Openness of the Economy, Terms of Trade, and Arms

Carlos Seiglie*

It is estimated that world military spending in 2011 amounted to over 2.5% of the world’s Gross Domestic Product (GDP). This corresponds to a spending of $233 per person in the world at 2010 constant prices, 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. I present a model that explores the determinants of a country’s level of military spending. I show how greater gains from trade can lead to greater military expenditures to protect them. It is also found that expansion in the demand for a country’s tradable commodities, that is, an improvement in that country’s terms of trade, will impact defense spending. Several other propositions emerge from the model which are then empirically tested using both pooled and time series data. The statistical results support the model’s propositions.

JEL Classification: D74, F51, F52, H56

1. 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, (when) 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 2011 amounted to over 2.5% of the world’s GDP. This amounts to a spending of $233 per person in the world at 2010 constant prices, 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 the Stockholm International Peace Research Institute (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. Looking at the merchandise trade balance of the world as a share of world

*Rutgers University, Department of Economics, 360 King Blvd., Newark, NJ, 07102, USA; E-mail: seiglie@andromeda.rutgers.edu; corresponding author.

Received January 2013; accepted January 2015.

1 The data is from the Stockholm International Peace Research Institute. The International Monetary Fund estimates that per capita GDP for Zimbabwe was $268 dollars at purchase power parity in 2008.
GDP, that is, the sum of merchandise exports plus imports as a percentage of world GDP, I 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 article is how trade exposure and changes in the terms of trade of a country impact the military capability of a nation. These changes 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 higher access fees on them, 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, 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); Polachek (1980, 1992); Skaperdas (1992); Grossman and Kim (1995); Garfinkel, Skaperdas, and Syropoulos (2008); Hirshleifer (1988, 1995); Seiglie (1988, 1992); Powell (1993); Skaperdas and Syropoulos (2001); Reuveny and Maxwell (1998); Reuveny (2000); Mintz and Heo (2014); and Anderton, Anderton, and Carter (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 article differs from these in several respects. First, I assume that military capability is produced using inputs from a country’s endowments. Once a country arms, the resources used to produce said armaments have no further value. As a result, this assumption leads to a country’s relative prices and, therefore, welfare being impacted by its 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, I explore how arms expenditures are affected as a country opens up to trade. Finally, I may view this article’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 article is organized as follows. First, section 2 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 3, which test these propositions. Finally, I conclude by discussing some other possible extensions in the field.

2. The Basic Model

The Autarky Case

I assume that there are four countries, with two of these countries being military adversaries. One of these countries seeks to confiscate the resources of the other, which as a result is forced to protect itself by arming. I designate one as being an attacker and the other as a defender. The other two remaining countries are each in a military alliance with either the attacker or the defender. They contribute arms to each ally in the event of a conflict but the amount provided is fixed. Therefore, the two countries involved in the conflict view the amount of arms provided by their ally as exogenous. Initially, I assume that both countries are in autarky and derive the Nash equilibrium levels of weapons for each. Later on, I introduce trade and examine how these expenditures are affected.
Let us assume the representative individuals of country A (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 \( W \) 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 quantity that is seized by an attacker depends upon the amounts that both spend on security or military capability, as well as the amounts provided by allies such as NATO or the Warsaw Pact. I denote these amounts for the adversary, defender, and allies, respectively, by \( F_i \), where \( i = A, D, N, R \). We assume that the attacker is allied with country R and the defender with country N. To produce military capability, each country must use inputs of its 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. 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 \( a_i' \) are the fixed unit input requirements in the production of military capability. An interpretation of this type of production function is that supporting troops requires both food in the form of wheat and weapons made of steel in fixed proportions.

Extending Grossman and Kim (1995, 1996) to include an ally’s spending, the proportion retained by the defender depends upon the amount of military spending by both the country and its ally, \( N \), relative to total military effort by all parties. More specifically, the percentage retained of his endowment, \( r \), or contest-success function is:

\[ r = \frac{F_D + F_N}{F_D + F_A + F_N + F_R}. \quad (5) \]

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

\[ (1-r) = \frac{F_A + F_R}{F_D + F_A + F_N + F_R}. \quad (6) \]

I assume that the allies’ spending is exogenous to each country. Finally, I assume that each country first chooses the amount to allocate to defense and attack (weapons) from its endowment. Then, based on these amounts, it chooses to consume the amount of \( W \) and \( S \) that maximizes its utility.

I proceed by solving the problem by backward-induction. Therefore, in the second stage, the attacker maximizes Equation 1 with respect to \( W_A \) and \( S_A \) subject to:
\[ P^W_A S^W_A + P^W_A W_A = P^W_A (E^W_A - a^W_A F_A) + P^S_A (E^S_A - a^S_A F_A) + [P^W_A (E^W_D - a^W_D F_D) + P^S_A (E^S_D - a^S_D F_D)](1-r) \]  
(7)

where \( F_A \) and \( F_D \) are the amounts of weapons chosen in the first stage. Denoting \( p_i \) as the relative price of \( S \) in terms of \( W \) for country \( i \), that is, \( p_i = \frac{p_i^S}{p_i^W} \), I can rewrite Equation 7 as:

\[ p_A S_A + W_A = (E^W_A - a^W_A F_A) + p_A (E^S_A - a^S_A F_A) + [(E^W_D - a^W_D F_D) + p_A (E^S_D - a^S_D F_D)](1-r) \]  
(7')

Equation 7 indicates that the attacker is able to consume the value of his endowment of each commodity, \( P^W_A E^W_A \) and \( P^S_A E^S_A \), net of the amount he requires to use for fighting of each, \( P^W_A a^W_A F_A \) and \( P^S_A a^S_A F_A \), plus the amount he confiscates from the defender after the conflict, \([P^W_A (E^W_D - a^W_D F_D) + P^S_A (E^S_D - a^S_D F_D)](1-r)\). Note that the amount that is confiscated of the defender’s endowment of each commodity, \( i \), \( P^A_i E^i_D \) is net of what the defender had to expend of each commodity in the conflict, \( P^A_i a^i_D F_D \) and \( P^A_i a^i_D F_D \), respectively. Furthermore, the amount that is confiscated by the attacker is valued at the price of the commodity in the attacker’s country.

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

\[ P^S_D S_D + P^W_D W_D = [P^W_D (E^W_D - a^W_D F_D) + P^S_D (E^S_D - a^S_D F_D)]r, \]  
(8)

or

\[ p_D S_D + W_D = [(E^W_D - a^W_D F_D) + p_D (E^S_D - a^S_D F_D)]r, \]  
(8')

where again \( F_A \) and \( F_D \) are the amounts of weapons chosen in the first stage. The defender is able to consume the portion of his endowment that is not confiscated net of the amount he requires to use for fighting. 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 leave less of his total endowment available for consumption, while increasing the fraction that he can confiscate from the defender. For the defender, military spending directly reduces the amount of his initial endowment available for consumption, but increases the amount retained if an attack occurs. Therefore, the effect on retained or acquired income is ambiguous.  

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

\[ W_A = \beta_A \{(E^W_A - a^W_A F_A) + p_A (E^S_A - a^S_A F_A) + [(E^W_D - a^W_D F_D) + p_A (E^S_D - a^S_D F_D)](1-r)\} \]  
(9)

\[ S_A = (1 - \beta_A) \left[ \frac{(E^W_A - a^W_A F_A)}{p_A} + (E^S_A - a^S_A F_A) + \left[ \frac{(E^W_D - a^W_D F_D)}{p_A} + (E^S_D - a^S_D F_D) \right](1-r) \right] \]  
(10)

\[ W_D = \beta_D \{(E^W_D - a^W_D F_D) + p_D (E^S_D - a^S_D F_D)\}r \]  
(11)

\[ S_D = (1 - \beta_D) \left[ \frac{(E^W_D - a^W_D F_D)}{p_D} + (E^S_D - a^S_D F_D) \right]r. \]  
(12)

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

\[ W_A + a^W_A F_A = E^W_A + (E^W_D - a^W_D F_D)(1-r), \]  
(13)

while the relative price for the defender, \( p_D \), must satisfy

\[ \frac{\text{For example, letting } e_D = [(E^W_D - a^W_D F_D) + p_D (E^S_D - a^S_D F_D)]r, \frac{\text{letting } e_D}{\text{letting } e_D} = \frac{\text{letting } e_D}{\text{letting } e_D} - (a^W_D + a^S_D p_D)r \geq 0.} \]
If each country is open to trade and faces the relative world price, \( p \), The Free Trade Case

11 and solving these two equations yields the equilibrium prices:

\[
W_D = (E_D^W - a_D^W F_D) r.
\]

The left-hand side of Equation 13 is the demand for \( W \) by the attacker for both consumption and warfare, while the right-hand side is his endowment of the good plus the amount he confiscates 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 him must be equal to the amount remaining after war. Substituting Equations 9 and 11 and solving these two equations yields the equilibrium prices:

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

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

Notice 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. Note that if both countries’ endowment and fighting technology are the same, that is, if \( E_D^A = E_D^W = E_A^S = E_A^W \) and \( a_D^A = a_D^W = a_A^S = a_A^W \), then \( p_i = (1 - \beta_i)/\beta_i \) for \( i = A, D \) and prices are governed only by tastes. 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:

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

\[
U_D = \Gamma_D \{ (E_D^W - a_D^W F_D) + p_D (E_D^S - a_D^S F_D)] r p_D^{\beta_D - 1}
\]

where \( \Gamma_A = \beta_A (1 - \beta_A)^{-1} \) and \( \Gamma_D = \beta_D (1 - \beta_D)^{-1} \). Notice that the solution for each country must not only maximize utility, but it must also 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 effect that its decision to arm has on relative prices of the final goods it consumes, and therefore, on its welfare.

The Free Trade Case

If each country is open to trade and faces the relative world price, \( p = \frac{p_A}{p_D} \), then each country maximizes its respective indirect utility functions in the first stage by choosing \( F_A \) and \( F_D \) at this world price. Therefore, they maximize

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

\[
U_D = \Gamma_D \{ (E_D^W - a_D^W F_D) + p (E_D^S - a_D^S F_D)] r p_D^{\beta_D - 1}
\]

The reaction functions that emerge from the first-order conditions of maximizing Equations 19 and 20 under free trade are the following:

\[
F_A = \sqrt{\frac{i_D (F_D + F_N) - a_D F_D^2 - a_D F_D F_N}{a_A}} - F_D - F_N - F_R
\]
For the defender, differentiation of Equation 22 yields

\[ F_D = \frac{a_D F_A^2 + a_D F_A F_N + i_D F_A + 2a_D F_A F_R + a_D F_N F_R + i_D F_R + a_D F_R^2}{a_D} - F_A - F_N - F_R \]  

(22)

where \( a_D = (a_D^W + a_D^S p) \), \( a_A = (a_A^W + a_A^S p) \), and where \( i_D = E_D^W + p E_D^S \) is the real income of the defender in terms of \( W \) at world prices. Equations 21 and 22 are the demands for weapons by the attacker and the defender. They are a function of the military spending of their adversary, the military spending of the adversary’s ally, as well as on the spending of their own ally. In addition, military spending depends upon the real income of the defender and relative prices.

3. 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 yields the following:

\[ \frac{\partial F_A}{\partial i_D} = \frac{F_D + F_N}{2a_A \sqrt{\left( i_D (F_D + F_N) - a_D F_D^2 - a_D F_D F_N \right) / a_A}} > 0, \]  

(23)

\[ \frac{\partial F_D}{\partial i_D} = \frac{F_A + F_R}{2 \sqrt{a_D^2 F_A^2 + a_D^2 F_A F_N + a_D^2 i_D F_A + 2a_D^2 F_A F_R + a_D^2 F_N F_R + a_D^2 F_R^2 + a_D^2 F_R^2}} > 0. \]  

(24)

Therefore, an increase in the defender’s income, holding \( p \), the terms of trade, constant leads to a shifting out of both reaction functions and an increase in the Nash-equilibrium amount of spending. The defender’s higher income increases the rewards to fighting for the attacker, that is, 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 his income reduces the cost to fighting and thereby leads him 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 Equation 21 and rearranging yields the following:

\[ \frac{\partial F_A}{\partial p} = \frac{(a_A^W - a_A^S p)(E_D^W - a_D^S p F_D) + 2a_A^S (a_D^W F_D - E_D^W)) (F_D + F_N)}{2a_A^2 \sqrt{i_D (F_D + F_N) - a_D^2 F_D^2 - a_D^2 F_D F_N}} \] \[ > 0. \]  

(25)

The impact of a change in the terms of trade on the attacker’s acquisition of arms is more complex. The reason is that an increase in the relative price of the commodities used in warfare has offsetting effects. The increase in the relative price raises the value to the attacker of the confiscated commodity whose relative price has increased, and therefore, he wishes to spend more on arms. Conversely, if the commodity is one which is used more intensely in battle, then the increase in price leads to an incentive to use less of it to conduct war and more of it for consumption. Furthermore, from Equation 25, we can see that the second term in the numerator is negative. The first term in the numerator can be either positive or negative depending upon the sign of \( (a_A^W - a_A^S p) \). This term will always be negative if \( p > \frac{a_A^W}{a_A^S} \), that is, if the terms of trade are greater than the cost of producing warfare with \( W \) instead of with \( S \). If this is the case, then the sign is unambiguously negative, meaning that an increase in the terms of trade reduces the amount spent on arms.

For the defender, differentiation of Equation 22 yields
It is interesting to note that if the defender has the same endowment of each good, and both countries require the
endowments of the two commodities of the defender, relative to his use of them in warfare. To give an example, suppose that commodity $S$ is steel and commodity $W$ is wheat. As
Equation 26 shows, for the general case, the effect will depend upon the intensity of the use of the resource in warfare. The attacker will always reduce arms spending if the relative price of steel is greater than the relative cost of producing war with steel instead of wheat. In the defender’s case, he will reduce military spending if the proportion of the steel required for warfare relative to its endowments is greater than the amount of the wheat relative to its endowments.$^3$

I now want to analyze the effects of an exogenous increase in either ally’s military spending. Again, differentiating Equations 21 and 22 yields:

$$
\frac{\partial F_D}{\partial p} = \frac{(a_D^W E_D^S - a_D^S E_D^W)(F_A + F_R)}{2 a_D \sqrt{a_D^W F_A^2 + a_D^S F_A F_N + a_D^S I_D^F_F_A + 2 a_D^S F_A F_R + a_D^S F_N F_R + a_D^D F_R + a_D^S F_R^2}} > 0, 
$$

(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 a change in the terms of trade will depend upon the endowments of the two commodities of the defender, relative to his use of them in warfare. To give an example, suppose that commodity $S$ is steel and commodity $W$ is wheat. As
Equation 26 shows, for the general case, the effect will depend upon the intensity of the use of the resource in warfare. The attacker will always reduce arms spending if the relative price of steel is greater than the relative cost of producing war with steel instead of wheat. In the defender’s case, he will reduce military spending if the proportion of the steel required for warfare relative to its endowments is greater than the amount of the wheat relative to its endowments.$^3$

$$
\frac{\partial F_D}{\partial F_R} = -1
$$

(27)

$$
\frac{\partial F_D}{\partial F_N} = \frac{a_D(F_A + F_R)}{2D \sqrt{a_D^W F_A^2 + a_D^S F_A F_N + a_D^S I_D^F_F_A + 2 a_D^S F_A F_R + a_D^S F_N F_R + a_D^D F_R + a_D^S F_R^2}} - 1 < 0. 
$$

(28)

If a country’s ally increases military spending, the effect is to reduce the amount spent by the country whether it is the attacker or the defender. The increase in the ally’s spending leads to greater defense or attack capability for either country and leads to a substitution of consumption for arms. This tendency to “free ride” is greater for the attacker than it is for the defender.

4. 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. Empirically, real military spending for country $i$ is equal to $(a_i^W + a_i^S p)F_i$ in the 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, and the results given by Equations 27 and 28 indicate that a country’s

---

$^3$ It is interesting to note that if the defender has the same endowment of each good, and both countries require the same fixed amount of each good in the production of fighting, then 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 in Equations 21 and 22 and for simplicity assume $a_D^W = a_D^S = a_D^W = 1$. This yields:

$$
F_A = \sqrt{E_D(F_D + F_N) - F_D F_N - F_D - F_R}
$$

(21')

$$
F_D = \sqrt{F_A^2 + F_A F_N + E_D F_A + 2F_A F_R + F_N F_R + E_D F_R + F_R^2 - F_A - F_R}
$$

(22')
military spending should be inversely related to the spending level of its allies. Sandler (1993) has discussed this in the context of the “free-riding” problem in military alliances. Therefore, I include other alliance members’ military spending as an explanatory variable. Finally, we want to control for regime type since it is possible that democracies spend less on arms than autocracies do. In my model, it amounts to testing for differences in taste as represented by the parameters of a country’s utility function.

As a proxy for the gains from trade, I use an economy’s openness to trade as a measure. Commonly used measures of the degree of openness of a country’s economy include the share of the sum of imports and exports to Gross National Product (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, I use the percentage change in a country’s terms of trade. Therefore, using panel data will only allow me to test the effects of changes in the country’s terms of trade on military spending. The data for the regime type is obtained from the Policy IV Project Marshall (2014) which gives an annual “Polity score” for 167 countries. The score ranges from 2 to 10, which is a hereditary monarchy, to 10, which is a consolidated democracy. It is calculated by taking into account such measures as the constraints on executive authority and the political competition that are allowed in the country.

The empirical test of these propositions is carried out at the country level. The sample used is for the 36 countries where data for terms of trade are available during the time period from 1968 to 1978. This period was used for three reasons. First, the data on military expenditures and GNP were being gathered by the U.S. 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. 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, I miss most of the Cold War period. Table 1 presents summary statistics for the variables. The average level of military spending is $6.6 billion for these countries, while real GNP is $155.5 billion. 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.

### Table 1. Summary Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Max</th>
<th>Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Military Expenditures</td>
<td>6,600</td>
<td>20,811</td>
<td>148,920</td>
<td>5</td>
</tr>
<tr>
<td>Changes in the Terms of Trade</td>
<td>1.42</td>
<td>17.20</td>
<td>204</td>
<td>-38</td>
</tr>
<tr>
<td>Openness of the Economy</td>
<td>0.26</td>
<td>0.19</td>
<td>1.70</td>
<td>0.04</td>
</tr>
<tr>
<td>Real GNP</td>
<td>155,465</td>
<td>345,525</td>
<td>2,132,900</td>
<td>1,140</td>
</tr>
<tr>
<td>Ally’s Military Expenditure</td>
<td>52,325</td>
<td>81,714</td>
<td>218,466</td>
<td>0</td>
</tr>
<tr>
<td>Adversary’s Military Expenditure</td>
<td>68,061</td>
<td>81,345</td>
<td>189,000</td>
<td>6</td>
</tr>
<tr>
<td>Polity</td>
<td>3.36</td>
<td>7.48</td>
<td>10</td>
<td>-10</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>379</td>
<td>379</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 (1984). 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 2. Results of Regressing Real Military Expenditures Using Pooled Data from 1968 to 1978.

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>ln(Expenditure) Fixed-Effects Model</th>
<th>ln(Expenditure) Fixed-Effects Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terms of Trade</td>
<td>-0.001b (3.48)</td>
<td>-0.001b (3.46)</td>
</tr>
<tr>
<td>Openness of the Economy</td>
<td>0.40b (3.24)</td>
<td>0.43b (3.23)</td>
</tr>
<tr>
<td>Real GNP</td>
<td>4.8 x 10^{-7}b (4.36)</td>
<td>4.8 x 10^{-7}b (4.36)</td>
</tr>
<tr>
<td>ln(Enemy’s Expenditure)</td>
<td>0.31b (8.44)</td>
<td>0.33b (8.04)</td>
</tr>
<tr>
<td>Ally’s Expenditure</td>
<td>-1.1 x 10^{-6}a (2.25)</td>
<td>-1.8 x 10^{-6}b (4.14)</td>
</tr>
<tr>
<td>Polity</td>
<td>-0.01b (3.82)</td>
<td>-0.01b (3.70)</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>379</td>
<td>379</td>
</tr>
</tbody>
</table>

Notes: The t-ratios are shown in parentheses.

*a* denotes significant at the 5% level.

*b* denotes significant at the 1% level.

Table 2 reports the results from regressing a country’s military spending in constant dollars on the variables that our model identified as being important. These variables were changes in a country’s terms of trade, the degree of openness of its economy, GNP in constant dollars, and its enemy’s military expenditures, as well as its ally’s military spending and the regime type of the country as measured by its Polity score. I estimate a fixed effects model correcting for the presence of cross-country heteroscedasticity and using White’s heteroscedasticity-consistent covariance matrix. 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 specification, the coefficient for the variable capturing the openness of the economy is positive and significant at the 1% level. The estimated effect of a change in this variable is quite large. For example, a 20% increase in the degree of openness of the economy from its mean of 0.26 results in military spending increasing by $132 million 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 significant at the 1% level. I 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 1% level. Equations 26 and 27 established the conditions where this result would be expected, namely when the terms of trade are greater than the relative cost of providing military capability with one factor of production instead of another. For example, suppose the endowments are the two factors of production: capital and labor, and the terms of trade improve. If this leads to an increase in wages, then it becomes optimal for the military sector to respond by becoming less soldier-intensive and more arms-intensive to reduce cost through the decline in the military payroll. Finally, the coefficient estimates for the Polity variable are negative and statistically significant at the 1% level. As countries become more democratic, their level of spending on the military declines. This is consistent with the “democratic peace” argument that democracies tend to not fight other democracies.

Next, I look at time-series data for adversarial dyads. One problem with time series is that much of the data is incomplete, and therefore, I concentrate only on the countries in adversarial relations where a long enough series is available. The data used are from the Penn World Table Heston et al. (2006), the International Monetary Fund’s International Financial Statistics (1961–2005), and for military expenditures, from the SIPRI Yearbook (1968–2005). Note that for time series, I was able to use the terms of trade index for the specific country, since the index has a consistent base year.

The issue of simultaneity in an arms race, that is, 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 1-year lagged military expenditure of the adversary (for an examination of the issues regarding the estimation of the 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. The regressions are estimated using ordinary least squares and the results are presented in Table 3.

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 Israel, Pakistan, and Turkey, the estimate for the coefficient of openness is positive, as expected, and statistically significant at the 1% level for Israel, while at the 5% level for the latter two countries. Although the coefficient is positive for Greece, it is not statistically significant. For India, the estimate for this coefficient is negative. Yet, for much of this time period, India’s trade policy was fairly prohibitive. The mean of the measure for the degree of openness of the economy was 14.2 for India, whereas during the same period it was 22.4 for Pakistan. The other unique factor that affected India’s military spending was its close relationship with the Soviet Union: it received large military assistance beginning in the mid-1950s from the Soviet Union. Therefore, this negative estimate for the openness variable may be capturing the effect that as India closed its economy to trade with the West, the Soviet Union increased its military assistance. This would be reflected in the inverse relationship that is observed. Overall, the results provide 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 1% level. Only for the case of Israel do I 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 1% level for Turkey and negative and significant at the 1 and 5% level for Israel and Greece, respectively. This is

<table>
<thead>
<tr>
<th>Country (Adversary)</th>
<th>Real Military Spending</th>
<th>Openness of the Economy</th>
<th>Terms of Trade</th>
<th>Country’s Real GDP</th>
<th>Cold War</th>
<th>Adjusted $R^2$</th>
<th>$F$-Statistic</th>
<th>Number of Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Israel (Egypt)</td>
<td>3.41a (4.57)</td>
<td>3.48 (1.37)</td>
<td>-33.8a (2.28)</td>
<td>-0.01 (0.19)</td>
<td>15.5 (0.04)</td>
<td>0.81</td>
<td>38.4</td>
<td>44</td>
</tr>
<tr>
<td>Greece (Turkey)</td>
<td>2.78a (5.64)</td>
<td>0.85b (2.18)</td>
<td>-3.44b (2.24)</td>
<td>0.04a (4.60)</td>
<td>-222.6a (7.51)</td>
<td>0.89</td>
<td>80.5</td>
<td>49</td>
</tr>
<tr>
<td>India (Pakistan)</td>
<td>-1.48a (3.73)</td>
<td>0.03 (0.71)</td>
<td>-0.05 (0.93)</td>
<td>0.04a (6.59)</td>
<td>-8.18b (2.00)</td>
<td>0.90</td>
<td>75.1</td>
<td>41</td>
</tr>
<tr>
<td>Pakistan (India)</td>
<td>1.59b (2.14)</td>
<td>0.33 (0.56)</td>
<td>-5.75 (0.34)</td>
<td>0.06b (3.26)</td>
<td>-18.1c (1.87)</td>
<td>0.90</td>
<td>46.9</td>
<td>27</td>
</tr>
<tr>
<td>Turkey (Greece)</td>
<td>2.85b (2.65)</td>
<td>0.17a (2.90)</td>
<td>1.21a (3.69)</td>
<td>0.01a (0.47)</td>
<td>51.6b (2.31)</td>
<td>0.63</td>
<td>13.3</td>
<td>37</td>
</tr>
</tbody>
</table>

Notes: The $t$-ratios are shown in parentheses.

$^a$ denotes significant at the 1% level.

$^b$ denotes significant at the 5% level.

$^c$ denotes significant at the 10% level.
consistent with the results shown by Equations 25 and 26, which indicate that the sign of the variable depends upon the relative endowments and the production function for defense of the country.

For each country, own military spending is positively related to the military spending of each country’s defined adversary’s, respectively. The estimated coefficients for this variable are statistically significant for three of these dyads. Finally, the end of the Cold War seems to have changed the structure of the Greece–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 military 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.

5. 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 article 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 the size of the military. It is also found that expansion in the demand for a country’s tradable goods, that is, an improvement in their terms of trade, tends to reduce military spending.

Empirical results provide support for the proposition that opening up an economy to international trade leads to greater resources being diverted toward the military sector. Although less conclusive, they are also consistent with the proposition that military spending is negatively impacted by improvements in a country’s terms of trade. Yet, much more research has to be conducted on not only the trade account, but also 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 future research.

Acknowledgments

I would like to thank David Goldbaum, Luis Locay, Sol Polachek, Alvaro Rodriguez, Todd Sandler, Manuel Santos, Stergios Skaperdas, and participants at seminars at the University of Miami and HEC Montreal for their comments and suggestions on the article. In particular, I want to acknowledge the valuable comments and suggestions provided by the two referees, which greatly improved the article.

References


---

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


