Diffusion of war through arms trade

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Abstract

International trade and conflicts are key aspects of this world. In particular, weapons are traded across the world and civil wars take place in multiple regions. However, not much is known about how those two are related. This paper combines methods in international trade, network analysis, and literature in both empirical and theoretical conflict to state the importance of this overlooked relationship. This paper uses the shift-share design and network measure derived from the Cournot competition in multiple markets to find significant weapons reallocation to other countries after a ceasefire. This paper then tests insights from a bargaining model with an imperfectly observed claim to illustrate how this exogenous increase in weapons may lead to conflicts. Using the predicted change in weapons due to the reallocation as an instrument, an increase in weapons led to more conflicts. Transparency of weapons trade, however, can counteract this rise in conflict.

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1 Introduction

Every end is a new beginning. This paper argues that an end of conflict in a country leads to more likelihood of conflicts beginning in another region. The mechanism is international arms trade. Weapons are essential in conflicts but are only produced widely in a number of developed countries. Therefore, much of the weapons used come mostly from international trade produced by predominantly developed countries and weapons from the Cold War. The dominance of developed countries in the exports of weapons is staggering. In 2018-2022, more than 70% of the global exports came from the U.S., Russia, France, China, and Germany (Thurner et al., 2019).

It is, thus, possible that a demand shock to these suppliers has a ripple effect on other buyers from those suppliers. As an example, consider a conflict ended. In this case, the demand for weapons in that region will decrease and suppliers will look elsewhere. This will then encourage other buyers in different regions to purchase those weapons either due to a decrease in price due to lower demand or an increase in the quantity supplied. In this scenario, then, an end of conflict led to more weapons in other regions.

To quantify the extent of this reallocation, this paper extends methodologies in empirical economics and network analysis. First, considering the end of a conflict as a shock to the supplier and then to the buyer, this paper uses the shift-share design. The more the supplier was supplying to the region that ended its conflict and the more the buyer was reliant on that supplier, the more exposed was that supplier to the end of the conflict. The estimate points out that higher exposure to the conflict ending in a peace agreement leads to more weapon imports.

To further quantify the reallocation in multiple suppliers and multiple ceasefires, this paper then extended the Cournot competition with multiple markets. This paper shows that the reallocation can be predicted by using Katz-Bonacich centrality, a well-used centrality measure in network analysis, under a number of assumptions. Data shows that this measure also significantly correlates with weapons flow for countries after ceasefires in different regions. In fact, the fit using this measure is better than a simple aggregate of shift shares, indicating reallocation over the entire supplier-buyer network is important in understanding how weapons are supplied.

Does this increase in weapons lead to conflicts? As conflicts are costly, it should not happen if both parties know how much the other party is demanding and how much they are prepared to fight. Conflicts, however, could happen if the claim is unclear. If the party perceives the other's claim as too high, this possibly leads to conflicts. Using the shock to suppliers due to the end of conflicts in other countries as an IV, this paper shows that an increase in weapons trade leads to more likelihood of conflicts. This use of IV is more plausible than past literature as it limits the variation to conflicts in other regions and the supplier-buyer network eliminating concerns such as proximity to ceasefires and other direct investments from developed countries not under competition.

What then can we do? The framework of imperfectly observed claims also suggests that more transparency in the other's claim leads to fewer conflicts. In the case of international trade shocks, it is possible that a more transparent weapons trade can make demands clearer. Using the transparency index in weapons trade from the Small Arms Survey, this paper shows that increased transparency leads to less likelihood of conflict with more arms trade.

2 Literature

This research combines three strands of literature. The first is empirical explorations of what leads to conflict. This has been covered extensively in (Blattman and Miguel, 2010). However, the relationships between international arms trade and conflict have only recently started to emerge. One such paper is (Gallea, 2023), which shows that after a large war breaks out in which the supplier of weapons participates, weapon flow to other countries decreases and leads to less severe conflict. Related to conflicts, Auer and Meierrieks (2021) provides a positive significant effect of the flow of weapons on terrorist activities. This paper is the first in the field of economics to investigate the impact of the inflow of weapons on conflicts. In related fields such as peace studies, the relationships between international arms and conflict have been explored using a panel data set (Moore, 2012) (Pamp et al., 2018) (Benson and Ramsay, 2018) (Mehrl and Thurner, 2020). These provide mixed evidence in terms of whether arms trade worsens conflicts. These papers use major conventional arms such as missiles, which are likely to involve more geopolitical considerations. A similar idea using trans-border spillovers is (A. Dube, O. Dube, and García-Ponce,

2013) which uses weapon bans in the U.S. on violence in Mexico. This paper explicitly incorporates international trade in small arms weapons into the model of conflict and uses spillover shocks to estimate the effect of arms trade on conflict. By so doing, this paper also gives insights into the arms treaty that aims to stop the flow of these weapons (Baronchelli, Caruso, and Ricciuti, 2022).

This paper also uses the theoretical framework of conflicts. In particular, this paper extends and empirically tests bargaining models. Various papers have modelled conflict using bargaining starting from (Fearon, 1995). The Coase theorem implies that rational agents who can bargain freely and make unrestricted transfers to each other will negotiate a surplus-maximizing outcome. As such, war never occurs as each party loses. (Baliga and Sjöström, 2020) uses incomplete information to study a host of issues that induce conflicts, such as first-mover advantage. Using incomplete information, (Chassang and Miquel, 2010) showed the relationship between increasing weapon stock and the likelihood of preemption attacks. Another insight comes from (Yu et al., 2022), which models conflict as a commitment failure. Building on this literature, this paper applies the framework of (Wolitzky, 2023) where the key element is imperfect claims. By modelling imperfect claims in international arms trade, this paper empirically tests the validity of this framework. In doing so, this paper tests whether obscure trade flows lead to worse or better outcomes.

Third, this paper extends methodologies developed in international trade to quantify the spillover effects. First, the shift-share instrument has been used in looking at the effect of the same shock in multiple regions (Autor, Dorn, and Hanson, 2013) (Topalova, 2010) (Kovak, 2013). These papers use a demand shock to regions. Here, this paper uses a demand shock to a supplier and then to the region of interest, which expands the use of the shift-share methodology. This paper also considers the Cournot competition in international trade. This is in line with past research investigating trade protection and dumping (Krugman, 1989). Recent research extended this analysis to multiple markets (Bimpikis, Ehsani, and İlkılıç, 2019). Yet, the changes in the global market after a market collapse are not their focus. This paper considers this problem and provides grounds for network analysis for implementation.

3 How trade and conflict is related: Theory

3.1 Trade

3.1.1 Shift-share

The general idea comes from the literature of shift-share design (Borusyak, Hull, and Jaravel, 2022), (Adão, Kolesár, and Morales, 2019). This captures the insight that the ending of a conflict affects suppliers and henceforth other buyers differently. Consider multiple small open economics $i = 1, ..., J$ with sectors $s = 1, ..., S$. Each sector has a downward-sloped labour demand.

$$\log L_{is}^D = -\sigma \log w_i + \log D_{is}$$
$$\log D_{is} = \rho \log \chi_s + \log \mu_s + \log \eta_{is}$$

Here L_{is}^D is the labour demand of sector s in country i, w_i is the wage, and D_{is} is composed of sector-level trade shock (χ_s) and other determinants of demand. Labour is freely mobile across sectors but immobile across countries. Labour supply is then

$$\log L_i^S = \phi \log w_i + \log v_i \quad \phi > 0$$

The labour market clearing in each country is

$$L_i^S(w_i) = \sum_s L_{is}^D(w_i, \chi_s, \mu_s, \eta_{is})$$

Now consider common shocks to the sector demand in all countries $\hat{\chi}_s$. Then given w, a shift in labour demand is a weighted sum of sector shocks $\hat{L}_i^D \approx \rho \sum_s l_{is}^0 \hat{\chi}_s$ where the weights are the initial share of labour. Up to a first-order approximation around the initial equilibrium, $\hat{L}_i^s = \sum_s \frac{L_{is}^{D,0}}{\sum_k L_{ik}^{D,0}} \hat{L}_{is}^D$.

In the case of weapons, consider sectors as weapons in different supplying countries. An end of conflict will cause a shock to the supplier's demand in all countries χ_s as the supplier needs to reallocate. In the case of an end in conflict, this shock is positive for other countries and can be quantified as the difference between the supply of weapons to the country before and after a conflict ended. This shock will affect i differently by the initial share of trading volumes between the suppliers.

The regression we, therefore, run in this case is $\hat{Y}_i = \beta X_i + \varepsilon_i$ where Y_i is the change in the supply of arms (assuming labour monotonically increases arms), $X_i = \sum_s l^0_{is}\hat{\chi}_s$ and $\varepsilon = \hat{v}_i + \sum_s l^0_{is}(\hat{\mu}_s + \hat{\eta}_{is})$. Given this setup, (Borusyak, Hull, and Jaravel, 2022) shows that the random assignment of χ_s is sufficient for identification. Specifically, $E[\hat{\chi}_s|\varepsilon_i, l^0_{is}] = 0$. This assumption is satisfied in the weapons case when a conflict ends and the decrease of trade for supplier s is independent of the state in another country.

This, however, poses an important issue when considering sector s as different suppliers of weapons. Specifically, each w_i (the price) is different between supplying countries and each sector will compete for market shares. The subsequent model takes emphasis on this.

3.1.2 Cournot competition

This paper considers a population of buyers and sellers of small arms and light weapons (SALW). Denote the set of buyers and sellers as $\boldsymbol{B} = \{1, 2, ..., \eta_b\}$ and $\boldsymbol{S} = \{1, 2, ..., \eta_s\}$.

Subsequently, this paper defines the trade network. For any $s \in \boldsymbol{S}$ and $b \in \boldsymbol{B}$, denote $g_{s,b} = 1$ if trade link is established and $g_{s,b} = 0$ otherwise. By definition $\forall s \forall b, g_{s,b} = \{0, 1\}$ and $g_{bs} = g_{s,b}$. A *network*, $g = \{(g_{s,b})_{s\in\boldsymbol{S},b\in\boldsymbol{B}}\}$, is a formal description of the trade links that exist between all buyers and sellers.

Given this network, sellers sell SALW to buyers. Let $q_{s,b}$ be the amount of SALW sold to $b \in \boldsymbol{B}$ from $s \in \boldsymbol{S}$. Thus, the total amount a buyer b obtains can be written as $q_b = \sum_{s\in\boldsymbol{S}} q_{s,b}$ and the total amount a seller s sells as $q_s = \sum_{b\in\boldsymbol{B}} q_{s,b}$. Let $a_s = (q_{s,1}, q_{s,2}, ..., q_{s,\eta_b})$ be the strategy set of seller s and $\boldsymbol{a} = (a_1, a_2, ..., a_{\eta_s})$ be the strategy profile of this game. Denote for each $k \in \boldsymbol{\Omega_c}$, $Q^b_k = \sum_{b\in b_k} q_b$ and $Q^s_k = \sum_{s\in s_k} q_s$ where the former is the total amount of SALW in country k and total amount sold from country k in the latter. The total amount of SALW is $Q = \sum_{k\in\boldsymbol{\Omega_c}} Q^b_k = \sum_{k\in\boldsymbol{\Omega_c}} Q^s_k$.

Seller s tries to sell SALW so as to maximize profit in line with the demand function for each buyer, $P_b(q_b) = f(q_b)$, and cost for selling (production), $C_s(q_s) = g(q_s)$ (both are assumed to be differentiable). From this, the seller's profit can be written as

$$\pi_s(\boldsymbol{a}) = \sum_{b\in\boldsymbol{B}} g_{s,b}P_b(q_b)q_{s,b} - C_s(q_s). \tag{1}$$

and each seller will maximize its profit given a_{-s}, the strategy profile of all sellers except s.

Suppose we assume the following demand and cost function

$$P_b(q_b) = \alpha_b - \beta_b q_b \tag{2}$$
$$C_s(q_s) = c_s q_s^2 \tag{3}$$

and define $\boldsymbol{\alpha} = (\alpha_1, ..., \alpha_{\eta_b})$, $\boldsymbol{\beta} = (\beta_1, ..., \alpha_{\eta_b})$, $\boldsymbol{c} = (c_1, ..., c_{\eta_s})$. Then as proved by (Bimpikis, Ehsani, and İlkılıç, 2019), the equilibrium is the solution to the problem of finding $\boldsymbol{z} \geq 0$ such that $\boldsymbol{z}^T(D\boldsymbol{z} - \bar{\boldsymbol{\alpha}}) = 0$ subject to $D\boldsymbol{z} - \bar{\boldsymbol{\alpha}} \geq 0$. Here D is the following edge-by-edge matrix

$$D_{s_k b_k, s_l b_l} = \begin{cases} 2(\beta_{b_k} + c_{s_k}) & \text{if} b_k = b_l, s_k = s_l \\ 2c_{s_k} & \text{if} b_k = b_l, s_k \neq s_l \\ \beta_{b_k} & \text{if} b_k \neq b_l, s_k = s_l \\ 0 & \text{otherwise} \end{cases} \tag{4}$$

and $\bar{\boldsymbol{\alpha}}$ is an edge vector with $\bar{\alpha}_{sb} = \alpha_b$.

3.1.3 Illustration

Let us first consider a simple example. There are two sellers (s_1 and s_2) and three buyers (b_1, b_2, and b_3). Assume network formation is fixed and as below. The network is common knowledge to all the players.

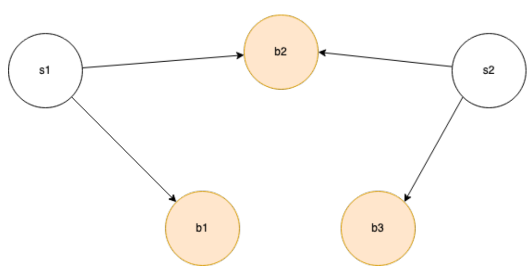


Figure 1: Example of a buyer and seller network

In addition, for $\alpha, \beta, c > 0$

$$P_b(q_b) = \alpha - \beta q_b \tag{5}$$
$$C_s(q_s) = c q_s^2 \tag{6}$$

Then profit for each seller is

$$\pi_{s_1} = P_{b_1}(q_{s_1,b_1}) q_{s_1,b_1} + P_{b_2}(q_{s_1,b_2} + q_{s_2,b_2}) q_{s_1,b_2} - C_{s_1}(q_{s_1,b_1} + q_{s_1,b_2})$$
$$\pi_{s_2} = P_{b_3}(q_{s_2,b_3}) q_{s_2,b_3} + P_{b_2}(q_{s_1,b_2} + q_{s_2,b_2}) q_{s_2,b_2} - C_{s_2}(q_{s_2,b_3} + q_{s_2,b_2}).$$

Solving for the first order conditions, we obtain

$$q_{s_1,b_1} = q_{s_2,b_3} = \frac{3\alpha}{10c + 6\beta} \tag{7}$$
$$q_{s_1,b_2} = q_{s_2,b_2} = \frac{\alpha}{5c + 3\beta} \tag{8}$$
$$q_{s_1,b_3} = q_{s_2,b_1} = 0. \tag{9}$$

Now suppose, conflict in country 2 ended and b_3 no longer demands SALW. Then the profit will become

$$\pi'_{s_1} = P_{b_1}(q'_{s_1,b_1}) q'_{s_1,b_1} + P_{b_2}(q'_{s_1,b_2} + q'_{s_2,b_2}) q'_{s_1,b_2} - C_{s_1}(q'_{s_1,b_1} + q'_{s_1,b_2})$$
$$\pi'_{s_2} = P_{b_2}(q'_{s_1,b_2} + q'_{s_2,b_2}) q'_{s_2,b_2} - C_{s_2}(q'_{s_2,b_2})$$

and again solving the first-order condition,

$$q'_{s_1,b_2} = \frac{\alpha}{8c + 3\beta} \tag{10}$$
$$q'_{s_2,b_2} = \frac{\alpha\beta + 4\alpha c}{3\beta^2 + 8c^2 + 11\beta c} \tag{11}$$
$$q'_{s_1,b_1} = \frac{3(\alpha\beta + 2\alpha c)}{2(3\beta^2 + 8c^2 + 11\beta c)}. \tag{12}$$

We can see that $q'_{b_2} > q_{b_2}, q'_{b_1} > q_{b_1}$ when $\alpha, \beta, c > 0$. Furthermore, $q'_{b_2} - q_{b_2} > q'_{b_1} - q_{b_1}$. Thus in this simple case, after country 2 ends its conflict, there will be more SALW for both sides in country 1. If b_2 decides to go on the offensive due to more SALW compared to b_1, then this might result in more conflicts and casualties.

3.1.4 Result

This paper provides a tractable result by three assumptions. First, all suppliers trade with all the buyers such that the first order condition of the quantity is always satisfied. Second, $\beta_b = \beta = 1\ \forall b$ and $c_s = c = 1/2\ \forall c$. The difference between different buyers comes from α_b which is the total supply of weapons if the price is 0. The price elasticity β of 1 comes from Smith and Tasiran, 2005 and the parameter for cost comes from tractability. Third, the parameter of $\alpha_b = 0$ when a conflict ends. That is the "node" of that country is deleted from the graph of the trade network. Given this assumption and using equation 4, we obtain the following result.

Proposition 1. The change in the equilibrium quantity Δq_t^* is given by the difference in Katz-Bonacich centrality with and without countries that ended the conflict where the edge weights are the equilibrium quantity at the previous period q_{t-1}^*.

The proof follows (Bimpikis, Ehsani, and İlkılıç, 2019) with additional assumption aforementioned. This result allows estimation of the predicted trade volumes after conflicts ending in multiple countries purely from the mechanism of the Cournot competition.

3.1.5 Extension

Due to more simplicity, the above result misses important components when considering reallocation through trade. Namely, the basic model does not account for endogenous link formation and trade cost. That is, the model does not consider link formation after the war ended. The suppliers will likely look for potential buyers after some of their buyers disappeared. The dynamic entry is a field of active research. The issue of network formation is due to multiple equilibria as illustrated in (Sheng, 2020). Multiple papers have sought to resolve this either through using random graphs or by iterative link formation (Christakis et al., 2020), (Mele, 2017). For this paper, we assume all suppliers and buyers are connected but subject to trade cost. Specifically, this paper assumes there is an iceberg cost $\tau_{s,b}$ for each unit supplied from supplier s to buyer b. The outcome after a certain country ceases war can be shown by making the trade cost to that country close to infinity. Given this, the profit for each firm (equation 1) becomes

$$\pi_s(\boldsymbol{a}) = \sum_{b \in \boldsymbol{B}} g_{s,b} P_b(q_b) q_{s,b} - C_s(q_s) - \sum_{b \in \boldsymbol{B}} \tau_{s,b} q_{s,b}. \tag{13}$$

where the last term is the additional iceberg trade cost. As this is a linear cost, the solution to this is almost identical to when there is no trade cost. The solution is $\boldsymbol{z} \geq 0$ such that $\boldsymbol{z}^T(D\boldsymbol{z} - \boldsymbol{\alpha} + \boldsymbol{\tau}) = 0$ subject to $D\boldsymbol{z} - \boldsymbol{\alpha} + \bar{\boldsymbol{\tau}} \geq 0$. Here $\bar{\boldsymbol{\tau}}$ is the edge vector of the iceberg cost and D is defined as before. This is more applicable in the setting where countries don't supply to all countries and trade cost is non-negligible as in the case of international trade.

3.2 Conflict

Given the changes in weapons, how does this change the likelihood of conflict? With complete information, as conflict is costly, both parties will bargain and accept the share of gains. This paper models conflict as an alternating-offers bargaining model (Rubinstein, 1982) with imperfectly observed claims to allow for the possibility of conflict, as seen in reality. The model yields two predictions. The first is that the larger the shock unobserved by the conflicting party, the more likely the conflict. Another is the more transparent the weapon stocks for each party, the less likely the conflict. This paper first starts out with a one-shot bargaining game and then processes to alternating offers following (Wolitzky, 2023). The last section gives an overview of how this model can be tested using international arms trade data.

3.2.1 One-shot bargaining

Players 1 and 2 bargain over a unit surplus. First, player 1 (*claimant*) claims $x \in X = [-M, M]$ where $M > 1$[1]. Player 2 (*responder*) then observes a signal $s \in S \subset \mathbb{R}$ where $s = x + \theta\varepsilon$. Imperfectly observed claim comes from $\theta > 0$, which captures the magnitude and $\varepsilon \sim \mathcal{N}(0,1)$, which makes the claim imperfectly observed. This paper denotes the distribution of s conditional on x as $f(s|x)$. After observing the signal, the responder either accepts or rejects the claim. If accepted, payoffs are x for Player 1 and $1-x$ for Player 2. If rejected, conflict takes place, and each player's payoff is 0.

[1]Most framework outlined in (Blattman and Miguel, 2010) uses $X = [0,1]$. However, the model needs to take into account $M > 1$ as the claim is imperfectly observed.

Given this setup, (Wolitzky, 2023) shows the following.

Theorem 1 . *A strategy profile is an NE of the one-shot bargaining game if and only if it takes one of the following two forms:*

1. *(Trivial) The claimant's strategy satisfies $E[x|s] \geq 1$ for all $s \in S$. The responder always rejects.*
2. *(Nontrivial) The claimant always demands $x = 1$. The responder's strategy σ satisfies $1 \in \arg\max_x x \int_{s \in S} \sigma(s) f(s|x) ds$.*

Moreover, when a nontrivial equilibrium exists, there is a unique nontrivial equilibrium that maximizes the probability that the responder accepts. In this equilibrium, the responder accepts if and only if $s \leq s^*$, where s^* satisfies

$$F(s^*|x = 1) + F_x(s^*|x = 1) = 0. \tag{1}$$

In a trivial equilibrium, player 1 claims unacceptable demands in expectation, and thus, the responder rejects every time. For the nontrivial equilibrium, the responder is indifferent between rejecting and accepting the offer. For this to be an equilibrium, it must be the case that accepting is optimal for the respondent as well. This can be achieved with the cutoff strategy above.

Further, if the claim is perfectly observed ($\theta = 0$), this game reduces to the standard ultimatum game. In this case, the claim is $x = 1$, and the responder accepts if and only if $s \leq 1$. Thus, the claim is always accepted. As the noise gets larger, there is less likelihood of accepting the claim[2].

3.2.2 Repeated offer bargaining

In certain cases, conflicts are more symmetric in that both players demand the other. This is captured by the alternating-offers bargaining model (Rubinstein, 1982). Formally, the game proceeds in discrete periods, $t = 1, 2, \ldots$. In odd periods, player 1 makes a claim x_1 and player 2 accepts or rejects given the signal s_1 the player gets, with the distribution $F_1(s_1|x_1)$. In even periods, the role is reversed and player 2 claims x_2, player 1 receives s_2 and decides whether to reject or accept. Assuming both have the same discount factor δ, if player j accepts player i's demand in period t, player i

[2] Proposition 4 of (Wolitzky, 2023)

receives $\delta^{t-1}x_i$ and player 2 receives $\delta^{t-1}(1-x_i)$. When an offer is rejected, play continues on to the next period. In theorem 4 of (Wolitzky, 2023), it is shown that the ability to make clear demands is an advantage in bargaining as similar to one-shot bargaining.

3.2.3 Trade and conflict

This paper combines the model in international arms trade and conflict onset in the following way. First, the claimant buys weapons q at cost $c(q)$ and demands x. The respondent observes x perfectly but observes only a noisy signal s of q. If the respondent accepts, payoffs are $x - c(q)$ for the claimant and $1 - x$ for the respondent. If the respondent rejects, payoffs are $-c(q)$ and 0, respectively. The claimant first claims x and then decides the obtain further q. This is a direct application of (Wolitzky, 2023) but where the claimant has a sunk cost to give its demand more credibility. Thus, the equilibrium is the claimant sets $q = x$ and the respondent accepts or rejects based on s.

International arms trade comes into the noisy signal s. Assuming the respondent cannot perfectly observe arms flow to the claimant, the respondent receives a mixed signal about how well-equipped the claimant is. Conflict takes place when the respondent receives a signal not accounting for a positive international trade shock to the claimant. In some cases, when the signal is noisy, the claimant may gain more by claiming a higher x as this incentivizes claimants to buy more q due to the sunk cost. This leads to high signals and the respondent accepts the demand. As such, the global arms market can work in opposite ways depending on how noisy the market is.

4 Empirical Strategy

4.1 Theory to data

This paper will test 4 hypotheses implied from the theoretical framework.

Hypothesis 1. Weapons were diffused to other regions after a war ended through trade.

To test this, this paper investigates two questions. One is does arms supply decrease to a country after a cease-fire? Another is whether arms supply to regions other than where the conflict increases after the war ends. This provides the primary variation this paper uses in subsequent analysis. For the first question, this paper runs an event study as in the following

$$Trade_{sb,t} = \alpha_1 Peace_{b,t} + \alpha_{sb} + \alpha_t + \zeta^{\alpha}_{sb,t} \tag{14}$$

where $Trade_{sb,t}$ is the trade amount from s to b in year t, $Peace_{b,t}$ is whether the country b is not in a conflict or not, and the subsequent terms are supplier-buyer fixed effect, year fixed effect, and the idiosyncratic shock, respectively. The regression for the second question is

$$Trade_{s\neg b,t} = \beta_1 Peace_{b,t} + \beta_s + \beta_t + \zeta^{\beta}_{s\neg b,t} \tag{15}$$

where $Trade_{s\neg b,t}$ is the export amount from country s to countries other than b where the war ended.

Hypothesis 2. Countries more connected to the cease-fire country via suppliers of arms see an increase in arms trade afterwards.

The second hypothesis delves deeper into the insights of the shift-share design and the Cournot competition. From the shift-share design, countries that are more exposed to the shock via suppliers increase demand for weapons. The regression this paper runs therefore is

$$Trade_{sb,t} = \gamma_1 Exposure_{sb,t} + \gamma_{sb} + \gamma_t + \zeta^{\gamma}_{sb,t}. \tag{16}$$

$Exposure_{sb,t}$ in the shift-share design consists of two elements: How exposed was the supplier to the country that ended the war at time $t-1$ and how important the supplier was to the country b at $t-1$. The first reflects the demand shock the supplier receives and the second term reflects how much of that demand shock is distributed to country b. Here, this paper takes to lag the approximate reallocation time. Specifically, the exposure of country b is computed by

$$Exposure_{sb,t} = \sum_{c \in C \cap r_c \neq r_b} Cease_{c,t-1} w_{sc,t-1} w_{bs,t-1}. \tag{17}$$

Here C is the set of all countries, r_i is the region of country i, $Cease_{c,t-1}$ is whether country c made cease-fire in year $t-1$, $w_{sc,t-1}$ is the share of exports to c from s in $t-1$, and $w_{bs,t-1}$ is the share of s in imports by b. The reason this paper omits peace-making in the same region is to address the possible omitted variable bias that stems from being close to countries that ended the war. This has been much documented in the political science literature as (Bara, 2018) reviews.

$Exposure_{sb,t}$ in the Cournot competition is defined from proposition 1. Specifically,

$$Exposure_{sb,t} = \sum_{s \in S} \boldsymbol{b}_s(G_{t-1}). \tag{18}$$

where $\boldsymbol{b}_s(G_{t-1})$ is the Katz-Bonacich centrality with scalar 1/3 for supplier s at year $t-1$.

Hypothesis 3. Countries exposed to more arms trade shocks have more likelihood of conflict taking place.

The third hypothesis relies on the insights from the bargaining model. Here, in both one-shot and repeated-offers bargaining, the model exhibits that the bigger the shock the less likelihood of acceptance. An ideal regression to regress the onset of conflict on weapon flow. However, this suffers from omitted variable bias. To address this, this paper uses an instrumental variable approach where the instrument is correlated with the flow of weapons but not to the error term. This paper uses the aggregate of regression 16 used to test hypothesis 2 as an instrument. Namely, the first stage is

$$Trade_{b,t} = \theta_1 \sum_{s \in S} Exposure_{sb,t} + \theta_b + \theta_t + \zeta^{\theta}_{b,t} \tag{19}$$

and the second stage is

$$Onset_{b,t} = \psi \hat{Trade}_{b,t} + \psi_b + \psi_t + \zeta^{\psi}_{b,t} \tag{20}$$

where $Onset_{b,t}$ is whether a conflict started in country b at year t.

This is akin to the shift-share design (Adão, Kolesár, and Morales, 2019) (Borusyak, Hull, and Jaravel, 2022) but adding intermediaries. (Borusyak, Hull, and Jaravel, 2022) shows that the shift-share estimate is consistent if the shocks, $\sum_{c \in C \cap r_c \neq r_b} Cease_{c,t-1} w_{sc,t-1}$, as-good-as-randomly assigned, mutually uncorrelated, and sufficiently dispersed in terms of their average exposure conditional on controls. First, as-good-as-randomly assigned is addressed by using conflicts in other regions and the network of suppliers. For country b, it is likely that what happens in a foreign country and its suppliers is fairly exogenous and cannot affect much. This is not the case for countries such as the U.S. which has strategic reasons to intervene across countries. For this reason, we limit to conflicts in developing nations. Second, mutually correlated could be an issue when suppliers of weapons are concentrated. For example, if the U.S. and the U.K. supply to the same set of countries, the shock would be correlated. In the results section, this paper shows that this is not the case. Lastly, this paper shows evidence that the shock is dispersed due to which country ended the conflict and who was supplying at certain times.

Hypothesis 4. Countries exposed to less noisy arms trade have less likelihood of conflict.

The fourth hypothesis comes from the second insight of bargaining. Namely, with more transparency, the model predicts that there is more likelihood of acceptance. For this, this paper adds an interaction term to hypothesis 3. Specifically, this paper runs

$$Onset_{b,t} = \phi_1 \hat{Trade}_{b,t} + \phi_2 Transp_{b,t} + \phi_3 \hat{Trade}_{b,t} Transp_{b,t} + \phi_b + \phi_t + \zeta^{\phi}_{b,t}. \tag{21}$$

Here $Transp_{b,t}$ is how transparent the arms trade is. This paper now turns to the data used.

4.2 Data

4.2.1 Conflict

Data on civil wars come from the UCDP/PRIO Armed Conflict Dataset (Davies, Pettersson, and Öberg, 2023). The main variables used are the year of conflict ended, conflict type (dispute over government or territory), estimated battle deaths, and the intensity of battles (battles exceed 1000 battle deaths or 250 battle deaths). To avoid spillover effects from interstate wars, this paper only used conflicts that occurred between states and actors in the same state. The observation unit is at the country level for each year.

For the onset conflict data, this paper uses UCDP Onset Dataset version 23.1 (Gleditsch et al., 2002). The unit of observation is country and year. It contains dummy variables indicating whether the intrastate conflict in the country is re-starting after 1, 2, 3, 5, 10 or 20 years. Thus, when determining whether a new onset has occurred the conflict (identified by conflict id) is compared only to its own history; but when determining whether an intrastate conflict restarted the conflict (identified by conflict id) is compared to the history of all intrastate conflict within the state, and not just its own history. This allows for the onset of new intrastate conflicts in countries with ongoing intrastate conflict.

For the conflict termination data, this paper uses UCDP Conflict Termination Dataset version 3-2021 (Kreutz, 2010). This dataset provides information on specific start- and end-dates for conflict activity and means of termination for each conflict episode.

To combine them with a country-level trade data set, this paper aggregates conflicts and causalities in each country by year. Further, for each year, every country is assigned a dummy for whether a conflict in that country started or ended in a peace agreement, victory for either the government of the other party, or inactivity (defined as no violence for a year).

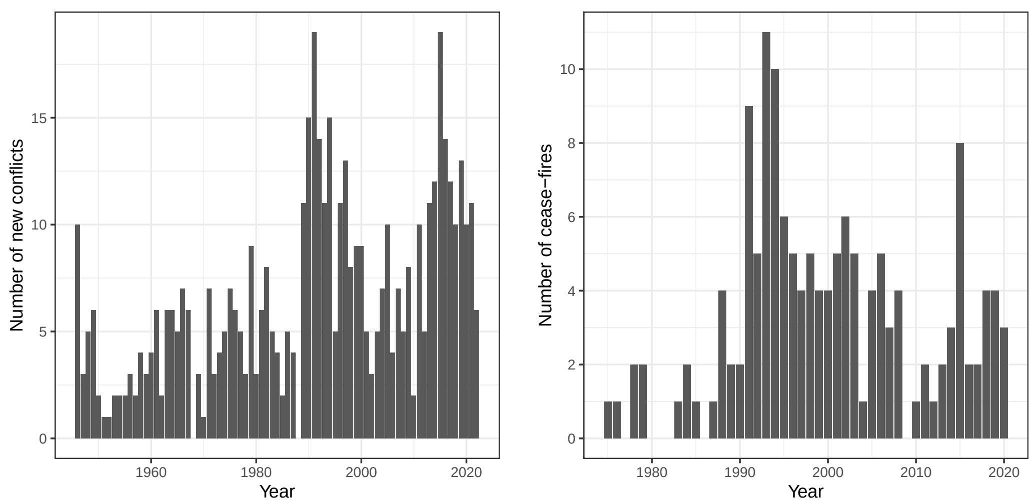
4.2.2 Arms trade

Data on weapons comes from NISAT (Marsh, 2014). NISAT data contain country year pairs of authorized transfers valued in USD. In addition to values, it also reports types of weapons and oftentimes their quantity and volume. This paper, out of consideration for geopolitical considerations in arms trade, focuses exclusively on small arms trade which is manufactured in abundance and more likely subject to competition in quantity. The data covers the period from 1962 to 2019.

In addition to trade volumes, this paper also digitizes PDF reports from the Small Arms Survey (*The Small Arms Trade Transparency Barometer* 2023). The Small Arms Trade Transparency Barometer assesses the transparency of top and major exporters—states that are believed to have exported at least USD 10 million worth of small arms and light weapons, including their parts, accessories, and ammunition. This paper uses the overall rating out of 20 for those countries from 2003 to 2017.

4.2.3 Descriptives

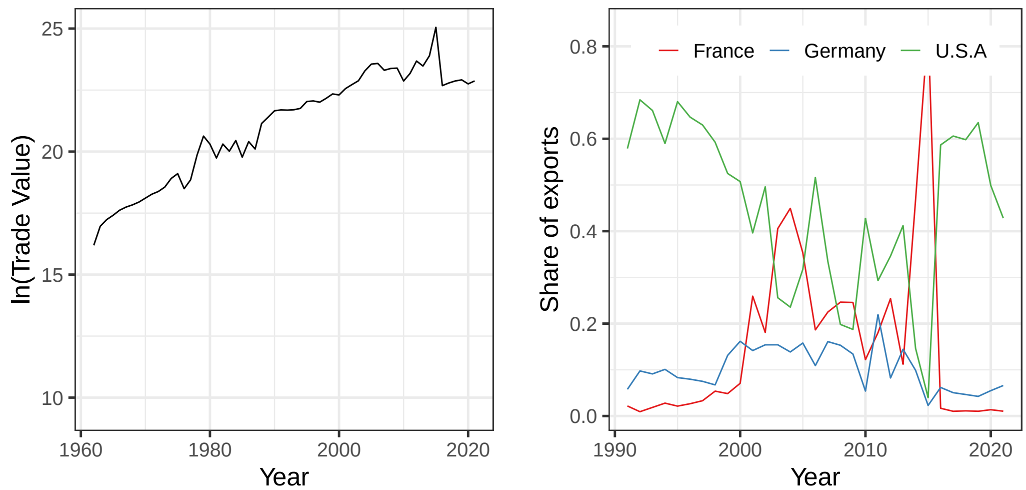
Figure 2 shows the distribution of the number of onset and ceasefire agreements by year. We can first observe that conflicts are consistently taking place throughout this period and so are the ceasefire agreements. These conflicts result in a large number of deaths in battle each year. Globally, about 50,000 people die each year on average ranging from 12,000 to 115,000 casualties.



(a) Number of onsets (b) Number of ceasefire agreements

Figure 2: Onset and Ceasefire

At the same time, exports of weapons are increasing. Figure 3a shows the total value of weapon export in logs for each year. We see that the overall trade volume is on an increasing trend. The volume of small arms and light weapons is dominated by Western nations. The top 3 exporters in this time period exported more than 70% of the total exports.



(a) Total trade volume by year

(b) Share of export by top exporters

Figure 3: Trade and Top exporters

Table 1 provides summary statistics for weapon trade's transparency index for each country from 2003 to 2018. We can see that the transparency index increased not only in levels but also in dispersion.

Table 1: Summary statistics of transparency index

Years	Median	SD	Min	Max
(2003,2008]	9.25	4.35	1.5	19.25
(2008,2013]	10.50	4.84	2.0	21.00
(2013,2018]	12.00	5.48	0.5	21.75

5 Empirical Results

5.1 Change in trade after peace

Here, this paper tests hypotheses 1 and 2 described in section **??**: whether we observe a change in international arms trade after a ceasefire. The left side of table 2 shows the change in overall arms trade volume after a country ended its conflict (regression 14). There are 4 categories for how the conflict ended: Peace agreement, victory for either the nonstate or the state, and low activity. We see from column (1) that after a peace agreement, the trade volume for that country decreases by about 40%. The magnitude of the decrease in arms volume is similar to conflicts that ended with a victory by the nonstate (column (2)). On the other hand, weapon trade increases after the state wins (column (3)) and no significant change due to low activity (column (4)). How those differential decreases take place is for further studies. This paper uses the decrease in arms trade after peace agreements to further see the effect on the overall international weapons trade.

Table 2: Trade volume after the country's ceasefire

Dependent Variables:	ln(Trade)				ln(Other trade)			
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables								
End - Peace	-0.386**				0.007***			
	(0.183)				(0.001)			
End - Victory (nonstate)		-0.393				0.007***		
		(0.315)				(0.001)		
End - Victory (state)			0.328*				0.004***	
			(0.169)				(0.001)	
End - Low activity				0.030				-0.007**
				(0.090)				(0.003)
Fixed-effects								
Export-Import pair	Yes	Yes	Yes	Yes				
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exporter					Yes	Yes	Yes	Yes
Fit statistics								
R^2	0.614	0.614	0.614	0.614	0.787	0.787	0.787	0.787
Observations	21,477	21,477	21,477	21,477	62,411	62,411	62,411	62,411

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: Clustered (Export-Import pair) standard-errors in parentheses for regression for trade from supplier to buyer and Clustered (Export) standard-errors in parentheses for regression for trade from supplier to rest of buyers.

Using this decrease in weapons trade for countries that enacted a peace agreement, table 2 shows the changes in the total value of weapons exported by a supplier except for the country that ended the conflict (regression 15). Consistent with the paper's hypothesis, we see that suppliers export to other countries more after a country ends its conflict with a peace agreement or a victory. We see that suppliers increase their supply by 0.7% to other markers on average after a peace agreement. This suggests that there is a certain degree of reallocation of supplies to other countries as the demand falls after peace in a certain country.

The question is, then, which countries do weapons get reallocated more? From the implication of the network model, countries that supplied a lot from a supplier that was also supplying its large share to the country that concluded their war are likely to receive more reallocation through the market. Table 3 uses regression 16 using the shift-share design to test this. Here column (1) uses all the countries while the rest of column (2) to (6) focuses on countries in each region. We observe that countries with higher exposure to the ceasefire country through their suppliers increase their weapons trade volume more. Specifically, countries that are 1% more exposed to the source of the ceasefire received 0.4% more weapons in terms of value. Looking at the rest of the column by region, we see that this increase is similar across regions. As the exposure measure was created excluding the region the country is located in, this suggests that this increase cannot be attributed to one particular region driving all the results.

Table 3: The effect of shift-share exposure to peace on trade

Dependent Variable:	ln(Trade)					
Region	Full sample	Europe	Middle East	Asia	Africa	Americas
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
ln(Exposure)	0.422***	0.377***	0.546***	0.465***	0.441***	0.362***
	(0.021)	(0.038)	(0.028)	(0.032)	(0.030)	(0.027)
Fixed-effects						
Export-Import pair	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
R^2	0.798	0.818	0.830	0.715	0.780	0.837
Observations	11,109	1,972	1,669	2,018	2,682	2,768

Clustered (Export-Import pair & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The result using the centrality measure for exposure produces the same results. Table 4 shows that the predicted trade volume from the Cournot competition positively correlates with the observed trade volume. The magnitude is largely the same across regions, except Africa. This may come from measurement error or certain market conditions in Africa.

Table 4: The effect of centrality exposure to peace on trade

Dependent Variable:	ln(Trade)					
Region	Full sample	Europe	Middle East	Asia	Africa	Americas
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
log(lag_centrality)	0.352***	0.374***	0.420**	0.430***	0.280**	0.351***
	(0.107)	(0.110)	(0.155)	(0.133)	(0.122)	(0.105)
Fixed-effects						
Export-Import pair	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
R^2	0.642	0.711	0.605	0.483	0.611	0.725
Observations	16,734	3,105	2,550	3,129	3,973	3,977

Clustered (Export-Import pair & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

5.2 Diffusion of conflict

5.2.1 Weapons and conflict

This paper now tests whether this increase in weapons increases the likelihood of conflict. For this, this paper uses the changes in international weapons trade due to ceasefires in other regions. This is captured by increased exposure using either the shift-share design or the Cournot competition. Table 5 provides the first stage and the second stage for the likelihood of an onset of a conflict using the shift-share as IV. First, the first stage, as shown in the previous results, is strong. The F-stat is 23.3. Using this predicted trade, we observe that the probability of conflict decreased by about 0.03 percentage points with a 1% increase in trade (column 1). However, we cannot reject the null hypothesis that weapon trade does not increase conflict at conventional levels. In column 2, we see that trade leads to an increase in battle deaths. Namely, a 1% increase in weapons leads to a 0.5% increase in battle deaths. This, however, also is not statistically significant to reject the null hypothesis. One reason for this null result may be due to a decrease in conflict due to increased weapons. The reasoning behind it is that some conflicts end as the power balance becomes steeper. From column 4, this is not the case. We see that increased weapons did not lead to more ceasefires both in terms of magnitude and significance.

Table 5: Effect of weapons using shift-share exposure as IV

Dependent Variables:	ln(Trade)	Onset	ln(Battle deaths)	Ceased
Model:	(1)	(2)	(3)	(4)
Variables				
ln(Exposure)	0.053***			
	(0.016)			
ln(Trade)		-0.025	0.574	0.000
		(0.049)	(1.446)	(0.040)
Fixed-effects				
Importer	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
R^2	0.827	-0.016	0.361	0.238
Observations	4,228	4,228	611	4,228

Clustered (Importer & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The effect of weapons using centrality as a measure yields a different conclusion. Table 6 uses the centrality measure for IV. Here, the first stage is stronger with a F-Stat of 194 compared to the shift-share. With this increased precision, we can see that trade leads to about a 1.5 percentage point increase in conflict (column 1). This is significant at the 10% level. The other outcomes, battle deaths and ceasefires are consistent with the shift-share design. The reversal of magnitude likely comes from a better capture of changes in trade. As the simulation in the model suggests, the end of conflict may work in different ways for other countries. As the centrality measure better captures this effect, it provides more precision as an IV.

Table 6: Effect of weapons using centrality as IV

Dependent Variables:	ln(Trade)	Onset	ln(Battle deaths)	Ceased
Model:	(1)	(2)	(3)	(4)
Variables				
ln(Exposure)	0.378***			
	(0.078)			
ln(Trade)		0.014*	0.207	-0.001
		(0.007)	(0.365)	(0.017)
Fixed-effects				
Year	Yes	Yes	Yes	Yes
Importer	Yes	Yes	Yes	Yes
Fit statistics				
R^2	0.827	0.053	0.518	0.225
Observations	4,672	4,672	685	4,672

Clustered (Importer & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

5.2.2 Transparency

This paper now provides the effect of transparent trade. The framework in conflict suggests that transparency matters in whether bargaining leads to conflict. Table 7 uses centrality as an IV for trade. The result suggests that transparency is in fact important in whether conflict takes place. Here, a country has transparent trade when the weighted average of transparency is above the median across countries. Due to limitations in data, the time period is from 2002 to 2017. First, we can see that those with more transparent trade have a higher likelihood of conflict. However, the interaction term is negative suggesting that an increase in transparent trade decreases the likelihood of conflict. The magnitude is also negative for battle deaths. One reason for this, as illustrated in the conflict model, is that a clear claim based on weapons gets heard well by the opponent and there are fewer rejections (conflicts).

Table 7: Effect of importing more from transparent suppliers

Dependent Variables:	Onset	ln(Battle deaths)
Model:	(1)	(2)
Variables		
Transp above median	0.408**	1.871
	(0.199)	(5.270)
ln(Trade)	0.001	0.240
	(0.041)	(0.573)
Transp above median x ln(Trade)	-0.030**	-0.125
	(0.015)	(0.353)
Fixed-effects		
Importer	Yes	Yes
Year	Yes	Yes
Fit statistics		
R^2	0.145	0.719
Observations	2,521	380

Clustered (Importer) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

5.3 Robustness

This paper considers two confounding issues. First, the key assumption of the IV apart from a strong first stage is that the IV only affects the outcome only through an increase in weapons in that country. The IV in this paper essentially uses the end of conflict shock through the supplier network. It is possible that a number of other goods than weapons go through this supplier network. One such good is foreign aid and immigration. Foreign aid is also predominantly from developed countries and an end of conflict may redirect aid to where the developed country was more connected to before. This is addressed by using the Cournot competition as aid is likely not governed by competition among countries. Furthermore, past literature described aid as a positive factor for conflict management (Bara, 2018). This suggests that the estimate obtained here includes a positive effect of a ceasefire in other regions. Thus, the conclusion that weapons lead to more conflicts still stands. Another concern is other movements such as people. It is also documented that large immigration leads to more conflicts (Bara, 2018). This concern is mitigated for the shift-share design by excluding shocks from the same region. It takes a certain period of time for people to move to other regions and thus the instrument excludes short-term immigration by ceasefire. In addition, as in the case of aid, those movements are likely not under Cournot competition and thus the IV using the centrality mitigates this concern.

Secondly, the centrality measure may capture the political relevancy of a country. For example, the United States is not only one of the largest exporters of weapons but also imposes a large influence on conflicts across the world. This paper tries to address this in two ways. First, the results exclude interstate conflicts which are likely more under the political influence worldwide. Second, this research excludes conflicts before 1991 as a robustness check. Weapon transfers under the Cold War were likely more influenced not just by competition in terms of quantity but by geopolitical concerns. The result does not change by excluding this time period.

Lastly, due to the nature of trade, the unobservable illegal arms trade is likely a crucial factor in the onset of conflict. Works such as (Della Vigna and La Ferrara, 2010) have tried to quantify it yet an estimate of the magnitude of illicit trade is still unknown. This paper deals with this in two ways. The instrumental variable employed here does address parts of this concern. Specifically, it attenuates measurement error. One can consider the following regression,

$$Onset_{i,t} = \alpha_0 + \alpha_1 Weapon^*_{i,t} + \nu_{i,t} \tag{22}$$

where $Weapon^*_{i,t} = ObservedWeapon_{i,t} + IllicitWeapon_{i,t}$ and the amount of illicit weapon is the error term in the regression using the observed weapon. For the measurement error to be insignificant, one can use an instrument that correlates with the observed weapon amount and is uncorrelated with both the illicit weapon amount and the error term ν. First, the instrument is shown to correlate with observed weapon trade. Second, the instrument is likely less correlated with illicit weapons as it is an interaction of two effects 1) substitution effect for the supplier and 2) demand effect for the buyer. Illicit weapon trade likely correlates with measures such as shortest distance and other informal routes that do not pass through large developed countries that are used in the instrument. Whether the instrument is uncorrelated with the error term is discussed above. However, it is possible that illegal arms trade also follows the path of official trade flows. The extent of this is for further studies.

6 Conclusion

This paper provides two results regarding trade and conflict. First, international arms trade reallocates weapons to other regions after a conflict ended. Second, this increase in arms to other regions leads to more conflicts in other regions. Combined, this suggests that an end of conflict in a country spreads conflicts to other regions through international arms trade. For this purpose, this paper extended two well-known methodologies in empirical economics. This paper extends the analysis of shift-share design to the exposure of both suppliers and buyers. This paper also provides a tractable way of incorporating reallocation in the Cournot competition using Katz-Bonacich centrality, a well-recognized centrality measure in network analysis. This paper further uses those changes in international trade to provide empirical insights into the bargaining literature. This integration of methods in trade, networks, and theories in conflicts provides further grounds for further insights into each of these fields. As we sadly observe multiple conflicts ongoing as well as starting, this research hopes to contribute to understanding how developed countries, primary suppliers of weapons, can make world peace happen.

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