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Insecure Resources, Trade, and National Defense: Will Greater Trade Openness Reduce Conflict?

by

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Abstract: This paper examines how interstate conflict over scarce resources affects final goods trade and vice versa. Specifically, we develop a game-theoretic model of conflict and trade to identify conditions under which two contending countries may or may not engage in trade while deciding on their welfare maximizing levels of arming for protecting their resources. In bilateral trade between "large open economies" under resource conflict, the impact of a country's arming on its domestic welfare is shown to contain three separate effects. The first is a *terms-of-trade effect*, which positively affects domestic welfare since an increase in arming increases its revenue from final good exports to the rival country. The second is an *output distortion effect*, which negatively affects domestic welfare due to the fact that increasing arming lowers the amount of resource allocated to final good production. The third is a *resource appropriation effect*, which positively affects domestic welfare because increasing arming enhances the probability of successfully appropriating its rival's resource for producing more final goods. We show that these three effects interact simultaneously in determining how resource conflict affects the equilibrium volumes of trade between two adversaries, as well as how greater trade openness (through reducing trade barriers) and interstate discrepancies in resource security affect their optimal amounts of national defense. The liberal peace hypothesis that trade reduces conflict (and hence promotes peace) may not hold true for contending countries with resource security *asymmetries*.

Keywords: Insecure resources; Interstate disputes; National defense; Trade openness; Conflict intensity
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1. Introduction

Wars over land and natural resources recur throughout human history.[1] Among the challenging questions posed to social scientists are the following. How do security concerns over resources (i.e., resource appropriation possibilities) affect a country's optimal decision on military buildup when engaging in final goods trade with its threatening rival? Will the classical liberal theory of "trading with the enemy" constitute an effective mechanism in reducing conflict and promoting peace? There are serious resource-constrained problems in many, if not all, parts of the world. In recent decades, a great deal of attention has focused on two related issues which are of particular importance to global economic development and stability. One issue concerns how interstate disputes over valuable resources (oil, minerals, water, islands or territories rich in resources, or other intermediate inputs) affect economic activities and final goods trade between contending nations. The other issue, which is relatively more important due to its policy relevance, concerns whether greater trade openness through reducing trade barriers has a positive effect in reducing the intensity of conflict (as measured by the aggregate expenditures on armaments).

Recognizing that interstate resource disputes and cross-border final goods transactions are intrinsically intertwined with each other, we develop a game-theoretic model of resource insecurity, trade, and conflict to answer the two challenging questions and to shed light on the aforementioned issues. Specifically, we identify conditions under which two resource-conflict countries may or may not engage in final goods trade while deciding on the socially optimal levels of arming (i.e., the welfare-maximizing amounts of national defense) to protect their own resources. We present a systematic analysis to tackle the following problems: How does resource conflict affect the volumes of trade (i.e., imports and exports of final goods) between two adversarial countries, and their optimal decisions on allocating endowed resources to productive activities and appropriative activities? What is the relationship between international trade and resource appropriation? Will greater trade openness be able to reduce conflict intensity when the contending countries are symmetric (i.e., similar to each other in terms of endowments,

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[1]See Findlay and O'Rourke (2010) for analyzing issues on natural resources, conflict, and trade from the historical perspective. As defined by the World Bank, natural resources are those "materials that occur in nature and are essential or useful to humans, such as water, air, land, forests, fish and wildlife, topsoil, and minerals." See: http://www.worldbank.org/depweb/english/modules/glossary.html. In a recent contribution by Garfinkel, Skaperdas, and Syropoulos (2015), the authors present an interesting review on current events related to trade and resource insecurity. These events include the first Gulf war resulting from Iraq's invasion of Kuwait in the earlier 1990s, the Kashmir dispute between India and Pakistan, and the territorial dispute between China and Vietnam (or that between China and Philippine) "as part of a larger ongoing dispute over islets in the South China Sea that involves numerous other countries (including Taiwan, Brunei, Indonesia, and Malaysia)" (Garfinkel et al. 2015, p. 100). For other contributions that analyze resource-based disputes and wars see, e.g., Klare (2001), Acemoglu, Golosov, Tsyvinski, and Yared (2012), and Morelli and Rohner (2015).

production technology, market conditions, and resource insecurity)? How will the conflict-trade nexus be affected by resource security/insecurity asymmetries? Taking into account resource appropriation possibilities, our aim goes beyond merely extending the standard peacetime theory of international trade to characterize the market equilibrium in imports and exports of consumption goods between adversaries. We attempt to characterize explicitly the conflicting equilibrium in the optimal levels of arming by two adversarial countries due to resource insecurity, on the one hand, and examine their incentives for bilateral trade under the shadow of resource conflict, on the other. Emphasis will be placed on the interaction of conflict and trade. In analyzing a bilateral trade between “large open economies” under resource conflict, we decompose the impact on a country's domestic welfare of its arming into three separate effects. The first is a *terms-of-trade effect*, which is welfare-enhancing since an increase in arming increases its revenue from final good exports to the rival country. The second is an *output distortion effect*, which is welfare-reducing due to the fact that increasing arming decreases the amount of resource allocated to final good production. The third is a *resource appropriation effect*, which is welfare-improving because increasing arming enhances the probability of successfully appropriating its rival's input for producing more final goods. We show that these three effects interact simultaneously in determining how resource-based conflict affects the equilibrium volumes of imports and exports between two adversaries, as well as how reductions in trade costs and differences in resource security/insecurity over disputed resources affect their optimal amounts of national defense.

The key findings of the present paper are summarized as follows. (i) In a two-country world without resource appropriation, the socially optimal levels of arming by two symmetric countries engaging in final goods trade are shown to be zero. This Pareto ideal outcome of “total peace” with no armaments is consistent with the presumptions that international property rights of resources are perfectly defined and costlessly enforced in the traditional trade analysis without resource-based conflict. (ii) With resource appropriation possibilities, however, whether greater trade openness resulting from reductions in trade barriers will reduce conflict intensity is shown to depend on the degree of national security as captured by the extent to which scarce resources are inalienable, and differences in resource endowments between the adversaries. (iii) Other things (e.g., resource endowments, production technology, and market demands) being equal, there is a positive relationship between the prohibitive levels of trade costs and the degrees of national security associated with the country-specific resources. To the extent that resource security is relatively lower (higher) for two adversaries, the likelihood of engaging in bilateral trade is accordingly lower (higher). (iv) Under symmetry in all aspects, greater trade openness through reducing trade barriers lowers the optimal levels of arming by two adversaries. In this case, trade unambiguously reduces conflict intensity. (v) Under asymmetry in resource security between two adversaries, all else remaining the same, greater trade openness is shown to reduce the arming level of the relatively more secure country. But the effect on the arming level of the relatively less secure country can be positive, zero, or negative. The impact that reductions in trade barriers have on conflict intensity cannot be determined unambiguously. Thus, trade may not reduce conflict for the case of contending countries with resource security *asymmetries*.

Our work is motivated by a growing body of theoretical and empirical literature on the economic implications of globalization and trade openness associated with interstate conflicts.[2] One widely accepted argument in the literature is that nations prefer peace over armed conformations in order to enjoy the benefits of international trade. The rationale behind this argument is that open conflict affects trade negatively. Polachek (1980) is the first to theoretically illustrate and then to empirically find a negative correlation between conflict and trade. This finding lends a strong support to the long-debating "liberal peace" hypothesis that trade promotes peace. The liberal view contends that economic interdependence through trade has a positive effect on reducing interstate conflicts. After the pioneering work of Polacheck (1980), a great number of empirical research has contributed to investigating the validity of the liberal peace proposition. The results appear to have been rather mixed, however. For example, Oneal and Russet (1999), who are in line with Polacheck (1980), contend that strengthening the extent of trade openness between contending countries can effectively reduce conflicts in term of overall armament expenditures. But other studies either show that the pacifying effect of greater trade openness is neutral (see, e.g., Kim and Rousseau, 2005) or find that trade may even foster conflict (see, e.g., Barbieri, 1996).[3]

On the theoretical front, Skaperdas and Syropoulos (1996) examine what harmful effects insecure property rights may have when there is a productive resource that no country possesses securely. The authors show that such resource conflict can have two possible outcomes: (i) violent as military power determines the distribution of the disputed resource, or (ii) non-violent when the resource is distributed through political or legal means. In their analysis, the authors do not focus on the possibility of trade between resource-conflict countries. Skaperdas and Syropoulos (2001) further incorporate endogenous conflict into a simple exchange model with two small open countries having disputes over a valuable resource that is indispensable for the production of tradable goods. They show that the introduction of trade does not guarantee to be superior to autarky in softening conflicts in terms of arming. For the case in which the international price of the contested resource is higher than a country's autarkic price, the opportunity cost of arming decreases. Accordingly, international trade hastens the intensity of competition for the disputed resource, increases arming, and reduces welfare relative to autarky. Based

[2]Issues concerning the role that international trade plays in conflict resolution have been a long-standing debate in political science. See, e.g., Barbieri and Schnider (1999), for a systematic survey on the issues explored by both the theoretical and empirical researchers.

[3]For studies on issues related to the association between trade and conflict see, e.g., Anderton and Carter (2001a, 2001b), Barbieri and Levy (1999, 2001), Barbieri and Schneider (1999), Glick and Taylor (2010), Levy and Barbieri (2004), Polachek (1992, 1999), Polachek, Robst, and Chang (1999), and Polachek and Seiglie (2007).

on the traditional assumption of small open economies, Garfinkel, Skaperdas, and Syropoulos (2015) develop a variant of the Heckscher-Ohlin model to analyze interstate disputes over resources. They find that if trade promotes adversarial countries to export goods that are intensive in disputed-resource, it may intensify interstate conflict so much that autarky is preferable to free trade—a finding that is rhyming with Skaperdas and Syropoulos (2001). Significantly different from the contest function approach adopted by the above contributions, Martin et al. (2008) investigate both theoretically and empirically the causes of trade for war, and find that enlarging the number of member countries within a regional economic institute reduces the economic dependency between any pair of two adversarial countries and thus makes war between them more likely.[4]

Despite differences in modeling setup, the present paper is closely related to the work of Garfinkel and Syropoulos (2015) on analyzing issues concerning final goods trade between two resource-conflict countries. One common feature of these two studies lies in not imposing the traditional assumption of small open economies. Rather, both studies employ a "large open economies" assumption to characterize bilateral trade under resource-based conflict as this assumption allows for the equilibrium terms of trade between two adversaries to be endogenously determined by their optimal levels of arming. By introducing elements of insecure resources into the Ricardian framework of trade, Garfinkel and Syropoulos (2015) show, among other things, that bilateral trade between resource-conflict nations lowers their optimal arming levels relative to the case under autarky. The authors conclude that greater trade openness reduces conflict and hence promotes peace. The negative association between trade and conflict is shown to hold true even in the presence of trade costs. These results provide a strong theoretical justification for the liberal peace hypothesis that "trading with the enemy" reduces conflict and promotes peace. In an alternative framework of resource conflict and final goods trade we develop, we show that whether trade has the pacifying effect on interstate relations depends crucially on differences in resource endowments between two adversaries and their different degrees of resource security/insecurity. We derive the conditions under which the contending countries may or may not engage in final goods trade in the threat of resource conflict. In the presence of a bilateral trade, the optimal arming levels may or may not decrease with greater trade openness when there are resource security asymmetries. The intuition behind this result is that conflicting countries with different degrees of resource security may respond to trade cost reductions differently: the relatively more secure country reduces its arming, whereas the relatively less secure country may instead increase its arming. Consequently, the impact that greater trade

[4]There is also a sizable theoretical literature that examines the effects of trade and its economic implications related to resourced-based appropriation, but from different respects. For example, some scholars have analyzed the interactive relationship among expropriation of traded goods (piracy), likelihood of free trade, and civil war (see, e.g., Anderson and Marcouiller 2005; Anderson and Bandiera 2006; Garfinkel et al. 2008; Stefanadis 2010; Bó and Bó 2011; Ghosh and Rpbertson 2012; and Garfinkel and Syropoulos 2015). Other researchers analyze various development issues associated with military conflicts (see, e.g., Gartzke 2007; Gartzke and Rohner 2011).

openness has on the overall conflict intensity cannot be determined unambiguously. The validity of the liberal peace hypothesis is shown to be contingent upon the interstate resource security discrepancies.

The remainder of the paper is organized as follows. In Section 2, we present a game-theoretic model of interstate disputes over valuable resources and discuss the optimal arming decisions of two symmetric countries without engaging in trade. Section 3 examines resource conflict and optimal arming in bilateral trade under symmetry in all aspects. In Section 4, we analyze the nexus of conflict and trade when there are resource security asymmetries. Section 5 concludes.

2. Resource Conflict in the Absence of International Trade

We wish to examine how insecure property rights of limited but valuable inputs affect resource allocations to productive and appropriative activities by two contending countries, as well as their incentives to engage in final goods trade under the shadow of conflict. Particularly, we attempt to analyze how resource-based conflict affects trade volumes (imports and exports of consumption goods) and optimal investments in armaments by the adversaries, as compared to conflict in the absence of trade. To do so, we consider the simple framework of a two-country world in which property rights of valuable inputs are not perfectly defined or enforced.

2.1 Insecure country-specific resources and technology of conflict

In a world with two countries having disputes over valuable inputs, we assume that each country owns a specific input which is used to represent its country's name. Denote these countries as *A* and *B*. Country *A* is endowed with R_A units of input *A*, among which σ_A portion is inalienable but the remaining portion $(1-\sigma_A)$ is unsecured. That is, $(1-\sigma_A)R_A$ is the total amount of input *A* subject to appropriation by country *B* under open conflict, where $0<\sigma_A \leq 1$. Similarly, country *B* is endowed with R_B units of a different input *B*, among which σ_B portion is inalienable but the remaining portion $(1-\sigma_B)$ is unsecured. That is, $(1-\sigma_B)R_B$ is the total amount of input *B* subject to appropriation by country *A* under open conflict, where $0<\sigma_B \leq 1$.

In the absence of international property rights law or enforcement, the equilibrium proportions of the insecure inputs are fundamentally determined by the contending countries' arming decisions for protecting (or appropriating) the valuable inputs, which affect their production decisions of final goods for domestic consumption and exportation. Due to concerns over insecure resources, the two adversaries may choose to arm. Denote $G_A(\geq 0)$ as country *A*'s level of arming for protecting not only its own input

A, but also for appropriating input B that country A is lacking. Also, denote $G_B(\geq 0)$ as country B's level of arming for protecting not only its own input B, but also for appropriating input A that country B is lacking. The probability of victory for each country in protection and appropriation is represented by a canonical "contest success function" (CSF) that reflects the technology of conflict (see, e.g., Tullock 1980; Hirshleifer 1989; Skaperdas 1996) as follows:

$$\Phi_A = \frac{G_A}{G_A + G_B} \text{ and } \Phi_B = \frac{G_B}{G_A + G_B} \text{ for } G_A + G_B > 0; \tag{1a}$$

$$\Phi_A = \Phi_B = \frac{1}{2} \text{ for } G_A = G_B = 0. \tag{1b}$$

For analytical simplicity, we assume that one unit of each country's specific input is required to produce one unit of weapons for protection and appropriation. we also consider the plausible condition that each country's arming level is no greater than its inalienable resource: $0 \leq G_i \leq \sigma R_i < R_i$ for $i = A, B.$ Given the Tullock-Hirshleifer-Skaperdas contest success function as specified above and in the event of fighting, the expected amount of input A being appropriated by country B is:

$$\Phi_B[(1-\sigma_A)R_A] \tag{2a}$$

and that of input B being appropriated by country A is

$$\Phi_A[(1-\sigma_B)R_B]. \tag{2b}$$

2.2 Production, consumption, and the social welfare maximization of arming

Our next step of the analysis is to discuss production and consumption of final goods in the adversarial countries, as well as their optimal decisions on arming.

Country A, which possesses the specific input A, uses the input to produce good X for both domestic consumption and exportation in the absence of conflict. Country B, which possesses the specific input B, uses the input to produce good Y for both domestic consumption and exportation in the absence of conflict. For each country i (i =A, B), we adopt the simple production technology that one unit of a specific input is required to produce one unit of a consumption good. Under open conflict, countries A and B allocate G_A and G_B amounts of resources to arming for protection and appropriation. As a result, the quantities of the final goods X and Y that country A produces are:

$$X_A = \sigma_A R_A + \Phi_A[(1-\sigma_A)R_A] - G_A \text{ and } Y_A = \Phi_A[(1-\sigma_B)R_B], \tag{3a}$$

and those of the final goods X and Y that country B produces are:

$$X_B = \Phi_B[(1-\sigma_A)R_A] \text{ and } Y_B = \sigma_B R_B + \Phi_B[(1-\sigma_B)R_B] - G_B. \tag{3b}$$

In each of the contending countries, citizens are interested in maximizing their utility from consuming the two final goods (*X* and *Y*). Despite disputes over the valuable inputs, countries *A* and *B* may engage in trade due to the fact that the two different consumption goods enter into the utility functions of their respect citizens/consumers. These assumptions are consistent with Boulding (1962, 1963) that a socio-economic system is fundamentally governed by three subsystems: the threat system, the exchange system, and the integrative system. The importance of the integrative system lies in the fact that it "establishes community between the threatener and the threatened and produces common values and common interest" (Boulding, 1963, p. 430). This suggests that countries in the global community devote their resources to producing goods and services for exchange (i.e., production) according to the comparative advantage principle, but they may also engage in interstate conflicts for more resources (i.e., appropriation). In the model we consider, insecurity arises because country *A* does not have the specific input *B* to produce final good *Y* for domestic consumption, whereas country *B* does not have the specific input *A* to produce final good *X* for domestic consumption.

To stress the importance of "economic interdependence" between two contending countries, we consider that each citizen in a country derives utility from consuming the two different goods: one is produced domestically using own input, while the other good is either imported from abroad or produced domestically using the specific input appropriated from the rival country. This simple framework can be used to examine the conditions under which there is a bilateral trade or a trade embargo. We assume that the preference function of the representative consumer in country *A* takes a symmetric quadratic utility function as follows:

$$U(C_X, C_Y) = \frac{1}{\beta}[\alpha(C_X + C_Y) - \frac{1}{2}(C_X^2 + C_Y^2)] + Z_A,$$

where C_X and C_Y are the quantities of final goods *X* and *Y* consumed and Z_A is consumption of a numeraire good. Corresponding to the quadratic preferences, the market demands for goods *X* and *Y* are:

$$C_X = \alpha - \beta P_X \text{ and } C_Y = \alpha - \beta P_Y, \tag{4a}$$

where α is the quantity intercept, β is the slope of the market demands, and P_X and P_Y are, respectively, the prices of goods *X* and *Y* in country *A*. We assume that α is greater than the country's endowed resource R when market prices are zero, that is, $\alpha > R$. Note that C_Y in (4a) defines country *A*'s total consumption of good *Y*, which is (i) imported from country *B* or (ii) produced in country *A* using the specific input that it appropriates from its rival.

As for the preference function of the representative consumer in country *B*, it is specified as

$$V(D_X, D_Y) = \frac{1}{\beta}[\alpha(D_X + D_Y) - \frac{1}{2}(D_X^2 + D_Y^2)] + Z_B,$$

where D_X and D_Y are the quantities of final goods *X* and *Y* consumed and Z_B is consumption of a numeraire. This implies that market demands for goods *X* and *Y* in country *B* are:

$$D_X = \alpha - \beta H_X \text{ and } D_Y = \alpha - \beta H_Y, \tag{4b}$$

where H_X and H_Y are, respectively, the prices of goods *X* and *Y* in country *B*. Note also that D_X in (4b) defines country *B*'s total consumption of good *X*, which is either (i) imported from country *A* or (ii) produced in country *B* using the specific input that it appropriates from its rival.

Based on (4a) and (4b), we have the consumer surplus measure for the two countries:

$$CS_A = \frac{1}{2\beta}(C_X)^2 + \frac{1}{2\beta}(C_Y)^2; \;\; CS_B = \frac{1}{2\beta}\left(D_X\right)^2 + \frac{1}{2\beta}\left(D_Y\right)^2. \tag{5}$$

Producer surplus in country *A* is the sum of $P_X X_A$ and $P_Y Y_A$, where X_A and Y_A are the quantities of goods *X* and *Y* produced by the country (see equations in 3a) and P_X and P_Y are their market prices.

$$PS_A = P_X[\sigma_A R_A + \frac{G_A}{G_A + G_B}(1-\sigma_A)R_A - G_A] + P_Y[\frac{G_A}{G_A + G_B}(1-\sigma_B)R_B]. \tag{6a}$$

Similarly, producer surplus in country *B* is the sum of $H_X X_B$ and $H_Y Y_B$, where X_B and Y_B are the quantities of goods *X* and *Y* produced by the country (see equations in 3b) and H_X and H_Y are their market prices.

$$PS_B = H_X[\frac{G_B}{G_A + G_B}(1-\sigma_A)R_A] + H_Y[\sigma_B R + \frac{G_B}{G_A + G_B}(1-\sigma_B)R_B - G_B]. \tag{6b}$$

As in the trade literature, social welfare in country *i* is taken to be the sum of consumer and producer surplus:

$$SW_i = CS_i + PS_i, \tag{7}$$

where CS_i and PS_i (for $i = A, B$) are given in (5) and (6). The objective of country *i* is to maximize its overall welfare SW_i in (7) by choosing an optimal level of investment in arms, G_i.

We consider a simultaneous-move game in which countries *A* and *B* independently determine G_A and G_B, respectively. For analytical simplicity, we examine in this section the case of symmetry in endowed resources $(R_A = R_B = R)$, resource security $(\sigma_A = \sigma_B = \sigma)$, and trade costs (if there is a departure from autarky).

2.3 Pure cconflict in the aabsence of trade

We now discuss the first case in which there is open conflict without bilateral trade. When two resource-conflict countries do not trade, market equilibrium conditions for final goods are separable across the national boundaries. In country *A*, the total amount of final good *X* produced and supplied, X_A, net of resource invested in arming, G_A, is equal to market demand for the final good, C_X. As for final good *B*, the total amount of the good produced and supplied in country *A*, Y_A, after appropriating input *B* for production, is equal to market demand for the good, C_Y. It follows from (3a) and (4a) that, under symmetry, we have

$$\sigma R + \frac{G_A}{G_A + G_B}[(1-\sigma)R] - G_A = \alpha - \beta P_X \text{ and } \frac{G_A}{G_A + G_B}[(1-\sigma)R] = \alpha - \beta P_Y .$$

Solving these two equations for the domestic market prices of goods *X* and *Y* in country *A* yields

$$P_X = \frac{(G_A + \alpha - R)G_A + (G_A + \alpha - \sigma R)G_B}{\beta(G_A + G_B)} \text{ and } P_Y = \frac{[\alpha - (1-\sigma)R]G_A + \alpha G_B}{\beta(G_A + G_B)} . \tag{8a}$$

Similarly, equations (3b) and (4b) imply that the market equilibrium conditions for country *B* are:

$$\sigma R + \frac{G_B}{G_A + G_B}[(1-\sigma)R] - G_B = \alpha - \beta H_Y \text{ and } \frac{G_B}{G_A + G_B}[(1-\sigma)R] = \alpha - \beta H_X .$$

Solving these two equations for the domestic market prices of goods *X* and *Y* in country *B* yields

$$H_X = \frac{\alpha G_A + [\alpha - (1-\sigma)R]G_B}{\beta(G_A + G_B)} \text{ and } H_Y = \frac{(G_B + \alpha - \sigma R)G_A + (G_B + \alpha - R)G_B}{\beta(G_A + G_B)} . \tag{8b}$$

We calculate the quantities of the final goods consumed in the two countries:

$$C_X = \frac{(R - G_A)G_A + (\sigma R - G_A)G_B}{G_A + G_B},\ C_Y = \frac{(1-\sigma)G_A R}{G_A + G_B}, \tag{9a}$$

$$D_X = \frac{(1-\sigma)G_B R}{G_A + G_B},\ D_Y = \frac{(\sigma R - G_B)G_A + (R_B - G_B)G_B}{G_A + G_B} . \tag{9b}$$

Making use of equations (5), (6), (8), and (9), we further calculate consumer and producer surplus for the two countries:

$$CS_A = \frac{1}{2\beta}\left[\frac{(R - G_A)G_A + (\sigma R - G_A)G_B}{G_A + G_B}\right]^2 + \frac{1}{2\beta}\left[\frac{(1-\sigma)G_A R}{G_A + G_B}\right]^2 , \tag{10a}$$

$$CS_B = \frac{1}{2\beta}\left[\frac{(1-\sigma)G_B R}{G_A+G_B}\right]^2 + \frac{1}{2\beta}\left[\frac{(R_B-G_B)G_B+(\sigma R-G_B)G_A}{G_A+G_B}\right]^2, \tag{10b}$$

$$\begin{aligned} PS_A = &\left(\frac{(G_A+\alpha-R)G_A+(G_A+\alpha-\sigma R)G_B}{\beta(G_A+G_B)}\right)[(\sigma R+\frac{G_A}{G_A+G_B}(1-\sigma)R-G_A)] \\ &+\left(\frac{[\alpha-(1-\sigma)R]G_A+\alpha G_B}{\beta(G_A+G_B)}\right)[\frac{G_A}{G_A+G_B}(1-\sigma)R], \end{aligned} \tag{11a}$$

$$\begin{aligned} PS_B = &\left(\frac{\alpha G_A+[\alpha-(1-\sigma)R]G_B}{\beta(G_A+G_B)}\right)[\frac{G_B}{G_A+G_B}(1-\sigma)R_A] \\ &+\left(\frac{(G_B+\alpha-\sigma R)G_A+(G_B+\alpha-R)G_B}{\beta(G_A+G_B)}\right)[\sigma R+\frac{G_B}{G_A+G_B}(1-\sigma)R_B-G_B]. \end{aligned} \tag{11b}$$

The first-order conditions (FOCs) for determining the socially optimal levels of arming by countries *A* and *B* without trade are given, respectively, as

$$\frac{\partial SW_A}{\partial G_A} = \frac{\partial(CS_A+PS_A)}{\partial G_A} = 0,$$

$$\frac{\partial SW_B}{\partial G_B} = \frac{\partial(CS_B+PS_B)}{\partial G_B} = 0,$$

where CS_i and PS_i are consumer and producer surplus for country $i(=A,B)$ in equations (10) and (11). Under symmetry in all aspects, we solve for the optimal arming level in the absence of trade to be

$$G_{\text{Autarky}} = \frac{3R-4\alpha+\sigma R+\sqrt{K}}{8},$$

where $K \equiv R^2(\sigma^2+22\sigma-7)+8\alpha(2\alpha+R-5\sigma R).$ Note the constrained condition that the amount of resource directed to arming is no greater than the inalienable portion of the endowment, i.e., $G \le \sigma R.$ It is easy to verify the existence of a critical value for σ, defined by $\hat{\sigma}_{\text{Autarky}} = 1/3,$ such that the optimal level of arming is equal to σR when $\sigma \le \hat{\sigma}_{\text{Autarky}}$, but is equal to G_{Autarky} when $\sigma > \hat{\sigma}_{\text{Autarky}}$. That is,

$$G^*_{\text{Autarky}} = \begin{cases} \sigma R & \text{if } 0<\sigma \le \frac{1}{3}, \\ G_{\text{Autarky}} & \text{if } \sigma > \frac{1}{3}. \end{cases} \tag{12}$$

Figure 1 presents a graphical illustration of these results. The reason why $G^*_{\text{Autarky}} = \sigma R$ for $0<\sigma \le 1/3$ should be explained. Each country's secure resource (σR) serves a dual purpose: one is used to produce domestic good for final consumption, and the other is used to produce arms for protection and appropriation. The lower the security coefficient, the higher the incentive for allocating more of its secure resource to arming. When the security coefficient is critically low $(\sigma \le 1/3)$, each country allocates its <u>entire</u> secure resource σR for arming. In contrast, when the security coefficient is sufficiently high $(\sigma > 1/3)$, each country's secure resource is allocated for final good production as well as for arming. In the later case, we have

$$\frac{\partial G_{\text{Autarky}}}{\partial \sigma} = -\frac{R(20\alpha - 11R - \sigma R - \sqrt{K})}{8\sqrt{K}} < 0,$$

$$\frac{\partial G_{\text{Autarky}}}{\partial R} = \frac{4\alpha - 7R + \sigma(22R - 20\alpha + R\sigma) + (3+\sigma)\sqrt{K}}{8\sqrt{K}} > 0.$$

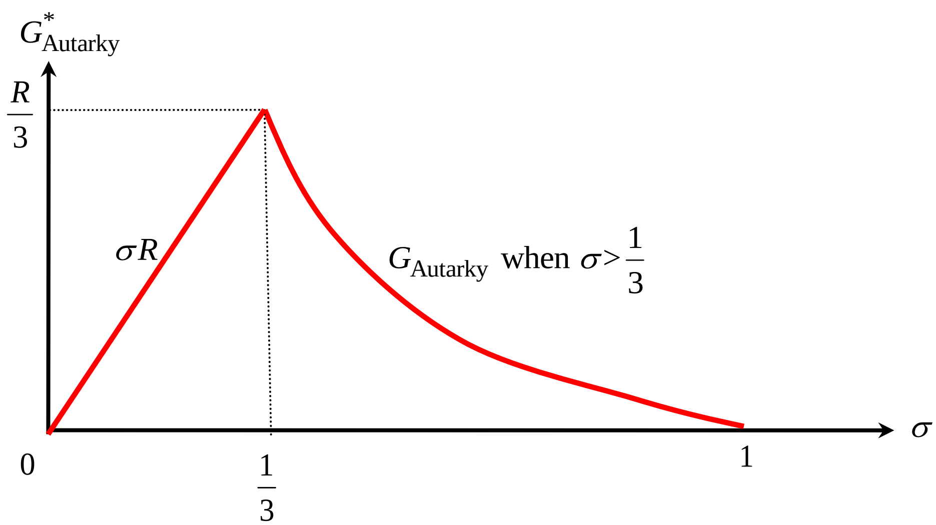

Figure 1. *Optimal arming under autarky may increase or decrease with resource security*

These results permit us to establish the first proposition:

PROPORTION 1. *Considering the scenario where there is no trade between two resource-conflict countries, which are symmetric in all aspects, the socially optimal level of arming by each country depends crucially on the coefficient of security associated with its endowed resource. In the framework we consider, we have the optimal arming by each country as shown in equation (12). When resource security is low* $(\sigma \le 1/3)$, *the optimal arming level increases with the security coefficient, i.e.,* $\partial G^*_{\text{Autarky}} / \partial \sigma > 0$. *But when resource security is sufficiently high* $(\sigma > 1/3)$, *the optimal arming level decreases with the security coefficient, i.e.,* $\partial G^*_{\text{Autarky}} / \partial \sigma < 0$. *Regardless of resource security, arming is always an increasing function of a country's endowment, i.e.,* $\partial G^*_{\text{Autarky}} / \partial R > 0$.

The implications of Proposition 1 are as follows. An increase in the security coefficient σ

implies that the proportion of resource subject to appropriation is decreasing, but the optimal arming level (or conflict intensity under symmetry) is non-monotonic in the security coefficient. As illustrated in Figure 1, only when the security coefficient exceeds its threshold value will the optimal arming level, G^*_{Autarky}, be a decreasing function of resource security.

It is plausible to define the size of a country in terms of its resource endowment, other things being equal. The positive sign for the derivative $\partial G^*_{\text{Autarky}} \big/ \partial R$ in Proposition 1 implies that a world composed of more-endowed countries is more "dangerous" than a world composed of less-endowed countries. This is because conflict intensity is higher for the more-endowed world than for the less-endowed world.

Next, we need to look at the autarkic prices of final goods in the resource-conflict countries and see how these prices are related to trade barriers (or costs) for a possible move from autarky to trade.

2.4 Resource endowments, departure from autarky, and patterns of trade

Given that country *A* possesses input *A*, a specific input for producing final good *X*, and that country *B* possesses input *B*, a specific input for producing final good *Y*, it is natural to consider that country *A* exports *X* in exchange for *Y* while country *B* exports *Y* in exchange for *X* once trade is opened up. Denote t_X as trade cost (per unit of output) that country *A* incurs when exporting good X to country *B*. Similarly, denote t_Y as trade cost (per unit of output) that country B incurs when exporting good *Y* to country *A*. To maintain the trade patterns as described, we note the comparative advantage principle that a country exports a good whose autarkic price in its own domestic market plus trade costs can never exceed the good's autarkic price in an importing country's market. It is then necessary to consider the following conditions for the emergence of a bilateral trade in final goods X and Y:

$$P_X + t_X < H_X \text{ and } H_Y + t_Y < P_Y,$$

where the autarkic prices of the two goods are given in (9a) and (9b), After calculation, we have the critical values of trade costs:

$$t_X^C = \frac{(R - G_A)G_A + G_B[(2\sigma - 1)R - G_A]}{\beta(G_A + G_B)} \text{ and } t_Y^C = \frac{(R - G_B)G_B + G_A[(2\sigma - 1)R - G_B]}{\beta(G_A + G_B)}.$$

Under symmetry that $G_A = G_B = G$ and $t_X = t_Y = t$, we find that the trade patterns remain as discussed above when trade costs satisfy the following condition:

$$t < t^C, \text{ where } t^C \equiv \frac{\sigma R - G}{\beta}.$$

This indicates that, other things being equal, trade costs must be sufficiently low (i.e., $t < t^C$) for the existence of cross-border final goods transactions.[5] In this case, the patterns of trade are such that country *A* exports good *X* while country *B* exports good *Y*. The above trade-cost condition further implies the following arming condition for a bilateral trade between the adversarial countries to emerge:

$$G < \sigma R - \beta t .$$

This indicates that each country's arming should be strictly less than the inalienable portion of its endowment, $\sigma R,$ minus the weighted trade costs (with the weight being equal to the slope of market demand (that is, βt). Alternatively, we have $\sigma R > G + \beta t,$ which means that the amount of secure resource must be strictly greater than the sum of armaments and the weighted trade costs for two conflating countries to trade. If this arming condition is violated (i.e., if $G \geq \sigma R - \beta t$ or $\sigma R \leq G + \beta t$), the trade-cost condition is automatically violated and there will be no bilateral trade. The economic implications of the results are summarized in the following Lemma:

LEMMA 1. *In a world with two symmetric countries that have disputes over their country-specific resources and decide on investments in armaments for protecting their own resources, each country will export the good produced by its endowed input and import a different good produced by a different input controlled by its rival country, provided that each one's arming satisfies the following condition:* $G < R\sigma - \beta t.$ *There will be no trade between the resource-conflict countries when each country's arming level falls within the following range:* $\sigma R - \beta t \leq G \leq \sigma R.$

The economic implications of Lemma 1 are as follows. Whether two resource-conflict countries will engage in final goods trade depends on several factors: (i) the size of trade costs, $t,$ (ii) the amount of resource endowment, $R,$ (iii) the coefficient of resource security, $\sigma,$ and (iv) the level of arming, $G.$ Factors (iii) and (iv), which are non-economic in nature, are ignored in the traditional peacetime analysis of international trade. Based on the necessary and sufficient condition for a bilateral trade: $G < \sigma R - \beta t,$ we see that simply taking into account possible measures to reduce trade barriers between two adversarial countries may not be sufficient enough to induce two conflicting countries to trade. Factors (i) and (ii), which are related to resource security/insecurity and military buildup, should also be considered when analyzing the incentives of two adversaries for trade. This promotes us to examine the optimal decisions on arming or national defense in the presence of bilateral trade.

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[5]Positive trade costs $(t^C > 0)$ imply that the level of arming can never be greater than the inalienable portion of a country's endowment, that is, $G < \sigma R.$

3. Resource Conflict in the Presence of International Trade

In this section, our aim is to see how greater trade openness (due to reductions in trade costs) affects the optimal arming decisions of two adversaries, as well as the equilibrium quantities of the goods produced for domestic consumption and for exportation to the markets in the rival counties. Also, we wish to see how resource-based conflict affects the equilibrium prices of imports and exports.

3.1 Trade between two resource-conflict countries and their optimal levels of arming

We introduce elements of resource-based conflict into the partial equilibrium framework of trade as developed by Bagwell and Staiger (1997, 1998). For trade equilibrium in final good *X*, the amount exported by country *A* is equal to the amount imported by country *B*, after taking into account resource appropriation for final good production. Based on equations (3) and (4), we have

$$X_A - C_X = D_X - X_B,$$

which implies that

$$[\sigma_A R_A + \frac{G_A}{G_A + G_B}(1-\sigma_A)R_A - G_A] - (\alpha - \beta P_X) = (\alpha - \beta H_X) - \frac{G_B}{G_A + G_B}(1-\sigma_A)R_A. \qquad (13a)$$

Similarly, for trade equilibrium in final good *Y*, the amount exported by country *B* is equal to the amount imported by country *A*, after considering resource appropriation for final good production. Making use of equations (3) and (4), we have

$$Y_B - D_Y = C_Y - Y_A,$$

which implies that

$$[\sigma_B R_B + \frac{G_B}{G_A + G_B}(1-\sigma_B)R_B - G_B] - (\alpha - \beta H_Y) = (\alpha - \beta P_Y) - \frac{G_A}{G_A + G_B}(1-\sigma_B)R_B. \qquad (13b)$$

We further consider the circumstances under which there are no arbitrages in the markets across the national boundaries. Non-arbitrage condition for good *X* requires that

$$H_X = P_X + t_X, \qquad (13c)$$

where t_X, as defined earlier, represents trade cost (per unit of output) that country *A* incurs in exporting good *X* to country *B*. Similarly, non-arbitrage condition for good *Y* requires that

$$P_Y = H_Y + t_Y, \qquad (13d)$$

where t_Y, as defined earlier, represents trade cost (per unit of output) that country *B* incurs in exporting good *Y* to country *A*.

Making use of the four equilibrium conditions in (13a) - (13d), we solve for the prices of the final goods in the two countries' markets as follows:

$$P_X = \frac{2\alpha + G_A - R_A - \beta t_X}{2\beta}, \;\; P_Y = \frac{2\alpha + G_B - R_B + \beta t_Y}{2\beta}, \tag{14a}$$

$$H_X = \frac{2\alpha + G_A - R_A + \beta t_X}{2\beta}, \;\; H_Y = \frac{2\alpha + G_B - R_B - \beta t_Y}{2\beta}. \tag{14b}$$

It should be noted that market prices of the final goods are independent of security coefficients σ_A and σ_B. From the perspective of the two-country world, the total amounts of inputs *A* and *B*, netting of those invested in arms, remain unchanged despite interstate redistributions of the two inputs through appropriation or non-market means. As such, market supplies of the final goods are unaffected and the equilibrium prices are independent of σ_A and σ_B.[6] For bilateral trade in final goods under resource conflict, we assume that the market prices of the goods are all positive. This assumption places the following restrictions on the values of the parameters:

$$R_A < 2\alpha + G_A - \beta t_X \text{ and } R_B < 2\alpha + G_B - \beta t_Y. \tag{14c}$$

We assume these conditions hold in bilateral trade under conflict.

According to the market prices P_X, P_Y, H_X, and H_Y in (14a) and (14b), we calculate the quantities of the final goods consumed in countries *A* and *B*:

$$C_X = \frac{R_A - G_A + \beta t_X}{2}, C_Y = \frac{R_B - G_B - \beta t_Y}{2}, D_X = \frac{R_A - G_A - \beta t_X}{2}, D_Y = \frac{R_B - G_B + \beta t_Y}{2}. \tag{15}$$

The amount of final good *Y* that country *A* imports from country *B*, net of the amount of the final good that country *A* produces using input *B* appropriated, is:

$$IM_Y = (\alpha - \beta P_Y) - \frac{G_A}{G_A + G_B}(1 - \sigma_B)R_B = \frac{R_B - G_B - \beta t_Y}{2} - \frac{G_A}{G_A + G_B}(1 - \sigma_B)R_B. \tag{16a}$$

Similarly, the amount of final good *X* that country *B* imports from country *A*, net of the amount of the final good that country *B* produces using input *A* appropriated, is:

$$IM_X = (\alpha - \beta H_X) - \frac{G_B}{G_A + G_B}(1 - \sigma_A)R_A = \frac{R_A - G_A - \beta t_X}{2} - \frac{G_B}{G_A + G_B}(1 - \sigma_A)R_A. \tag{16b}$$

[6]One extension is to introduce conflict-related destructions into the analysis. In this case, destructions of resources will affect the availability of inputs for production and hence the equilibrium quantities and prices of the consumption goods. This extension is left for future research. For studies on conflict that takes into account destruction costs see, e,g., Chang and Luo (2013, 2016), Sanders and Walia (2014), and Chang, Sanders and Walia (2015).

Based on C_X, C_Y, D_X, and D_Y in (15), we calculate consumer surplus for each country:

$$CS_A = \frac{(R_A - G_A + \beta t_X)^2 + (R_B - G_B - \beta t_Y)^2}{8\beta}, \tag{17a}$$

$$CS_B = \frac{(R_A - G_A - \beta t_X)^2 + (R_B - G_B + \beta t_Y)^2}{8\beta}. \tag{17b}$$

Producer surplus in country *A* is the sum of $P_X X_A$ and $P_Y Y_A$, where X_A and Y_A are the amounts of goods *X* and *Y* produced by the country (see equations 3a) and P_X and P_Y are their market prices (see equations 14a). That is,

$$PS_A = P_X[\sigma_A R_A + \frac{G_A}{G_A + G_B}(1-\sigma_A)R_A - G_A] + P_Y[\frac{G_A}{G_A + G_B}(1-\sigma_B)R_B]. \tag{18a}$$

Similarly, producer ssurplus in country *B* is the sum of $H_X X_B$ and $H_Y Y_B$, where X_B and Y_B are the amounts of goods *X* and *Y* produced by the country (see equations in 3b) and H_X and H_Y are their market prices (see equations in 14b). That is,

$$PS_B = H_X[\frac{G_B}{G_A + G_B}(1-\sigma_A)R_A] + H_Y[\sigma_B R + \frac{G_B}{G_A + G_B}(1-\sigma_B)R_B - G_B]. \tag{18b}$$

The objective of country *A* is to determine an optimal level of investment in arms G_A that solves the following welfare maximization problem:

$$\underset{\{G_A\}}{\text{Max}}\, SW_A = CS_A + PS_A,$$

where CS_A and PS_A are given in (17a) and (17b). The FOC for country *A* is:

$$\frac{\partial CS_A}{\partial G_A} + \frac{\partial PS_A}{\partial G_A} = 0. \tag{19}$$

The first term on the left-hand side of the FOC shows how country *A*'s arming affects the benefits of its consumers. It follows from (17a) that

$$\frac{\partial CS_A}{\partial G_A} = \frac{C_X}{\beta}\frac{dC_X}{dG_A} = -\frac{C_X}{2\beta} < 0.$$

This indicates that an increase in arming raises the domestic price of good *X*, causing its total consumption to fall and consumer surplus to decline. The second term on the left-hand side of the FOC shows how country *A*'s arming affects producer surplus, which measures the total value of domestic production. It follows from PS_A in (18a) that

$$\frac{\partial PS_A}{\partial G_A} = X_A \frac{\partial P_X}{\partial G_A} + P_X \frac{\partial X_A}{\partial G_A} + Y_A \frac{\partial P_Y}{\partial G_A} + P_Y \frac{\partial Y_A}{\partial G_A},$$

(+) (-) (0) (+)

where we have from X_A and Y_A in (3a) and P_X and P_Y in (14a) the following:

$$\frac{\partial P_X}{\partial G_A} = \frac{1}{2\beta} > 0, \quad \frac{\partial X_A}{\partial G_A} = (1-\sigma_A) R_A \frac{\partial \Phi_A}{\partial G_A} - 1 = \frac{(1-\sigma_A) R_A G_B}{\left(G_A + G_B\right)^2} - 1 < 0, \quad \frac{\partial P_Y}{\partial G_A} = 0,$$

and

$$\frac{\partial Y_A}{\partial G_A} = (1-\sigma_B) R_B \frac{\partial \Phi_A}{\partial G_A} = \frac{(1-\sigma_B) R_B G_B}{\left(G_A + G_B\right)^2} > 0.$$

After substituting these derivatives back into country *A*'s FOC in (19a), we decompose the welfare effect of its arming into three separate terms, which are referred to as (i) the terms-of-trade effect, (ii) the output distortion effect, (iii) the resource appropriation effect. This yields

$$\frac{\partial SW_A}{\partial G_A} = \underbrace{\frac{(X_A - C_X)}{2\beta}}_{\substack{\text{Terms-of-trade effect} \\ \text{of arming} \\ (+)}} + \underbrace{P_X \left[\frac{(1-\sigma_A) R_A G_B}{(G_A + G_B)^2} - 1 \right]}_{\substack{\text{Output distortion effect} \\ \text{of arming} \\ (-)}} + \underbrace{P_Y \frac{(1-\sigma_B) R_B G_B}{(G_A + G_B)^2}}_{\substack{\text{Resource appropriation effect} \\ \text{of arming} \\ (+)}} = 0. \qquad (20a)$$

Country *A*'s increase in arming increases its revenue from exporting good *X*, which is welfare-increasing. This explains why the terms-of-trade effect of arming is positive. An increase in arming, however, has two opposite effects on the total value of domestic outputs. When country *A*'s arming increases, the amount of input *A* available for producing final good *X* unambiguously decreases, which reduces domestic consumption of the good and hence is welfare-decreasing. This explains why the output distortion effect is negative. But country *A*'s increase in arming raises its probability of successfully appropriating input *B* to produce final good *Y* for domestic consumption, which is welfare-increasing. This explains why the resource appropriation effect of arming is positive. These three effects interact simultaneously in determining the socially optimal level of arming for country *A*.

There are interesting observations in connection with the three effects separately. First, the terms-of-trade effect of arming on welfare is greater when country *A*'s final good export, $X_A - C_X$, increases. Second, when country *A*'s resource security (σ_A) increases, its increase in arming is welfare-reducing due to the fact that the output distortion effect of arming aggravates. Third, when the rival's resource security (σ_B) decreases, country *A*'s increase in arming is welfare-enhancing since the positive resource appropriation effect strengthens.

Similarly, country *B* decides on an optimal level of investment in arms G_B that solves the following welfare maximization problem: $\underset{\{G_B\}}{\text{Max}}\, SW_B = CS_B + PS_B$, where CS_B and PS_B are given in (17b) and (18b). We can also decompose the welfare effect of arming into three terms for country *B*:

$$\frac{\partial SW_B}{\partial G_B} = \underbrace{\frac{(Y_B - D_Y)}{2\beta}}_{\substack{\text{Terms of trade effect}\\ \text{of arming}\\ (+)}} + \underbrace{H_Y\left[\frac{(1-\sigma_B)R_B G_A}{(G_A+G_B)^2} - 1\right]}_{\substack{\text{Output distortion effect}\\ \text{of arming}\\ (-)}} + \underbrace{H_X \frac{(1-\sigma_A)R_A G_A}{(G_A+G_B)^2}}_{\substack{\text{Resource appropriation effect}\\ \text{of arming}\\ (+)}} = 0. \tag{20b}$$

Under symmetry in all aspects $(R_A = R_B = R,\ \sigma_A = \sigma_B = \sigma,\ \text{and}\ t_A = t_B = t),$ we use the FOCs for countries *A* and *B* in (20a) and (20b) to solve for the Nash equilibrium level of arming:

$$G_{\text{Trade}} = \frac{\left(3R - 4\alpha + t\beta\right) + \sqrt{L}}{6}, \tag{21}$$

where $L \equiv t^2\beta^2 + 16\alpha^2 + 3(4\sigma - 1)R^2 + 6Rt\beta - 24R\alpha\sigma - 8t\alpha\beta.$ Given the constrained condition as shown in Lemma 1 that $G < \sigma R - \beta t$ for the two symmetric countries to trade, we need to consider the possibility of a corner solution. Setting G_{Trade} in (21) to be identical to $\sigma R - \beta t,$ we solve for the critical value of σ (denoted as σ_S) above which there is an interior solution for the optimal level of arming as shown in (21). This yields

$$\sigma_S = \frac{\left(4R - 6\alpha + 7t\beta\right) + \sqrt{t^2\beta^2 + 36\alpha^2 + 4R^2 - 24R\alpha - 36\alpha\beta t + 20t\beta R}}{6R}.$$

It is easy to verify $\sigma_S = 1/3$ when $t = 0.$ Also, the value of σ_S increases with *t*. This implies that $\sigma_S \geq 1/3.$ In view of G_{Trade} in (21) and G_{Autarky} in (12), it can easily be verified that the optimal level of arming under trade is identical to that under autarky when $\sigma = \sigma_S$. Each country's optimal level of arming for $0 < \sigma \leq 1$ are:

$$G^* = \begin{cases} \sigma R & \text{if } 0<\sigma \leq \frac{1}{3}; \\ G_{\text{Autarky}} & \text{if } \frac{1}{3} < \sigma \leq \sigma_S; \\ G_{\text{Trade}} & \text{if } \sigma_S < \sigma \leq 1. \end{cases} \tag{22}$$

These results are illustrated in Figure 2(i) as follows:

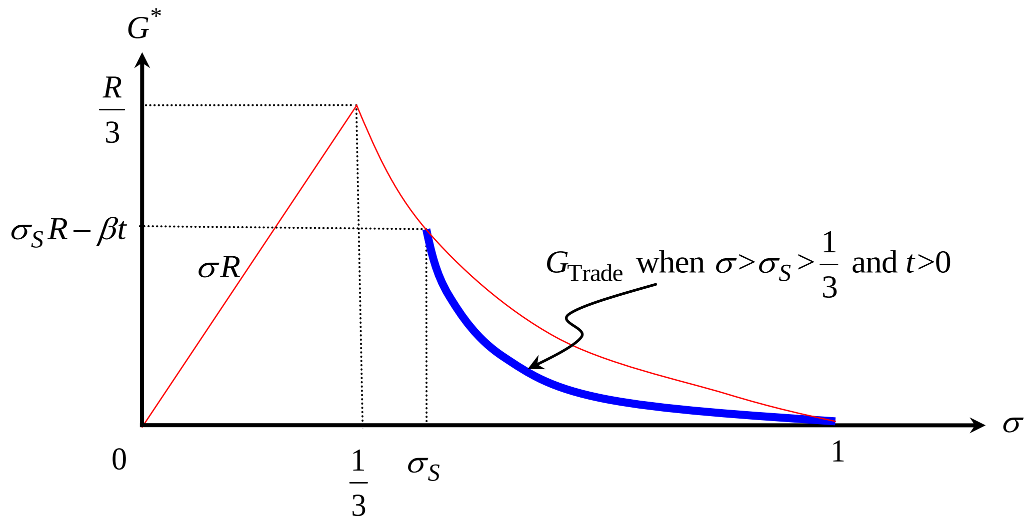

Figure 2(i). *Optimal arming in bilateral trade under resource conflict*

It is instructive to examine the optimal level of arming when property rights are perfectly defined or costlessly enforced. In this case, we set the value of σ to be equal to one in G_{Trade} and find that $G_{\text{Trade}}\big|_{\sigma=1}=0$. Alternatively, we set $\sigma_A=\sigma_B=1$ in the FOCs for countries *A* and *B* (see equations 20a and 20b). This yields

$$\frac{\partial SW_A}{\partial G_A}\Big|_{\sigma_A=\sigma_B=1}=\frac{(X_A-C_X)}{2\beta}-P_X=-\frac{4\alpha-3R+3G_A-\beta t}{4\beta}<0,$$

$$\frac{\partial SW_B}{\partial G_B}\Big|_{\sigma_A=\sigma_B=1}=\frac{(Y_B-D_Y)}{2\beta}-H_Y=-\frac{4\alpha-3R+3G_B-\beta t}{4\beta}<0,$$

noting that the signs are implied by the constrained conditions in (14c). These results imply that the optimal level of arming for each country is zero zero under completer resource security, i.e., $G_A^*=G_B^*=0$. The economic implication is straightforward. Under complete resource security, there is no such thing as the resource appropriation effect. However, the positive terms-of-trade effect is fully dominated by the negative output-distortion effect, with the result that arming levels are all zero for both countries. Stated alternatively, arming cannot be used as a tool to improve an export country's terms of trade in the absence of resource insecurity. The results of the analyses lead to the following proposition:

PROPORTION 2. *In a two-country world with the absence of insecure resources (that is, the resource security coefficient is one for each country), the socially optimal levels of arming by two symmetric countries engaging in final goods trade are shown to be zero. With insecure resources, however, the optimal level of arming is determined by the interactions of the terms-or-trade effect, the output distortion* *effect, and the resource appropriation effect. Under symmetry in all aspects, the optimal level of arming is strictly positive as given by (21). This optimal arming level depends on the degree of resource security/insecurity, the amount of resource endowment, and the size of trade costs.*

Proposition 2 indicates that in the absence of insecure resources, there is a peacetime equilibrium of international trade. But with the possibilities of resource appropriation, optimal investments in armaments are strictly positive.

3.2 Effects of changes in trade costs, resource security, and national endowment

Under the shadow of resource conflict, the amount of good *Y* imported by country *A* is:

$$IM_A = (\alpha - \beta P_Y) - \frac{G_A}{G_A + G_B}(1-\sigma_B)R_B.$$

Substituting P_Y from (14a) and $G_A = G_B = G_{\text{Trade}}$ from (21) into the above expression yields

$$IM_A = \frac{(4\alpha - 3R + 6R\sigma - 7t\beta) - \sqrt{L}}{12}.$$

Considering the constrained conditions that $G < \sigma R - \beta t$ (see Lemma 1) for the two symmetric countries to trade, we find that

$$IM^* = \begin{cases} 0 & \text{if } \sigma \le \sigma_S; \\ IM_A > 0 & \text{if } \sigma > \sigma_S. \end{cases} \tag{23}$$

noting that σ_S is the critical value of the resource security coefficient above which the optimal arming level is given by G_{Trade}.

One important question concerns how each country's optimal arming decision is affected by greater trade openness (resulting from reductions in trade costs). To answer this question, we take the derivative of G_{Trade} in (21) with respect to t. This yields

$$\frac{\partial G_{\text{Trade}}}{\partial t} = \frac{\beta G_{\text{Trade}}}{\sqrt{L}} \ge 0. \tag{24}$$

Given that $G^* = \sigma R - \beta t$ if $\sigma \le \sigma_S$ and $G^* = G_{\text{Trade}}$ if $\sigma > \sigma_S$ as shown in (22), we have from (24) that

$$\frac{\partial G_{\text{Trade}}}{\partial t} > 0 \text{ if } \sigma > \sigma_S.$$

Figure 2(ii) presents a graphical illustration of this result. A decrease in t causes the optimal arming curve for G_{Trade} to shift leftward, noting that at the same time the value of σ_S decreases as t decreases and that the lowest value of σ_S is 1/3 when t equals zero.

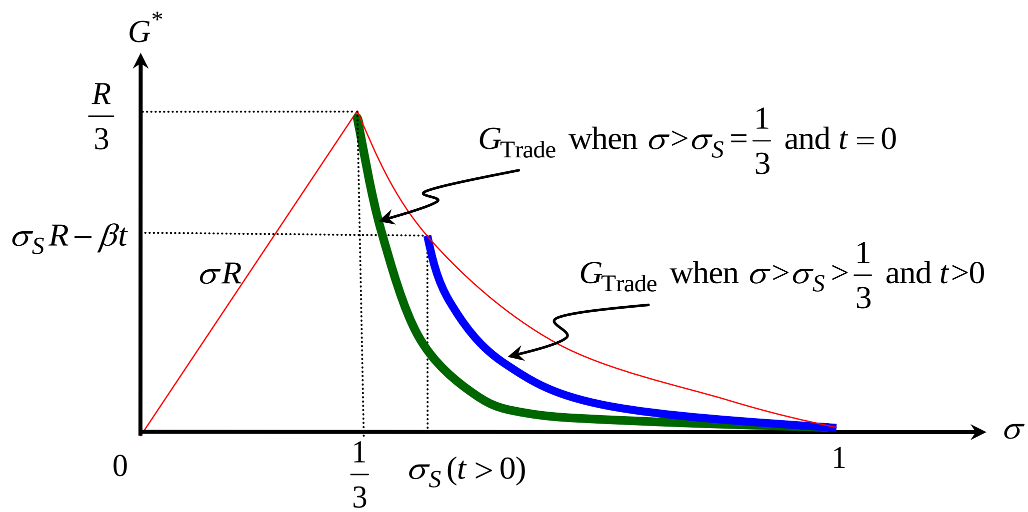

Figure 2(ii). *Optimal arming decreases with trade costs (the pacifying effect of opening trade)*

In bilateral trade under resource conflict, we have the following comparative-static derivatives:

$$\frac{\partial G_{\text{Trade}}}{\partial \sigma} = -\frac{R(2\alpha - R)}{\sqrt{L}} < 0,$$

$$\frac{\partial G_{\text{Trade}}}{\partial R} = \frac{(4R\sigma - R + t\beta - 4\alpha\sigma) + \sqrt{L}}{2\sqrt{L}} > 0.$$

Based on these results, we have

PROPOSITION 3. *In a world with two symmetric countries in which there are insecure resources and a bilateral trade, if the coefficient of resource security is sufficiently high (i.e., $\sigma > \sigma_S$), reductions in trade costs lead each country to reduce its arming level* $(\partial G_{\text{Trade}} / \partial t > 0)$. *Consequently, greater trade openness through trade cost reductions reduce conflict intensity. Other things being equal, a decrease in each country's resource security or an increase in its endowment increases arming* $(\partial G_{\text{Trade}} / \partial \sigma < 0$ *and* $\partial G_{\text{Trade}} / \partial R > 0)$.

The first result in Proposition 3 that arming is positively related to trade costs suggests the pacifying effect of greater trade openness between adversaries under symmetry. The other two results have interesting implications. A country's concerns over resource security can be captured by the value of $\sigma_i (i = 1, 2)$. A decrease in the security coefficient σ_i leads a country to increase its investment in arms for national defense. That is why the sign of the derivative $\partial G_{\text{Trade}} / \partial \sigma$ is negative. From the perspective of social welfare maximization, a resource-rich country would invest more in military buildup for national defense than a resource-poor country would do. This explains why the sign of the derivative $\partial G_{\text{Trade}}/\partial R$ is positive.

Note that in trade equilibrium under symmetry, we have $P_Y = H_x$. This means that the importing price of good *Y* to consumers in country *A*, P_Y, is identical to the importing price of good *X* to consumers in country *B*, H_x. It is convenient to just look at P_Y to see how it is affected by changes in trade costs under the shadow of resource conflict.

Taking the derivative of P_Y in (14a) with respect to t yields

$$\frac{dP_Y}{dt} = \frac{\partial P_Y}{\partial t} + \frac{\partial P_Y}{\partial G}\frac{\partial G_{\text{Trade}}}{\partial t},$$

where the first term, $\partial P_Y/\partial t$, is the *direct* effect of trade cost on P_Y due to the arbitrage behavior, and the second term, $(\partial P_Y/\partial G)(\partial G_{\text{Trade}}/\partial t)$, is the *indirect* effect of trade cost through its impact on arming. Note that at the trade equilibrium, an exogenous decrease in trade cost makes P_Y to be higher than the good's domestic price in country *B* (H_Y) plus the trade cost. That is, $P_Y > H_Y + t$. This discrepancy in prices resulting from a lower trade cost encourages the sales of good *Y* to country *A*, causing its importing price to decline. We have from (14a) that $\partial P_Y/\partial t = 1/2 > 0$, which reflects the direct effect of a decrease in trade cost on reducing good *Y*'s importing price. With resource appropriation possibilities, a lower trade cost can lead each country to reduce its arming, providing that resource insecurity is not high. It can easily be verified from P_Y in (14a) that

$$\frac{dP_Y}{dt} = \frac{1}{2\beta}\frac{\partial G_{\text{Trade}}}{\partial t} + \frac{1}{2} > 0. \tag{26}$$

Given the result in (24) that $G_{\text{Trade}}/\partial t > 0$ if $\sigma > \sigma_S$, we have from (26) that

$$\frac{dP_Y}{dt} > 0 \text{ if } \sigma > \sigma_S.$$

The economic implication is straightforward. When each country's resource security is sufficiently high (i.e., $\sigma > \sigma_S$), reductions in trade costs encourage both countries to allocate less resources to arming and more resources to produce final goods for exportation. Consequently, the equilibrium volumes of trade (imports and exports) unambiguously increase. We, therefore, have

PROPOSITION 4. *For the symmetric case in which two resource-conflict countries engage in trade, greater trade openness through reductions in trade costs generates a positive effect in lowering the prices of final goods exported to markets in the two adversaries. Consequently, the volumes of imports and* *exports the two-country world increase.*

For the symmetric case of trade without resource appropriation, we have $\sigma = 1$ and $G_A = G_B = 0$ which imply that $dP_Y/dt = 1/2 > 0.$ As long as there is bilateral trade between two adversaries, the effects that trade cost reductions have on lowering the importing prices of final goods are fundamentally in line with the traditional theory of international trade without conflict. Nevertheless, we can see from equation (26) that the effects on lowering the importing prices of final goods (X and Y) under conflict exceeds those under peace. This is because the positive sign for the derivative: $\partial G_{\text{Trade}}/\partial t > 0,$ which demonstrates the pacifying effect of greater trade openness (through trade cost reductions) in reducing conflict-related arming. As such, the increase in trade volume for each country is relatively greater under conflict than under peace.

3.3 Ranges of trade costs leading to bilateral trade under conflict or under peace

We have shown that there is bilateral trade when resource security is high, other things being equal. That is, $IM^* = IM_A > 0$ for $\sigma > \sigma_S$. From a different angle, it is instructive to determine the critical value of trade cost above which there is no trade. By setting IM_A to be zero, we solve for the prohibitive levels of trade costs for the two resource-conflict countries as

$$\hat{t}^{\text{Conflict}} = \frac{16\alpha - 12R + 21R\sigma + \sqrt{N}}{24\beta}, \tag{27}$$

where $N \equiv 9R^2\sigma^2 - 96R\alpha - 128\alpha^2 - 216R^2\sigma + 72R^2 + 384R\alpha\sigma.$ For the case of perfect security such that $\sigma = 1,$ we have

$$\hat{t}^{\text{Peace}} = \frac{16\alpha + 9R + \sqrt{288R\alpha - 128\alpha^2 - 135R^2}}{24\beta} > 0.$$

In the absence of resource conflict, the two countries engage in trade when trade costs are lower than $\hat{t}^{\text{Peace}}$. Figure 3 illustrates these results.

One interesting issue is how the different degree of resource security affects the prohibitive levels of trade costs for $0 < \sigma < 1.$ To answer this question, we take the derivative of $\hat{t}^{\text{Conflict}}$ in (27) with respect to $\sigma.$ This yields

$$\frac{\partial \hat{t}^{\text{Conflict}}}{\partial \sigma} = \frac{R[(64\alpha - 36R + 3R\sigma) + 7\sqrt{N}]}{8\beta\sqrt{N}} > 0.$$

The sign of this derivative is unambiguously positive.

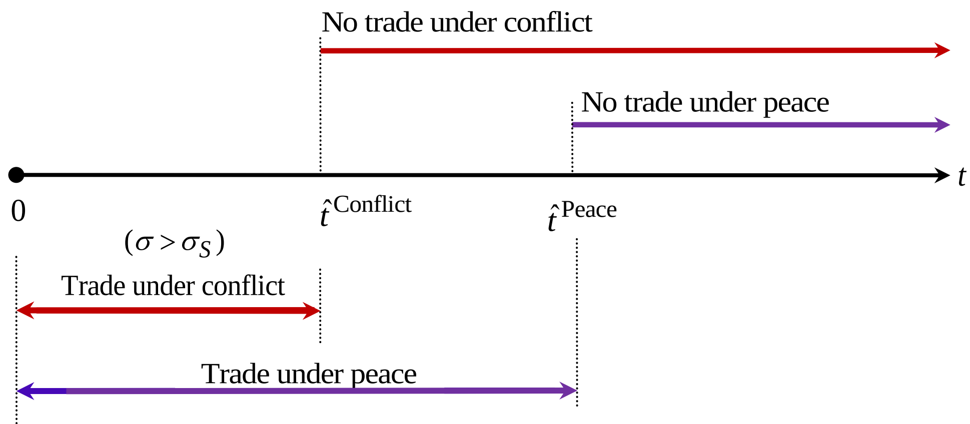

Figure 3. *The range of trade costs leading to bilateral trade under conflict or peace*

We thus have

PROPOSITION 5. *Other things (e.g., national resource endowments, production technology, and market demands) being equal, there is a positive relationship between the prohibitive level of trade barriers and the level of a country's resource security.*

Proposition 5 implies that for the case of two resource-conflict countries with their resource security being relatively lower, all else remaining unchanged, the prohibitive level of trade barriers $(\hat{t})$ will be relatively lower. As such, the likelihood that the two adversaries engage in final goods trade is relatively lower.

4. Conflict and Trade under Asymmetry in Resource Security/Insecurity

Not all countries are identical in terms of their security concerns over scarce resources. Instead of assuming that two resource-conflict countries are symmetric in all dimensions, we proceed to analyze the scenario where there are differences in national security/insecurity associated with the country-specific resources. In terms of our notations for countries *A* and *B*, their security coefficients σ_A and σ_B differ.

4.1 Effects of resource security differential on optimal arming and conflict intensity

Without lost of generality, we introduce a new parameter ε with $\varepsilon = \min\{1-\sigma, \sigma\}$ and assume that $\sigma_A = \sigma + \varepsilon$ and $\sigma_B = \sigma - \varepsilon$, where σ can be interpreted as the "world" average of resource security. That is, country *A* is more secure than country *B* in terms of valuable resources being appropriated by its rival in an open conflict. We use the parameter ε to capture the discrepancy in resource security between countries *A* and *B*; the higher the value of ε, the greater the resource security differential between the adversaries. Two questions we wish to answer are: (i) Other things being equal, will the more secure country allocate more or less of resource to arming as compared to the less secure country? (ii) How does the resource security differential affect the overall conflict intensity (i.e., the aggregation of armaments by the adversaries)?

We consider the case the two adversarial countries engage in final goods trade. Under the assumptions that $\sigma_A = \sigma + \varepsilon$ and $\sigma_B = \sigma - \varepsilon,$ other things being equal $(R_A = R_B = R$ and $t_A = t_B = t),$ we have from (17) and (18) that

$$SW_A = CS_A + PS_A = \frac{(R - G_A + \beta t)^2 + (R - G_B - \beta t)^2}{8\beta} + (\frac{2\alpha - R + G_A - \beta t}{2\beta})[(\sigma+\varepsilon)R + \frac{G_A}{G_A + G_B}(1-(\sigma+\varepsilon))R - G_A)] + (\frac{2\alpha - R + G_B + \beta t}{2\beta})[\frac{G_A}{G_A+G_B}(1-(\sigma-\varepsilon))R], \tag{28a}$$

$$SW_B = CS_B + PS_B = \frac{(R - G_A - \beta t)^2 + (R - G_B + \beta t)^2}{8\beta} + (\frac{2\alpha + G_A - R + \beta t}{2\beta})[\frac{G_B}{G_A + G_B}(1-(\sigma+\varepsilon))R] + (\frac{2\alpha + G_B - R - \beta t}{2\beta})[(\sigma-\varepsilon)R + \frac{G_B}{G_A+G_B}(1-(\sigma-\varepsilon))R - G_B]. \tag{28b}$$

For social welfare maximization, the two countries' FOCs are given, respectively, as

$$\frac{\partial SW_A(G_A, G_B; \varepsilon)}{\partial G_A} = 0, \tag{29a}$$

$$\frac{\partial SW_B(G_A, G_B; \varepsilon)}{\partial G_B} = 0, \tag{29b}$$

where SW_A and SW_B are, respectively, given in (28a) and (28b). Country *A*'s FOC in (29a) implicitly defines its arming reaction function to the arming level chosen by country *B*, i.e., $G_A = G_A(G_B; \varepsilon).$ Country *B*'s FOC in (29b) implicitly define its arming reaction function to the arming level chosen by country *A*, i.e., $G_B = G_B(G_A; \varepsilon).$ Given $\varepsilon,$ these reaction functions determine the Nash equilibrium arming levels, $\{\tilde{G}_A, \tilde{G}_B\},$ that maximize the social welfare of the two asymmetric adversaries.

Due to the complexity of finding the reduced-form solutions for $\tilde{G}_A$ and $\tilde{G}_B,$ we adopt a comparison methodology that uses the symmetric Nash equilibrium as a reference base. When the value of ε is equal to zero such that $\sigma_A = \sigma_B = \sigma$, we have the equilibrium levels of arming under symmetry in all aspects. Denote these equilibrium arming levels as $\{G_A^*, G_B^*\}$. In Figure 3, this symmetric Nash equilibrium is illustrated by a point such as S on the 45-degree degree line, where $G_A^* = G_B^*$. This is the point of intersection between A's arming reaction curve, RF_A^{Sym}, and B's arming reaction curve, RF_B^{Sym}.

Under the assumption of resource security asymmetry, we have $\varepsilon > 0$. We need to see the effects of a change in ε on the signs of the two derivatives: $\partial SW_A / \partial G_A$ and $\partial SW_B / \partial G_B$. Making use of SW_A in (28a), we find that

$$\frac{\partial}{\partial \varepsilon}\left(\frac{\partial SW_A}{\partial G_A}\right) = \frac{(G_B + t\beta)G_B R}{\beta(G_A + G_B)^2} > 0. \tag{30a}$$

The positive sign in (30a) indicates that, when enjoying a higher level of resource security than its rival, country A's marginal welfare benefit from arming, $\partial SW_A / \partial G_A$, is strictly increasing with the security differential, ε. Thus, when the discrepancy in resource security is widen, country A's increase in arming is welfare-improving, given the level of arming by country B. As can be seen from Figure 4, an exogenous increase in resource security differential (relative to the symmetric equilibrium) causes country A's arming reaction curve to move rightward to the one as shown by RF_A^{Asym}.

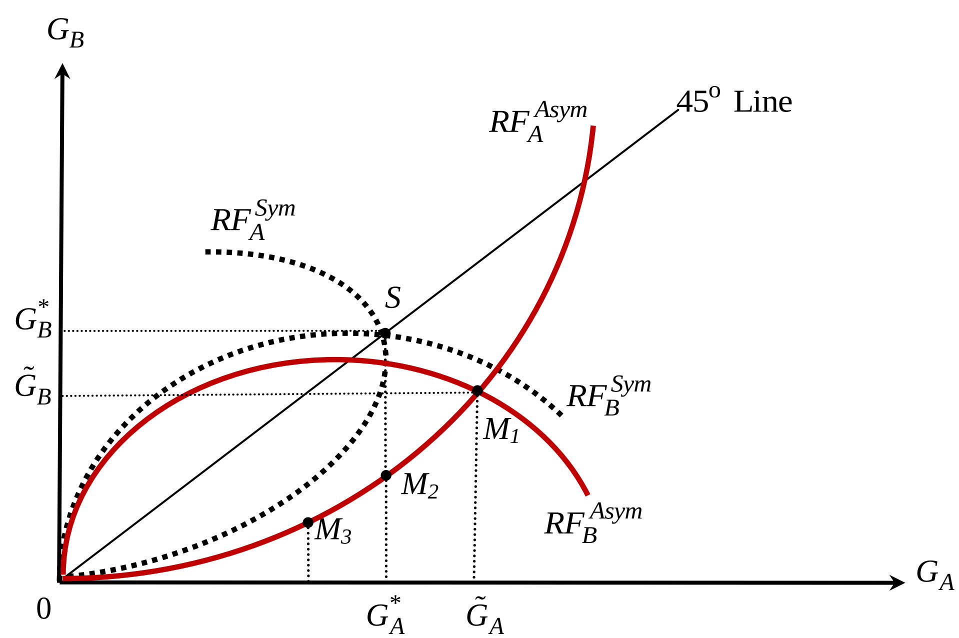

Figure 4. *Optimal arming and conflict intensity under resource security asymmetry*

On the other hand, using SW_B in (28a), we find that

$$\frac{\partial}{\partial \varepsilon}\left(\frac{\partial SW_B}{\partial G_B}\right) = -\frac{(G_A + t\beta)G_A R}{\beta(G_A + G_B)^2} < 0. \tag{30b}$$

The negative sign in (30b) indicates that, when having a lower level of resource security than its rival, country *B*'s marginal welfare benefit of arming, $\partial SW_B / \partial G_B$, decreases as the resource security differential, ε, increases. As a result, country *B*'s increase in arming is welfare-reducing, given the level of arming by country A. As can be seen from Figure 4, an exogenous decrease in resource security differential (relative to the symmetric equilibrium) causes country *B*'s arming reaction curve to move downward to the one as shown by RF_B^{Asym}.

Depending on the relative shifts of the curves RF_A^{Asym} and RF_B^{Asym}, there are three possibilities for the equilibrium arming levels under asymmetry, as compared to the case under symmetry. Given country *A*'s arming reaction curve under asymmetry as RF_A^{Asym}, three possible results are:

(i) $\tilde{G}_A > G_A^*$ and $\tilde{G}_B < G_B^*$ when RF_B^{Asym} passes through point M_1 on RF_A^{Asym};

(ii) $\tilde{G}_A = G_A^*$ and $\tilde{G}_B < G_B^*$ when RF_B^{Asym} passes through point M_2 on RF_A^{Asym};

(iii) $\tilde{G}_A < G_A^*$ and $\tilde{G}_B < G_B^*$ when RF_B^{Asym} passes through point M_3 on RF_A^{Asym}.

Figure 3 illustrates the asymmetric equilibrium at M_1 for case (i). The asymmetric equilibrium at M_2 or M_3 for case (ii) or (iii) can be shown straightforwardly. It follows that the overall conflict intensity under security asymmetry, $\tilde{G}_A + \tilde{G}_B$, can be higher, equal to, lower than that under security symmetry $G_A^* + G_B^*$. Regardless of the three possible outcomes, we note that the asymmetric equilibrium always occurs at a point below the 45-degree line. This implies that $\tilde{G}_A > \tilde{G}_B$. We, therefore, have

PROPOSITION 6. *Under asymmetry in resource security between two adversaries, other things being equal, the socially optimal level of arming is* <u>*greater*</u> *for the more secure country than for the less secure country. When comparing the intensity of conflict under resource security asymmetry to that under resource security symmetry, the result cannot be determined unambiguously.*

Proposition 6 implies that, relative to the symmetric equilibrium, resource security asymmetry does not necessarily lower the intensity of conflict. From the perspective of resource insecurity, a world with two asymmetric adversaries may not necessarily be "safer" (or "dangerous") than a world with two symmetric adversaries.

4.2 Effects of greater trade openness on arming and conflict under security asymmetry

The next issue concerns the effect of greater trade openness on conflict intensity under resource security asymmetry. Given an asymmetric equilibrium in arming such as point M_1 in Figure 4, it is interesting to see how it is affected by lower trade costs between two adversaries. To answer this question, we first look at how the marginal welfare effects of arming by countries *A* and *B*, $\partial SW_A/\partial G_A$ and $\partial SW_B/\partial G_B$, will change as t decreases.

For country *A*, it follows from (20a) that

$$\frac{\partial}{\partial t}\left(\frac{\partial SW_A}{\partial G_A}\right)=\frac{1}{2\beta}\frac{\partial(X_A-C_X)}{\partial t}+\left(\frac{\partial P_X}{\partial t}\right)\left[\frac{(1-\sigma_A)R_AG_B}{(G_A+G_B)^2}-1\right]+\left(\frac{\partial P_Y}{\partial t}\right)\frac{(1-\sigma_B)R_BG_B}{(G_A+G_B)^2},\qquad(31)$$

noting that we have from (3a), (4a), (8a), and (14a) the following derivatives:

$$\frac{\partial(X_A-C_X)}{\partial t}=-\frac{\beta}{2},\ \frac{\partial P_X}{\partial t}=-\frac{1}{2},\ \text{and}\ \frac{\partial P_Y}{\partial t}=\frac{1}{2}.$$

Substituting the above derivatives back into (31), assuming that $R_A=R_B=R$, yields

$$\frac{\partial}{\partial t}\left(\frac{\partial SW_A}{\partial G_A}\right)=\underbrace{\left(-\frac{1}{4}\right)}_{\substack{\text{Terms-of-trade effect}\\ \text{of arming as } t \text{ decreases}\\ (-)}}+\underbrace{\left(-\frac{1}{2}\right)\left[\frac{(1-\sigma_A)RG_B}{(G_A+G_B)^2}-1\right]}_{\substack{\text{Output distortion effect}\\ \text{of arming as } t \text{ decreases}\\ (+)}}+\underbrace{\left(\frac{1}{2}\right)\frac{(1-\sigma_B)RG_B}{(G_A+G_B)^2}}_{\substack{\text{Resource appropriation effect}\\ \text{of arming as } t \text{ decreases}\\ (+)}}.\qquad(32)$$

Combining the three terms on the right-hand side of equation (32), we have

$$\frac{\partial}{\partial t}\left(\frac{\partial SW_A}{\partial G_A}\right)=\frac{1}{4}+\frac{(\sigma_A-\sigma_B)RG_B}{2(G_A+G_B)^2}>0.$$

Under the assumption that $\sigma_A>\sigma_B$, the sign of the above derivative is strictly positive.

The economic intuitions behind the positivity of the derivative can be explained by the three effects as shown in equation (32). When there are reductions in trade costs between countries *A* and *B*, the marginal welfare benefit of arming for country *A*, $\partial SW_A/\partial G_A$, is affected in three different ways. First, as trade costs are lower, the terms-of-trade effect of arming increases since country *A*'s export volume (X_A-C_X) increases and hence its revenue from the final good export. The terms-of-trade effect resulting from trade cost reductions, which is negative as shown in (32), encourages country *A* to increase arming. Second, as trade costs are lower, the output distortion effect of arming aggravates. This is because lower trade costs raise the opportunity cost of arming. It is to the benefit of country *A* to produce more final good *X* for exportation since the good's exporting price increases. The output distortion effect of arming resulting from trade cost reductions, which is positive as shown in (32), encourages country *A* to reduce arming. Third, as trade costs are lower, the resource appropriation effect of arming decreases. This is because lower trade costs cause the importing price of good *Y* to decline. When good *Y* becomes relatively chapter, country *A's* import demand for the good increases. As such, country *A*'s incentive for appropriating input *B* in order to produce final good *Y* will be declining. This resource appropriation effect of arming resulting from trade cost reductions, which is positive as shown in (32), encourages country *A* to reduce arming.

In equilibrium, we find that $\partial SW_A / \partial G_A$ decreases as t decreases. This indicates that, as t decreases, the terms-of-trade effect is dominated by the output distortion effect plus the resource appropriation effect. Thus, under resource security asymmetry, trade cost reductions lead country *A* to reduce its optimal level of arming (holding constant the level of arming by country *B*). In Figure 5, this decrease in country *A*'s arming is illustrated by a leftward shift in its reaction curve toward the 45-degree line from RF_A^{Asym} to $RF_A^{Asym'}$.

Next, we look at how the marginal welfare effect of country *B*'s arming, $\partial SW_B / \partial G_B$, is affected by a decrease in t. It follows from (20b) that

$$\frac{\partial}{\partial t}\left(\frac{\partial SW_B}{\partial G_B}\right) = \frac{1}{2\beta}\frac{\partial(Y_B - D_Y)}{\partial t} + \left[\frac{(1-\sigma_B)R_B G_A}{(G_A+G_B)^2} - 1\right]\left(\frac{\partial H_Y}{\partial t}\right) + \frac{(1-\sigma_A)R_A G_A}{(G_A+G_B)^2}\left(\frac{\partial H_X}{\partial t}\right), \quad (33)$$

noting that we have from (3b), (4b), (8b), and (14b) the following derivatives:

$$\frac{\partial(Y_B - D_Y)}{\partial t} = -\frac{\beta}{2},\ \frac{\partial H_Y}{\partial t} = -\frac{1}{2},\ \text{and}\ \frac{\partial H_X}{\partial t} = \frac{1}{2}.$$

Substituting the above derivatives back into (33), assuming that $R_A = R_B = R,$ yields

$$\frac{\partial}{\partial t}\left(\frac{\partial SW_B}{\partial G_B}\right) = \underbrace{\left(-\frac{1}{4}\right)}_{\substack{\text{Terms-of-trade effect}\\ \text{of arming as } t \text{ decreases}\\ (-)}} + \underbrace{\left(-\frac{1}{2}\right)\left[\frac{(1-\sigma_B)RG_A}{(G_A+G_B)^2} - 1\right]}_{\substack{\text{Output distortion effect}\\ \text{of arming as } t \text{ decreases}\\ (+)}} + \underbrace{\left(\frac{1}{2}\right)\frac{(1-\sigma_A)RG_A}{(G_A+G_B)^2}}_{\substack{\text{Resource appropriation effect}\\ \text{of arming as } t \text{ decreases}\\ (+)}}. \quad (34)$$

It follows from (34) that, after combining the three terms, we have

$$\frac{\partial}{\partial t}\left(\frac{\partial SW_B}{\partial G_B}\right) = \frac{1}{4} + \frac{(\sigma_B - \sigma_A)RG_A}{2(G_A+G_B)^2}. \quad (35)$$

Under the assumption that $\sigma_A > \sigma_B$, the sign of the derivative in (35) can be positive, zero, or negative. Accordingly, greater trade openness may cause country *B*'s arming reaction function to shift upward or downward, depending on the resource security differential.

We cannot rule out the possibility that, when trade costs are lower, the sum of the output distortion effect and the resource appropriation effect is dominated by the terms-of-trade effect. Stated alternatively, if σ_B is sufficiently lower than σ_A such that the marginal welfare benefit of arming $(\partial SW_B/\partial G_B)$ *increases* when t decreases, the optimal strategy for country B is to increase its arming. Figure 5 to illustrate this possibility that country B's arming reaction curve shifts upward from RF_B^{Asym} to $RF_B^{Asym'}$. The two arming reaction curves $RF_A^{Asym'}$ and $RF_B^{Asym'}$ for countries A and B determine the new asymmetric equilibrium at a point like $M_1^{'}$.

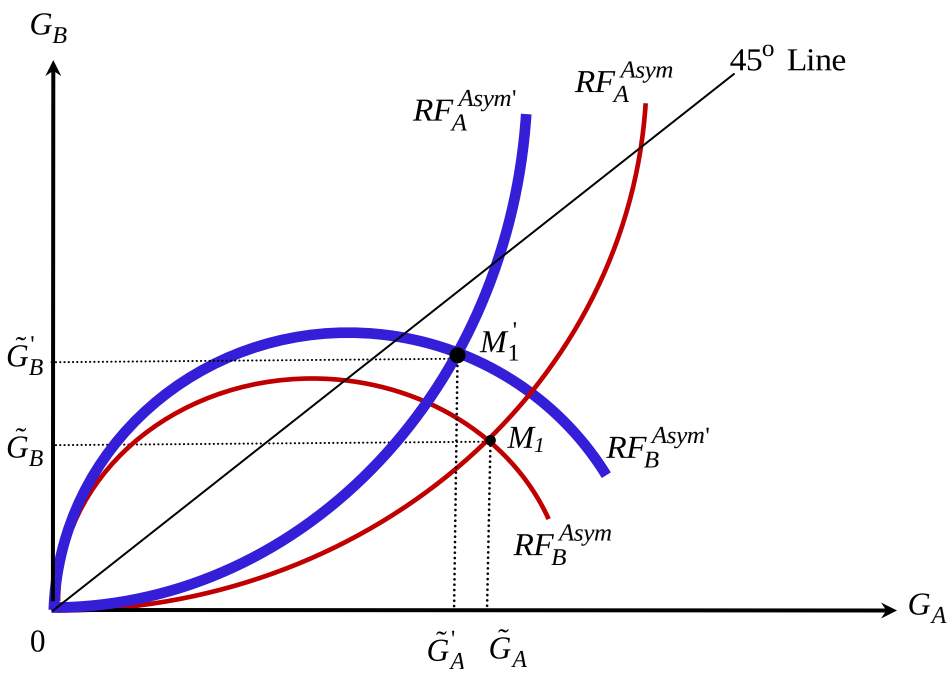

Figure 5. *Greater trade openness may increase conflict intensity under security asymmetry*

Comparing $M_1^{'}$ to the original equilibrium at M_1, we see the following results:

$\tilde{G}_A^{'} < \tilde{G}_A$, $\tilde{G}_B^{'} > \tilde{G}_B$, and $\tilde{G}_A^{'} + \tilde{G}_B^{'} > \tilde{G}_A + \tilde{G}_B$.

In this case, country A's arming decreases whereas country B's arming increases. Moreover, the overall conflict intensity increases despite that trade costs are lower. It should be notes that although there is a decrease in arming for country A (the relatively more secure country), its arming level continues to be greater than the level of arming by country B (the relatively more secure country). As discussed in Section 4.1, we have $\tilde{G}_A^{'} > \tilde{G}_B^{'}$ under resource security asymmetry. We thus have

PROPOSITION 7. *Under asymmetry in resource security between two adversaries, other things being equal, greater trade openness through reductions in trade costs leads the relatively more secure country (country A) to reduce its optimal level of arming. But the effect on the arming level of the relatively less secure country (country B) can be positive, zero, or negative. Consequently, the impact that greater trade openness has on the overall conflict intensity cannot be determined unambiguously.*

The intuition behind this result is that resource-conflict countries with different degrees of security/insecurity respond to trade cost reductions differently: the relatively more secure country reduces its arming, whereas the relatively less secure country may increase its arming. The overall intensity of conflict may or may not be reduced. The implication of Proposition 7 is straightforward. The liberal peace hypothesis that international trade reduces conflict (and hence promotes peace) may or may not hold true for the case of contending countries with asymmetries in resource insecurity.

5. Concluding Remarks

In this paper, we develop a simple game-theoretic model to examine two related issues concerning how resource appropriation possibilities affect international trade and whether greater trade openness reduces conflict intensity. In the analysis, we incorporate elements of resource-based conflict and a Tullock-Hirshleifer-Skaperdas contest success function into the Bagwell-Staiger model of trade to identify the conditions under which two contending countries may or may not engage in final goods trade while determining their socially optimal levels of arming for protecting their respective resources.

In bilateral trade under resource conflict, the impact of a country's arming on its domestic welfare has been decomposed into three effects. The terms-of trade-effect encourages arming, which is welfare-increasing since increasing arming increases the revenue of final good exports to the rival country. The output distortion effect discourages arming because increasing arming lowers the amount of resource allocated to final good production, which is welfare-decreasing. The resource appropriation effect encourages arming since it increases the likelihood of successfully appropriating its rival's resource for producing more final goods, which is welfare-increasing. We show that these three effects interact simultaneously in determining how resource appropriation affects the equilibrium volumes of trade between two conflicting countries, as well as how reducing trade barriers affect their optimal amounts of national defense.

In the absence of resource conflict, the optimal levels of arming for two countries engaging in trade are shown to be zero. Consequently, the countries allocate all of their endowed resources for domestic production and consumption, as well as for cross-border trade in final goods. This is consistent with the traditional approach to international trade with no resource conflict. With resource appropriation possibilities, however, we find that the welfare-maximizing level of arming for each country is strictly positive. It has been shown that whether greater trade openness will reduce the intensity of conflict depends on both economic and political variables. These include the coefficient of resource security/insecurity, trade costs, and differences in resource endowments between the adversaries. We show a positive relationship between the prohibitive levels of trade costs and the degrees of national security associated with country-specific resources. For two symmetric adversaries with resource security being relatively higher (lower), the likelihood that they engage in trade is relatively higher (lower). We further discuss an extension of the conflict-trade model to allow for asymmetry. We find that under resource security asymmetry, the more secure country has a higher level of arming than the less secure country. Greater trade openness through trade cost reductions has a positive effect in reducing the arming level of the relatively more secure country. But the effect on the arming level of the relatively less secure country can be positive, zero, or negative. As such, whether opening trade reduces the overall conflict intensity cannot be determined unambiguously.

In view of the growing tensions in the international arena due to resource insecurity, our theoretical findings have relevant implications for trade between resource-conflict countries and their investments in armaments. However, we admittedly recognize that our trade-conflict model has been built upon a number of simplifying assumptions. One potentially interesting extension of the model is to see how the conflict-trade equilibrium in a two-country framework is altered by the strategic intervention of a third country.[7] It is our future research agenda to elaborate our findings in a less restrictive or more general setting.

[7]Garfinkel and Syropoulos (2015) examine an interesting case where two conflicting countries do not engage in trade but do trade with a third country. For issues on how the equilibrium outcome of a two-country conflict is affected by the strategic involvement of a third country without trade, see Chang, Potter, and Sanders (2007a), Chang and Sanders (2009), Sanders and Walia (2014).

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