

Openness of the Economy, Terms of Trade and Arms

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Abstract

It is estimated that world military spending in 2008 amounted to over 2.4 percent of the world's GDP. This corresponds to spending of \$217 per person in the world, an amount close to the GDP per capita of the poorest country in the world. Therefore, it is important for economists to understand the allocation of resources to this sector of the economy. We present a model that explores the determinants of a country's level of military spending. We show how greater gains from trade can lead to greater military expenditures in order to protect them. It is also found that expansion in the demand for a country's tradable commodities, i.e., an improvement in their terms of trade will impact defense spending. Several other propositions emerge from the model which are then empirically tested using both pooled, as well as time series data. The statistical results support the model's propositions.

Introduction

“In 128 BC a venturesome Chinese diplomat named Chang-k’ien traveled westward to ... Jaxartes where he discovered the easternmost fringes of the civilized Middle East. Thereafter, the Chinese maintained ... trading contacts with central Asia, until in 101 BC, Chinese armies conquered a string of oases as far as Jaxartes ... (which) led to the establishment of the caravan route between China and the Middle East-the so called “Silk Road” (McNeill, 1963).” As this passage suggests, the association between the development or extent of trading relationships and of a strong military capability is a long-standing one in history. Notable examples also include the Roman, Spanish and British empires.

It is estimated that world military spending in 2008 amounted to over 2.4 percent of the world’s GDP. This amounts to spending of \$217 per person in the world, an amount close to the GDP per capita of the poorest country in the world.¹ In fact, contrary to what may have been expected, the end of the Cold War saw only a relatively small reduction in real military spending. For example, world military expenditures in 2004 were estimated by SIPRI to have been just 6% lower in real terms than at the peak of the Cold War in 1987-1988. Since 1998, there appears again to be an increasing trend in spending. For example, the average annual rate in world military expenditures in the period between 1995 and 2004 was 2.4% in real terms. This period of time also marked an increase in international trade. If we look at the merchandise trade balance of the world as a share of world GDP, i.e., the sum of merchandise exports plus imports as a percentage of world GDP, we find that during this same period that military spending was rising, this index of trade openness rose at a rate of 3% per year.

Consequently, the first issue considered in this paper is how trade exposure and changes in the terms of trade of a country impact on the military capability of a nation. These improvements may come about not just exogenously, but may result from countries resorting to various economic, military or political means. Examples of some of these strategies include denying a competitor navigational access or rail transport, imposing on them higher access fees and employing preferential tariffs. Understanding the determinants of military spending is of considerable interest since a certain amount of military capability may be a necessary condition for the development and the survival of the state, not to mention that it has been used throughout history as a means to forcefully redistribute resources through conquest.

The economic literature on conflict has grown over the last decade. Some examples include Brito and Intriligator (1985), Skaperdas (1992, 2000), Grossman and Kim (1995), Garfinkel, et al. (2008), Hirshleifer (1988, 1995), Seiglie (1988), Powell (1993), Skaperdas and Syropoulos (2001) and Anderton, et al., (1999). Hirshleifer (1988) was one of the first to introduce conflict as an economic activity which is consistent with the realist notion of Morgenthau (1978) “that nations active in international politics are continually preparing for, actively involved in, or recovering from organized violence in the form of war.”

This paper differs from these in several respects. First, we assume that military capability is produced by utilizing inputs from a country’s endowments. Once a country arms, the resources used to produce them have no further value. As a result, this assumption leads to a country’s relative prices and therefore, welfare being impacted by their allocation of resources to the military sector. Since the general equilibrium prices in this model differ from the ones in the conventional model of a world without conflict, a country’s gains from trading with the rest of the world will also be different. Subsequently,

we explore how arms expenditures are affected as a country opens up to trade. Finally, we may view this paper's contribution as furthering the development of a theory of international trade in a world where conflict exists.

In exploring the issue of trade and security, the paper is organized as follows. First, Section I introduces conflict in an exchange economy and examines the effects on the military sector of opening an economy to international trade. This is followed by empirical results in Section II that tests these propositions. Finally, we conclude by discussing some other possible extensions in the field.

I. The Basic Model

i) The Autarky Case

Initially, we assume that both countries are in autarky and derive the Nash equilibrium levels of weapons for each. Later on, we introduce trade and examine how these expenditures are affected. Let us assume the representative individual of country A (*potential attacker*) and country D (*defender*) have the following Cobb-Douglas utility functions defined over two-commodities in the economy, W (wheat) and S (steel):

$$U_A = W_A^{\beta_A} S_A^{1-\beta_A}, \quad (1)$$

$$U_D = W_D^{\beta_D} S_D^{1-\beta_D}. \quad (2)$$

Let the total endowment of each good for the attacker be E_A^W and E_A^S , while for the defender the endowment of each is E_D^W and E_D^S units. Then denoting the autarky prices of

F and S by P_A^W and P_A^S for the attacker and P_D^W and P_D^S for the defender, the income I_i of each country before a conflict is:

$$I_A = P_A^W E_A^W + P_A^S E_A^S, \quad (3)$$

$$I_D = P_D^W E_D^W + P_D^S E_D^S. \quad (4)$$

We now want to introduce conflict and the need for spending on armaments to either use them to attack and confiscate an adversary's resources or to defend oneself against such a possibility. The amount that is seized by an attacker depends upon the amounts that both spend on security or military capability which we denote by F_i where $i=A, D$. To produce military capability each country must use inputs of their endowment of the two-goods. More specifically, to produce a unit of fighting capability requires that country A allocates a_A^W units of W and a_A^S units of S . Similarly, country D produces a unit of fighting capability by allocating a_D^W and a_D^S units of each commodity to it. Therefore, the production

function for military capability for each country is $F_A = \min \left\{ \frac{E_A^W}{a_A^W}, \frac{E_A^S}{a_A^S} \right\}$ and

$F_D = \min \left\{ \frac{E_D^W}{a_D^W}, \frac{E_D^S}{a_D^S} \right\}$, where a_i^j are the fixed unit input requirements in the production of

military capability. An interpretation of this type of production function is that to support troops requires both food in the form of wheat and weapons made of steel in fixed proportions.

Following Grossman and Kim (1995, 1996), the proportion retained by the defender depends upon the relative amount of defense versus attack effort. More specifically, the percentage retained of their endowment, r , or contest-success function is:

$$r = \frac{F_D}{F_D + F_A}. \quad (5)$$

Therefore, the defender retains r and the attacker $(1-r)$ of the value of the defender's endowment during an attack where:

$$(1-r) = \frac{F_A}{F_D + F_A}. \quad (6)$$

Finally, we assume that each country first chooses the amount to allocate to defense and attack (weapons) from their endowment. Then based on these amounts they choose the amounts of W and S to consume that maximizes their utility.

We proceed by solving the problem by backward-induction. Therefore, in the second stage the attacker maximizes equations (1) with respect to W_A and S_A subject to:

$$\begin{aligned} P_A^S S_A + P_A^W W_A &= P_A^W (E_A^W - a_A^W F_A) + P_A^S (E_A^S - a_A^S F_A) \\ &+ \left[P_A^W (E_D^W - a_D^W F_D) + P_A^S (E_D^S - a_D^S F_D) \right] (1-r) \end{aligned} \quad (7)$$

or denoting p_i as the relative price of S in terms of W for country i , i.e., $p_i = \frac{P_i^S}{P_i^W}$, we can

rewrite it as:

$$\begin{aligned} p_A S_A + W_A &= (E_A^W - a_A^W F_A) + p_A (E_A^S - a_A^S F_A) \\ &+ \left[(E_D^W - a_D^W F_D) + p_A (E_D^S - a_D^S F_D) \right] (1-r) \end{aligned} \quad (7')$$

Similarly, the defender maximizes equation (2) with respect to W_D and S_D subject to

$$P_D^S S_D + P_D^W W_D = \left[P_D^W (E_D^W - a_D^W F_D) + P_D^S (E_D^S - a_D^S F_D) \right] r, \quad (8)$$

or

$$p_D S_D + W_D = \left[(E_D^W - a_D^W F_D) + p_D (E_D^S - a_D^S F_D) \right] r, \quad (8')$$

where F_A and F_D are the amounts of weapons chosen in the first stage. Notice that the attacker is able to consume the value of their endowment net of the amount they require to use for fighting, plus the amount they confiscate from the defender after conflict. The defender is able to consume the portion of their endowment that is not confiscated net of the amount they require to use for fighting. Furthermore, the amount that is confiscated by the attacker is valued at the price of the commodity in the attacker's country. As equations (7) and (8) show, resources used for fighting are lost. One way to interpret this is that food to feed soldiers and ammunition expended during combat cannot be regained. Finally, note that expenditures by the attacker on fighting leaves less of their total endowment available for consumption, while increasing the fraction that they can confiscate from the defender. For the defender, military spending directly reduces the amount of their initial endowment available for consumption, but increases the amount retained if an attack occurs. Therefore, the effect on retained or acquired income is ambiguous.²

The solution to this maximization yields the following demand functions for W and S :

$$W_A = \beta_A \left\{ (E_A^W - a_A^W F_A) + p_A (E_A^S - a_A^S F_A) + \left[(E_D^W - a_D^W F_D) + p_A (E_D^S - a_D^S F_D) \right] (1-r) \right\} \quad (9)$$

$$S_A = (1 - \beta_A) \left\{ \frac{(E_A^W - a_A^W F_A)}{p_A} + (E_A^S - a_A^S F_A) + \left[\frac{(E_D^W - a_D^W F_D)}{p_A} + (E_D^S - a_D^S F_D) \right] (1-r) \right\} \quad (10)$$

$$W_D = \beta_D \left[(E_D^W - a_D^W F_D) + p_D (E_D^S - a_D^S F_D) \right] r \quad (11)$$

$$S_D = (1 - \beta_D) \left[\frac{(E_D^W - a_D^W F_D)}{p_D} + (E_D^S - a_D^S F_D) \right] r. \quad (12)$$

In order to determine the domestic relative price under autarky for each country, the quantity demanded for either commodity must be equal to its supply by Walras' law.

Therefore, focusing on the market for commodity W , the relative autarky price for the attacker, p_A , must satisfy

$$W_A + a_A^W F_A = E_A^W + (E_D^W - a_D^W F_D)(1-r). \quad (13)$$

while the relative price for the defender, p_D , must satisfy

$$W_D = (E_D^W - a_D^W F_D)r. \quad (14)$$

The left-hand side of equation (13) is the demand for W by the attacker for both consumption, as well as to support warfare, while the right-hand side is their endowment of the good plus the amount they confiscate from the unused portion available to the defender after the conflict. Similarly, equation (14) states that the autarky price for the defender must satisfy the condition that the quantity demanded of good W by them must be equal to the amount remaining after war. Substituting equations (9) and (11) and solving these two equations yields the equilibrium prices:

$$p_A = \left(\frac{1-\beta_A}{\beta_A} \right) \frac{(E_A^W - a_A^W F_A) + (E_D^W - a_D^W F_D)(1-r)}{(E_A^S - a_A^S F_A) + (E_D^S - a_D^S F_D)(1-r)} \quad (15)$$

$$p_D = \left(\frac{1-\beta_D}{\beta_D} \right) \frac{(E_D^W - a_D^W F_D)}{(E_D^S - a_D^S F_D)}. \quad (16)$$

We can see that in a world with conflict, prices are generally determined by not only taste and endowment, but also by the resources devoted to the military sector.³

Finally, inserting equations (9)-(12) into the respective utility functions given by equations (1) and (2) yields the following indirect utility functions that each country

maximizes by choosing F_A and F_D in the first stage, subject to equations (15) and (16) and

$$F_A \leq \min \left\{ \frac{E_A^W}{a_A^W}, \frac{E_A^S}{a_A^S} \right\}, F_D \leq \min \left\{ \frac{E_D^W}{a_D^W}, \frac{E_D^S}{a_D^S} \right\} \text{ respectively:}$$

$$U_A = \Gamma_A \left\{ (E_A^W - a_A^W F_A) + p_A (E_A^S - a_A^S F_A) + \left[(E_D^W - a_D^W F_D) + p_A (E_D^S - a_D^S F_D) \right] (1-r) \right\} p_A^{\beta_A - 1} \quad (17)$$

$$U_D = \Gamma_D \left[(E_D^W - a_D^W F_D) + p_D (E_D^S - a_D^S F_D) \right] r p_D^{\beta_D - 1}, \quad (18)$$

where $\Gamma_A = \beta_A^{\beta_A} (1 - \beta_A)^{1 - \beta_A}$ and $\Gamma_D = \beta_D^{\beta_D} (1 - \beta_D)^{1 - \beta_D}$. Notice that the solution for each country not only must maximize utility but it also has to be consistent in the sense that it clears the goods market. This model differs from others in that the country is taking into account the effects that their decision to arm has on relative prices of the final goods they consume and therefore, on their welfare.

ii) The Free Trade Case

If each country is open to trade and faces the relative world price $p = \frac{P^S}{P^W}$, then

each country maximizes their respective indirect utility functions in the first stage by

choosing F_A and F_D at this world price. Therefore, they maximize

$$U_A = \Gamma_A \left\{ (E_A^W - a_A^W F_A) + p (E_A^S - a_A^S F_A) + \left[(E_D^W - a_D^W F_D) + p (E_D^S - a_D^S F_D) \right] (1-r) \right\} p^{\beta_A - 1} \quad (19)$$

$$U_D = \Gamma_D \left[(E_D^W - a_D^W F_D) + p (E_D^S - a_D^S F_D) \right] r p^{\beta_D - 1}. \quad (20)$$

subject only to the production function constraints. If the constraints are not binding, then the reaction functions that emerge from the first-order conditions of maximizing equations (19) and (20) under free trade are:

$$F_A = \sqrt{\frac{i_D F_D - (a_D^W + a_D^S p) F_D^2}{(a_A^W + a_A^S p)}} - F_D \quad (21)$$

$$F_D = \sqrt{\frac{i_D F_A + (a_D^W + a_D^S p) F_A^2}{(a_D^W + a_D^S p)}} - F_A \quad (22)$$

where $i_D = E_D^W + pE_D^S$ is the real income of the defender in terms of W at world prices. If

both constraints are binding, then $F_i = \min \left\{ \frac{E_i^W}{a_i^W}, \frac{E_i^S}{a_i^S} \right\}$, while if one is and the other is not,

we replace the binding constraint for either (21) or (22) accordingly. It is interesting to note that the attacker's reaction function does not depend upon their endowment unless their constraint is binding. In other words, their demand for military capability does not depend upon their income unless their constraint is binding.

1) Some Comparative Statics

First, let us explore the effects of an increase in the real income of the defender on the amount spent on arms when both countries are open to trade. Differentiation of equations (21) and (22) and ruling out the trivial solution of $F_A = F_D = 0$ (where the contest success function is undefined) and the solution when the constraint is binding yields the following:

$$\frac{\partial F_A}{\partial i_D} = \frac{1}{2} \frac{F_D}{(F_A + F_D)(a_A^W + a_A^S p)} = \frac{1}{2} \frac{r}{(a_A^W + a_A^S p)} > 0, \quad (23)$$

$$\frac{\partial F_D}{\partial i_D} = \frac{1}{2} \frac{F_A}{(F_A + F_D)(a_D^W + a_D^S p)} = \frac{1}{2} \frac{(1-r)}{(a_D^W + a_D^S p)} > 0. \quad (24)$$

Therefore, an increase in the defender's income, holding p , the terms of trade constant, leads to a shifting out of both reactions functions. The defender's higher income increases the rewards to fighting for the attacker, i.e., at the previous level of F_A , the marginal gain from an additional amount spent on fighting is greater than the cost. As a result, expenditures on weapons are increased. For the defender, the increase in their income reduces the cost to fighting and thereby leads them to spend more on arms.

We next look at the effects of an increase in the terms of trade on arms expenditures.

Again differentiation of equations (21) and (22) yields the following:

$$\frac{\partial F_A}{\partial p} = \frac{1}{2} \left[\frac{i_D F_D - (a_D^W + a_D^S p) F_D^2}{(a_A^W + a_A^S p)} \right]^{\frac{1}{2}} \left[\frac{(a_A^W E_D^S - a_A^S E_D^W) F_D + (a_D^W a_A^S - a_D^S a_A^W) F_D^2}{(a_A^W + a_A^S p)^2} \right] \begin{matrix} \geq 0 \\ < 0 \end{matrix} \quad (25)$$

depending upon if $\frac{a_A^W}{E_D^W} > \frac{a_A^S}{E_D^S}$ and $\frac{a_D^W}{a_D^S} > \frac{a_A^W}{a_A^S}$

and

$$\frac{\partial F_D}{\partial p} = \frac{1}{2} \left[\frac{i_D F_A + (a_D^W + a_D^S p) F_A^2}{(a_D^W + a_D^S p)} \right]^{\frac{1}{2}} \left[\frac{(a_D^W E_D^S - a_D^S E_D^W) F_A}{(a_D^W + a_D^S p)^2} \right] \begin{matrix} \geq 0 \\ < 0 \end{matrix} \quad (26)$$

depending upon if $\frac{a_D^W}{E_D^W} > \frac{a_D^S}{E_D^S}$.

We can see that the effects of changes in the terms of trade will depend upon the endowments of the two commodities of the defender relative to their use in warfare by each country. If we assume that each country uses the same amount of both goods in warfare,

i.e., $a_i^j = a$ for $i = A, D$ and $j = W, S$, then the signs of equations (25) and (26) will only depend upon relative endowments. In this case, equations (25) and (26) become:

$$\frac{\partial F_A}{\partial p} = \frac{1}{2} \left[\frac{i_D F_D - a(1+p) F_D^2}{a(1+p)} \right]^{-\frac{1}{2}} \left[\frac{(E_D^S - E_D^W) F_D}{a(1+p)^2} \right] \begin{matrix} > 0 \\ < 0 \end{matrix} \quad (25')$$

$$\frac{\partial F_D}{\partial p} = \frac{1}{2} \left[\frac{i_D F_A + a(1+p) F_A^2}{a(1+p)} \right]^{-\frac{1}{2}} \left[\frac{(E_D^S - E_D^W) F_A}{a(1+p)^2} \right] \begin{matrix} > 0 \\ < 0 \end{matrix} \quad (26')$$

Keeping in mind that $p = \frac{P^S}{P^W}$, then when p increases, if the defender has a larger

endowment of S than W , i.e., $E_D^S > E_D^W$, then we can see that *both* countries will spend more on arms. This occurs because for the defender an increase in p results in an improvement in their terms of trade, and leads to an increase in the value to protecting this commodity from confiscation. Conversely, the opposite is true if the endowment of S is less than W . In this case, a worsening in the defender's terms of trade reduces the value to protecting this commodity from confiscation, while at the same time also decreasing its value to the attacker.

To give an example, suppose that commodity S is oil. Then when the terms of trade of an oil producing nation increases, they as well as their adversary, will spend more on arms, regardless of whether the adversary is also an oil producing country or not. More generally, as equations (25) and (26) show, the effect will depend upon the intensity of the use of the resource in warfare as well. The attacker will always increase arms spending if

$\frac{a_D^W}{a_D^S} > \frac{a_A^W}{a_A^S} > \frac{E_D^W}{E_D^S}$. For the oil example, this would be the case if the attacker requires

relatively more oil than the defender to conduct military operations and the defender is an oil producing nation (i.e., is relatively more abundant in oil).⁴

2) A Numerical Example

In order to provide some numerical results, let us assume that both countries have similar preferences given by $\beta_D = .5$ and $\beta_A = .5$ and our initial country endowments are such that the attacker is relatively more endowed with good S and the defender with good W .⁵ More specifically, let $E_A^W = 50$, $E_D^W = 100$, $E_A^S = 100$ and $E_D^S = 50$. Furthermore, we assume that the requirements for maintaining troops are equal and given by

$a_D^S = a_D^W = a_A^S = a_A^W = 1$. Substitution of these values yields an equilibrium price under autarky of $p_A = 0.71$ and $p_D = 2.63$. As shown in Table 1, the amounts spent on arming under autarky are $F_A = 14.7$ and $F_D = 19.3$.

Assuming the constraints are not binding, then under the same assumptions regarding preferences, endowments and technology, if each country now opens up to international trade at various prices the Nash equilibrium amount spent on arms are given in Table 1. First, note that opening up to trade always makes the defender better off since at different world prices the utility of the defender is always greater than that under autarky. As Figure 1 shows, the world price that minimizes their level of utility when both countries are completely open to trade is at $p = 2$. At this price, if both countries are open to trade the defender's level of utility, ($U_D=31.6$) is above that which would prevail if both countries were instead closed to international trade ($U_D=28.2$). From Table 1 we can see that as the defender's terms of trade improves the amount that they export and import increases. In this model of international trade with conflict, net exports of commodity S from the defender equals the difference between the amount of S that remains after they engage

country A and the amount they consumed, i.e., $(E_D^S - a_D^S F_D) r - S_D$, while similarly, their net exports of commodity W equals $(E_D^W - a_D^W F_D) r - W_D$.

We must also investigate the payoffs from the possible strategy that the defender or attacker may choose to remain closed to trade while the rest of the world is open to trade.⁶ Table 2 shows the different payoffs for remaining autarkic versus open to world trade at the specified prices. For example, if both countries are in autarky and the world price if they engage in trade with the rest of the world is $p = 0.5$, then we can see that the dominant strategy for country D is to open up to trade. Its level of utility U_D would increase from 28.2 to 40.5 at the new level of arms and transfers. In this situation, the equilibrium autarky price for the attacker would decline to $p_A = 0.68$ and its payoff to remaining closed declines to $U_A = 79.6$. But we can see that this is also not a dominant strategy for country A since if it opens up to international trade its level of utility would increase to 80.0. Note that at these terms of trade, the attacker prefers for both countries to continue to be closed, but assuming they cannot dictate country D's trade regime they are forced to open up. Similarly, if both countries are autarkic while the world price is 1, both countries are better off opening their economy to trade. For the defender, utility would increase from 28.2 to 32.9. If the attacker remained closed its domestic price would now be 0.69 and its level of utility would decline to 79.6. It is clear that under these circumstances it would also choose to open up to trade resulting in U_A increasing to 82.9. Similar outcomes continue to be the case at different world prices.

Furthermore, if their constraint is not binding, as the world price increases for the commodity that they have more in abundance, then the defender's expenditures on weapons increases. In our case, this implies a lower p . Table 3 presents the corresponding levels of

fighting at the different world prices. For example, in autarky the defender spends 19.3 of their resource on arms. As they open up to world trade at a price of 1, they increase their Nash equilibrium level of spending to 20.7. Finally, if their terms of trade improve further to 0.5 they now spend 23.0 on defense. This is what is expected from equation (25').

Conversely, as equation (26) shows, the impact of a change in the terms of trade of the attacker on the amount they spend on arms is more complex. It will depend not only on the relative endowments of the defender, and not on the attacker's, but it will also depend on the required inputs of the endowments to produce warfare, i.e., on the a_i^j 's. Since in our example, we have assumed that these are equal and that the defender is endowed with relatively more W , then as the attacker's terms of trade improves, by equation (26') they spend *less* on arms. Since they are endowed with relatively more of commodity S this implies an increase in p . We see that in autarky the attacker spends 14.7 on arms. As they open up to world trade at a price of 1, they decrease their Nash equilibrium level of spending to 12.8. Finally, if their terms of trade improve further to 3 they now spend only 10.7 on defense.

To summarize, an increase in the gains from trade as measured by the difference between a defender's relative autarky price and the world price for the commodity which they have a greater endowment of, leads to an increase in military spending. This increase in the value of the relatively more endowed commodity will increase the returns from using force to defend it. As a consequence, this leads nations to respond by acquiring more weapons to protect their endowment of these goods. In addition, as Table 1 shows this is also positively associated with the total volume of trade, i.e., exports plus imports. Finally, increases in real income should lead to greater military expenditures.

III. Empirical Evidence

The previous model shows that the degree of openness of an economy to international trade will have an impact on the level of military spending.⁷ In our model, equations (23) and (24) also yield that an increase in real income results in an increase in military spending. In fact, to examine the effects of the degree of openness of an economy on military spending, we want to control for any impact that trade has on national income by including it as a separate variable in our estimations. In addition, the reaction functions given by equations (21) and (22) indicate that the level of the adversary's military spending is important. There are other variables that have been found to have an effect on the size of the military sector. For example, Seiglie (1988, 1992) also finds that the level of international aggression or hostility directed at a country is also a determinant of military expenditures. In addition, for countries that are members of a military alliance increases in their allies' expenditures should reduce their "own" spending if free-riding exists as discussed by Sandler (1993).⁸ Therefore, we include other alliance members' military spending as an explanatory variable.

To control for whether a country is an attacker or defender we use a measure that captures the hostility of a country, the Conflict and Peace Data Bank (COPDAB) developed by Azar (1980a, 1980b). The COBDAB consists of approximately 500,000 international events that occurred from 1948 to 1978. Each event entry in the database lists the actor and target nation, the issue involved and the date of occurrence. The sources for this information are almost 100 regional and international publications. The data base consists of a ranking of events according to a predetermined scale aimed at quantifying the intensity of the event ranging from the most cooperative given a value of 1, such as the voluntary unification of nation-states to the most conflictful which is given a value of 15, an extensive

war act. In order to arrive at a level of aggression towards a country from the rest of the world, I take the average of the scaling of hostility from all countries in the database towards that particular country during the year. So for example, if a country has had three international interactions in a particular year: 1) war was declared against it by a neighboring country (scale=15), 2) a country strongly attacked it verbally (scale=10), 3) it formed a major strategic alliance with another country (scale=2), then the index of hostility for the year would be 9, $(15+10+2)/3$. This index was calculated for all the countries in the sample for the time period examined.

As a proxy for the gains from trade, we use an economy's openness to trade as a measure. Commonly employed measures of the degree of openness of a country's economy include the share of the sum of imports and exports to GNP, although other measures such as the share of imports or exports to GNP yield the same results since all three are very highly correlated. Since the terms of trade index for each country has a different base year, it is difficult to interpret the effects of this variable across countries. Instead we use the percentage change in a country's terms of trade. Therefore, using panel data will only allow us to test the effects of changes in the country's terms of trade on military spending.

The empirical test of these propositions is carried out at the country level. The sample employed is for the 36 countries where data for terms of trade are available during the time period from 1968-1978. This period was used for four reasons. First, the data on military expenditures and GNP were being gathered by the US Arms Control and Disarmament Agency and published in their World Military Expenditures and Arms Transfers. Second, this period covers part of the Cold War period where the Warsaw Pact nations were perceived as enemies by NATO countries. Third, this period allows for the use of COPDAB. Finally, the other possible source for data is from SIPRI, yet a recent change

in their methodology only allows consistent data on military spending beginning in 1988 and therefore, we miss most of the Cold War period. Table 4 presents summary statistics for the variables. The average level of military spending is \$6.2 billion dollars for these countries, while real GNP is \$148 billion dollars. Furthermore, the average level of an adversary's military expenditures is large since for a vast number of countries, including the NATO allies, the adversary was chosen to be the nations of the WARSAW Pact.

Using a fixed effects model, Table 5 reports the results from regressing a country's military spending in constant dollars on changes in its terms of trade, the degree of openness of their economy, GNP in constant dollars, their enemy's military expenditures, as well as their ally's and the amount of international hostilities directed towards it. These estimates are corrected for the presence of heteroscedasticity by taking the log of the military spending variables, as well as using White's heteroscedasticity-consistent covariance matrix.⁹ To account for the possible endogeneity of GNP either through the level of trade or military spending, the second regression specified excludes GNP. As can be seen the results are robust to its exclusion.

For the first regression, the coefficient for the variable capturing the openness of the economy is positive and significant at the 5-percent level. The estimated effect of a change in this variable is quite large. For example, a 20 percent increase in the degree of openness of the economy from its mean of 0.27 results in military spending increasing by \$139 million dollars annually. This higher level of spending is sustained so long as the country continues to be as open to world trade.

The coefficient for enemy's military spending is also positive and highly significant. We find that the coefficient for GDP is positive and significant as expected. In addition, the coefficient for the rate of change in the terms of trade is negative and significant at the

10% level. This could result if as a country's terms of trade improves wages increase, and the military sector responds by becoming less soldier-intensive. As a result, military payrolls would decline. The coefficient estimates for the COBDAB variable is found not to be significant in either specification. Although not reported, it should be noted that this variable is positive and significant when the intercept is constrained to being the same across countries, i.e., when a fixed effects model is not used. Seiglie (1991) also found this result.

Next, we look at time-series data for adversarial dyads. One problem with time series is that much of the data is incomplete and therefore, we concentrate only on the countries in adversarial relations where a long enough series is available. The data used are from the Penn World Table (Version 6.2), the IMF's International Financial Statistics and for military expenditures from the SIPRI Yearbook. Note that for time series we are able to use the terms of trade index for the specific country since the index has a consistent base year. As in the pooled-time series, there is the problem that we do not have any theoretical guide for the length of the lag structure for many of these variables including the effects of a change in the terms of trade on the arms procurement process. More specifically, there is no reason to expect that the decision is made contemporaneously, but may take several years for an improvement in the terms of trade to significantly affect the government's budget to allow for the added expenditures. Additionally, expectational issues, i.e., changes in expected income or in expected changes in the terms of trade could also have an effect on the procurement process.

Therefore, the results presented in Table 6 assumes the effects are contemporaneous since there is no justifiable specification of another lag structure, although it was found that lagging the variables improves the statistical significance considerably. The regressions are estimated using OLS. The issue of simultaneity in an arms race, i.e., the endogeneity of the

adversary's expenditures, can lead to estimates of the coefficients that may be biased and inconsistent. To avoid this problem, I use the one-year lagged military expenditure of the adversary (for an examination of the issues regarding the estimation of arms race model see Smith, et al., 2000). Furthermore, to capture any changes that may have occurred after the Cold War, a dummy variable was created taking on a value of one after 1991, and zero, otherwise.

For the specific countries involved in an adversarial relationship, the evidence is mixed. Note also that since data for Egypt is very incomplete we are not able to look at the dyadic expenditures in both directions. For all countries with the exception of India, the estimate for the coefficient of openness is positive as expected and statistically significant at the 5% level, while for Greece it is at the 10% level. This is important since we are holding the country's real GDP constant. This provides further evidence that more open economies tend to spend more on arms, holding other factors constant. The estimate for the coefficient of real GDP is positive and significant for three of the countries at the 5% level. Only for the case of Israel, do we get a negative coefficient although it is statistically insignificant. Therefore, military spending is a "normal" good. As for coefficient estimates for the terms of trade variable, the results are ambiguous; it is positive and statistically significant at the 5% level for Turkey and negative and significant at the 5% level for both Greece and Israel. This is consistent with the results shown by equations (25) and (26) which indicated that the sign of the variable depended upon the relative endowments and the production function for defense of the country.

For all the countries, own military spending is positively related to their defined adversary's and the coefficient for this variable is significant for four out of the five dyads.¹⁰ Finally, the end of the Cold War seems to have changed the structure of the Greek-Turkey

military spending relationship, as well as that of the India-Pakistan one. In all these cases with the exception of Turkish military spending, the end of the Cold War resulted in a decline in defense spending. In conclusion, using both panel data and time-series for specific dyads, it appears that there is empirical support for the model's proposition that greater trade leads to greater military spending.

V. Conclusions

There have been many studies that have examined the impact that trade has on conflict. Yet, if international trade is beneficial to a country, then a country may want to protect these gains from trade. This paper shows that world trade has implications for the size of the military sector of a country. A model is presented that shows how openness of an economy and gains from trade impact on the size of the military. It is also found that expansion in the demand for a country's tradable commodities, i.e., an improvement in their terms of trade can impact on defense spending.

Empirical results provide support for the proposition that opening up an economy to international trade leads to greater resources being diverted towards the military sector. Although less conclusive, they are also consistent with the proposition that military spending is impacted by improvements in a country's terms of trade. Yet, much more research has to be conducted not only on the trade account, but also on the impact that the capital account has on military spending. This latter issue has been largely neglected (see Polachek, Seiglie and Xiang, 2007 for an analysis of FDI and conflict). Given the degree of development in the world capital markets and the extent that nations in the international system are integrated in it, we cannot fail to neglect the impact of the capital account in our future research.

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Figure 1: Utility of Defender for different world prices. Minimum utility is 31.6 when $p=2$.

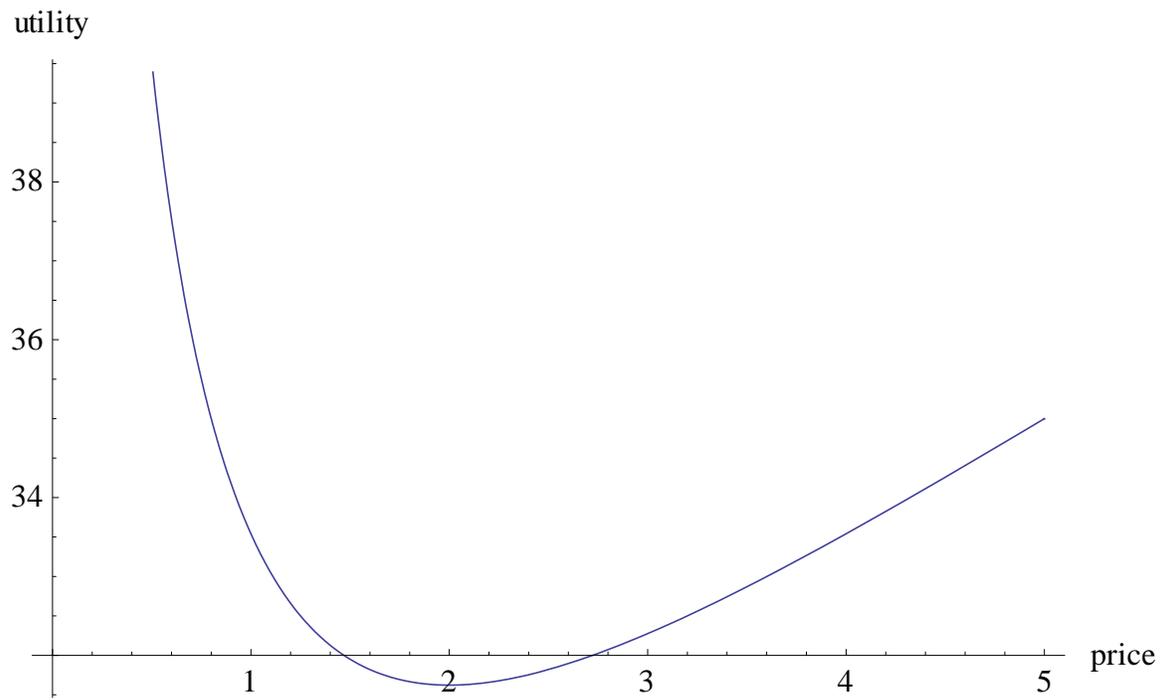


Figure 2: Utility of Attacker for different world prices. Minimum utility is 79.8 when $p=0.58$.

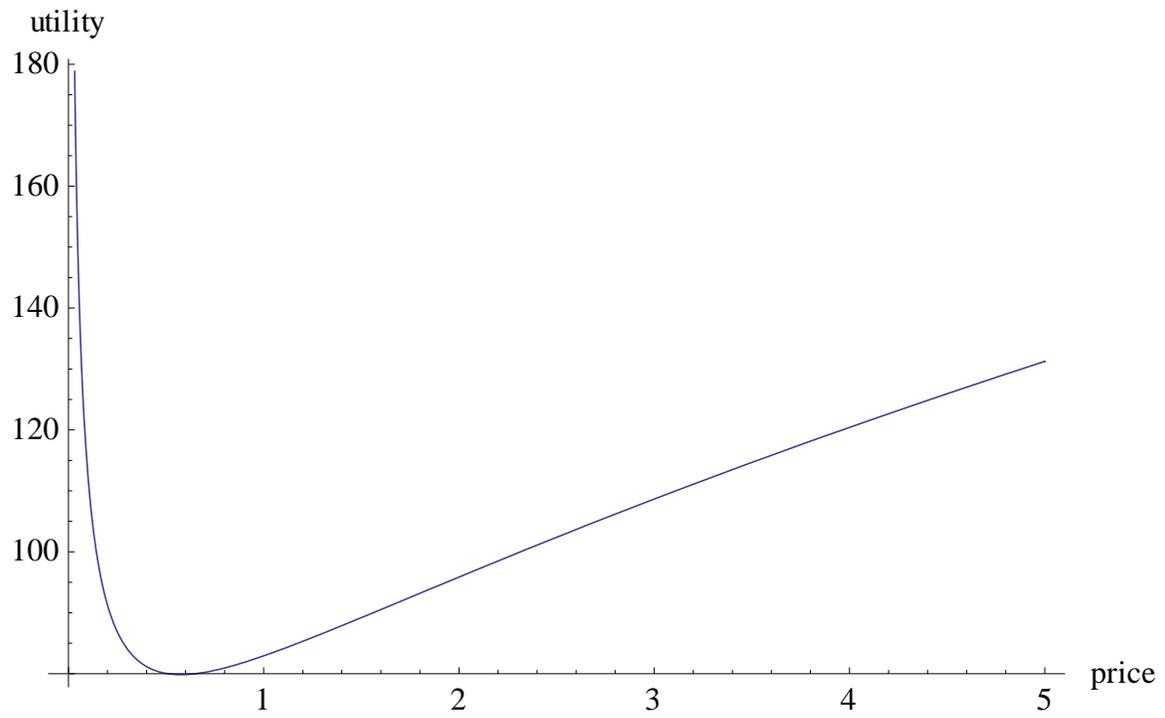


Table 1. Effects on trade and military spending from varying gains from trade.

$$X_A^W = \text{Exports of W from A} = (E_A^W - a_A^W F_A) + (E_D^W - a_D^W F_D)(1-r) - W_A$$

$$X_A^S = \text{Exports of S from A} = (E_A^S - a_A^S F_A) + (E_D^S - a_D^S F_D)(1-r) - S_A$$

$$X_D^W = \text{Exports of W from D} = (E_D^W - a_D^W F_D)r - W_D$$

$$X_D^S = \text{Exports of S from D} = (E_D^S - a_D^S F_D)r - S_D$$

$$\beta_A = \beta_D = .5, a_D^W = a_D^S = a_A^W = a_A^S = 1, E_A^W = 50, E_A^S = 100, E_D^W = 100, E_D^S = 50.$$

p	$p_A = .71$ $p_D = 2.63$	$p = .5$	$p = 1$	$p = 3$
F_A	14.7	14.2	12.8	10.7
F_D	19.3	23.0	20.7	17.3
M_A	70.2	56.6	82.9	188.2
S_A	98.6	113.2	82.9	62.7
M_D	63.3	28.0	33.5	55.9
S_D	24.1	55.9	33.5	18.6
U_A	83.2	80.0	82.9	108.7
U_D	28.2	39.5	33.5	32.3
(X_A^W, X_A^S)	(0, 0)	(8.6, -17.1)	(-15.5, 15.5)	(-117.3, 39.1)
(X_D^W, X_D^S)	(0, 0)	(19.6, -39.2)	(15.5, -15.5)	(-4.8, 1.59)

Table 2. Utility Payoffs (U_A , U_D) under different scenarios.

		Country D			
		Autarky $p_D = 2.63$	$p = 0.5$	$p = 1$	$p = 3$
Country A	Autarky $p_A = 0.71$	(83.2, 28.2)	(79.6, 40.5) $p_A = 0.68$	(79.6, 32.9) $p_A = 0.69$	(79.6, 28.9) $p_A = 0.72$
	$p = 0.5$		(80.0, 39.5)		
	$p = 1$			(82.9, 33.5)	
	$p = 3$				(108.7, 32.3)

Table 3: Levels of weapons (F_A, F_D) under different scenarios.

		Country D			
		Autarky $p_D = 2.63$	$p = 0.5$	$p = 1$	$p = 3$
Country A	Autarky $p_A = 0.71$	(14.7, 19.3)	(13.4, 22.6) $p_A = 0.68$	(13.9, 21.3) $p_A = 0.69$	(14.8, 19.0) $p_A = 0.72$
	$p = 0.5$		(14.2, 23.0)		
	$p = 1$			(12.8, 20.7)	
	$p = 3$				(10.7, 17.3)

Table 4. Summary Statistics

Variable	Mean	Standard Deviation
Military Expenditures	6,261	20,183
Changes in the Terms of Trade	1.30	16.7
Openness of the Economy	0.27	0.18
GNP	147,556	335,783
Ally's Military Expenditure	60,528	85,740
Adversary's Military Expenditure	69,146	81,636
Foreign Aggression	6.2	1.20
Number of Observations	379	379

Notes: The data for military expenditures are from various issues of the US Arms Control and Disarmament Agency, World Military Expenditures and Arms Transfers. Trade data are taken from the World Bank's World Tables. To be consistent with the exchange rate used to calculate military expenditures the data on GNP was obtained from the US Arms Control and Disarmament Agency. All data are in millions of 1978 constant dollars. The sample of countries are the following: United States, Canada, United Kingdom, France, West Germany, Netherlands, Belgium, Denmark, Switzerland, Italy, Greece, Turkey, Norway, Australia, New Zealand, Spain, Dominican Republic, Jamaica, El Salvador, Nicaragua, Colombia, Venezuela, Ecuador, Peru, Argentina, South Africa, Tanzania, Nigeria, Libya, Syria, Israel, Japan, India, Pakistan, Thailand, Singapore and the Philippines.

Table 5. Results of Regressing Real Military Expenditures Using Pooled Data from 1968-1978.

Independent Variables	ln(Expenditure) Fixed-Effects Model	ln(Expenditure) Fixed-Effects Model
Terms of Trade	-0.001 * (1.81)	-0.001 * (1.75)
Openness of the Economy	0.41 ** (3.47)	0.45 ** (3.76)
GNP	4.4×10^{-7} ** (2.57)	
ln(Enemy's Expenditure)	0.32 ** (9.84)	0.33 ** (10.4)
Ally's Expenditure	-9.84×10^{-7} * (1.76)	-1.54×10^{-6} ** (3.00)
Foreign Aggression	-0.01 (1.17)	-0.01 (1.21)
Number of Observations	379	379

Notes: The t-ratios are shown in parentheses below coefficients.

** denotes significant at the 5% level.

* denotes significant at the 10% level.

Table 6. Results of Regressing Real Military Expenditures on Adversary's Real Military Spending, Openness of the Economy and Other Variables.

Country (Adversary)	Israel (Egypt)	Greece (Turkey)	India (Pakistan)	Pakistan (India)	Turkey (Greece)
Independent Variables					
Constant	2764.7 (1.71)	298.8 (1.29)	5.53 (0.57)	-50.0 (1.95)	-222.4 (2.49)
Openness of the Economy	34.11* (4.57)	3.48 (1.37)	-1.48* (3.73)	1.59* (2.14)	2.85* (2.65)
Adversary's Real Military Spending	2.78* (5.64)	0.85* (2.18)	0.03 (0.71)	0.33* (0.56)	0.17* (2.90)
Terms of Trade	-33.8* (2.28)	-3.44* (2.24)	-0.05 (0.93)	-5.75 (0.34)	1.21* (3.69)
Country's Real GDP	-0.01 (0.19)	0.04* (4.60)	0.04* (6.59)	0.06* (3.26)	0.01 (0.47)
Cold War	15.5 (0.04)	-222.6* (7.51)	-8.18* (2.00)	-18.1** (1.87)	51.6 (2.31)
Adjusted R²	0.81	0.89	0.90	0.90	0.63
F-Statistic	38.4	80.5	75.1	46.9	13.3
Number of Observations	44	49	41	27	37

Notes: The t-ratios are shown in parentheses below coefficients.

** denotes significant at the 5% level.

* denotes significant at the 10% level.

Footnotes

¹ The data is from the Stockholm International Peace Research Institute. The IMF estimates that per capita GDP for Zimbabwe was \$268 dollars at purchase power parity in 2008.

² For example, letting $e_D = \left[(E_D^W - a_D^W F_D) + p_D (E_D^S - a_D^S F_D) \right] r$,

$$\frac{\partial e_D}{\partial F_D} = -(a_D^W + a_D^S p_D) r + \frac{e_D(1-r)}{r(F_D + F_A)} \stackrel{\geq}{<} 0.$$

³ Note that if both country's endowment and fighting technology are the same, i.e. if $E_D^S = E_D^W = E_A^S = E_A^W$ and $a_D^S = a_D^W = a_A^S = a_A^W$, then $p_i = (1 - \beta_i) / \beta_i$ for $i=A, D$ and prices are governed only by tastes.

⁴ It is interesting to note that if the defender has the same endowments of each good, both countries expenditures on the military are invariant to world prices. In other words, world prices do not affect the Nash equilibrium level of expenditures. This can be seen by replacing $E_D^W = E_D^S = E_D$ in the reaction functions (21) and (22) and continuing to assume $a_D^S = a_D^W = a_A^S = a_A^W = 1$ yielding:

$$F_A = \sqrt{E_D F_D - F_D^2} - F_D \quad (21')$$

$$F_D = \sqrt{E_D F_A + F_A^2} - F_A \quad (22')$$

⁵ Note that $F_A = F_D = 0$ is a Nash equilibrium for all values of β and therefore, we concentrate only on the interior solutions.

⁶ There have been a couple of countries that have adopted this strategy in recent past. They include Albania under Enver Hoxha and to an extent, North Korea under Kim Jong-il and his father.

⁷ Empirically, real military spending for country i is equal to $(a_i^W + a_i^S p) F_i$ in the model.

⁸ The model presented also yields this result if we modify the contest success functions given by equations (5) and (6) by introducing a third country allied with either A or D. For example, if we denote the ally by N and it is allied with D, then (5) becomes

$r = \frac{F_D + F_N}{F_D + F_A + F_N}$. The resulting Nash equilibrium level of military spending for the defender declines.

⁹ The regression estimates in real constant levels (not logs) while correcting for heteroscedasticity using White's matrix is:

$$\begin{aligned} \text{MILITARY SPENDING} = & 871.2 \text{ OPEN} - 6.43 \text{ AGGRESSION} + .01 \text{ ENEMY'S} \\ & (5.25) \quad (1.01) \quad (1.94) \\ & - .01 \text{ ALLY'S} - .20 \text{ TOT} \\ & (1.66) \quad (0.66) \end{aligned}$$

¹⁰ See Seigle (1996) and Seigle and Liu (2002) for an analysis of arms races and causality tests.