Alberto Vesperoni

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Abstract

We develop a model of arms trade where a dealer considers to sell weapons to both sides of a conflict over some resources. We assume that the more the weapons of a buyer the larger its share of resources. A *contest success function* defines the mapping from weapons to shares. We show that, although not generally true, it is always optimal to sell to both sides if the success function is *exhaustive*, i.e., if the sum of buyers' shares is always equal to total resources. Given this, we discuss a series of historical case studies where opposite sides of conflicts made relevant purchases of weapons from the same supplier.

1 Introduction

War profiteering is the act of transferring weapons to parties of a conflict with an objective of pure economic gain. Arms transfers whose primary goal is political do not fall into this category. In this work we study the trade of weapons from a theoretical view point. Our results define an empirical strategy to identify economically motivated transactions. By a series of cases studies we show that, throughout history, arms transfers have often been led by economic profit.

Our argument is the following. Suppose a seller is politically motivated in supplying weapons in a conflict. Being political, this seller must have a preferred side, and would supply weapons to this side only. Conversely, an economically motivated seller may supply all sides, provided that this is profitable. Then, a theoretical question arises. Is it profitable to sell weapons to opposite sides? In this work we show that this is not generally true, as we provide theoretical examples where it is preferable to supply one side only. However, we find that it can be optimal to supply opposite sides, and we identify a simple sufficient condition for this to be the case.

Theoretical studies of the arms trade are surprisingly few. Note that, from a theoretical view point, trade in armaments is radically different from trade in standard commodities. Firstly, it necessarily induces externalities, as a purchase of weapons negatively affects the security of everyone but the buyer. Secondly, a purchase of weapons may undermine the balance of power on which the enforcement of trade agreements relies upon. In short, it may be that the more weapons are purchased, the less likely that they are paid, as the newly acquired military strength of the buyer allows to bully the seller and refuse to pay. Thirdly, as information asymmetries are known to be a leading cause of outbreaks of violent

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conflict, the arms trade could facilitate peaceful solutions. This is because trade of weapons may lead to common knowledge of relative military strengths, and therefore to a peaceful agreement about sharing resources. Given this, the arms trade cannot be represented with standard exchange models and clearly needs a theoretical framework of its own. In this work we exclusively address the issue of externalities. The second and third issues remain unexplored and define a challenging research agenda.

Let us discuss our framework in more detail. We model conflict as a two-parties contest for the control of some valuable resources. Each contestant purchases weapons to increase its share of resources. We study the incentives of an arms dealer, uniquely motivated by economic gain, to sell weapons to one or both sides of the conflict. The dealer makes a take or leave offer to each contestant, which consists in the delivery of some weapons for a payment. Each contestant can accept or reject the offer. We find a sufficient condition for both contestants to purchase weapons in equilibrium. This condition concerns the relation between weapons and shares.

In our model a contestant's share depends on both contestants' weapons, and a *contest success function* defines the mapping from weapons to shares. We always assume a success function to be *mutually exclusive*, *monotonic* and *anonymous*. Mutual exclusivity requires the sum of all contestants' shares to be smaller or equal than the resources. Monotonicity assumes that, the more weapons a contestant has, the higher its share of resources and the lower the opponent's share. Anonymity requires that the shares depend only on contestants' weapons, and not on their identity.

In this work we show that these three properties are not sufficient to determine whether both contestants purchase weapons in equilibrium. However, we identify a simple condition for this to be the case, which we name *exhaustivity*. Exhaustivity requires the sum of all contestants' shares to be always equal to the total resources.

Exhaustivity is also relevant for welfare analysis. We define welfare as the sum of players' payoffs. In our model it is not generally true that an equilibrium is welfare inefficient, as we provide several examples where this is not the case. However, if success functions are exhaustive, an equilibrium is always welfare inefficient. Then, exhaustivity captures a crucial aspect of conflict, i.e., its intrinsic wastefulness. By selling weapons to opposite sides an arms dealer may become individually richer, but decreases total welfare.

Exhaustivity is a standard assumption in contest models. Besides this, exhaustive success functions are opportune for modeling some situations more than others. These situations are the ones where the value of the contended resources is relatively independent of weapons' expenditures. This is arguably the case when a conflict is only an arms race, and there is no actual outbreak of violence. On the other hand, it is open to discussion whether exhaustive success functions are reasonable representations of violent conflicts, as the contended resources may be damaged.

Our theoretical results are of empirical interest, as they help to distinguish economically motivated transactions from politically motivated ones. In this work we discuss a series of case studies where opposite sides of a conflict purchased weapons or other strategic goods from the same supplier. These episodes span from the late Middle Ages to nowadays. They involve both public and private actors, as buyers or sellers. Besides firearms and other weaponry, we also discuss the exchange of other strategic goods, as mercenaries, financial instruments and oil. Overall, these case studies show that, throughout history, arms transfers have often been led by economic profit.

The paper develops as follows. Section 2 reviews the related literature and Section 3 defines the model. Section 4 exposes the results, including a brief discussion of welfare efficiency. Section 5 discusses the case studies and Section 6 concludes.

2 Related literature

Schelling (1966) was first to introduce game-theoretic tools in the study of international relations. This seminal work points out that military strength influences every aspect of foreign affairs, as it defines a country's security, and hence its bargaining power. Since then, the economics of conflict developed into a well established field. See Garfinkel and Skaperdas (2012) for a review. It became customary in the literature to model a country's security as a *probability of victory* in an armed conflict. A country's winning probability is assumed to increase in its own weapons and decrease in others' weapons, and a mapping from weapons to winning probabilities is called *contest success function*. See Jia et al. (2013) for a review on contest success functions and their foundations.

There has been a lot of writing on the economics of conflict, both in theoretical and empirical terms. However, a crucial question remains relatively unexplored: how are the weapons which fuel conflicts all around the world purchased and sold? To be clear, there is a vast empirical literature on the arms trade, which is partly reviewed in Hartley and Sandler (2007). However, these contributions tend to have a macro perspective, and abstain from analyzing "who sells weapons to who". An exception is Akerman and Seim (2013), who conduct a network analysis of international arms transfers for the period 1950-2007. They explore the relationship between countries' political systems and their willingness to trade weapons with each other. They compare this relationship between two time periods, during and after the Cold War, interpreting the end of the Cold War as an exogenous shock to the arms market. Besides the econometric analysis, it is interesting to look at their network graphs, which show how trade links have evolved throughout the last 60 years.

The theoretical study of the arms trade started with the seminal work by Levine and Smith (1995). Levine and Smith (1995) develop a dynamic model where a large number of buyers purchase weapons from few suppliers. In each period, a buyer faces a trade off between consumption and security. Security is represented by a function which is increasing in own weapons and decreasing in other's weapons in a linear fashion. The linearity comes at a cost, as the function does not necessarily take value between 0 and 1, and therefore is not a winning probability. Contributions which developed along these lines are reviewed in Garcia-Alonso and Levine (2007).

As argued before, a crucial aspect of the arms trade is that it induces negative externalities between buyers. Then, the sale of a finite number of weapons can be modeled as a multiple-prize auction with externalities. The study of these auctions started with Jehiel et al. (1996), who motivate their contribution as a model of sale of nuclear weapons. They analyze a winner-pay auction with identity-dependent externalities where the seller can condition its strategy on buyers' bids. They show that, under some conditions, it is optimal for the seller to give no weapons. This contribution generated a literature on winner-pay auctions with externalities which is reviewed in Jehiel and Moldovanu (2006). Other types of auctions with identity-dependent externalities are studied in Esteban and Ray (1999), Klose and Kovenock (2012) and Klose and Kovenock (2013).

In a broader sense, our work belongs to the literature on *contracting with externalities*, where a principal sells goods to multiple agents and these goods induce externalities between them. See Galasso (2005) for a review. Segal (1999) defines a very general framework for this problem. He focuses on the perfect information case, and identifies sufficient conditions for welfare inefficiencies. His work has been extended in Möller (2007), which studies sequential contracting, and in Segal and Whinston (2003), which considers broader commitment possibilities for the principal. None of these contributions studies whether the principal sells to one, few or all agents. However, this issue is addressed in applications of the framework to industrial organization, more precisely in the literature on *vertical contracting* between a supplier of an intermediate good and firms competing in a downstream market. Early contributions to this subject are Katz and Shapiro (1986) and Kamien et al. (1992). These models are highly specialized, as they focus on sales of discrete intermediate goods and assume a specific functional form for aggregate demand in the downstream market. Hart and Tirole (1990) follow an alternative approach, allowing for sales of continuous goods. However, for tractability, they also assume specific functional forms and, more importantly, a firm's profits in the downstream market must be zero whenever the firm does not purchase any intermediate goods. The literature which developed from these seminal contributions presents similar limitations. See Rey and Tirole (2007) for a review.

3 Model

Two buyers purchase weapons. We refer to them as 1 and 2 and to a buyer $i \in \{1,2\}$'s weapons as $y_i \geq 0$. The buyers purchase weapons because they contend some resources, whose total value we normalize to 1. A buyer's share of these resources is a function of both buyers' weapons. More precisely, each buyer $i \in \{1,2\}$'s share is a function $s_i : \mathbb{R}^2_+ \to [0,1]$. We call these functions *success functions*. We impose three properties on them: mutual exclusivity, monotonicity and anonymity. Success functions are

- *mutually exclusive* if $s_1(y_1, y_2) + s_2(y_2, y_1) \leq 1$ for any $y_1, y_2 \geq 0$;
- *monotonic* if $s_i(y_i, y_{\neg i})$ is increasing in y_i and decreasing in $y_{\neg i}$ for any $i \in \{1,2\}$ and $y_1, y_2 \geq 0$;[1]
- *anonymous* if $s_1(a,b) = s_2(a,b)$ for any $a, b \geq 0$.

Buyers purchase all their weapons from a same seller, which we denote as 3. The seller makes an offer (q_i, p_i) to each buyer $i \in \{1,2\}$, which consists in delivering $q_i \in [\underline{q}, \overline{q}]$ weapons for a payment $p_i \geq 0$, where $\overline{q} > \underline{q} > 0$.[2] An offer profile is a vector $x = (q_1, q_2, p_1, p_2)$ and X is the space of all such profiles. Each buyer independently accepts or rejects the offer. For any $x \in X$, a buyer $i \in \{1,2\}$'s weapons are $y_i(x) \in Y_i(x) = \{0, q_i\}$, where $y_i(x) = 0$

[1] Formally, $s_i(y_i, y_{\neg i})$ is *increasing* in y_i if $s_i(y'_i, y_{\neg i}) \geq s_i(y_i, y_{\neg i})$ for any $y'_i > y_i$ and $y_1, y_2 \geq 0$, and $s_i(y'_i, y_{\neg i}) > s_i(y_i, y_{\neg i})$ for some $y'_i > y_i$ and some $y_1, y_2 \geq 0$. Similarly, $s_i(y_i, y_{\neg i})$ is *decreasing* in $y_{\neg i}$ if $s_i(y_i, y'_{\neg i}) \leq s_i(y_i, y_{\neg i})$ for any $y'_{\neg i} > y_{\neg i}$ and $y_1, y_2 \geq 0$, and $s_i(y_i, y'_{\neg i}) < s_i(y_i, y_{\neg i})$ for some $y'_{\neg i} > y_{\neg i}$ and some $y_1, y_2 \geq 0$.

[2] We impose weapons to take value within the boundaries $\underline{q}$ and $\overline{q}$ to guarantee the existence of an equilibrium. We always assume $\underline{q}$ to be sufficiently small and $\overline{q}$ to be sufficiently large to avoid any "distortion" in the allocation of weapons in equilibrium. An example of distortion is the following. The seller wants to deliver $q > 0$ weapons to buyer 1 and 0 to buyer 2. Suppose $q > \overline{q}$. Then, the seller cannot implement its most preferred option, and must go for a second best. For instance, the seller could offer $\overline{q}$ to buyer 1 and $q - \overline{q}$ to buyer 2 (assuming $q - \overline{q} \leq \overline{q}$). This allocation is distorted, in the sense that only buyer 1 would purchase weapons if boundaries were sufficiently loose.

if i rejects and $y_i(x) = q_i$ if i accepts. For a given $x \in X$, a weapons profile is a vector $y(x) = (y_1(x), y_2(x))$ and $Y(x)$ the space of all weapons profiles.

Denote by $c > 0$ the seller's opportunity cost of delivering a weapons' unit to a buyer. The seller's payoff $\pi_3(x, y)$ is $p_1 + p_2 - cq_1 - cq_2$ if $y_i = q_i$ for all $i \in \{1, 2\}$, $p_i - cq_i$ if $y_i = q_i$ and $y_{\neg i} = 0$ for any $i \in \{1, 2\}$, and 0 if $y_i = 0$ for all $i \in \{1, 2\}$. A buyer $i \in \{1, 2\}$'s payoff $\pi_i(x, y)$ is $s_i(q_i, y_{\neg i}) - p_i$ if $y_i = q_i$, and $s_i(0, y_{\neg i})$ if $y_i = 0$.

We solve for subgame perfect equilibrium. A *subgame perfect equilibrium* is an offer profile $x^* \in X$ and a weapons profile $y^*(x) \in Y(x)$ for each $x \in X$ such that the offer profile satisfies $\pi_3(x^*, y^*(x^*)) \geq \pi_3(x, y^*(x))$ for any $x \in X$ and the weapons profiles satisfy $\pi_i(x, y_i^*(x), y_{\neg i}^*(x)) \geq \pi_i(x, y_i(x), y_{\neg i}^*(x))$ for any $x \in X$, $y_i(x) \in Y_i(x)$ and $i \in \{1, 2\}$. As a tie breaking rule we assume that, if a buyer achieves the same payoff by accepting or rejecting an offer, the buyer accepts the offer.

4 Results

Success functions are *perfectly discriminative* if $s_i(y_i, y_{\neg i}) = 1$ for any weapons profile such that $y_i > y_{\neg i}$ and any $i \in \{1, 2\}$. Perfectly discriminative success functions are used for modeling conflicts where a marginal advantage guarantees absolute defeat of the enemy. A perfectly discriminative success function is

$$s_i(y_i, y_{\neg i}) = \begin{cases} 0 \text{ if } y_i = 0 \text{ or } y_i < y_{\neg i}, \\ 1/2 \text{ if } y_i > 0 \text{ and } y_i = y_{\neg i}, \\ 1 \text{ if } y_i > 0 \text{ and } y_i > y_{\neg i}, \end{cases} \tag{1}$$

Note that in (1) we have $s_i(0, a) = 0$ for any $a \geq 0$ and $i \in \{1, 2\}$. In other words, the share of a buyer with no weapons is always zero. This is reasonable for modeling situations where there is a third entity contending the resources, which holds a positive and fixed amount of weapons. As $s_1 + s_2 = 1$ whenever $y_1 > 0$ or $y_2 > 0$, the third entity is absolutely defeated by any positive amount of weapons.

Proposition 4.1 *Assume success functions to be as in (1). In an equilibrium* ***only one buyer*** *purchases weapons if $c < 1/\underline{q}$ while no buyer purchases weapons if $c > 1/\underline{q}$.*

Proof: See Appendix.

The result in Proposition 4.1 is led by two facts: 1) a buyer's payoff is always zero if it rejects an offer; 2) the purchase of any amount of weapons guarantees to a buyer absolute victory if the opponent is unarmed. Then, the seller extracts all the surplus ($p_1 + p_2 = 1$) by delivering weapons to one buyer only. Note that, among all success functions, (1) is the one to maximize the seller's equilibrium payoff, as it extracts all the surplus at the minimum opportunity cost.

Perfectly discriminative success functions are a very special case. All other functions are said to be *imperfectly discriminative*. An example of imperfectly discriminative success function is

$$s_i(y_i, y_{\neg i}) = \frac{f(y_i)}{f(y_1) + f(y_2) + 1}\ , \tag{2}$$

where $f : \mathbb{R}_+ \to \mathbb{R}_+$ is continuous and increasing. The success function in (2) is axiomatically characterized in Blavatskyy (2010). As in (1), with the function in (2) we have $s_i(0, a) = 0$ for any $a \geq 0$ and $i \in \{1, 2\}$. Then, as (1), this function is opportune for modeling conflicts where there is a third contestant with a fixed endowment of weapons.

Proposition 4.2 *Assume success functions to be as in (2) and $f(0) = 0$.*

1. *For any convex f, there exists $\hat{c} > 0$ such that in an equilibrium* ***only one buyer*** *purchases weapons if $c < \hat{c}$ while no buyer purchases weapons if $c > \hat{c}$.*
2. *For any concave f, there exists $\hat{c} > 0$ such that in an equilibrium* ***each buyer*** *purchases weapons if $c < \hat{c}$ while no buyer purchases weapons if $c > \hat{c}$.*

Proof: See Appendix.

The result in Proposition 4.2 is due to 1) a buyer's payoff being always zero if the buyer rejects an offer; 2) total shares $s_1 + s_2$ being increasing in total weapons $y_1 + y_2$. Then, the seller wants to maximize total shares $s_1 + s_2$ with a minimum cost $y_1 + y_2$. The result can be interpreted via an analogy with a production function. Success functions present increasing marginal returns if f is convex, and decreasing marginal returns if f is concave.

Until now we considered success functions such that $s_1 + s_2$ is zero when buyers have no weapons and increasing in $y_1 + y_2$. Consider the opposite case. Suppose $s_1 + s_2 > 0$ if buyers have no weapons and $s_1 + s_2$ to be decreasing in $y_1 + y_2$. A success function which fulfills these properties is

$$s_i(y_i, y_{\neg i}) = \frac{f(y_i)}{f(y_1) + f(y_2) + f(y_1)f(y_2)} \ , \tag{3}$$

where where $f : \mathbb{R}_+ \to \mathbb{R}_{++}$ is continuous, increasing, and $f(0) \geq 1$. The success function in (3) is axiomatically characterized in Bozbay and Vesperoni (2013). It belongs to a family of functions to model contests with three or more players, where each pair can be in a neutral or antagonist relation. The success function in (3) corresponds to the case with three players, i.e., the two buyers and a third entity with a fixed endowment of weapons. The relations are such that, while the two buyers antagonize each other, they are both neutral towards the third entity.

Proposition 4.3 *Assume success functions to be as in (3) and $f(q_i) = 1 + q_i$. There exists $\hat{c} > 0$ such that in an equilibrium* ***only one buyer*** *purchases weapons if $c < \hat{c}$ while no buyer purchases weapons if $c > \hat{c}$.*

Proof: See Appendix.

The result in Proposition 4.3 is led by 1) total shares $s_1 + s_2$ being decreasing in total weapons $y_1 + y_2$; 2) y_1 and y_2 being strategic complements in decreasing total shares. Then, the seller maximizes a buyer's willingness to pay by denying weapons to its opponent.

We considered success functions where $s_1 + s_2$ is increasing or decreasing in $y_1 + y_2$. Let us examine an obvious intermediate case where $s_1 + s_2$ is constant in $y_1 + y_2$. Success functions are *exhaustive* if $s_1 + s_2 = 1$ for any weapons profile. While the success functions in (1), (2) and (3) are for modeling conflicts where a third entity has a claim on the contended resources, exhaustive success functions are opportune for situations where the two buyers are the only (relevant) parts involved. A perfectly discriminative and exhaustive success function is

$$s_i(y_i, y_{\neg i}) = \begin{cases} 0 \text{ if } y_i < y_{\neg i}, \\ 1/2 \text{ if } y_i = y_{\neg i}, \\ 1 \text{ if } y_i > y_{\neg i}, \end{cases} \quad (4)$$

and an imperfectly discriminative and exhaustive one is

$$s_i(y_i, y_{\neg i}) = \frac{f(y_i)}{f(y_1) + f(y_2)} \quad (5)$$

if $f(y_1) + f(y_2) > 0$ and $s_i(y_i, y_{\neg i}) = 1/2$ otherwise, where $f : \mathbb{R}_+ \to \mathbb{R}_+$ is continuous and increasing. The success function in (5) is axiomatically characterized in Skaperdas (1996). These two success functions are the most widely known in the literature.

One can show that, with success functions as in (4) or (5), in an equilibrium both buyers purchase weapons if c is "small enough", while no buyer purchases weapons otherwise. In fact, as shown in Theorem 4.1, this result is much more general.

Theorem 4.1 *Assume success functions to be* ***exhaustive****. There exists $\hat{c} > 0$ such that in an equilibrium* ***each buyer*** *purchases weapons if $c < \hat{c}$, while no buyer purchases weapons if $c > \hat{c}$.*

Proof: See Appendix.

The result in Theorem 4.1 is led by two facts: 1) if both buyers have no weapons, a buyer's share is positive and decreasing in the opponent's weapons; 2) total shares $s_1 + s_2$ are non-decreasing in total weapons $y_1 + y_2$. Then, a buyer's willingness to pay for weapons is larger when the opponent is armed than when is not, and the seller extracts the highest payments by playing buyers against each other. Note that this reasoning is different from the one of Proposition 4.2. The goal of the seller is not to maximize total shares, which here are fixed to 1, but to minimize each buyer's outside option.

We define *welfare* as the sum of all players' payoffs, $W(x, y) = \pi_1(x, y) + \pi_2(x, y) + \pi_3(x, y)$. We say that a profile (x, y) is *welfare efficient* if it maximizes welfare, i.e.,

$$(x, y) \in \arg\max [W(x, y)]$$

and welfare inefficient otherwise. We discuss below whether an equilibrium profile $(x^*, y^*(x^*))$ is welfare efficient.

Remark 4.1 *If success functions are*

1. *as in (1) or (2), an equilibrium profile is always* ***welfare efficient****.*
2. *as in (3) or exhaustive, an equilibrium profile is always* ***welfare inefficient****.*

The results in Remark 4.1 directly follow from Segal (1999), who shows that, in a more general model, there are welfare inefficiencies in equilibrium if and only if $s_i(0, y_{\neg i}) = 0$ for each buyer $i \in \{1, 2\}$. The intuition is that, if this is the case, each buyer's outside option is zero, hence the equilibrium payments satisfy $p_i^* = s_i$. Then, the seller's equilibrium payoff is equal to welfare, i.e., $\pi_3(x^*, y^*(x^*)) = W(x^*, y^*(x^*))$, and the equilibrium profile must be efficient. Conversely, if $s_i(0, y_{\neg i}^*(x^*)) \neq 0$ for some buyer $i \in \{1, 2\}$, we have $\pi_3(x^*, y^*(x^*)) \neq W(x^*, y^*(x^*))$ and the seller's offers are inefficient. Three lessons can be drawn from Remark 4.1. Firstly, exhaustive success functions always lead to welfare inefficiency. The reason is that, as $s_1 + s_2$ is constant, we have efficiency if and only if no weapons are sold. Besides this, weapons are offered to each buyer, as they increase the opponent's willingness to pay. Secondly, selling weapons to both sides does not necessarily induce welfare inefficiencies. Recall that, with success functions as in (2), given a concave f, the seller supplies weapons to both sides. This is welfare efficient, as by doing so the seller maximizes $s_1 + s_2$ at the minimum cost. Thirdly, welfare inefficiencies are not necessarily associated with supplies to both sides. With success functions as in (3), given $f(q_i) = 1 + q_i$, weapons are purchased by one side only. The reason for inefficiencies is that, as $s_1 + s_2$ is decreasing in total weapons, welfare is maximized if and only if no weapons are sold.

5 Case studies

Gunpowder was invented in China in the 9th century and was introduced in European warfare during the 13th century. Since then, the Belgian city of Liége prospered by manufacturing firearms and selling them all around the world. During the Dutch revolt, when the Low Countries rebelled against Spain and gained their independence, the arms makers of Liége supplied weapons to both sides of the conflict, i.e., to their Dutch compatriots and their Spanish enemies (Engelbrecht and Hanighen (1934)).

From the 13th to the 16th century European warfare was dominated by mercenary armies of long-term professionals. Among the most influential there were the German Landsknechts, characteristically armed with pike and halberd. They literally fought for anyone willing to pay. In the Great Italian Wars of the 16th century it was common that Landsknecht troops would serve both sides of a same conflict, as in the Battle of Ravenna (1512) and the Battle of Pavia (1525) (Miller (1976)).

Warfare became increasingly costly in the 17th and 18th centuries. As expenditures systematically exceeded fiscal capacities, a ready access to credit became essential. During the Napoleonic Wars, the London-based House of Baring was involved in financing both British and French war efforts. The Barings virtually monopolized the issuance of British debt (Ziegler (1988)). France did not seek liquidity in financial markets, but funded a considerable share of war efforts by selling Louisiana to United States. The Barings brokered the Louisiana sale, lending to United States the necessary funds (Ziegler (1988)). Then, the Barings funded both sides of the Napoleonic wars.

From the Congress of Vienna of 1815 to the Crimean War of 1853, the House of Rothschild had absolute control of European high finance, being the largest creditor of most European powers. The "Rothschilds era" coincided with one of the most peaceful periods of European history. However, the rivalry between European powers was higher than ever. Their race for world supremacy led to a massive growth of public debt, to fund the making of European modern states as they are known today. The Rothschilds financed each side of this race (Ferguson (1999)).

The second half of the 19th century witnessed the triumph of standardization and mechanization in arms manufacturing. Industrial arms manufacturers as the German Krupp, the British Amstrong and the American Remington made their fortunes in these years. Each of these firms sold weapons to both sides of the conflict between Russia and the Ottoman Empire, which lasted throughout all the century (Grant (2007)). Some of the first submarines in naval history were sold in the late 1880s by the Swedish firm Nordenfelt to both sides of the arms race between Greece and the Ottoman Empire. These sales were brokered by the legendary Greek arms dealer Sir Basil Zaharoff (Grant (2007)). Zaharoff is also known to have sold weapons to both sides of the Boer Wars, the Russo-Japanese conflict and WW1 (Feinstein (2011)).

Arms sales peaked with WW1. The horrors of the war, and the belief that bankers and arms manufacturers had profited from them, led to first attempts of regulating the arms industry. The arms embargo to warlord China was perhaps the most significant of them (Grant (2007)). However, the ideological cleavages of the 20th century were soon to hamper these efforts. It is significant that in the Spanish Civil War, the first of the many ideological wars of that century, both nationalists and republicans purchased weapons from the same German firm, Rheinmetall-Borsig. Hermann Göring was directly involved in these transactions. While Nazi Germany officially supported the nationalists, secret German supplies reached the republicans through the Greek arms dealer Prodromos Bodosakis-Athanasiades (Beevor (2012)).

The crucial asset of 20th century warfare was a safe supply of oil. The blitzkrieg-style warfare of WW2 could have been possible only with armored vehicles and fighting airplanes, which both relied on oil. Until the late 1940s, more than 50% of the world's supply of oil came from United States (Yergin (1991)). Then, how could the Axis powers fuel their WW2 efforts? They purchased large amounts of oil from various American and British firms shortly before the war. Among them, the largest supplier was perhaps Standard Oil of New Jersey, which kept shipping oil to Nazi Germany even after Pearl Arbor (Higham (1983)).

During the Cold War most arms sales were within the two blocks, and dominated by state-to-state transactions. As the arms market was heavily controlled, states would almost exclusively sell weapons to their political allies (Akerman and Seim (2013)). An interesting exception is the Cuban Civil War, where the United States government indirectly supplied weapons to both sides via the American arms dealer Samuel Cummings (Feinstein (2011)). We find another exception in the Middle East, where the United States government pursued a strategy of balance of power, selling comparable amounts of weapons to Saudi Arabia, Egypt and Israel (Feinstein (2011)). Another case is the India-Pakistan arms race, where in the early 60s the German firm Merex sold fighter planes to both sides, despite an international ban (Feinstein (2011)). Moreover Merex, who regularly supplied NATO members, sold plans for a new 120mm cannon by Rheinmetall to Norinco, the leading weapons manufacturer of China, in the early 70s (Feinstein (2011)).

The end of the Cold War witnessed a renaissance of private arms suppliers, who smuggled the large stocks of outdated armaments to the markets of Africa, Asia and Latin America. An example is the Russian arms dealer Viktor Bout, who armed most conflicts in Sub-Saharian Africa. Viktor Bout supplied both sides of the Angola's Civil War (Feinstein (2011)). Moreover, together with the arms dealers Nicholas Oman and Joseph der Hovsepian, Bout supplied Merex weapons to both sides of the Balkan Wars in the 90s (Feinstein (2011)). As the largest deals are always at the state-to-state level, the loosening of Cold War's political alliances offered new opportunities. For instance, the United States government is currently brokering large deals between American arms manufacturers and the Indian government (SIPRI (2013)). India and Pakistan, respectively the first and the third largest arms importers in this decade, are in an arms race since their independence in 1947. While Pakistan is a historical ally of United States and had regularly purchased American weapons, India was similarly bounded to the Soviet Union and had rarely done so (Paul (2005)).

6 Conclusion

This paper is a theoretical and empirical contribution to the literature on the arms trade. In the theoretical part we identify a sufficient condition for an arms dealer to supply to opposite sides of a conflict over some resources. This condition, which we name exhaustivity, requires the sum of contestants' shares of resources to be always equal to their total value. In the empirical part we discuss a series of case studies where opposite sides of a conflict purchased weapons from the same supplier. We argue these to be empirical evidence that arms transfers are often led by pure economic gain.

This work can be extended in several directions. From a theoretical view point, one could analyze the incentives for trade of weapons between opposite sides of a conflict. In other words, each contestant would be both a seller and a buyer of weapons. Along these lines, one could study the incentives of a seller to be neutral or to participate in a conflict. The success function axiomatized in Bozbay and Vesperoni (2013) provides a framework for modeling. From an empirical view point, one could complement our case-based approach with statistical analysis from a broader sample. The Stockholm Institute for Peace Research provides an comprehensive database of international arms transfers to do so.

Appendix

Proof of Proposition 4.1.

Assume success functions as in (1). Under which conditions a buyer $i \in \{1, 2\}$ accepts an offer? If buyer $\neg i$ accepts, buyer i's payoff is $1/2 - p_i$ if accepts and 0 if rejects. Then, buyer i accepts if $p_i \leq 1/2$. If instead buyer $\neg i$ rejects, buyer i's payoff is $1 - p_i$ if accepts and 0 if rejects, hence buyer i accepts if $p_i \leq 1$. Suppose offers are such that only buyer i accepts, while $\neg i$ rejects. Buyer i accepts if $p_i \leq 1$, and buyer $\neg i$ rejects if $p_{\neg i} > 1/2$. The seller requires the highest payment which is accepted by buyer i and any payment which is rejected by buyer $\neg i$, i.e., $p'_i = 1$ and $p'_{\neg i} > 1/2$. It offers to i the minimum amount of weapons which guarantees absolute victory ($q'_i = \underline{q}$), and any amount $q'_{\neg i}$ to the other, as the offer to $\neg i$ is to be rejected. Given this, the seller's payoff is $\pi'_3 = 1 - c\underline{q}$. Consider now an offer profile such that both buyers accept. The seller requires the highest payment which is accepted by a buyer, i.e., $p''_1 = p''_2 = 1/2$, and delivers the minimum weapons $q''_1 = q''_2 = \underline{q}$. Given this, its payoff is $\pi''_3 = 1 - 2c\underline{q}$. Note that, if offers are such that both buyers reject, the seller's payoff is 0. If $c < 1/\underline{q}$, we have $\pi'_3 > \pi''_3$ and $\pi'_3 > 0$, and in an equilibrium we have that a buyer $i \in \{1, 2\}$ purchases $\underline{q}$ for a payment $p_i = 1$, while the other buyer $\neg i$ purchases no weapons. Conversely, if $c > 1/\underline{q}$ both buyers reject in equilibrium.

□

Proof of Proposition 4.2.

Assume success functions as in (2). Note that, if a buyer $i \in \{1, 2\}$ rejects an offer (q_i, p_i), its payoff is always 0. Suppose buyer i accepts the offer. Its payoff is $f(y_i)/(f(y_i) + 1) - p_i$ if buyer $\neg i$ rejects and $f(y_i)/(f(y_1) + f(y_2) + 1) - p_i$ if buyer $\neg i$ accepts. Suppose the seller wants buyer i to accept. Then, it charges the highest payment which is acceptable by i, i.e., $p'_i = f(y_i)/(f(y_i) + 1)$ if the seller wants only i to accept and $p''_i = f(y_i)/(f(y_1) + f(y_2) + 1)$ if the seller wants also $\neg i$ to accept. The seller charges $p''_{\neg i} = f(y_{\neg i})/(f(y_1) + f(y_2) + 1)$ if it wants $\neg i$ to accept, while it charges any $p'_{\neg i} > f(y_{\neg i})/(f(y_1)+f(y_2)+1)$ if it wants $\neg i$ to reject. By backward induction, the seller's indirect payoff is $\pi'_3(q_i) = f(q_i)/(f(q_i)+1) - cq_i$ if it makes an offer which only buyer $i \in \{1,2\}$ would accept, while it is $\pi''_3(q_1,q_2) = (f(q_1)+f(q_2))/(f(q_1)+f(q_2)+1) - c(q_1+q_2)$ if the offer is acceptable by both buyers. Note that, for any $q'_i = q''_1 + q''_2$, we have $\pi''_3(q''_1,q''_2) > \pi'_3(q'_i)$ if f is concave, $\pi''_3(q''_1,q''_2) < \pi'_3(q'_i)$ if f is convex and $\pi''_3(q''_1,q''_2) = \pi'_3(q'_i)$ if f is linear. If both buyers reject the offers the seller's payoff is always 0. Then, for any convex f, there exists $\hat{c} > 0$ such that in an equilibrium only one buyer purchases weapons if $c < \hat{c}$ and no buyer purchases weapons if $c > \hat{c}$. Conversely, for any concave f, there exists $\hat{c} > 0$ such that in an equilibrium each buyer purchases weapons if $c < \hat{c}$ and no buyer purchases weapons if $c > \hat{c}$.

□

Proof of Proposition 4.3.

Assume share functions to be as in (3). Suppose buyer a $i \in \{1,2\}$ accepts an offer (q_i, p_i). Its payoff is $f(q_i)/(f(q_1)+f(q_2)+f(q_1)f(q_2)) - p_i$ if buyer $\neg i$ accepts and $f(q_i)/(2f(q_i)+1) - p_i$ if buyer $\neg i$ rejects. If instead buyer i rejects the offer, its payoff is $1/(2f(q_{\neg i})+1) - p_i$ if buyer $\neg i$ accepts and $1/3 - p_i$ if buyer $\neg i$ rejects. Suppose the seller wants buyer i to accept. Then, it charges the highest payment which is acceptable by i, i.e., $p'_i = f(q_i)/(2f(q_i)+1) - 1/3$ if the seller wants only i to accept and $p''_i = f(q_i)/(f(q_1)+f(q_2)+f(q_1)f(q_2)) - 1/(2f(q_{\neg i})+1)$ if the seller wants also $\neg i$ to accept. By backward induction, the seller's indirect payoff is $\pi'_3(q_i) = f(q_i)/(2f(q_i)+1) - 1/3 - cq_i$ if it makes an offer which only buyer i would accept, while it is $\pi''_3(q_1,q_2) = f(q_i)/(f(q_1)+f(q_2)+f(q_1)f(q_2)) - 1/(2f(q_{\neg i})+1) - c(q_1+q_2)$ if the offer is acceptable by both buyers. Suppose f to be linear, i.e., $f(q_i) = 1 + q_i$. It is easy to verify that, for any $q'_i = q''_1 + q''_2$, we have $\pi'_3(q'_i) > \pi''_3(q''_1,q''_2)$. Then, there exist $\hat{c} > 0$ such that the seller wants only one buyer to accept for any $c < \hat{c}$, and both buyers to reject for any $c > \hat{c}$.

□

Proof of Theorem 4.1.

Assume exhaustive success functions. Under which conditions a buyer $i \in \{1,2\}$ accepts an offer? When buyer $\neg i$ refuses the offer, buyer i accepts if $p_i \leq s_i(q_i,0) - 1/2$. Conversely, when buyer $\neg i$ accepts, buyer i accepts if $p_i \leq s_i(q_i,q_{\neg i}) - s_i(0,q_{\neg i})$. Suppose offers are such that only one buyer $i \in \{1,2\}$ accepts. The seller charges the highest payment which buyer i accepts, i.e., $p'_i = s_i(q_i,0) - 1/2$, and any payment which buyer $\neg i$ rejects, i.e., $p_{\neg i} > s_{\neg i}(q_{\neg i}, i) - s_i(0,q_i)$. Then, the seller's payoff is $\pi'_3(q_i) = s_i(q_i,0) - 1/2 - cq_i$. Suppose now that offers are such that both buyers accept. The seller charges the highest payment each buyer $i \in \{1,2\}$ accepts, i.e., $p''_i = s_i(q_i,q_{\neg i}) - s_i(0,q_{\neg i})$. The seller's payoff is $\pi''_3(q_1,q_2) = s_1(0,q_2) - s_2(0,q_1) - cq_1 - cq_2$. By exhaustivity of success functions we have $s_2(0,q_1) = 1 - s_1(q_1,0)$, therefore $\pi''_3(q_1,q_2) = \pi'_3(q_1) + \pi'_3(q_2)$. If $\pi'_3(a) > 0$ for some $a \in [\underline{q}, \overline{q}]$, then $\pi''_3(a,a) > \pi'_3(a)$. Conversely, if $\pi'_3(a) < 0$ for all $a \in [\underline{q}, \overline{q}]$, then $\pi''_3(a,a) < \pi'_3(a)$. Then, there exist $\hat{c} > 0$ such that the seller wants both buyers to accept for any $c < \hat{c}$, and both buyers to reject for any $c > \hat{c}$.

□

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