the volume of the small arms transfers between and within countries. The only data that is currently available is on authorised quantities (see, for instance, the UN Comtrade Database or the Norwegian Initiative on Small Arms Transfers) or data on seized arms trade flows (UNODOCA). However, based on these data sources, it is impossible to make any inference about the size of the illicit market as this is rather endogenous (i.e., depends on the efforts to combat illegal proliferation).

This study builds on the alternative premise that current market prices of small arms can be obtained by observing individual transactions. For our dependent variable, we use data on small arms prices collected by the Illicit Small Arms Prices (iSAP) project. This project records illegal small arms transactions worldwide (Marsh and McDougal, 2017; 2021). The main advantage of transaction data is that its observations are all directly reported, documented, and gathered entirely based on verifiable and reliable sources ranging from the journalistic media to reports from the Small Arms Survey, individual researchers, NGOs, and industry reports. The time, location, type of weapon, and transaction price are recorded for each transaction.

However, the initial setup of the transaction dataset does not directly allow for a longitudinal analysis, which requires panel data. Marsh and McDougal (2017) follow a two-step approach to prepare the price data for panel analysis. In the first step, the transaction price data is standardised as empirical research requires an operational definition of the variable of interest that will provide consistency across time, countries, and especially across the different types of SALW. To make the observed transaction price data comparable, Marsh and McDougal (2017) converted it into weapons-adjusted prices. Weapons-adjustment is intended to align all weapons' prices to a common standard so that they might be compared with one another. Specifically, the authors have aligned the dataset based on PRIO category two weapons – small arms. The choice of adjusting prices to this category of weapons is that it refers to assault rifles such as the AK-47, which are the most common among illicit small arms (Marsh and McDougal, 2017; Small Arms Survey, 2004). In the second step, the recorded transactions are weighted and combined to build a country-year dataset. The transformation into such a structure involved collapsing data into means, linear interpolation between data points, and spatial and temporal lags to fill data holes in the panel (Marsh and McDougal, 2017). However, by collapsing the data, the data becomes more subject to a measurement error. Nevertheless, the fact that the price data is uncertain is less problematic in our case because we are foremost interested in how prices change from year to year, not the prices in themselves. Although the price estimates are uncertain, interannual changes in these estimates aim to reflect the true direction and magnitude of price growth as long as the measurement error is random. As a result, the price index should be regarded as an approximation of the actual small arms price in each country-year. This obtained collapsed data set covers the period between 1960 and 2015 and reports the small price index in constant 2010 U.S. dollars. However, the index in the period between 1960 and 1990 is only based on a limited number of transactions, producing a less reliable index and creating only low variation between years within a country. As a response, we decided to base our analysis only on the period from 1990 to 2015. Figure 4.1 shows the price development of small arms over the period of our analysis.

Figure 4.1. Distribution of droughts and small arms prices.



Note: the small arms price index is weighted by the real GDP per capita.

4.3.2 Independent variable – Climatic droughts

Following the most recent studies on climate and conflict, we base our climate change variable on meteorological droughts (see, for example, Von Uexkull et al., 2016; Ide et al., 2020; Schleussner et al., 2016; Thiesen et al., 2011; 2013). One of the main challenges in the literature about the impacts of droughts is the identification strategy of these events, as they are the product of hazard, exposure, and vulnerability. Most scholars agree that a large part of the hazard to a natural event is beyond government control or the behaviour of an individual (exogenous). In contrast, the exposure and vulnerability part of a disaster event, in terms of the number of people affected or physical damage created, depends to some extent on the socio-economic situation or government choices made (Kellenberg and Mobarak, 2008; Neumayer et al., 2014). For instance, the total damage created by a disaster is usually positively related to the level of income, while the number of people affected is negatively affected by the level of income. To estimate the impact of droughts, it is therefore essential to separate the exposure and vulnerability element from the drought impact and focus exclusively on the hazard part. As a response, a meteorological drought is typically defined as a prolonged lack of or below-normal rainfall (Keyantash and Dracup, 2002), possibly aggravated by hot temperatures causing high evapotranspiration rates (Vicente-Serrano et al., 2015). It is argued that the ongoing process of climate change will lead to longer spells of drought and shorter periods with more intensive rainfall. However, there is not a single consensus in the meteorological literature as to how the hazard risk of drought should be measured or captured (Guttman, 1998; Wells et al., 2004; Vicente-Serrano et al., 2010). This study uses the Standardised Precipitation-Evapotranspiration Index (SPEI) as it offers an important advantage. Whereas many studies have focused exclusively on rainfall, the SPEI is more effective at capturing drought conditions as it also accounts for temperature[2]. This is rather important, considering that evapotranspiration is the major form of water loss in dry regions with high temperatures. In essence, the SPEI measures drought severity in terms of climatic water balance, which is the difference between the available water (precipitation) and the atmospheric evaporative demand. Thus, the SPEI compares the actual biophysical and climatic situation to normal conditions in various natural and managed systems such as crops, ecosystems, rivers, water resources, etc. A statistical probability distribution is fitted over a baseline period to compute the standardised indicator that fits the input variables (Středová et al., 2011; Vicente-Serrano et al., 2010).

SPEI-based data has the advantage of being exogenous to the outcome. Following Spinoni et al. (2019), a drought starts once the SPEI within a particular territory falls below the value corresponding to a given standard deviation for at least two consecutive months and ends when the indicator rises above zero. The data on these events used in this study is collected by the Global Drought Observatory of the European Commission's Joint Research Centre and is available from three spatial scales: global at 0.5° spatial resolution, macro-regional, and country scale (Spinoni et al., 2019). In total, the database includes approximately 4,800 events in the past decades. Each event is described in the dataset by its start and end date, duration, intensity, severity, peak, average, and maximum area in drought.

Given the distribution of the drought severity in the dataset, it is conceivable that less severe droughts will have only a negligible impact on the security situation of a country and, therefore, on the incentive to strengthen the armed capabilities.

For a drought to have an empirical effect, it should be of a magnitude that can directly harm the socio-economic situation of a country. For this reason, we adopt a decision rule that filters out the extreme droughts based on severity, intensity, and area affected. Based on a detailed scoring system, each drought is assigned a severity score ranging from zero to 25. Using the threshold from Spinoni et al. (2019), an extreme drought is recognised when it scores at least 12 points. This condition reduces the number of droughts considerably by two-thirds.

To assess the impact of climate change on the arms trade, we construct for each country-year a drought variable that considers the timing of a drought in the course of a year. This allows droughts happening at the beginning of the year to have a different impact than those that occur near the end of the year. Since the contemporaneous impact of a drought within one year is considered, our annual disaster measure is weighted by the month M when the respective drought starts. That is, we assign the value $(12 - M)/12$ to a drought year and $M/12$ to the post-drought year. In all other years, its value is set to zero. This drought variable gives equal weight to the drought events. This has the advantage of reducing the potential influence of outlier events at the upper end of the SPEI distribution. Finally, we normalise the number of droughts by the land area. Obviously, larger countries have a higher probability of experiencing a climatic event[3].

As shown in Figure 4.1, a clear time trend is visible in the number of droughts during the analysis period. On average, there are about 23 droughts each year. We compare the arms price index before and after a drought as a preliminary statistical test. According to a simple Chi-squared test, this difference is statistically significant at common significance levels ($p = 0.05$). However, this nonparametric test is only suggestive, as unobserved country heterogeneity and other confounding variables are not considered.

4.3.3 Empirical model

The model used to estimate the effect of climatic droughts on the annual change in the country-specific small arms price index is given by

$$\Delta \ln sap_{it} = \alpha + \delta_i + \mu \ln sap_{it-1} + \beta_k \mathbf{x}^k + \sum_{t'=t-2}^{t} \gamma_{t'}\, drought_{it} + \varepsilon_{it} \qquad (1)$$

Where the dependent variable is the log-change in the small arms price index in country i in year t. The parameter α is the intercept, while δ_i is a country-specific fixed effect captured by a series of country dummies. By using country-fixed effects, we control for observable and unobservable time-invariant country-specific characteristics, such as the location of a country (i.e., landlocked, porous borders, etc.) that might influence the illicit small arms market of a country. Besides, this approach will place the emphasis of the regression on the identification of the within-country variation over time. The variable $drought_{it}$ is our constructed climate change measure discussed above. The hypothesis tested suggests that γ is expected to be statistically larger than zero. Equation (1) is formulated as an augmented diff-in-diff estimator, where the country-years when a drought has started are the "treated", and those without droughts are the "controls". This expectation is based on the economic laws of supply and demand, which determine the illicit small arms prices in many countries. Since supply is largely guaranteed by porous borders of most arms-importing countries, price changes should primarily reflect changes in demand (Killicoat, 2007). The discussion in the theoretical section implies that the small arms demand increases after a climatic event as the conflict risk rises. Simple economic reasoning suggests that this increase in demand is translated into higher local small arms prices. However, this expectation thrives on a crucial assumption that arms prices are flexible to a certain extent. When arms prices are completely rigid and cannot adjust in the short run, there would be no statistical relationship between these climatic events and small arms prices, making γ insignificant. Moreover, rebel organisations may not react directly to the start of a drought since these events are recognised to have a slow onset, and the complete societal impact is not immediately clear. To capture this rigidity and response lag, we consider the contemporaneous impact of two successive years after the start of a drought.

To estimate the price equation given in equation (1), it is necessary to include a set of k-lagged control variables $\mathbf{x}^k$ to avoid any omitted variable bias. The set used is based on the earlier literature and related to the arms demand motives, supply cost, and regulatory effectiveness (see, for instance, Killicoat, 2007; McDougal et al., 2019). More specifically, the vector includes the real GDP per capita, armed conflict dummy, regional armed conflict dummy, number of terrorist attacks, military spending, democracy dummy, UN arms embargoes target dummy, and institutional quality. All variables are included with a one-year lag to avoid any simultaneous issues. Table 4.A1 in the appendix provides the source and definition of the control variables used. The final parameter ε_{it} is the error term.

The dynamic panel specification provided in equation (1) contains a potential bias owing to the inclusion of the lagged dependent variable that could make the estimation results biased when not controlling for it. As a response, we estimate the model using a bias-corrected fixed effects specification (Bun and Kiviet, 2003). The Least Squares Dummy Variable Corrected (LSDVC) estimation avoids the Nickell bias but assumes strict exogeneity of the explanatory variables. Especially, in this estimation, we can safely assume that this restriction is fulfilled, as small arms prices do not affect the occurrence of climatic droughts.

4.4 Empirical Findings

In Table 4.1, we present our estimation results of the effect of climate change on small arms prices. In view of the unequal distribution of droughts across countries, we cluster the standard errors on the country level and use the bootstrap procedure with 1,000 replicators to obtain robust standard errors. We start first using a global panel including about 160 countries. To make the interpretation easier, we have normalised the coefficients on the drought variable by the average country size in our sample. In columns (1)-(3), we start estimating the main model with and without control variables and including and excluding country-fixed effects. The size effect reported is based on the sum of two consecutive years after the start of the drought, while the significance is based on the joint significance test on this aggregate effect. The results of the pooled model in column (1) indicate a significant positive effect of droughts on small arms prices. However, as demonstrated in columns (2) and (3), including country-fixed effects or control variables makes this positive relationship disappear. Based on this finding, one can argue that a large part of the variation in the small arms price index is explained by country-specific factors. Controlling for these factors reduces the observed variation in the data, especially since the time period of our analysis is relatively short.

However, one drawback of these first results is that it implicitly assumes that the empirical relationship between droughts and small arms prices is the same for all countries considered in the sample. As already mentioned in the theoretical section above, it is highly likely that the impact differs between developing states and other countries. Developing and developed countries differ in their exposure and vulnerability to climate change and their capacity to implement efficient coping policies that limit conflict risk. Thus, climate change is expected to have the most adverse economic and societal impact in low-income countries. Meanwhile, a large part of the arms proliferation in the last decade has taken place in these countries.

To capture this issue in more detail, we create an interaction term between a developing country dummy and the drought variable. The developing country dummy takes the value one when a country is classified as being a developing country in a particular year by the United Nations Development Programme (UNDP). One major advantage of the UNDP classification, compared to, for instance, the definition used by the World Bank or IMF, is that it is not only based on the level of income per head, but also includes other aspects of development such as the social situation. This is of importance as the difference between developing and developed countries goes beyond an economic development gap[4]. For instance, improved access to education will enhance job opportunities and reduce the reliance on agriculture as an economic sector. This will, in turn, reduce the risk of an armed conflict after an adverse natural shock and improve institutional quality (Kamdar and Basak, 2005; Paulsen, 1991; Wezel et al., 2018).

The results presented in column (4) indicate that, although the general effect of droughts remains insignificant, the interaction between the developing country dummy and the drought dummy is statistically significant at common confidence levels. Interpreting this finding, one additional drought increases the local price of SALWs by approximately 2% annually in the two years following the start of a drought. This finding suggests that violent parties in developing countries that suffer from major droughts are likely to increase their arms acquisitions in the following years[5].

However, these results may still suffer from an identification problem as it is possible that droughts already caused a violent conflict before there was an increase in arms purchases. In that case, the outbreak of the conflict might have caused an increase in the arms demand instead of the occurrence of a drought. This argument would make our findings spurious. To explore whether this is the case and if our results are affected by this simultaneity bias, we re-estimate in column (5) of Table 4.1 the main model but exclude all country-year observations when there was a violent conflict ongoing in a time window of two years before and after a particular year[6]. Although the significance slightly drops on the drought indicator, the results still show that droughts create upward pressure on the local small arms prices in LDCs. This strengthens the idea that rebel groups increase their capabilities in the wake of a drought, regardless of whether a conflict is already ongoing or escalating, as arms acquisitions provide a visible signal of deterrence to other parties.

So far, the results do not provide any insight into the underlying mechanism that drives the relationship between climate change and arms demand. Many developing countries are recognised as fragile states. Fragile states have characteristics that substantially impair their economic and social performance, including weak governance, limited administrative capacity, weak state legitimacy, chronic humanitarian crises, persistent social tensions, and often, a legacy of armed conflict. In practice, the term fragile states refers to a broad range of failing, failed, and recovering states that are unable or unwilling to adequately assure the provision of security within their borders, the institutional capacity to provide basic social needs to a significant portion of their populations, and where the political legitimacy of the governments to represent their citizens at home or abroad effectively is in question. As a result of these adverse conditions, fragile countries have a lower adaptive capacity to deal with climate stress and, at the same time, lack the necessary effective bureaucracy to combat illicit arms trade or avoid a violent conflict (Loayza et al., 2012; Fomby et al., 2009; Noy, 2009). For instance, more than two-thirds of the countries in sub-Saharan Africa have experienced civil conflict in the last five decades.

Table 4.1. Droughts and small arms prices – Baseline findings.

	(1)	(2)	(3)	(4)	(5)
Droughts	0.100* (0.061)	0.032 (0.023)	0.029 (0.021)	0.026 (0.037)	0.016 (0.014)
Droughts x LDC dummy				0.020** (0.015)	0.008* (0.004)
Sample	ALL	ALL	ALL	ALL	Excluding conflict years
Estimation method	LSDVC	LSDVC	LSDVC	LSDVC	LSDVC
Control variables	NO	YES	YES	YES	YES
Country-fixed effects	NO	NO	YES	YES	YES
Number of observations	4261	3844	3844	3844	2691

*Note: **/* Indicating significance levels of respectively 5 and 10 percent. Bootstrapped standard errors are shown between brackets.*

To take these issues into account, we include an interaction term between the drought dummy and the annual country-specific score in the Fragile State Index developed by the Fund For Peace. This index is a composite index on the degree of fragility based on four different dimensions: 1) cohesion and internal security, thereby considering the security apparatus, fractionalised elites, and group grievance; 2) economic conditions, including economic decline, unequal economic development, and human capital and brain drain; 3) political conditions referring to state legitimacy, public service, and human rights, and the rule of law and 4) social conditions capturing demographic pressure, refugees and IDPs, and external intervention. For each of these dimensions, a country receives a score of a maximum of thirty points, with higher values indicating more fragility. We classify a country as fragile when it is rated in the top 25% of the overall ranking. The results in columns (1) and (2) of Table 4.2 indicate that, although the general drought effect remains insignificant, the interaction between the fragile country dummy and the drought dummy is statistically significant at common confidence levels. This finding suggests that especially fragile LDC countries that suffer from major droughts increase the small arms price index in the following years.

Moreover, as argued above, droughts might work as a learning mechanism. Rebels might identify the opportunity to gain influence after a drought shock more easily when these shocks occur more frequently. To test this idea, we re-estimate the main model, including only countries that are regularly affected by a drought. We classified a country as being regularly hit by a drought when they have been struck at least five times by a large-scale drought during our period of analysis. The results in column (3) confirm this idea.

Finally, to test for the robustness of the results, we estimate in columns (4)-(5) of Table 4.2 the main models using an alternative estimation technique (OLS-FE). These findings confirm our earlier results and imply that the estimation method applied does not affect our main conclusions. However, one important note is that using the simple OLS estimation technique with fixed effects might yield biased estimators since our model specification poses a dynamic component.

Table 4.2. Droughts and small arms prices – Fragile states and mechanisms.

	(6)	(7)	(8)	(9)	(10)
Droughts	0.013 (0.023)	0.014 (0.012)	0.017* (0.010)	0.017 (0.012)	0.030 (0.045)
Droughts x LDC dummy				0.007* (0.004)	0.027* (0.014)
Droughts x fragile country dummy	0.041** (0.008)	0.023* (0.011)	0.050* (0.005)		
Sample	ALL	Excluding conflict years	Frequently affected countries	ALL	ALL
Estimation method	LSDVC	LSDVC	LSDVC	OLS-FE	OLS-FE
Control variables	YES	YES	YES	NO	YES
Country-fixed effects	YES	YES	YES	YES	YES
Number of observations	3460	2422	1713	3959	3959

*Note: **/* Indicating significance levels of respectively 5 and 10 percent. Bootstrapped standard errors are shown between brackets.*

4.5 Conclusions

This chapter explored whether there is a statistically significant relationship between small arms prices and the occurrence of extreme droughts. The idea underlying this relationship is that climate change potentially increases the demand for small arms as the risk of a violent conflict rises. Based on the findings, one can draw several conclusions. First, there exists a significant positive effect of droughts on the price of small arms in developing countries. Second, this positive effect is mainly explained by weak governance and a higher conflict risk in many of these countries. Finally, droughts create a learning mechanism since the climate change effect is larger in countries that are regularly affected by a drought. Future research could be focused on disentangling in more detail the vulnerability and coping capacity channels underlying the present results.

Appendix

Table 4.A1. Data and sources used.

Variable	Definition	Source
Real GDP per capita	GDP per capita in constant 2010 U.S. dollars taken in logarithms.	World Development Indicators
Armed conflict dummy	Dummy taking the value one when a country is involved in an armed interstate or intrastate conflict, and zero otherwise.	UCDP/PRIO
Regional conflict dummy	Dummy taking the value one when an armed interstate or intrastate conflict is ongoing in the region where the country is located, and zero otherwise. The regions are based on the classification of the World Bank.	UCDP/PRIO
Terroristic attacks	Number of terroristic attacks in a particular country-year.	Global Terrorism Index
Military spending	Military expenditures as a share of GDP.	World Development Indicators
Democracy dummy	Dummy taking the value one when a country is recognised as a democracy in a particular year based on the Polity V, and zero otherwise. The Polity V identifies a country as a full democracy when it receives a score of at least seven on the scale running from +10 democracies to -10 (autocracies).	Polity V
UN arms embargoes dummy	Dummy variable taking one when a country is subject to a United Nations arms embargo, and zero otherwise.	PRIO
Institutional quality	Dummy variable based on the median value of the first-principal component in the indices on voice and accountability, government effectiveness, regulatory quality, rule of law and control of corruption.	Worldwide Governance Indicators

Notes

[1] This conclusion is shared among several literature reviews on this topic (see, for instance, Burke et al., 2015; Buhaug et al., 2014; Buhaug and Nordkvelle, 2014; Hsiang et al., 2014a,b).

[2] For instance, the SPEI is considered to be superior to the Standardized Precipitation Index, which only takes precipitation into account.

[3] When not controlling for the land size, our drought measure may be correlated with the error term in our empirical estimation.

[4] The classification is primarily based on the Human Development Index which is a composite index of three indices measuring countries' achievement in health, education and income per head.

[5] These results are also confirmed using a simple stratified sample split between fragile and non-fragile country-years.

[6] The data on the occurrence of an armed conflict is taken from PRIO.

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