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Abstract

The question over whether resource abundance or scarcity is an important cause of conflict has been a lively area of research. We examine this question in a simple trade-theoretic model where two regions are in conflict and where war equilibrium is determined endogenously. We find that while abundance of *uncontested* natural resources discourages conflict (the Malthusian view), abundance of *contested* natural resources encourages conflict. We also show that when the warring regions have influence over the terms of trade and take this influence into account when deciding war efforts, the effect of endowments on conflict may be strengthened or weakened depending on factor intensities of production and the relative strength of income and substitution effects.

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1 Introduction

Wars — both international and civil — unfortunately are more common than one would like.[1] What are the economic sources of such conflict? In the literature, one finds many attempts at explanations, one of which is in terms of resource abundance or scarcity. This paper takes a fresh look at this particular explanation.

The traditional view going back to Malthus is that a low level of resources relative to the size of the population leads to conflict because of a shortage of, and entitlement to, basic necessities that a scarcity of resources entail.[2] Recently, in a series of interesting papers Collier and Hoeffler (1998, 2004) point out that an abundance of resources can actually be the cause of conflicts, even though it increases income. The hypothesis that they put forward is that there is an additional channel through which resources affect conflict, and this channel works in the opposite direction of the traditional explanation.[3] Collier and Hoeffler emphasize the benefit of conflict to the rebels from looting resources (the greed or opportunity motivation) as opposed to traditional explanations that emphasize inequities and relative deprivation as source of conflict (the grievance motivation).

Though there exists enough informal evidence to support the Malthusian scarcity-conflict nexus, Grossman and Mendoza (2003) argue that it is difficult to show analytically using formal conflict models that scarcity increases warfare. In this paper, we show that it is indeed possible to explain analytically both the positive and negative effects of resource endowments on conflict. We do so by building on a theoretical literature on war and conflict

[1] According to Gleditsch (2004), there have been 450 international and civil wars between 1816 and 2002. Civil wars have steadily increased since World War II and are now the predominant form of violent conflict in the world. Most of the civil wars of the past generation or two have occured in developing countries. This is not to say that international wars between developing countries are rare. India, for example, has been involved in three major wars with Pakistan and one with China, disputed borders being the *casus belli* for all four cases.

[2] See, for example, Tilly (1975), Dreze and Sen (1989), Homer-Dixon (1999), Grossman and Mendoza (2003), and Diamond (2005).

[3] The Collier-Hoeffler approach has been to show that the share of primary commodity exports in GDP — which is taken to be a proxy of the degree of resource abundance — is positively associated with conflict even after controlling for income and income growth. There is now a sizeable literature that debates the Collier-Hoeffler approach (for recent examples see Lederman and Maloney, 2003; Ross, 2004; Fearon, 2005; Blattman, 2005; Stijns, 2005).

that describes a war equilibrium by analytically spelling out the marginal costs and benefits of war activities in terms of the opportunity costs of conflict (the value of resources used in fighting) and the benefits of conflict (the value of the prize).[4] With such an equilibrium established, we show that it is very important to distinguish between disputed and undisputed resources in the analysis of conflicts. In particular, we find that whereas an abundance of undisputed resource reduces conflict (the traditional Malthusian view), an abundance of disputed resource does just the opposite (the Collier-Hoeffler view).

We develop a unified framework that has two or three regions that produce, consume, and trade goods. Two regions may choose to direct resources from productive activity to war, where conflict is over a productive input. Specifically, regions are endowed with labor, which may be used for production or warfare, and land (or natural resources), which is also used for production but may either be contested or uncontested (or disputed or undisputed). Production is characterized by incomplete specialization. The conflict equilibrium is specified as a Nash one where each warring region decides on the level of its war activity by equating the marginal costs of conflict with the marginal benefit of conflict taking the war activity of the other region and prices as given. Contested land acts as a prize for the conflict with predatory activity determining how it is allocated between the warring parties, while the opportunity cost of conflict is given by the wages of productive employment. Factor endowments influence the relative size of costs and benefits of warfare and thus conflict.

It is to be noted that the hypothesis that an abundance of a resource can have a perverse effect is not new; the so-called Dutch Disease phenomenon is precisely that (see, for example, Corden, 1984; Sachs and Warner, 1995, 2001; and Humphreys, 2005.)[5,6] The

[4] A growing literature follows the seminal work of Hirshleifer (1988 and 1991) and develops game-theoretic models where two rival groups allocate resources between productive and appropriative activities (see, for example, Grossman, 1991; Skaperdas, 1991; Grossman and Kim, 1995; and Neary, 1997). Recent contributions emphasize the connections between trade and war, where trade is seen as a peaceful way to gain access to foreign resources and war is seen as its violent counterpart. Trade theoretic models with conflict have either used a two country framewok (Skaperdas and Syropoulos, 2001) or a three country framework (Becsi and Lahiri, 2004; Syropoulos, 2004).

[5] It is also closely related to the phenomenon of immizerizing growth (Bhagwati, 1958).

[6] Some have emphasized that the instability produced by volatile natural resource prices may be also be driving conflict. Though there do not exist formal models that connect volatility and conflict directly,

primary mechanism by which perverse outcomes occur is the price mechanism: changes in relative prices caused by factor abundance may increase distortions in the economy and this may outweigh the benefits. An increase the endowment of a resource, for example, may increase cash crop production which in turn may crowd out food production, with the resulting scarcity of food leading to conflict. In this paper, first of all, we show that resource abundance can have both positive and negative effects on conflict when goods prices are exogenous. We then endogenize the terms of trade, and show that the additional effect which endogenous terms of trade brings in can either mitigate or accentuate the earlier effects depending on factor intensities of production and on the magnitude of income and substitution effects.

The lay out of the paper is as follows. The following section sets up the basic model and carries out some initial analysis. The effect of resources on conflict are then analyzed in section 3 and 4, the two sections considering cases of small and large open economies respectively. Finally, in section 5 we make some concluding remarks.

2 Model and Initial Analysis

We develop a three-region, two-good, many-factor model where two of the regions — labeled region a and region b — are engaged in a war with each other. The third region is the rest of the world. All product and factor markets are perfectly competitive. There are many inelastically supplied factors of production; however, two of the factors play important roles in our analysis. For expositional ease, we shall call these factors labor and land although one could interpret them differently. Labor that is not used in production is used to fight the war and land is what they fight for. Each region i ($i = a, b$) has an amount of land $\bar{V}^i$ that is undisputed, and the war is about a disputed amount of land denoted by D. For simplicity and without loss of any generality we shall assume that the disputed land is initially in

Hausman and Rigobon (2003) show how resource price volatility and economic growth can be connected, which provides an indirect avenue for conflict.

possession of region b. Regions fight over the disputed land by employing soldiers L_s^a and L_s^b and ultimately divide the disputed land on the basis of a 'contest-success' function $f(L_s^a, L_s^b)$ which is the share of D going to region a. For this net-gain function we make the following assumptions.

ASSUMPTION **1** *$f(\cdot)$ is homogeneous of degree zero in the two arguments and satisfies:*[7] $f_1 > 0,\ f_2 < 0,\ f_{11} < 0,\ f_{22} > 0.$.

The production side of the economies indexed by $i = a, b$ is described the revenue functions $R^a(p, \bar{L}^a - L_s^a, \bar{V}^a + f(L_s^a, L_s^b)D)$ and $R^b(p, \bar{L}^b - L_s^b, \bar{V}^b + \{1 - f(L_s^a, L_s^b)\}D)$, where p is the international price of the non-numeraire goods.[8] To start with, we assume the two warring regions to be small open economies so that p is exogenous to these two regions (it is determined in the rest of the world). In section 4 we shall follow Becsi and Lahiri (2004) and allow p to be determined endogenously in a three-country framework. The revenue function has the property that its partial derivative with respect to the price R_1^i is equal to the region's supply function and that supply increases with the price, or $R_{11}^i > 0$. Also, the partial derivative of the revenue function with respect to the factor endowment levels $\bar{L}^i$ and $\bar{V}^i$ are the region's inverse factor demand functions, which express the regions' factor returns as functions of exogenous and endogenous variables. Factor endowments tend to decrease factor returns in each region i, or $R_{22}^i < 0$ and $R_{33}^i < 0$. We also assume that the two factors are complements in each region, or $R_{23}^i > 0$. Formally,

ASSUMPTION **2** $\qquad R_{23}^a > 0 \quad \textit{and} \quad R_{23}^b > 0.$

[7]The sign of f_{12} is in general ambiguous. If the function f takes the form $f(L_s^a, L_s^b) = (g(L_s^a)/(g(L_s^a) + g(L_s^b))D$, where $g' > 0$ and D is the amount of disputed land, we have $f_{12} \gtreqless 0$ if and only if $L_s^a \gtreqless L_s^b$. In particular, if the warring countries are symmetric, then $f_{12} = 0$.

[8]All factors other than land and labor are suppressed in the revenue functions as they do not change in our analysis. As is well known the partial derivative of a revenue function with respect to the price of a good R_1^i gives the output supply function of that good. Similarly, the partial derivatives of a revenue function, R_2^i and R_3^i, with respect to a factor endowment give the price of that factor. The revenue functions are positive semi-definite in prices and negative semi-definite in the endowments of the factors of production. In particular, they satisfy $R_{jj}^i \leq 0$, for $i = a, b$ and $j = 2, 3$. For these and other properties of revenue functions see Dixit and Norman (1980).

The consumption side of the economies is represented by the expenditure function $E^i(p, u^i)$, where u^i is the utility level of a representative consumer in region i. The partial derivative of the expenditure function with respect to the price of a good E^i_1 gives the compensated individual demand function of that good, which falls when prices rise, or $E^i_{11} < 0$. The partial derivative E^i_2 is the reciprocal of the individual's marginal utility of income and goods are assumed to be normal, or $E^i_{12} > 0$.

The income-expenditure balance equations of consumers in the regions are given by:

$$\bar{L}^a E^a\left(p, u^a\right) = R^a(p, \bar{L}^a - L^a_s, \bar{V}^a + f(L^a_s, L^b_s)D), \tag{1}$$

$$\bar{L}^b E^b\left(p, u^b\right) = R^b(p, \bar{L}^b - L^b_s, \bar{V}^b + \{1 - f(L^a_s, L^b_s)\}D), \tag{2}$$

Implicitly, we have assumed that wages paid to soldiers are paid for by taxing the representative consumer.

To determine the war efforts in the two warring regions, L^a_s and L^b_s, we follow Skaperdas and Syropoulos (2001) and assume that each warring region chooses its own war effort to maximize its welfare, taking war effort in the other region and the international prices of the non-numeraire good as given. The first order conditions are given by:

$$\frac{\partial u^a}{\partial L^a_s} = 0 \quad \Longrightarrow \quad -R^a_2 + R^a_3 f_1 D = 0, \tag{3}$$

$$\frac{\partial u^b}{\partial L^b_s} = 0 \quad \Longrightarrow \quad -R^b_2 - R^b_3 f_2 D = 0. \tag{4}$$

An increase in L^i_s, *ceteris paribus*, increases income in region i $(i = a, b)$ by increasing the amount of land, but it also has a cost in the sense that it reduces the amount of labor than can be used for producing goods and services. The first term in (3) and (4) is the marginal cost of warfare and the second term is the marginal benefit. Equating marginal costs and benefits yields two reaction functions in the warring regions that are simultaneously solved.

This completes the description of the basic model. There are four endogenous variables, L^a_s, L^b_s, u^a and u^b, and these variables are solved from the four equations (1)-(4).

We conclude this section by deriving our basic welfare equations. Differentiating equations (1) and (2) and using (3) and (4), we obtain

$$\bar{L}^a E_2^a \, du^a = -m^a dp + (R_2^a - E^a)\, d\bar{L}^a + R_3^a d\bar{V}^a + R_3^a f dD + R_3^a D f_2 dL_s^b, \tag{5}$$

$$\bar{L}^b E_2^b \, du^b = -m^b dp + \left(R_2^b - E^b\right) d\bar{L}^b + R_3^b d\bar{V}^b + R_3^b (1-f) dD - R_3^b f_1 D dL_s^a, \tag{6}$$

where the excess demand function

$$m^i = \bar{L}^i E_1^i - R_1^i \tag{7}$$

represents the imports of the non-numeraire good by region i ($i = a, b$).

The first term on the right hand side of (5) and (6) gives the direct terms-of trade effect on utility, while the second, third and fourth terms give the direct effect of endowments. The last term gives the international externality of war effort on the two warring regions. Higher war effort by one region, *ceteris paribus*, reduces utility in the other warring region by reducing the endowment of land in the latter. However, higher war effort in a region has no effect on its own welfare, as war effort is optimally chosen. The direct effects of land endowments — both disputed and undisputed — on welfare are positive. However, the effect of an increase in labor endowment in region i increases welfare in that region if and only if $R_2^i - E^i > 0$. The positive effect (R_2^i) is due to the income-generating effect of the additional labor, and the negative effect (E^i) is due to the fact that there are more people to share income.[9]

The two regions in our model can be two countries (in which case the war is an international one), or they can be interpreted as two different regions within a country (in which case the conflict is a civil war). However, this interpretation should not be taken to imply that the present model can explain all types of civil war which can be very heterogeneous. The type of civil wars that we model are those where the warring groups live in two distinct regions in a country with no mobility of labor between the two regions, and they

[9]If land and labor are the only two factors of production and $f(\cdot) = L_s^a/(L_s^a + L_s^b)$, then it can be shown that $R_2^i - E^i$ is in fact negative.

fight over the ownership of a factor of production. There are some civil wars which satisfy the stylized facts of our model. For example, in the Tamil conflict in Sri Lanka the warring groups are restricted geographically with the Tamil rebels living mostly in the Jaffna region in the north of the country and with very limited mobility of labor. In other words, we are interested in conflicts with a sufficient amount of spatial separation or polarization amongst the population. Furthermore, for the civil war interpretation, we do not distinguish which side is the government side and which side is the rebel side. We assume that there is some form of governance for each side which can raise funds through taxation.

3 Resources and war: the case of small open economies

In this section we examine the effect of various shocks on the war efforts of the two warring regions. We focus on what happens when the endowments of one of the regions are altered.

Differentiation of the reaction functions of the warring regions (3) and (4) results in:

$$\alpha_1 dL_s^a + \alpha_2 dL_s^b = [R_{22}^a - f_1 D R_{23}^a] d\bar{L}^a + [R_{23}^a - f_1 D R_{33}^a] d\bar{V}^a - f_1 R_3^a \theta_a dD, \quad (8)$$

$$\alpha_3 dL_s^a + \alpha_4 dL_s^b = f_2 R_3^b \theta_b dD, \quad (9)$$

where

$$\begin{aligned}
\alpha_1 &= R_{22}^a - 2f_1 D R_{23}^a + R_3^a D f_{11} + (f_1 D)^2 R_{33}^a < 0, \\
\alpha_2 &= -R_{23}^a D f_2 + R_3^a D f_{12} + f_1 f_2 D^2 R_{33}^a, \\
\alpha_3 &= R_{23}^b D f_1 - R_3^b D f_{21} + f_1 f_2 D^2 R_{33}^b, \\
\alpha_4 &= R_{22}^b + 2f_2 D R_{23}^b - R_3^b D f_{22} + (f_2 D)^2 R_{33}^b < 0, \\
\theta_a &= 1 - \epsilon_{33}^a \cdot \frac{fD}{\bar{V}^a + fD}, \quad \theta_b = 1 - \epsilon_{33}^b \cdot \frac{(1-f)D}{\bar{V}^a + (1-f)D}, \\
\epsilon_{33}^a &= -\frac{\partial R_3^a}{\partial(\bar{V}^a + fD)} \cdot \frac{\bar{V}^a + fD}{R_3^a} = -\frac{R_{33}^a(\bar{V}^a + fD)}{R_3^a}, \\
\epsilon_{33}^b &= -\frac{\partial R_3^b}{\partial(\bar{V}^b + (1-f)D)} \cdot \frac{\bar{V}^b + (1-f)D}{R_3^b} = -\frac{R_{33}^b(\bar{V}^b + (1-f)D)}{R_3^b}.
\end{aligned}$$

Note that $\alpha_1 < 0$ and $\alpha_4 < 0$ because of the second order conditions in the determination of L_s^a and L_s^b respectively. We assume that $\alpha_3 > 0$ and $\alpha_2 > 0$ so that both reaction functions are upward sloping and employment of soldiers is a strategic complement in both regions.[10] We also make the realistic assumption that that the ratio of disputed land to total amount of land endowment is sufficiently small so that $\theta_a > 0$ and $\theta_b > 0$.[11] Formally,

ASSUMPTION **3** $\theta_a > 0 \quad and \quad \theta_b > 0.$

Solving (8) and (9), we obtain for the endowment shocks:

$$\frac{\partial L_s^a}{\partial \bar{L}^a} = \frac{\alpha_4[R_{22}^a - f_1 D R_{23}^a]}{\Delta_s} > 0, \quad \frac{\partial L_s^b}{\partial \bar{L}^a} = -\frac{\alpha_3[R_{22}^a - f_1 D R_{23}^a]}{\Delta_s} > 0, \tag{10}$$

$$\frac{\partial L_s^a}{\partial \bar{V}^a} = \frac{\alpha_4[R_{23}^a - f_1 D R_{33}^a]}{\Delta_s} < 0, \quad \frac{\partial L_s^b}{\partial \bar{V}^a} = -\frac{\alpha_3[R_{23}^a - f_1 D R_{33}^a]}{\Delta_s} < 0, \tag{11}$$

$$\frac{\partial L_s^a}{\partial D} = \frac{-R_3^a f_1 \alpha_4 \theta_a - f_2 R_3^b \alpha_2 \theta_b}{\Delta_s} > 0, \quad \frac{\partial L_s^b}{\partial D} = \frac{R_3^b \alpha_1 f_2 \theta_b + \alpha_3 f_1 R_3^a \theta_a}{\Delta_s} > 0. \tag{12}$$

where $\Delta_s = \alpha_1 \alpha_4 - \alpha_2 \alpha_3 > 0$ for the stability of the Nash equilibrium.

From (10) it follows that when the labor endowment in region a rises or the land endowment falls, competition for scarce resources intensifies and the reaction function of region a shifts up. The intuition is that an increase in the endowment of labor decreases the wage rate which lowers the opportunity cost of soldiers and thus increases warfare. Similarly, from (11) we find that an increase in the undisputed land endowment reduces the return to land relative to the wage rate, which raises the opportunity cost of soldiers and thus decreases warfare. In other words, war effort in both regions increases when labor becomes more abundant relative to undisputed land in any one region. However, from (12) we also find than a reduction in the amount of disputed land decreases warfare. A decrease in disputed land — like that in undisputed land — increases the return to land and thus the level of

[10] Note that when the two countries are symmetric and $f(\cdot) = g(L_s^a)/(g(L_s^a) + g(L_s^b))$, we have $f_{21} = 0$ and in this case α_2 and α_3 are indeed positive.

[11] When civil conflict encompasses all land in the two regions, we have $\bar{V}^a = \bar{V}^b = 0$ and $\theta_i = 1 - \epsilon_{33}^i$. In this case the assumption requires ϵ_{33}^i which measures the responsiveness of the rental rate of land to the net endowment of land, is less than unity.

warfare. However, it also decreases the stake, *i.e.*, potential gain for a given rental rate of land (the greed or opportunity motivation in Collier and Hoeffler (2004)). This second effect would dominate if the share of disputed land is sufficiently small, an assumption that we have made. Thus, changes in the endowment of disputed and undisputed land have very different effects on the level of warfare. Formally,

PROPOSITION **1** *An increase in the amount of undisputed land or a decrease in the endowment of labor or disputed land in a region unambiguously decreases the level of warfare in both countries.*

This result formalizes the Malthusian observation that population pressures or lack of natural resources in one region encourages warfare. Because disputed land is the prize in the conflict, more disputed land encourages conflict as well (the Collier-Hoeffler effect). That is, whether resource abundance encourages conflicts depends on if the resource is disputed or undisputed. Our results are also consistent with Neary (1997) who shows that conflict tends to increase with wealth in equilibrium conflict models. In these models wealth can be used either for production or warfare, which is analogous to the role played by the labor endowment in our model.

Turning to welfare effects, from (5) and (6) we find that shocks to the endowments in region a have the following effects. For an increase of the undisputed land endowment in region a, which can be interpreted as a discovery of natural resources or better extraction technology, the results are clear. Because war effort falls in both regions, conflict is reduced which has a positive indirect effect on welfare. This positive indirect effect reinforces the direct welfare gain in region a that occurs when any endowment increases. By contrast, the welfare effects are ambiguous for an increase in the labor endowment in region a , which can be interpreted as a population increase relative to region b. However, when $R_2^a - E^a < 0$ an increase in labor endowment in a region will reduce welfare levels in both countries.[12] Thus,

[12]As shown in footnote 9, there are realistic situations when $R_2^a - E^a$ will be negative.

we have

PROPOSITION **2** *An increase in the undisputed land endowment of a region causes welfare to increase in both regions. The effect of an increase in disputed land endowment in general have ambiguous effects on welfare levels in the two regions. The effect of an increase in labor endowment in a region has negative effect on welfare levels in the other region, and has an ambiguous effect on its own welfare.*

4 The case of large open economies

In this section we relax the small open economy assumption of the preceding section and thus treat the price of the non-numeraire good endogenously. Given the chance, the embattled regions may want to influence the terms-of-trade in their favor through any means, peaceful or not. By this view, conflict is not only about gaining access to resources but also about greater control over the terms of trade.

With endogenous terms of trade, we assume for simplicity that the excess demand function of the non-numeraire good in the rest of the world is given by $m^c(p)$ with $m^c_p \leq 0$. The following market-clearing conditions determines p:

$$m^a + m^b + m^c = 0, \tag{13}$$

where m^a and m^b are defined in (7).

We now extend the war equilibrium given by (3) and (4) to the case where p is endogenous. Here we assume that each warring region decides on the levels of its soldiers — L^a_s and L^b_s for the two countries — taking the amount of soldiers in the other region as given, but taking into account the effect of its own action on the terms of trade. Under these

circumstances, the first order conditions are given by

$$E_2^a \frac{\partial u^a}{\partial L_s^a} = -R_2^a + R_3^a f_1 - m^a \frac{\partial p}{\partial L_s^a} = 0, \tag{14}$$

$$E_2^b \frac{\partial u^b}{\partial L_s^b} = -R_2^b - R_3^b f_2 - m^b \frac{\partial p}{\partial L_s^b} = 0, \tag{15}$$

where the determination of $\partial p/\partial L_s^i$ $(i = a, b)$ will be taken up shortly.

Equations (14) and (15) give the reaction functions of both countries when they have influence over the terms of trade. Compared to (3) and (4) (the case of small open economy), each region has to take into account, while deciding on the level of warfare, the marginal effect of its action on world prices. Countries internalize the effect of world prices when committing soldiers to war by adding a second term to the marginal cost of warfare. For large open economies the marginal cost of warfare equals the loss in productive wages, R_2^i, plus the higher cost of imports if warfare increases world prices, $m^i(\partial p/\partial L_s^i)$.

For the rest of the paper, and mainly for ease of analysis, we shall assume that the two warring countries are identical in every respect so that $L_s^a = L_s^b = L_s$ (say), $f_1 = -f_2$, $f_{12} = 0$ (see footnote 7), and $f(\cdot) = 0$. For the rest of the paper, because of the symmetry, we shall shall use the superscripts a for both countries. The assumption is plausible for many civil war scenarios, because as Collier and Hoeffler (2004) show polarization and inequality between nations do not appear to be major determinants of civil conflict.

Totally differentiating (1), (2) and (13), we derive

$$\begin{aligned} \Delta\, dp &= 2\beta^a\, dL_s^a + [-(E_1^a - R_{12}^a) + c_y^a(E^a - R_2^a)]\, d\bar{L}^a \\ &\quad + [R_{13}^a - c_y^a R_3^a]\, d\bar{V}^a + [R_{13}^a - c_y^a R_3^a]\, dD, \end{aligned} \tag{16}$$

where $\beta^a = -R_{12}^a + c_y^a R_2^a$, $\Delta = 2\left(E_{11}^a - R_{11}^b\right) + m_p^c - 2c_y^a m^a$, $c_y^a = \dfrac{E_{12}^a}{E_2^a}$,

and $d\bar{L}^a$ and $d\bar{V}^a$ are the changes in the endowments of labor and land in one of the two warring countries. The term Δ is the slope of the uncompensated excess demand function

of the non-numeraire good, which has to be negative for Walrasian stability. The term c_y^a is the marginal propensity to consume the non-numeraire good in the two warring countries.

The partial effects of a region's war efforts on the terms of trade ($\partial p/\partial L_s^a$) is represented by β^a and is ambiguous *a priori*, because an increase in war effort has two countervailing effects. An increase in the employment of soldiers L_s^a reduces the supply of workers for the private sector and this reduces output of the non-numeraire good if and only if $R_{12}^a > 0$. The reduction in output will increase p by reducing the world supply of the non-numeraire good. The first term in β^a captures this effect. Moreover, an increase in L_s^a also has a negative income effect on p that comes from a reduction in employment in the private sector. We note that the assumption of symmetry implies that ultimately there is no actual transfer of land so that the effects through war-induced changes in land endowments are absent.

An increase in the amount of disputed land raises the output of the non-numeraire good in the warring countries, and thus reduces the price, if and only if $R_{13}^a > 0$. An increase in D also has a positive income effect via increases in total rental income on land. This income effect unambiguously increases the price. An increase in the amount of undisputed land $\bar{V}$ or labor endowment $\bar{L}$ in either region a or b also has similar output supply and income effects.

Using the equilibrium price response from (16), we can rewrite the Nash reaction function in (14) under the assumption of symmetry as

$$-R_2^a \Phi + R_3^a f_1 = 0, \tag{17}$$

$$\begin{aligned} \text{where} \qquad \Phi &= 1 - \frac{\epsilon_{12}^a}{\tilde{\Delta}}, \quad \tilde{\Delta} = \frac{p\Delta}{m^a} = 2\epsilon_m^a - 2\epsilon_m^c - 2pc_y^a, \\ \epsilon_m^a &= \frac{\partial m^a}{\partial p} \cdot \frac{p}{m^a}, \qquad \epsilon_m^c = \frac{\partial m^c}{\partial p} \cdot \frac{p}{m^c}, \ \epsilon_{12}^a = \frac{R_{12}^a p}{R_2^a}, \end{aligned}$$

where ϵ_{12}^a is the elasticity of the wage rate of productive labor with respect to the price of the non-numeraire good, and ϵ_m^i is the price elasticity of import demand of the non-numeraire good in region i ($i = a, b, c$).

The term $R_2^a\Phi$ is now the combined marginal cost of warfare including the effect of warfare on world prices. For small open economies $\Phi = 1$, but for large open economies $\Phi \lesseqgtr 1$ depending on whether warfare increases or decreases the world price of the non-numeraire good. If warfare increases p and $m^a < 0$, it follows that $\Phi < 1$ and the marginal cost of warfare is less than the loss of productive wages because of a gain from the terms-of-trade improvement.

Differentiating (17) and treating Φ as a constant, we obtain

$$\begin{aligned} \Delta_s \, dL_s &= [\Phi R_{21} - f_1 R_{31}] \, dp + [\Phi R_{22} - f_1 R_{32}] \, d\bar{L}^a \\ &\quad + [\Phi R_{23} - f_1 R_{33}] \, d\bar{V}^a - R_3 f_1 \, dD, \end{aligned} \tag{18}$$

where $\Delta_s = \Phi R_{22} - f_1 R_{23} + R_3 f_{11} < 0$.

Before we discuss the above equation, it will be useful to introduce the concept of labor and land intensity. In a many-good, many-factor model, the terminology labor intensive can be misleading. In this paper, we call the non-numeraire good more labor intensive if $\Phi R_{12}^a - f_1 R_{13}^a > 0$. In other words, if an increase in the labor endowment, or a decrease in the land endowment, increases the output of the non-numeraire good, this condition will be satisfied and the non-numeraire good is called labor intensive. Land-intensity is similarly defined. Formally,

DEFINITION **1** *The two warring regions are labor (land) intensive in the production of the non-numeraire good if* $\Phi R_{12}^a - f_1 R_{13}^a > 0$ *(*$\Phi R_{12}^a - f_1 R_{13}^a < 0$*).*

Comparing equation (18) with its small open economy analog (8), we find that we have an additional term that represents the terms of trade effect; the direct effects are qualitatively the same as before. The terms of trade effect — the first term on the right hand side of (18)— says that an increase in p reduces war efforts if and only if the non-numeraire good is labor intensive. The reason for this result is that an increase in p increases the net marginal

cost of war if and only if the the non-numeraire good is labor intensive. Thus, the terms of trade effect make war more or less likely by shifting the balance between the marginal cost of war and marginal benefit of war.

Substituting (18) in (16) and invoking symmetry we can write

$$\begin{aligned}\tilde{\Delta}\, dp &= 2\left[(R^a_{13} - c^a_y R^a_3) + \frac{(c^a_y R^a_2 - R^a_{12})(\Phi R^a_{23} - f_1 R^a_{33})}{\Delta_s}\right] d\bar{V}^a \\ &+ \left[R^a_{13} - c^a_y R^a_3 - \frac{2(c^a_y R^a_2 - R^a_{12})R^a_3 f_1}{\Delta_s}\right] dD \\ &+2\left[\{-(E^a_1 - R^a_{12}) + c^a_y(E^a - R^a_2)\} + \frac{(c^a_y R^a_2 - R^a_{12})(\Phi R^a_{22} - f_1 R^a_{32})}{\Delta_s}\right] d\bar{L}^a,\end{aligned} \tag{19}$$

$$\text{where} \qquad \tilde{\Delta} = \Delta + \frac{2\beta^a(\Phi R^a_{21} - f_1 R^a_{31})}{\Delta_s} < 0,$$

and $\tilde{\Delta}$ has to be negative for the Walrasian stability of goods market.

As compared to (16), changes in the endowment of each resource now has an additional term which comes from changes in equilibrium war efforts. Using (18) and (19) and comparing with (8) and (9), we note that the direct effect of a change in $\bar{L}$, $\bar{V}$ and D on war efforts would be the same as that in Proposition 1. The indirect effect via changes in p are given respectively by:

$$\frac{\partial L_s}{\partial p} \cdot \frac{dp}{d\bar{L}^a}, \ \frac{\partial L_s}{\partial p} \cdot \frac{dp}{d\bar{V}^a}, \text{ and } \frac{\partial L_s}{\partial p} \cdot \frac{dp}{d\bar{D}^a},$$

for the three endowments. That is, the endowment effect through changes in the international price on war effort is the product of two terms representing the effect of the price on war effort and the effect of endowments on the price.

From (18), we know that $\partial L_s/\partial p > 0$ when the non-numeraire good is labor intensive. Furthermore, from (19) we find that $dp/d\bar{L}^a$, $-dp/d\bar{V}^a$, and dp/dD are positive (negative) if $c^a_y R^a_2 - R^a_{12} >> 0$ ($<< 0$). Note that when the terms of trade is exogenous, an increase in endowments of land and disputed land and a decrease in undisputed land, increases warfare

(see Proposition 1). Therefore, we are now able to ascertain if the presence of a terms-of-trade effect strengthens or weakens the results in Proposition 1. The results are stated below as a proposition.

PROPOSITION **3** *Suppose that the two warring regions are labor intensive in the production of the non-numeraire good. A sufficient condition for the results in Proposition 1 (the case of small open economies) to be strengthened (weakened) because of the presence of a terms-of-trade effect is that* $R_2^a c_y^a >> R_{12}^a$ *(*$R_2^a c_y^a << R_{12}^a$*). This sufficient condition is reversed when the two regions are land-intensive.*

It is to be noted that the sufficient condition in Proposition 3 is about the size of $\partial p/\partial L_s$ (see (16)). That is, the terms of trade effect strengthens (weakens) the results for the small open economy (Proposition 1) if the reduction in war efforts significantly increases (decreases) the price of the non-numeraire good.

Let us now examine the condition $R_2 c_y >> R_{12}$ more closely. This condition can be rewritten as $pc_y^a >> \epsilon_p^a$, where $\epsilon_p^a = (\partial R_2^a/\partial p)(p/R_2^a)$ is the price elasticity of wage rate and pc_y^a is the marginal propensity to spend the non-numeraire good. The terms pc_y^a and ϵ_p^a represent respectively the the income effect and substitution effect. Thus, the sufficient condition is a restriction on the size of the substitution effect relative to the income effect.

5 Conclusion

We examine the connection between conflict and resource endowments of two warring regions. In the literature arguments have been put forth for either a positive relationship between natural resources and conflict or a negative relationship. According to the Malthusian view, scarcity of resources may lead to impoverishment and thus conflict. On the other hand, abundance of resources may lead to 'greed and opportunity' and thus conflict (Collier-Hoeffler hypothesis). A third channel via the work of the price mechanism has also been mentioned

as a cause of conflict (the Dutch-disease hypothesis). In this paper we have developed a unified trade-theoretic model that synthesizes the different strands in the literature. In our model, a Nash war equilibrium is established endogenously. Each region decides on its war efforts equating marginal costs and benefits of war, taking war efforts of the other region as given.

When the terms of trade is exogenous, we find generally that uncontested natural resource scarcity increases conflict, but that conflict increases with the size of the contested territory. While contested resource scarcity tends to lower the opportunity costs of warfare, having more contested territory tends to also increase the marginal benefit of warfare. When the terms of trade is endogenous, these results are either strengthened or weakened depending on factor intensities in production and on the relative strength of income and substitution effects.

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