Transmission of Civil War Conflict through Trade Networks

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Abstract

Does the global trade in small arms and light weapons affect the deadliness of civil war conflict? We show how the arms trade network transmits conflict from terminated civil war locations to countries with ongoing civil war, creating a partial conservation of violence. Terminating a civil war reduces battle deaths and demand for weapons in that country. Countries with ongoing civil wars import more weapons at lower prices and experience an increase in battle deaths. Consequently, civil war terminations reduce global violence, but a portion of that violence is conserved and transmitted to civil wars elsewhere. Two implications follow. First, violence in civil wars is sensitive to changes in economic conditions in global markets. Second, the termination of war is itself a source of spillover for civil war.

1 Introduction

Does the global trade in small arms and light weapons (SALW) affect the level of violence in civil war countries? Countries with ongoing civil wars import significant amounts of SALW. Between 1992 and 2013 the sale of small arms and light weapons (SALW) to civil war locations accounted for US$8 billion of US$31.7 billion in total non-US legal global SALW imports.[1] In spite of the fact that nearly all battle-related deaths in modern civil wars are caused by small arms and light weapons,[2] the relationship between the SALW trade and civil conflict remains an open question - the answer to which could provide greater guidance to policy-makers seeking to limit the diffusion of violence.

Our analysis begins with the observation that antagonists in a conflict must procure weapons in order to fight, and they are therefore subject to basic market features that affect any purchase: supply, demand, and price. Changes in a conflict in one place affect global markets, and these market effects influence warfighting in other countries with ongoing civil war. It seems possible, then, that the SALW trade network causes violence to diffuse from one conflict to another.

We analyze two main questions. First, how does the termination of civil wars affect arms imports to other civil war countries? Second, how does the arms trade impact the intensity of civil war, regarded here as deadliness or number of people killed, in the importing countries? There are two broadly held and contradictory intuitions related to this question.[3] On the one hand, more weapons on one side may deter and prevent casualties. On the other hand, more arms may result in more live fire, which leads to more casualties. This claim is supported by theories about commitment problems as a cause of civil conflict (Fearon, 2004; Miguel et al.,

[1]US imports are significantly higher than any other country. We eliminate US imports from this calculation to get a sense of the role of civil wars in the non-US trade. These figures say nothing about black market sales or government-to-government arms transfers.

[2]By Klare's (1999, p.20) count, 80-90 percent of all casualties in recent civil wars have been produced by such weapons.

[3]See, for example, Killicoat (2007).

2004). Changes in warfighting capabilities change actors' valuations of fighting, which may weaken commitments not to fight or not to escalate violence.[4] Therefore, SALW imports may lead to shifts in relative capabilities and, as a result, more casualties.

We find that civil war terminations result in an increase in SALW imports in countries with ongoing civil wars. We also find that increases in SALW imports in countries with ongoing civil wars cause battle deaths to increase. However, the most important part of our finding is conceptual: arms trade markets transmit and partially conserve violence. Terminating a civil war clearly reduces conflict in one part of the world, but that decrease in battle related casualties is partially offset by an increase in battle deaths in other ongoing civil wars due to market effects. When a civil war ends, arms imports to the war-torn area decrease significantly, as do battle deaths, but the reduced demand for weapons there results in more weapons becoming available in the global marketplace at lower prices. Locations with ongoing civil war, where demand for weapons remains relatively high, are able to import more weapons at lower prices producing more battle deaths in these wars. Moreover, the spillover is significantly greater for countries that are in closer proximity on a trade network pathway to the war termination. In other words, the more direct a trade route for SALW between a civil war termination and another civil war country, the more SALW imports and battle deaths in the ongoing civil war.

Our argument proceeds in two steps. First, we develop a simple theory of how civil war terminations influence SALW imports in other countries. We then use SALW import data to show that, in fact, the termination of civil wars leads to an increase in SALW imports in countries where civil war is still ongoing. These imports are sensitive to the network and geographic proximity to the civil war terminations. Second, we analyze the effect of SALW imports on battle deaths in the importing countries. In this step of the analysis, we show

[4]While existing arguments about commitment problems in civil war mostly focus on the effect on war onset and duration, a similar argument can be made for changes in war intensity.

that imports increase battle deaths and this effect is causally identified.

We find that a 1% increase in arms imports produces approximately two additional battle deaths in a year of a given civil war. This is a sizable effect given that the average variation in arms imports to war countries results in a shift in approximately 38 deaths in a year. These new imports alone produce enough yearly battle-related deaths for a conflict to meet the commonly used definition of a civil war.[5] In the average year, terminating civil wars reduces global violence by approximately 4242 battle deaths, but the movement of arms to other conflicts increases violence in ongoing civil wars by 386, conserving 9% of the battle deaths. While the death toll is the most direct measure of the impact of the SALW, there are economic consequences as well. For instance, Colombia and the Philippines were both beset by civil war between 1992 and 2013. Both countries experienced notable growth in GDP per capita in this time, which many studies find leads to a reduction in violence CITES. However, that expected reduction in violence based on the growth of GDP per capita was reduced by the increase in arms imports due to war terminations in other countries.

There are two main implications of our findings. First, violence in civil wars is sensitive to changes in economic conditions in global markets. Ongoing civil conflict can be inflamed by changes in global market prices as well as civil war countries' positions in the SALW trade network. Trade network proximity to other civil war locations causes countries to be in an especially vulnerable position. The more direct the trade route to another civil war country, the greater the intensity of the outbreak of violence when the trade partner terminates its civil war.

Second, the termination of war is itself a source of contagion for civil war. Existing studies have identified several factors that account for the diffusion of violence across borders into

[5] For a conflict to be admitted as a civil war in the UCDP/PRIO Armed Conflict Dataset, v4 (Gleditsch et al., 2002), there must be at least 25 battle related deaths in a calendar year. We use UCDP data for all conflict-related measures throughout our analysis.

contiguous states,[6] but, in much of the literature, it is the onset or escalation of violence in a civil war that triggers spillover. Existing studies show that *both* civil war onset leads to the diffusion of civil war violence. Our analysis is the first to show that additionally, civil war termination also leads to the diffusion of civil war violence.

While the idea that violence can diffuse from place to another is not new, existing studies on the diffusion of intra-state conflict focus primarily on spillover within states (Lane, 2016) or in immediate civil war neighborhoods (Beardsley, 2011). A main takeaway of the contagion literature is that spillover effects dissipate over geographic distances. Our findings support this result, but we also demonstrate that spillover travels through trade network pathways in addition to geographic pathways. In fact, trade network pathways may be more important, at least when the cause of spillover is civil war termination. Consequently, violence might be spread to geographically distant locations that are nevertheless closely connected in a trade network. Because there are multiple pathways through which violence might be transmitted, different civil war shocks, including both war onset and termination, might trigger spillover.

Our research also contributes to the growing literature that seeks to understand what makes civil conflict more or less deadly. Studies on this subject have identified many political factors, including the relative balance of power, pre-war political institutions (Benson), democracy, political instability (Gleditsch Hegre Strand), and ethnic divisions (Eck). A growing literature has focused on the economic factors that may affect civil war severity. Lu and Thies (2011) show that economic grievances that arise from pre-war inequality lead to more deadly civil wars for combatants. In other research on economic factors in civil war, Lujala (2009) demonstrates that geographic overlap of various natural resources with conflict zones—specifically, factors such as gem production, drug cultivation, and hydrocarbon production—can impact the severity of conflict. Buhaug, Gates and Lujala (2009) show

[6]These factors include state capacity and refugee flows (Braithwaite, 2010; Salehyan and Gleditsch, 2006), ethnic and religious ties (Metternich, Minhas and Ward, 2015; Buhaug and Gleditsch, 2008; Fox, 2004), and ties to separatist movements (Buhaug and Gleditsch, 2008).

similar effects of geography, resources, and rebel capacity on civil war duration. Our research focuses on how shocks to the international market for SALW and the trade networks in place can impact the severity of violence in civil war.

Closely related work by David Kinsella on the global trade in major weapons systems and small arms addresses some issues similar to our own. While focusing on different political outcomes than the severity of violence, Kinsella (2012) studies the impact of the global arms trade on militarization and the onset of violence in developing countries. Kinsella also draws on insights from network theory. Kinsella (2014) applies the basic tools of network analysis to the illicit arms trade and shows the prominent role of former Soviet bloc countries in supplying Africa with arms in the post-Cold War period. Similarly Kinsella (2006) studies the network connections in the black market for small arms and provides an empirical foundation for the importance of network connections in the small arms trade.

Perhaps closest to our work is research focused on the links between globalization and civil war severity. Olzak (2011) shows how different components of globalization affect the death toll of internal armed conflicts. Distinguishing between ethnic and non-ethnic based civil wars, Olzak (2011) finds that there is a robust relationship between economic and cultural globalization and violence in ethnic civil wars, while social and political globalization decrease the severity of non-ethnically based civil conflicts. Relatedly, Suzuki (2007) studies the effect of major arms imports on African civil wars, with a focus on onset rather than severity, finding that an increase in imports leads to an increase in the likelihood that a civil war will break out. Ours is the first cross-national study of the impact of the trade in primary instruments of violence in civil war on the war's severity.

2 The Market for Arms

The SALW trade does not look like the normal trade in goods and services. If we measure the density of a network by the fraction of actual connections divided by the total number of possible connections, then we can compare the trade in goods and services to the small arms trade. We find that global trade's proportion of realized links between countries is about half of all possible links. By contrast, the fraction of total possible connections in the small arms trade is 0.047, implying that less than five percent of all possible trading links are active in any given year. This means that these weapons of war flow through relatively few trade routes, even though the arms trade consists of many active buyers and sellers.

How does the low density of the small arms trade network affect the impact of economic shocks on the small arms market? We argue that economic shocks travel through linked paths between states, and the impact of these shocks are felt more intensely by geographic neighbors as well as neighbors in the trade network.

While the effect of *geographic distance* on the magnitude of changes in trade between countries is intuitive and consistent with well known theories such as the gravity model, it is useful to develop a simple model of how *network distances* affect sales in the arms market. Our model begins by taking a network of buyers and sellers, like those in Figure 1, as given. We do this because the arms trade network is shaped by non-market variables including colonial legacy, cold war and contemporary alliances, and personal leadership ties. As a result, the market's structure is rigid in the short run. We can think of sellers in our models as arms dealers or countries supplying weapons, and buyers as the groups demanding arms in a given civil conflict.

In this model of a small arms trade network, there are three buyers and two sellers. Importantly, not every buyer and seller are linked. We assume that buyers in this market can buy from connected sellers and sellers can sell to connected buyers, but buyers and sellers

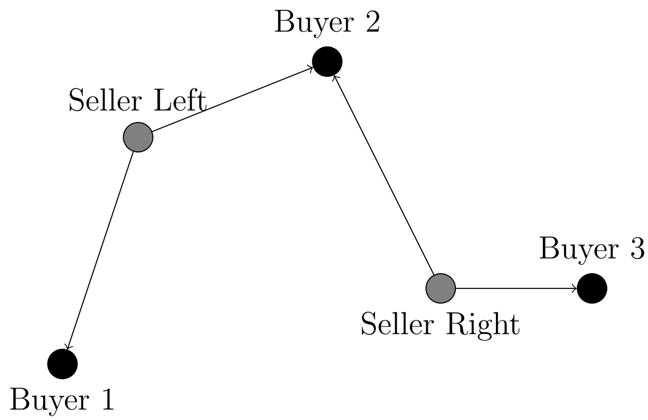


Figure 1: Arms trade network with three buyers and two sellers

cannot form new links. Our model has two different kinds of market structures. Buyers 1 and 3 face single suppliers, and here the sellers have a captured monopoly. Buyer 2 has two potential suppliers. Here there is market competition between Seller Left and Seller Right. We also assume that the sellers simultaneously choose quantities to sell to each buyer to whom they are linked. We analyze a simple symmetric game and assume all buyers and all sellers are fundamentally the same. We focus on the Nash equilibrium of this game of market competition in quantities.

To keep things simple, we start with the buyers of arms and assume that each group i's inverse demand, i.e., the unit price they are willing to pay for a given quantity of small arms q, is

$$P(q_i) = \alpha - \beta q_i. \tag{1}$$

For the sellers, their profits are determined by the quantity sold times the price (which is a function of the quantity), and they pay an increasing marginal cost of making and

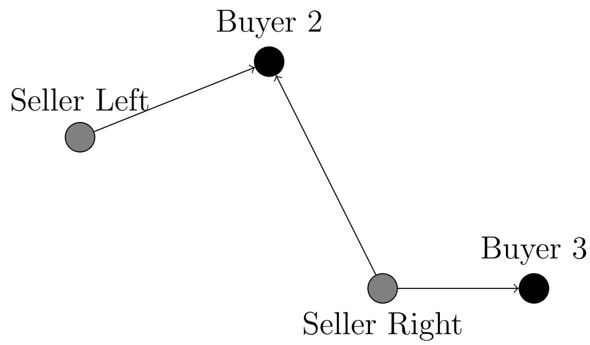


Figure 2: Arms trade network with two buyers and two sellers

transporting the small arms. The sellers' profit functions are

$$\Pi_L(q_1, q_{2L}, q_{2R}, c) = P(q_1)q_1 + P(q_{2L} + q_{2R})q_{2L} - c(q_1 + q_{2L})^2, \tag{2}$$

$$\Pi_R(q_{2L}, q_{2R}, q_3, c) = P(q_{2L} + q_{2R})q_{2R} + P(q_3)q_3 - c(q_{2R} + q_3)^2. \tag{3}$$

The sellers face symmetric equilibrium strategies in this arms trade network: both sellers act as monopolists in the markets for which they are the only sellers and compete by offering an equal quantity of arms to the buyer serviced by both sellers, resulting in a lower price and higher quantity of arms in the market with two sellers. This result is presented formally in the Appendix as Lemma 1.

Next, suppose that Buyer 1's civil war ends. As a result, its demand for arms drops to zero. How does this change the market for arms in the remaining civil wars? Now the two sellers are in a new network, depicted in Figure 2, where the Left Seller's only potential buyer is Buyer 2, who is connected to both sellers. The Right Seller, meanwhile, is still able to sell to Buyer 2 and maintains its monopoly with Buyer 3.

This change in demand and market structure results in a new set of equilibrium quantities, presented in Lemma 2 in the Appendix. In this new environment the Left Seller sells a higher quantity of small arms to Buyer 2 than it did previously, and as a result, the Right Seller reallocates its supplies by decreasing its sales to Buyer 2 and increasing the quantity offered to Buyer 3. In equilibrium we have the following result:

Proposition 1. *The quantities purchased by Buyer 2 and Buyer 3 increase when Buyer 1's demand drops to zero and the quantity purchased by Buyer 2 increases more than quantity purchased by Buyer 3 increases.*[7]

The global consequence of the termination of the civil war in country 1 is a decrease in global arms sales, but an increase in arms imported by the two remaining civil war countries. The first effect results from the seller, who lost a market, increasing the quantity offered in the market with competition. The second effect follows from the reallocation of supplies by the competitor in the jointly supplied market away from competition and toward its monopoly. Such a reallocation is going to occur in any situation in which there is a demand shift in one market because it pushes the seller's decision on how much to sell out of equilibrium. The seller then must re-evaluate the quantities it is offering. The changes will lead to cascading effects along network pathways to sellers who operate in other markets. Each seller will adjust by less than the last, dissipating the effect of the demand shock the further removed buyers are in the network from the original shift in demand.

This effect is not merely the consequence of Buyer 2 participating in a competitive market and Buyer 3 facing a single supplier. It is true that market competition, in general, can affect the size of the change faced by a buyer, but network distance also matters. In fact, one can show that in a model where Left Seller had two isolated buyers instead of one and then faced competition supplying Buyer 2, the same result would hold. If Buyer 1 decreased its demand, the two buyers connected directly to Left Seller would have larger increases in their equilibrium quantities than the buyer who feels the indirect demand shock, mediated by the

[7]This qualitative fact can be generalized to models with convex costs of production and more than two markets. It is also true that if the linking buyer terminates, then each seller sells a higher quantity of guns to their monopoly markets. It is easy to show that the monopoly quantities are $\alpha/2(c+\beta) > 3\alpha/2(5c+3\beta)$.

equilibrium response of her own supplier. It is also not important that Buyer 1 is on the “edge” of the network. If the ”middle” buyer, Buyer 2, decreases its demand, it still affects the markets connected to both sellers Left and Right. In a model with more players, the effect would travel through market connections, driven by the changes in best response of connected sellers.

To summarize, we can think about the market for small arms as a network of buyers and sellers in which not all buyers are linked to all sellers. In such a situation, our model shows that changes in the demand of a buyer (Buyer 1 in our model) has a cascading effect through the network. The biggest effect is on the allocation of the seller who supplied Buyer 1. In our model, the seller increases the quantity it sells to Buyer 2, by lowering the price. The effect of the change then continues to spread as the other seller, who also supplies Buyer 2, changes its quantity allocation, moving some arms away from Buyer 2 and toward Buyer 3. Note that for the demand shock to have an effect outside the seller’s immediate clients, the seller must be competing with others to sell to at least one buyer.

After this reallocation occurs, although the total number of guns sold globally goes down, the quantities sold to both active buyers goes *up*. Furthermore, those buyers who are directly linked to the seller, which is the first step in this network, increase their purchased quantity more than those buyers who are further away on the network pathway. These more distant buyers buy more than they did before the demand shock but less than the closer buyers, because the quantity supplied to them is affected by the reallocation of sales by sellers who supply to the initial buyer. In this way, the network structure is critical: sellers face competition, but not perfect competition (not all buyers are connected to all sellers). This means the effect of a demand shock is felt throughout the trade network, but that effect is not identical across buyers and sellers.

With this in mind, our empirical analysis of the effects of the small arms trade proceeds in two steps. First we use data on network distance and geographic distance to construct variables that measure the demand shocks in the small arms markets that result from civil war terminations. This analysis examines the intuition from our model that demand shocks from civil war terminations result in increases in arms purchases in ongoing civil wars and the magnitude of this effect dissipates the greater the network distance between an ongoing civil war and the original country with the terminated civil war. In addition, we also evaluate the well-established result in economics from the gravity model of trade in economics that trade effects dissipate over geographic distances.

We then use the shocks from external civil war terminations as an instrument for the quantity of small arms imports to ongoing civil wars. This analysis gives us a causal estimate of the size of the effect of arms imports on battle deaths. Together, the two findings show that the market for small arms creates a force for conserving violence in the wake of war termination by affecting the import of weapons in ongoing conflicts.

3 Data

We construct a dataset of civil wars, battle deaths, and legal interstate SALW imports from 1992–2013. The data is structured as a civil war panel that describes factors related to ongoing civil wars including weighted geographic and network distances to external civil war termination countries, arms flows to battle locations in ongoing civil wars, and levels of violence for each year in the duration of a civil war. The unit of analysis is a conflict-year, so an observation is a year within a unique, ongoing civil war. We include all civil wars from 1992–2013 taken from the UCDP/PRIO Armed Conflict Dataset, v4 (Gleditsch et al., 2002). The threshold for a conflict to qualify as a civil war is 25 battle deaths. If a war began prior to 1992 but was ongoing between 1992-2013, then we include the relevant years in the dataset. The years between 1992-2013 of civil wars that had not terminated by the end of 2013 are also included in the data.

In compiling the dataset, we include internationalized and non-internationalized intrastate wars because some conflicts change from non-internationalized to internationalized or vice versa, but in robustness checks we include a variable for war years in which conflicts are internationalized so that we can control for external intervention in the analysis.[8] Our dataset includes a total of 114 ongoing civil wars between 1992-2013 and a total of 899 total civil war years across these ongoing civil wars.

Table 1: Descriptive Statistics of Weighted Distance, SALW Imports, and Battle Deaths Variables.

	N	Mean	Standard Deviation	Min	Max
Geographic Closeness	899	0.001	0.003	0	0.060
Network Closeness	899	1.427	1.150	0	6.500
SALW Imports (million US$)	899	874	24.4	0	459
Battle Deaths	898	774.254	1839.153	25	30633.000

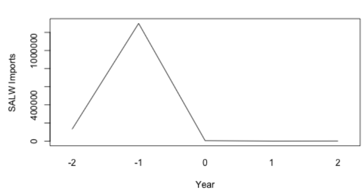
We generate four sets of variables for all parts of our analysis. First, we create measures of geographic distance and network distance between termination countries and locations with ongoing civil war. These distance measures will serve as independent variables in the regression that tests the theoretical prediction that network and geographic distances from civil war terminations will lead to increases in arms imports in civil war locations. These variables will also be included as instruments in the two-stage estimation that causally estimates the effect of arms imports on civil war intensity. Second, we include measures of imports of SALW to civil war locations. Third, we include a variable for our outcome of interest, which is civil war intensity. A summary description of these first three sets of variables are included in Table 1. Fourth, we include in our analysis a set of controls both to account for other observable factors that are known to affect conflict intensity and to test potential violations of the exclusion restriction for the instrumental variables analysis.

[8] We do not want to exclude war years based on this distinction and then inadvertently miscode transitions across types of conflict as the beginning or end of episodes of conflict.

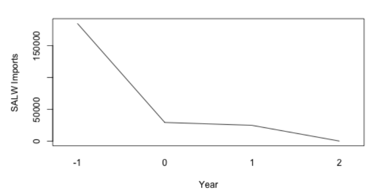
Our first set of variables includes geographic and network distance measures to account for the trade shocks of civil war terminations. Trade shocks are not the same for every importing country. Although the decrease in arms imports in the terminating country is a unique event, the trade shock from the termination varies across countries elsewhere that are experiencing ongoing civil war. Civil war countries experience the shock differently depending on geographic and network proximity to the war termination. Geographic distance is the number of miles between an importing country and a country with a terminated civil war, and network distance is the number of arms trading countries between the same two countries on the shortest trade network pathway. Trade becomes more costly to transport goods over long geographic distances and between countries that trade only indirectly through one or more other trade partners.

Our argument focuses on market dynamics as mechanisms for signaling price shifts to arms importers, specifically that war termination causes a demand shock: when wars terminate, these countries no longer import as many weapons, and supplies of weapons previously used in the civil war become available for trade in the arms network. This assumption is borne out in the data. Figure 3 shows the logged value of SALW imports for a variety of countries that recently experienced a civil war. The graphs are centered on the year that the civil war ended. For all cases, imports to locations with civil war terminations drop the year of a war termination. For nearly all the cases of terminated wars, small arms imports remain dramatically lower following war termination. For two countries, Guinea and Serbia, imports rose for one year before dropping permanently. In only one case, Ethiopia, do we see arms imports increasing starting one year after the war termination.

An illustration is helpful. In 2008, the Sri Lankan government withdrew from a ceasefire with the LTTE, reigniting the country's civil war. That year, small arms and light weapons imports were US$5.9 million. In 2009, the LTTE conceded defeat, and Sri Lanka's small arms imports dropped to approximately $476,000. In the termination year, the imports were



(a) Cambodia



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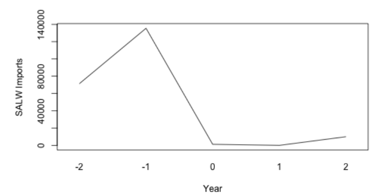
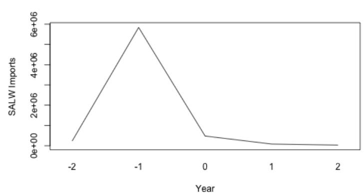
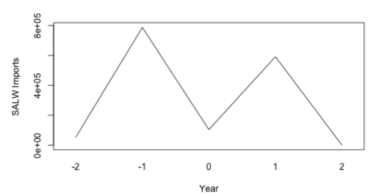


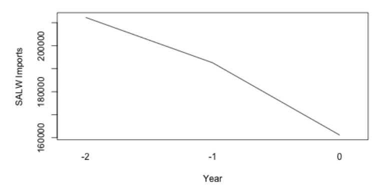
(c) Congo



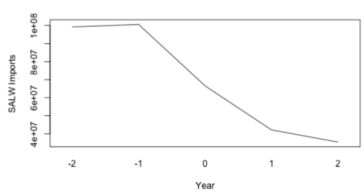
(d) Sri Lanka



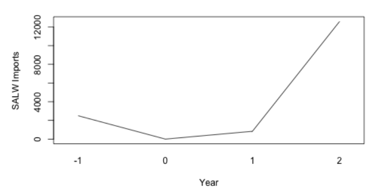
(e) Guinea



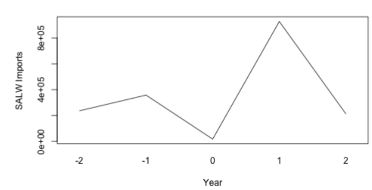
(f) Tajikistan



(g) United Kingdom



(h) Ethiopia



(i) Serbia

Figure 3: Time series of arms imports centered at war termination

less than one-tenth the level the year before. A number of other countries were also involved in ongoing civil wars in 2009, including India, the Philippines, and Columbia. We might expect that the dramatic decrease in arms imports to Sri Lanka might impact the market for arms in these countries. However, Colombia is more than 10,000 miles away from Sri Lanka while India is a neighbor. We might reasonably conclude, as conventionally modeled in the gravity model of trade(Tinberger, 1962), that import shocks are diminishing with geographic distance.[9] However, this is not to say that Colombia won't be impacted at all. In fact, there is evidence of weapons from various civil wars, including the Balkan War, showing up in conflicts around the world. Thus local changes in demand can have far reaching effects.

We generate two variables that measure geographic and network distance. For every ongoing civil war conflict-year, we measure the geographic and network distances from the primary civil war country to each country with a civil war termination in the same year. For ease of analysis, we take the multiplicative inverse of these distances to give measures of closeness. Because there is typically more than one civil war termination in a given year, we sum the closeness measures to give one variable each for geographic and network distances.

The first variable, GEOGRAPHIC CLOSENESS, is constructed from distance data from the C-shape database (Weidmann, Kuse and Gleditsch, 2010), which measures the distance between capital cities of countries through 2011.[10] We measured the capital-to-capital distance from every primary civil war country to the location of each country in which there was a civil war termination. For each country with an ongoing civil war, we add up its distance to each country with a civil war termination, and then take one over this sum as our variable. This generates a "weighted" trade shock of civil war terminations to each ongoing civil war. The measure gives greater weight to nearby terminations, as regional markets are known

[9]Bourne (2007) discusses the spillover of arms to proximate countries.

[10]Since these distances tend to be unchanging within conflict panels, we extrapolate the distance values through 2013 based on 2011 distances to fill missing values.

to be important in the small arms trade (Bourne, 2012). [11] As seen in Table 2, the mean geographic closeness is 0.001 with a standard deviation of 0.003.

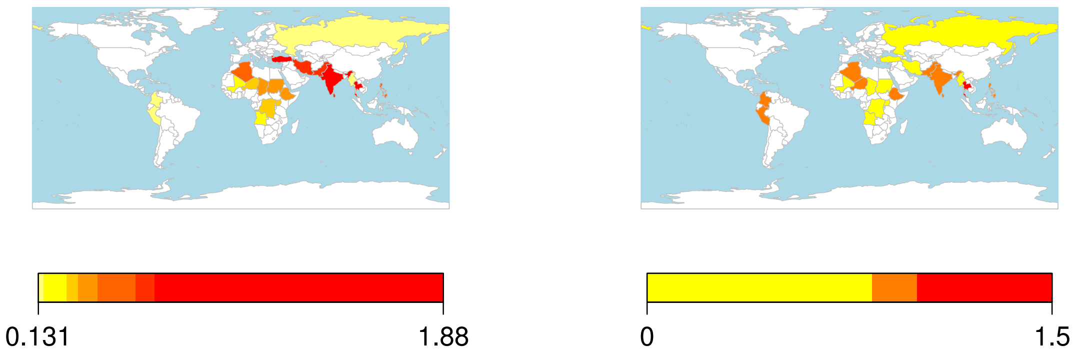
For the second distance variable, Network Closeness, we repeat the process above using non-directed geodesic distance between trading dyads in the SALW trade network in 1992 rather than geographic distance. Another way to think of the network distance is to consider how many trade partners exist between countries on the trade pathway of shortest distance. If country A imports directly from country B, then the network distance is 1. If country A does not import directly from country B but imports from country C, which imports directly from country B, then the network distance between countries A and B is 2. To create a measure of closeness, we calculate the network distance between every pair of primary conflict countries with a civil war using trade data from 1992. Then for each conflict-year, we take the sums of the distance between the country with an ongoing civil war and each war termination. Finally, we take the inverse. Table 2 shows that the mean network closeness is 1.427 and standard deviation is 1.150.

We limit ourselves to the network connections in 1992, which is the first year of our data, to limit the effect that changing conflict patterns may have on network connections year to year. Because there is significant persistence in the small arms trade network over our time period, due to non-market variables, this provides a good measure of network closeness.[12] Ultimately, the usefulness of this measure is determined by the results, which are strong in the analysis. In our robustness checks we also consider the implications for our analysis if the network shocks have a direct effect on battle deaths.

The measures of network and geographic closeness produce different distributions of

[11] Accounting for the increased costs of transporting goods across distances is standard method for predicting trade flows between countries. See Tinberger (1962) for the earliest use of the gravity model of trade.

[12] We also include conflict fixed effects in each estimate to help control for any other factors that might be associated with network structure and conflict intensity. We also do a number of robustness checks to increase our confidence that this measure is really capturing the economic shock and not other network effects.



(a) Heat map of 2007 distance treatment

(b) Heat map of 2007 network treatment

Figure 4: Termination Treatments

shocks. The two variables are weakly correlated at 0.12. Many countries that are geographically close do not trade directly with one another (trading instead through one or more other countries), and some countries that trade directly with each other are geographically distant. To see this, consider the heat maps in Figure 4. The panel on the left shows the distribution of the Geographic Closeness variable and the panel on the right shows the distribution for Network Closeness in 2007. All primary civil war locations in 2007 are shaded; unshaded countries were not involved in civil war during that year. Countries that are in closer proximity to countries with a civil war termination in 2007 are shaded darker and become lighter the farther from the termination country. We chose the year 2007 for this illustration because there are only two civil war terminations in this year, one in Myanmar and one in Russia. Having fewer terminations makes it easier to see how the two measures of closeness vary.

The contrast between the geographic and network closeness measures illustrates that these two measures are capturing two different aspects of economic proximity. Trading over geographic distances increases trade costs, but the trade pathway may be shorter or longer depending on the number of trade partners along the way. Notice that in the left panel that depicts Geographic Closeness, the civil war countries located geographically closer to Myanmar and Russia are shaded dark and then become lighter the farther away those countries get. India and Iran, for example, were experiencing civil wars in 2007 and both are geographically close to both Russia and Myanmar. As a result, both are shaded dark compared to Peru, which also experienced a civil war in 2007 but is relatively far from both termination countries.[13] By contrast, as can be seen in the right hand panel showing Network Closeness, Peru is shaded darker than Iran and about the same as India, indicating that it is on a more direct trade pathway to the terminating countries, even though it is geographically distant.

The next main variable is arms imports. This is a measure of legally traded small arms and light weapons imported to countries with ongoing civil war. These data are taken from the United Nations Comtrade data agglomerated by the Norwegian Initiative on Small Arms Transfers (NISAT), and the variable we use is the conventional measure used for SALW (Marsh, 2013). As is standard, we include imports of SALW only and exclude larger conventional weaponry and heavy artillery. Reliable data of small arms and light weapons are available from 1992-2013. The value of arms imports is reported in US dollars and adjusted for inflation in 2013 dollar values. The average value of arms imports to a civil war country in a given conflict-year is $8,743,298. On average, yearly arms imports trend slightly upward over the course of a civil war, but otherwise there is a great deal of variation in arms imports within and across civil wars.

A complication with the data is the fact that some civil wars spill across borders, resulting in battles in multiple countries that all potentially import small arms for one civil war. To

[13] The countries with civil war terminations are also shaded but are noticeably lighter than proximal countries with ongoing civil war. This is because it is considered a civil war country in 2007 but it does not have a value for distance to itself.

create a measure of the total value of legal arms imported to a civil war in a given year, we first identified all of the countries indicated by the UCDP/Conflict data as serving as battle locations for an intrastate war in a given year. We then summed the reported yearly value of small arms imports to each of these country locations to give the annual value of arms imports to a civil war.

Another challenge with our arms data is that it accounts only for legal trade. It does not include data on illicit arms or legal arms that were not reported by customs. We choose not to include illicit arms trade data because there is not yet a reliable source for this information. There are some additional limitations to the observed trade data. Customs data relies on self-reporting by exporters and importers, so the reliability of the value of the arms in the data depends on the accuracy of these reports. Additionally, these reports only document the transfer of shipments across borders. Consequently, it is not known what percentage of reported imports flow to the various antagonists within a conflict (government or rebel groups) or that get routed illegally to end destinations outside the country.

These are all known limitations of the data. Nevertheless, these data are currently the best description of the arms trade available, and there is reason to be confident that they provide a fairly accurate approximation of the arms trade in spite of the known limitations. According to the *Small Arms Survey 2012*, the known small arms trade is worth approximately US$8.5 billion annually, nearly all of which is accounted for by legal Comtrade data (Grzybowski, Marsh and Schroeder, 2012). The best estimates project that the unknown trade may add as much as US$1.5 billion to that amount. Thus, it is believed that the reported legal small arms imports in our data account for a significant percentage of the global arms trade. Because our first stage analysis estimates effects with incomplete arms data, we expect that our first stage findings underestimate the overall effect of trade shocks on arms imports.

Our final main variable is BATTLE DEATHS, which is the measure we use to proxy for civil war severity. While there are many ways one might measure severity, using battle related casualties makes our work comparable to other results in the literature (Lu and Thies, 2011; Olzak, 2011; Lacina, Gleditsch and Russett, 2006). For this measure, we use the number of battle-deaths recorded annually in a civil war according to best estimates from the UCDP Battle-Related Deaths Dataset v.5 (Lacina and Gleditsch, 2005). Between 1992 and 2013 the average number of battle deaths in a conflict-year was 707 and the median was 180. Battle deaths vary a great deal both across different wars and across time within wars. As seen in Table 2, the mean battle deaths in a conflict-year is 774.25 with a standard deviation of 1839.15. The highest number of battle deaths that occurred in a single conflict year is 30,633. Because we are interested in the effect on the increase in the number of battle deaths, we use the unlogged value of battle deaths. However, because there is skew in the distribution, we also estimate our models using logged battle deaths. Those results are not reported, but the effects hold in the baseline models.

On average, battle deaths tend to decrease over the life of a civil war. Some wars, however, are marked by an intense outbreak of battle deaths at the beginning and then the severity gradually levels off over the duration of the war. In other wars, battle deaths spike at the end or fluctuate throughout the duration of the conflict. Because there appears to be some subtle time trends with respect to both ARMS IMPORTS and BATTLE DEATHS, we include year fixed effects.

We also include data on several additional conflict- and country-level variables in our empirical models that may be associated with violence in civil wars. These variables measure income, regime type, development aid, and total bilateral trade of all goods and services for the primary civil war government. Additionally, we include variables indicating whether an ongoing civil war experiences intervention from a foreign country or the presence of foreign fighters in a given year. Our variable for income is logged GDP PER CAPITA, which we take from Penn Tables GDP data, v8.1 (Feenstra, Inklaar and Timmer, 2015). This variable is available through 2011. For regime type for the primary government of an ongoing civil war, we use the POLITY variable, available through 2013, from the Polity IV data project, v2014 (Marshall and Jaggers, 2001). POLITY measures regime authority on a 21-point scale ranging from -10 (hereditary monarchy) to +10 (consolidated democracy). For our FOREIGN AID variable, we include the logged amount of foreign development aid received by a country as reported by the AidData project, v3.0 (Tierney et al., 2011). These data run through 2011. The aid values are in constant 2009 US$. We also include a variable for TOTAL TRADE, which is total imports and exports for each country involved in a civil war. The data, provided by Barbieri and Keshk (2012), v3.0, runs through 2009. We include a dummy variable, INTERNATIONALIZED, to indicate whether foreign countries intervened in a civil war in a given year from the UCDP/PRIO Armed Conflict Dataset, v4 (Gleditsch et al., 2002). If a foreign country intervenes, then the variable is coded 1. Finally, we include the dummy variable FOREIGN FIGHTERS, which is coded as 1 if foreign fighters are present in a conflict-year. This data is taken from Malet's Foreign Fighter Project (Malet, 2013).

4 Empirical Model

In the first part of the analysis we verify that shocks from civil war terminations are related empirically to arms imports in civil war locations elsewhere. Our theoretical expectation is that war terminations increase arms imports to other civil war locations but that this effect is stronger for civil war locations that are in closer geographic and network proximity to the country of the civil war termination. The linear regression that we use to estimate this relationship is

$$\textsc{log}\ (\textsc{arms imports})_{it} = \mu + \theta_1 G_{it} + \theta_2 N_{it} + \delta X_{it} + \eta_{it}.$$

ARMS IMPORTS$_{it}$ is the log of the dollar value of small arms and light weapons imports for conflict i in year t; G_{it} is GEOGRAPHIC CLOSENESS; N_{it} is the NETWORK CLOSENESS; X_{it} is a vector of control variables, including both conflict and year fixed effects in some iterations; and η_{it} is conflict-year specific error term.

In the second part of the analysis, we test the causal effect of arms imports to civil war locations on the intensity of violence in those conflicts, as measured by in combat casualties. We estimate a two-stage GMM regression and use shocks from external civil war terminations weighted by geographic and network distances to those civil war terminations as instruments for arms imports. We estimate the following two-stage model:

$$\text{LOG (ARMS IMPORTS)}_{it} = \mu + \theta_1 G_{it} + \theta_2 N_{it} + \delta X_{it} + \eta_{it}.$$

$$\text{BATTLE DEATHS}_{it} = \alpha + \beta \text{ LOG (ARMS IMPORTS)}_{it} + \gamma X_{it} + \epsilon_{it}.$$

Here, X_{it} is a series of controls including conflict fixed effects, and ϵ_{it} is a conflict-year specific error term.

A condition of the instrumental variables approach is the exclusion restriction. To satisfy the exclusion restriction, we need

$$cov(G, N, \epsilon_{it}|X_{it}) = 0.$$

Conditional on the controls, the covariance between the instruments and the error term in the second stage needs to be zero. That is, for the purposes of our analysis, terminations of civil war, as weighted by GEOGRAPHIC CLOSENESS and NETWORK CLOSENESS, must have no effect on the outcome of interest, BATTLE DEATHS, except through the arms trade. We consider six possible violations of the exclusion restriction. To address these potential violations of the exclusion restriction, we conduct various robustness checks.

First, because the distribution of aid affects civil wars, it is a potential confounder of both the instrument, which is a measure that includes civil war terminations, and the dependent variable of the second stage, which is battle deaths. In a robustness check, we control for foreign aid. Second, trade in goods and services other than SALW may pose an exclusion violation. Civil war terminations may affect that country's engagement in international trade in goods and services that may alter or improve trade pathways to other countries including countries with ongoing civil war. That is, the instrument may have a direct effect on battle deaths via another route, which is trade to the country with ongoing civil war. Exclusion violations due to the direct effect of the instrument on the dependent variable are difficult to rule out empirically. However, this exclusion violation is not very plausible. Indeed, a direct test of the effect of the instrument on trade volume to the country with ongoing civil war shows no significant effect (this result is not reported here). Given that there is no empirical effect of the instrument on trade, then there is little evidence of an exclusion violation. Nevertheless, in practice it is safest to control for trade in a robustness check.

Third, the existence of third-party support in an ongoing civil war might impact both civil war termination elsewhere and battle deaths. As in the case of foreign aid, third-party intervention in this story is a confounder of both the instrument and dependent variable. To rule out this potential exclusion violation, we control for internationalized civil wars. Fourth, terminations of civil war may make foreign fighters available to participate in ongoing conflicts elsewhere. Again, this is a potential direct exclusion violation. As in the case of trade, we find no direct effect of the instrument on foreign fighters in the ongoing civil war country. Nevertheless, we control for foreign fighters in a robustness check. Fifth, geographic contiguity is a well-known determinant of war onset and civil war spillover. It may be a confounder for both civil war termination and civil war intensity. To test this potential exclusion violation, we eliminate all countries in ongoing conflicts that are contiguous (distance $<$ 100 miles) to a civil war termination and reestimate the baseline model.

Finally, if we think civil war terminations may transmit violence via trade networks to other civil war locations, then there may be feedback from ongoing civil war locations if imports increase the likelihood that those wars terminate. In this case, the instrument may be directly related to the dependent variable via a reverse causality pathway. Exclusion here is only violated if imports in fact lead to war termination, but we find that they don't (results not reported here).

5 Results

In this section, we first inspect the linear regression of geographic and network distances on arms imports to test the predictions from our theory about the impact of war termination shocks on trade behavior. Second, we examine the results from the two-stage model to determine whether arms imports affect battle deaths, and, more broadly, to assess whether there is an empirical case for inferring that violence may be transmitted between civil war locations through trade network pathways.

5.1 Effect of War Termination on the Arms Trade

Table 2 presents the results from the analysis of the effect of civil war terminations on the arms trade. The model is the simplest specification, a linear regression of geographic closeness and network closeness on SALW imports. We estimate models with both conflict and year fixed effects as indicated in the Table. Column 1 is the bivariate regression including only GEOGRAPHIC CLOSENESS. Column 2 includes only NETWORK CLOSENESS, and Column 3 includes both closeness measures. Columns 4 and 5 include year fixed effects, and Column 5 includes a set of control variables. These tests all indicate a statistically significant effect of both geographic and network distance on arms imports.[14]

[14] These results hold for lagged values of GEOGRAPHIC CLOSENESS and NETWORK CLOSENESS.

Table 2: Effect of Geographic and Network Closeness to War Terminations on Small Arms Imports to Civil War Locations

	(1)	(2)	(3)	(4)	(5)
Geographic	66.29**		53.87***	61.13***	58.82***
Closeness	(23.05)		(14.11)	(15.21)	(13.70)
Network		0.473***	0.455***	1.254***	1.092***
Closeness		(0.104)	(0.103)	(0.243)	(0.302)
GDP per cap					-0.337
(logged)					(0.829)
Polity					-0.099*
					(0.048)
Foreign Aid					0.090
(logged)					(0.095)
Total Trade					0.844
(logged)					(0.605)
N	663	663	663	663	458
Conflict FE	Y	Y	Y	Y	Y
Year FE	N	N	N	Y	Y

Standard errors in parentheses

Conflict and Year FE where indicated, Robust SE

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In our data the average GEOGRAPHIC CLOSENESS is 0.0012 and has a standard deviation of 0.0025. To get a sense of the substantive effect of GEOGRAPHIC CLOSENESS, a one standard deviation change in a country's termination score results in a 15.28% change in small arms imports. The average NETWORK CLOSENESS is 1.416 and standard deviation is 1.152. A one standard deviation change in a country's network closeness results in a 164.81% change in small arms imports.

These results indicate that, as expected, there is empirical evidence that civil war terminations result in an increase in arms imports to locations with ongoing civil war. Further, the impact of the shock is felt more intensely the closer the importing country is to the termination location, both geographically and along the network pathway. Moreover, the network pathway has the greatest effect among all the variables in our regression models. We see that the data is consistent with our theoretical claim that economic shocks from civil war terminations are transmitted to other conflict locations and the effect of these shocks on trade dissipates over geographic and network distances.

5.2 Effect of Arms Imports on Battle Deaths

We now examine the results from the two-stage estimation of the effect of arms imports on battle deaths. Table 3 presents the second-stage results for several models with conflict and year fixed effects as indicated in the Table. In Column 1 we present the simple OLS regression with no instrument of BATTLE DEATHS on ARMS IMPORTS. Here we see a rather small and insignificant effect of arm imports on the number of battle deaths. Specifically, the estimate shows that a one-percent increase in small arms and light weapons imports accounts for an additional 0.3 battle deaths in a given year. But the result is not statistically significant.

The results of the causally identified models (models 2-8) are more in line with our expectations. In Columns 2 and 3, we run a model specification with only GEOGRAPHIC

Table 3: Effect of Imports on Battle Deaths, 2-Stage GMM, Second Stage Results

	(1) OLS	(2) Geographic Closeness Only	(3) Geographic Closeness Year FE	(4) Network Closeness Only	(5) Network Closeness Year FE	(6) Both Closeness Measures	(7) Both Closeness Year FE	(8) Both Closeness Measures
Arms Imports (logged)	31.78 (20.81)	274.4** (84.65)	284.1** (98.59)	175.5+ (101.51)	43.96 (122.3)	227.2** (79.50)	144.9 (95.53)	216.5* (98.06)
GDP per cap (logged)								-934.0** (346.41)
Polity								-32.85 (20.45)
Conflict FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	N	N	Y	N	Y	N	Y	N
N	661	661	661	661	661	661	661	527
K-P Wald F-Stat		8.190	14.82	21.17	25.63	16.47	21.64	12.08

Standard errors in parentheses.
Conflict and Year FE where indicated, Heteroskedastic and Autocorrelation Consistent SE, Bartlett Kernel Bandwidth 3.
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

closeness as an instrument. Year fixed effects are included in the model in Column 3. We analyze these models with just geographic closeness because of the potential strength of the instrument, with both external civil war terminations and geographic distances being plausibly exogenous to the severity of other ongoing civil wars. In both models, the effect of small arms imports is statistically significant and over eight to nine times as large as the OLS estimate. Here a 1% increase in small arms imports leads to nearly three new battle deaths. We are partial to the just-identified model in Column 3 because the Network instrument introduces potentially problematic exclusion violations in later models, and Model 3 includes both conflict and year fixed effects.

Columns 4 and 5 use only network closeness as an instrument with year fixed effects added in the model in Column 5. Columns 6 and 7 include both geographic closeness and network closeness instruments, and Column 8 includes both instruments and the control variables. In the model with both instruments in Column 6, imports have a statistically significant effect on battle deaths. Substantively, a 1% increase in arms imports to civil war locations, on average, results in just over two additional battle deaths in a given conflict-year. While we are partial to Model 3, which yields a larger coefficient, we adopt this more conservative estimate in Model 6 when making substantive claims about the model. This effect holds when the controls are included (Column 8). We note that including year fixed effects in the specifications with NETWORK CLOSENESS instrument results in a statistically insignificant relationship between imports and battle deaths (Columns 5 and 7). However, when we replace the year fixed effects with cubic time trend variables, then the results hold (results not reported here).

Across models, the Kleinbergen-Papp Walk F-Statistic is close to or exceeds the recommended threshold of 10. These F-Statistics are large enough to reject the null hypothesis of weak instrumentation. Overall, arms imports appear to increase battle deaths in ongoing civil wars, and substantively this effect ranges from approximately 2-3 battle deaths when arms imports increase by 1%.

5.3 Robustness

The validity of the instrumental variable analysis in the previous section depends on the assumption that our GEOGRAPHIC CLOSENESS and NETWORK CLOSENESS instruments are exogenous and have no direct effect on the severity of ongoing civil wars in other countries. Though this assumption has face validity, especially with respect to the exogeneity of GEOGRAPHIC CLOSENESS,[15] we can further substantiate our results by looking at additional models that include variables that could potentially violate the exclusion restriction.

Table 4 presents five additional models, each of which tests for a potential violation of the exclusion restriction. Model 1 adds a control for foreign aid receipts, as reported by AidData 3.0. The results show that FOREIGN AID is negatively associated with battle deaths, and, importantly, the effect of SALW imports remains positive and significant.

The model in Column 2 controls for the log of total trade to countries with ongoing

[15]The Hansen J statistic in the model with both instruments is 0.733 and not significant, and the Kleibergen-Paap rk LM statistic for underidentification test is 24.302 and significant. Over- and underidentification tests support the inclusion of both instruments.

Table 4: Robustness Checks for Exclusion Restriction. Effect of Imports on Battle Deaths, GMM, conflict and year fe, robustness

	(1)	(2)	(3)	(4)	(5)
Arms Imports	303.8*	212.2*	260.7*	278.1*	242.0**
(logged)	(120.3)	(103.9)	(112.5)	(115.4)	(103.1)
GDP per cap	-678.86†	-255.14	-790.85*	-821.58*	
(logged)	(371.2)	(403.39)	(351.96)	(364.39)	
Polity	-18.52	-26.95	-25.79	-21.59	
	(29.64)	(29.86)	(27.79)	(29.54)	
Foreign Aid	-123.54*				
(logged)	(49.05)				
Total Trade		-562.06†			
(logged)		(298.97)			
Internationalized			-497.82		
			(374.50)		
Foreign				-246.60	
Fighters				(345.22)	
N	507	473	527	506	485
K-P Wald F-Stat	14.26	15.22	12.81	12.64	13.20

Standard errors in parentheses.

† $p < .10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Conflict FE, Heteroskedastic and Autocorrelation Consistent SE, Bartlett Kernel Bandwith 3.

civil war. The result for small arms remains positive and significant, though the number of observations drops because our trade data only runs through 2009. Column 3 reports the result of a model that includes a dummy for internationalized conflicts. The internationalized dummy is not significant, but the coefficient on SALW imports remains positive and significant. Model 4 tests the potential exclusion violation due to foreign fighters. Coding data found in Malet (2013), we generate an indicator variable for the presence of foreign fighters in the primary civil war location in a given year. Again, SALW imports is positive and significant. In Model 5, we drop all conflicts that are contiguous to a country with a civil war termination. SALW imports is still positive and significant. Thus we rule out exclusion violations from these sources.

6 Discussion

As noted in the Introduction, the relationship between the quantity of weapons and actual violence in a conflict has been the subject of theoretical debate. Our analysis provides evidence that the two are positively correlated: when the quantity of weapons goes up, so do battle deaths. What's more, this effect is substantively significant, thus limiting arms imports could be an effective policy to reduce battle death in civil conflicts. On average, our analysis in Column 8 of Table 3 predicts 2.1 battle deaths for every one percent increase in arms imports. In an average year of an ongoing civil war, there is a 26 percent change in the level of imports and at 2.1 battle deaths per percentage point, changes in imports account for, on average, 52 battle deaths.

To illustrate the effects of the small arms trade we can also look at particular transactions. For example, in 1992 South Korea exported $23,052 worth of small arms to Serbia, about 8% of Serbian small arms imports that year, and by our estimates South Korean exports resulted in 16 battle deaths.

We can also analyze the positive effects of sanctions in this light. In cases such as Liberia, Eritrea, and South Sudan, the interventions by international community could decrease the loss of life. For example, in May of 2000 UN Security Council Resolution 1298 embargoed the shipment of arms and ammunition to Eritrea. Between 2000 and 2001 the arms imports to Eritrea fell by 99%, which we estimate would result in 199 fewer casualties in that year.

We can also quantify another implication of our analysis—that a decrease in violence that results from the termination of one conflict is partially offset by the transfer of arms from the terminating conflict to new conflicts. For instance, consider the wars of independence in the former Yugoslavia. Many countries supplied arms to this conflict, including Russia and Iran. Then in 1998, Croatia exported $1,000,000 in arms to Colombia, a 10% increase from the previous year's total. These additional weapons imply 20 additional battle deaths in that year in Colombia, amounting to about 3% of the annual total.

As we see from the substantive effects, the impact of the small arms trade on the level of violence is significant and sizable. These effects illustrate how the connectedness of war locations through international arms markets perpetuates violence. Our analysis shows that stopping a war in one location leads to more arms imports elsewhere and, therefore, more civil war violence in other locations. This effect results in a conservation of violence as a result of the arms trade. How might we get a sense of the coefficient on the conservation of violence? Consider a simple calculation based on data in our sample. If the average number of civil war terminations in a year is approximately 6 and the average number of battles deaths is 707, then the termination of civil wars decreases battle deaths by 4242 on average. On the other hand, the increase in the log of SALW imports multiplied by the average number of ongoing wars (37) gives us 386 new battle deaths that are the result of changes to the arms market. That is, 9% of the lives saved when a war is terminated in an average year are offset by the increased battle deaths that result from the changes in the arms trade.

7 Conclusion

Most of the death in modern civil wars is from small arms: pistols, machine guns, grenades, and mines. By Klare's (1999, p.20) count, 80 to 90 percent of all casualties in recent civil wars have been produced by such weapons. As Boutwell and Klare (2000) point out, small arms are the weapon of choice in civil conflicts because they are readily obtainable, cheap, deadly, and easy to transport. It is also the case that large stockpiles of small arms exist from previous wars, including the Cold War, and unlike major weapons systems, there exists an easily accessible market for their purchase outside the direct control of states. This is particularly important when the groups looking to arm might be classified as outlaws and pose threats to their own state or neighboring regimes.

Though there are many factors that contribute to the onset and severity of civil war, many of them are outside the control of policy makers. It is valuable, then, to identify factors that can be influenced by policy. Here we show there are significant effects of the trade in small arms on the severity of civil war, measured in terms of battle deaths. From our analysis we can conclude that the effect is positive and that sanctions and arms embargoes decrease the loss of combatant life. Second, our estimation strategy implies an effect of markets and trade networks on severity of violence. In essence the results show that market changes impact warfighting. We also see that mechanisms of civil war contagion are not limited to immediate civil war neighborhoods and the outbreak of violence. Economic connections matter too. Notably, trade networks may facilitate the spread of violence beyond immediate geographic neighborhoods. In this way, civil war terminations, in addition to civil war onset, may lead to the diffusion of civil war because of the impact war termination has on the price and availability of weapons to other combatants. Indeed, the analysis here suggests the possibility that any event that causes a major market shock may trigger the spread of violence through connected arms markets. Finally, the arms trade produces a partial *conservation of violence* for global civil war. As one war ends, the incentives to sell unused arms on the international market leads other war-torn countries' imports to increase, and this increases the casualties in other theaters of violence.

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Appendix

Lemma 1. *In the unique Nash equilibrium to the market on the arms trade network in Figure 1 with three buyers and two sellers, equilibrium quantities are*

$$q_1 = \frac{3\alpha}{2(5c+3\beta)}, \tag{4}$$

$$q_{2L} = \frac{\alpha}{5c+3\beta}, \tag{5}$$

$$q_{2L} = \frac{\alpha}{5c+3\beta}, \tag{6}$$

$$q_3 = \frac{3\alpha}{2(5c+3\beta)}. \tag{7}$$

Proof. With linear demand from each buyer and the seller profit functions in equations (2) and (3), the solution to the first order conditions are as in Lemma 1. Checking the Hessian, the solutions are profit maximizing. □

Lemma 2. *In the unique Nash equilibrium to the market on the arms trade network in Figure 2, with two buyers and two sellers, equilibrium quantities are*

$$q_{2L} = \frac{\alpha\beta + 4\alpha c}{3\beta^2 + 8c^2 + 11\beta c}, \tag{8}$$

$$q_{2R} = \frac{\alpha}{3\beta + 8c}, \tag{9}$$

$$q_3 = \frac{3(\alpha\beta + 2\alpha c)}{2\left(3\beta^2 + 8c^2 + 11\beta c\right)}. \tag{10}$$

Proof. The proof is the same as for Lemma 1 but replace Seller Left's profit function with

$$\Pi_L(q_{2L}) = P(q_{2L} + q_{2R})q_{2L} - c(q_{2L})^2. \tag{11}$$

□

Proposition 1. The quantities purchased by Buyer 2 and Buyer 3 increase when Buyer 1's demand drops to zero and the quantity purchased by Buyer 2 increases more than quantity purchased by Buyer 3.

Proof. If Buyer 2's quantity increase we need that

$$\frac{\alpha}{3\beta+8c}+\frac{\alpha\beta+4\alpha c}{3\beta^2+8c^2+11\beta c}>\frac{2\alpha}{3\beta+5c}.$$

Simplification of the algebra reduces this inequality to

$$\alpha c(\beta+c)(\beta+3c)(3\beta+5c)(3\beta+8c)>0$$

which is always true for positive α, β, c. A similar calculation shows Buyer 3 also gets a large quantity after Buyer 1 exits the market.

To show that Buyer 2's quantity increases more than buyer 3's, notice

$$\left(\left(\frac{\alpha}{3\beta+8c}+\frac{\alpha\beta+4\alpha c}{3\beta^2+8c^2+11\beta c}\right)-\frac{2\alpha}{3\beta+5c}\right)-\left(\frac{3(\alpha\beta+2\alpha c)}{2\left(3\beta^2+8c^2+11\beta c\right)}-\frac{3\alpha}{2(3\beta+5c)}\right)$$

simplifies to

$$\frac{3\alpha c(\beta+2c)}{(\beta+c)(3\beta+5c)(3\beta+8c)}$$

which is always positive. $\square$