Ratio Indicators for the Effect of Trade given Limited Conflict

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1. Introduction

Hegre (2001) demonstrates that the difference-indicators used in Dorussen (1999) are inappropriate to measure the effect of an increasing number of countries on trade. As an alternative, he proposes to use ratio-indicators. In the absence of secure resources, the ratio indicator becomes:

$$\frac{\underline{p}_v^{\,l}}{\underline{p}_v^{\,0}} = 1 + l\,(n-1)z\,, \tag{1}$$

where $z = \dfrac{r^2(1-p_s)(1-f)}{r(r-1)(1-p_s)(1-f)+c}$.

Observe that the ratio-indicator has several nice properties. First, the ratio is always larger than 1, which demonstrates that trade reduces the incentives for conflict. Second, the derivative of (1) with respect to l (the efficiency of trade) is positive: more efficient trade has a more pronounced conflict reducing effect. These two findings are in agreement with Dorussen (1999). Third, the derivative of (1) with respect to n (the number of countries) is also positive. If the number of countries increases, more trade reduces the incentives for conflict. The latter finding contradicts the conclusions of Dorussen (1999).

In the remainder, I derive the ratio-indicators for the more general case with the possibility of secure resources—following the approach of Hegre (2001). In section 2, I consider the case of no trade following conflict. In section 3, I derive the ratio-indicator when there is trade following conflict. This allows us to evaluate propositions 1 and 2 in Dorussen (1999: 453). Whereas a ratio-indicator quite similar to the one proposed by Hegre (2001) is appropriate in case of no trade ‘ex post,’ I propose a different ratio-indicator for the case in which trade following conflict exists. In the latter case, the difference-indicator may actually be preferable.

2. Secure Resources and No Trade Following Conflict

In Dorussen (1999: 452-3), two difference-indicators for the effect of trade given secure resources are derived. The proportion of resources that are contested is indicated by the parameter s. Consequently, $(1\text{-}s)$ gives the proportion of resources that is secure. If some resources are secure, countries can continue to trade even after they have lost a conflict.

However, they could also decide to refuse to trade. Under the latter assumption (no trade following conflict), the difference indicator is given in equation (7) (Dorussen 1999: 452):

$$\underline{p}_{v2}^{\,l} - \underline{p}_{v2}^{\,0} = \left(\frac{n-1}{n}\right)\left(\frac{lr(1-p_s)(1-f)}{s\,(2r-1+nsr-2sr)}\right)$$

The above indicator is based on the minimum probability of victory making conflict preferable to trade. To calculate the minimum probability of victory, we need to consider the implication of secure resources. Also, it matters whether countries are willing to trade following conflict. More precisely, without trade following conflict, we determined the value of p_v for which $W_2^0 \geq B$, where W_2^0 is given in equation (6.1):

$$W_2^0 = \frac{p_v(r+nrs-rs)(r+nrs-rs-1)+p_d(r-rs)(r-rs-1)-c}{(1-p_s)(1-f)^2}$$

The value of the minimum probability of victory (with secure resources) is, as before, found by setting $W_2^0 \geq B$. Some straightforward calculations show that:

$$\underline{p}_{v2}^{\,l} = \frac{\left[r(r-1)+(n-1)lr^2\right](1-p_s)(1-f)-(1-p_s)(r-rs)(r-rs-1)+c}{(r+nrs-rs)(r+nrs-rs-1)-(r-rs)(r-rs-1)},$$

and

$$\underline{p}_{v2}^{\,0} = \frac{(1-p_s)[r(r-1)(1-f)-(r-rs)(r-rs-1)]+c}{(r+nrs-rs)(r+nrs-rs-1)-(r-rs)(r-rs-1)}.$$

Consequently:

$$\frac{\underline{p}_{v2}^{\,l}}{\underline{p}_{v2}^{\,0}} = \frac{(1-p_s)\left[r(r-1)+(n-1)lr^2\right](1-f)-(1-p_s)(r-rs)(r-rs-1)+c}{(1-p_s)[r(r-1)(1-f)-(r-rs)(r-rs-1)]+c}$$

$$= 1+\frac{(1-p_s)(n-1)lr^2(1-f)}{(1-p_s)[r(r-1)(1-f)-(r-rs)(r-rs-1)]+c}.$$

In other words,

$$\frac{\underline{p}_{v2}^{\,l}}{\underline{p}_{v2}^{\,0}} = 1+(n-1)lz_2, \qquad (2)$$

where $z_2 = \dfrac{r^2(1-p_s)(1-f)}{(1-p_s)[r(r-1)(1-f)-(r-rs)(r-rs-1)]+c}$.

In case $s = 1$ (no secure resources), $z_2 = z$, which shows that the ratio indicator (1) is a special case of (2). It is also straightforward to determine the derivatives of the ratio indicator of (2) with respect to l and n.

$$\frac{\partial\left[\frac{p_{v2}^{l}}{p_{v2}^{0}}\right]}{\partial l} = (n-1)z_2 , \tag{3}$$

and

$$\frac{\partial\left[\frac{p_{v2}^{l}}{p_{v2}^{0}}\right]}{\partial n} = l z_2 . \tag{4}$$

In this case, however, the term z_2 deserves closer attention. In particular, the denominator, $(1-p_s)[r(r-1)(1-f)-(r-rs)(r-rs-1)]+c$, is no longer necessarily positive for all values of r, p_s, f, s, and c. Consequently, the effect of trade efficiency and number of countries may be decreasing. We can make two useful observations:

- $(r-rs)(r-rs-1) = (r(1-s))(r(1-s)-1) \geq 0$,

and

- The term z_2 is most likely to be negative given zero costs of conflict, or when both p_s and c equal 0. Consequently $z_2 > 0$, given $p_s = 0$ and $c = 0$, if:

$$f < 1 - \frac{(r(1-s))(r(1-s)-1)}{r(r-1)} \tag{5}$$

This leaves us to consider two cases depending on the value of z_2.

(i) $z_2 > 0$

In this case, the conclusions of Hegre (2001) apply also to the situation with secure resources. Trade reduces the incentives for conflict, and more efficient trade even more so. A larger number of countries *increases* the effect of trade. Moreover, the effect of trade efficiency and number of countries are mutually reinforcing.

To derive the equivalent of proposition 1 in Dorussen (1999: 453), we have to compare (2) with (1). Observe that the only difference between z_2 and z in their denominators (the denominator of z_2 is smaller than of z), thus $z_2 \geq z$ (as in Proposition 1). Since the effect of trade increases in the number of countries, proposition 2 has to be wrong. Comparing the partial derivatives with respect to n of (2) and (1), it is easy to see that the effect of trade increases more strongly under a larger proportion of secure resources (and no post-conflict trade). This confirms at least the intuition of proposition 2 that the deterrent effect of trade is larger given secure resources (or limited conflict) than under total conflict.

(ii) $z_2 < 0$.

In the second case, strictly speaking none of the above conclusions are valid. Trade would seem to increase the incentives for conflict. A larger number of countries, moreover, appears to exacerbate the conflict inducing effect of trade. The conditions under which this counter-intuitive finding may appear are given under (5). An important observation is, that if $z_2 < 0$, also $\underline{p}^0_{v2} < 0$ (because the numerator of the former equals the denominator of the latter). Theoretically, the minimum probability of winning is, however, bounded downward by zero. On the other hand, a negative probability of victory may simply mean that a country always has an incentive to go to war. Regardless, the ratio-indicator (2) only leads to correct inferences when the minimum probability is larger than zero.

When may this happen? Condition 5 provides us with an answer to this question. Condition (5) always holds if $s = 1$ (no secure resources). In other words, the ratio-indicator is unproblematic under the assumption that conflict is total—as in Hegre's comment. However, the larger the proportion of secure resources, the more countries should discount the future. Whenever nearly all resources are secure ($s \approx 0$), condition (5) cannot hold and, thus, the ratio-indicator incorrectly suggests that trade increases conflict.[1] Clearly if the costs of conflict (c) are significant or the probability of stalemate (p_s) is large, it is unlikely that $z_2 < 0$.

In summary, given limited conflict with no 'ex post' trade, the possibility of trade before conflict reduces the incentives for conflict. More efficient trade and a larger number of countries strengthens the effect of trade before conflict. The deterrent effect of trade is larger given secure resources (or limited conflict) than under total conflict. If condition (5) is not met the ratio-indicator is easily misleading.

3. Secure Resources and Trade Following Conflict

A second difference-indicator is given in Dorussen (1999: 453) measuring the effect of trade given limited conflict and 'ex post' trade. As before the difference-indicator relies on the minimum probability of winning. In this case, the relevant expected gains from conflict are as follows:

$$W_2^l = W_2^0 + \frac{p_v l(n-1)(r+nrs-rs)(r-rs) + p_d l(r-rs)(r+nrs-rs) + p_d l(n-2)(r-rs)^2}{(1-p_s)(1-f)^2},$$

or equation 6.2 in Dorussen (1999: 452).[2]

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[1] The partial derivatives (3) and (4) are always increasing with respect to f. In other words, if the future is discounted less, the deterrent effect of trade increases.

[2] Note the typo in Dorussen (1999: 452); the formula is given more correctly in Appendix 2 (Dorussen 1999: 459), but also here the costs of conflict are counted twice. The formula as presented here corrects for this as well.

It is still fairly straightforward to calculate the minimum probabilities of victory (with $\underline{p}_{v3}^{l}$ or without trade $\underline{p}_{v3}^{0}$). It is, however, helpful to define the following terms:

- $x = (r + nrs - rs)(r + nrs - rs - 1)$
- $y = (r - rs)(r - rs - 1)$
- $u = l(n-1)(r + nrs - rs)(r - rs)$
- $w = l\left[(r - rs)(r + nrs - rs) + (n-2)(r - rs)^2\right]$

Consequently:

$$\underline{p}_{v3}^{l} = \frac{\left[r(r-1) + (n-1)lr^2\right](1-p_s)(1-f) - (1-p_s)(y+w) + c}{(x+u-y-w)},$$

and

$$\underline{p}_{v3}^{0} = \frac{(1-p_s)(r(r-1))(1-f) - (1-p_s)(y+w) + c}{(x+u-y-w)}.$$

It follows that:

$$\frac{\underline{p}_{v3}^{l}}{\underline{p}_{v3}^{0}} = \frac{(1-p_s)\left[r(r-1) + (n-1)lr^2\right](1-f) - (1-p_s)(y+w) + c}{(1-p_s)\left[r(r-1)(1-f) - (y+w)\right] + c}$$

$$= 1 + \frac{(1-p_s)(n-1)lr^2(1-f)}{(1-p_s)\left[r(r-1)(1-f) - (y+w)\right] + c}.$$

Or:

$$\frac{\underline{p}_{v3}^{l}}{\underline{p}_{v3}^{0}} = 1 + (n-1)lz_3, \qquad (6)$$

where $z_3 = \dfrac{r^2(1-p_s)(1-f)}{(1-p_s)\left[r(r-1)(1-f) - (y+w)\right] + c}$,

$$= \frac{r^2(1-p_s)(1-f)}{(1-p_s)\left[r(r-1)(1-f) - (r-rs)(r-rs-1) - l\left[(r-rs)(r+nrs-rs) + (n-2)(r-rs)^2\right]\right] + c}$$

If no resources are secure, equation (6) becomes equivalent to equation (1). If some resources are secure, but there is no trade following conflict (l=0), equation (6) becomes equivalent to equation (2).

Since l and n are part of z_3, the partial derivatives of (6) with respect to these terms are not as easy to determine as before. Consequently, it becomes more difficult to assess the implications if we allow for 'ex post' trade. Observe, however, that the denominator of z_3 is the same as the numerator of $\underline{p}_{v3}^{0}$. In other words, a negative value of z_3 implies that $\underline{p}_{v3}^{0} < 0$. A further problem is that in the case of 'ex post' trade, it is possible that $\underline{p}_{v3}^{l} < 0$. Given 'ex post' trade, the interpretation of the ratio-indicator can easily becomes misleading. The minimum probabilities are causing problems if 'ex post' trade is very efficient ($l \uparrow 1$), the share of insecure resources is very small $s \downarrow 0$, or the future is highly valued ($q \uparrow 1$).

Limiting ourselves to the situation in which both $\underline{p}^{0}_{v3} > 0$ and $\underline{p}^{l}_{v3} > 0$, we assess the effect of trade efficiency and the number of countries on the ratio-indicator with the help of simulation. The simulations show first of all that the partial derivatives are positive, which means that the effect of trade is increasing (conforming to the findings of Hegre, 2001).

However, the simulations also show that:

$$\frac{\underline{p}^{l}_{v3}}{\underline{p}^{0}_{v3}} > \frac{\underline{p}^{l}_{v2}}{\underline{p}^{0}_{v2}} > \frac{\underline{p}^{l}_{v}}{\underline{p}^{0}_{v}} \ .$$

This would suggest that trade 'ex post' conflict increases the deterrent effect of trade (even more so than no 'prior' trade. The inequality is, however, caused entirely by the rapidly decreasing value of $\underline{p}^{0}_{v3}$. I conclude that if trade 'ex post' is feasible (which it is only in case of limited conflict), the minimum probability of victory in the absence of trade ($\underline{p}^{0}_{v3}$) is no longer an appropriate standardization.

Turning to the minimum probabilities of victory, simulations show that the following condition holds: $\underline{p}^{l}_{v2} \geq \underline{p}^{l}_{v3}$, which is, in part, in agreement with proposition 1. However, $\underline{p}^{l}_{v3}$ can be larger or smaller than $\underline{p}^{l}_{v}$. Because the effect of trade is increasing, proposition 2 no longer applies. Since the minimum probabilities of victory all tend toward zero if the number of countries increases, it is rather obvious that:

$$\frac{\partial \underline{p}^{l}_{v2}}{\partial n} \leq \frac{\partial \underline{p}^{l}_{v3}}{\partial n} \quad \text{(for all of its meaningful values).}$$

The most likely alternative candidate for ratio-indicator of the effect of trade 'ex post' is: $\frac{\underline{p}^{l}_{v3}}{\underline{p}^{l}_{v2}}$. Simulations show that:

$$\frac{\partial \left[\frac{\underline{p}^{l}_{v3}}{\underline{p}^{l}_{v2}} \right]}{\partial l} > 0 \text{, but}$$

$$\frac{\partial \left[\frac{\underline{p}^{l}_{v3}}{\underline{p}^{l}_{v2}} \right]}{\partial n} \text{ can be both larger and smaller than zero.}$$

In summary, the ratio-indicator for the situation with trade 'ex post' is easily misleading. It does not have any of the nice analytical properties of the other ratio- or difference-indicators. Simulations reveal that propositions 1 and 2 do not generally hold for the case of trade 'ex post.' Finally, I can see no immediately obvious alternative ratio-indicator for this situation. Arguably, to simply analyze the pacifying effect of trade regardless of the number of countries, as in proposition 1 (Dorussen, 1999: 453), the difference-indicators are preferable.

4. Discussion

In several important respects, Hegre (2001) extends and amends the analyses of the multi-country model presented in Dorussen (1999). Most importantly, contrary to what is claimed in Dorussen, a larger number of countries *increases* the deterrent effect of trade.

I have shown that it is straightforward to extend the ratio-indicator to encompass situations of 'limited conflict' when there is no trade 'ex post.' The ratio-indicator moreover reveals important restrictions of the minimum probability of victory. However, the ratio-indicator becomes easily misleading for situations of limited conflict with trade 'ex post.' The problem is that the minimum probability of winning without trade can easily drop below zero (its theoretical bound). The ratio-indicator is particularly sensitive to this problem, which makes its use questionable in case of trade 'ex post.'

In Dorussen (1999), propositions 1 and 2 compare the situations with total and limited conflict and with or without trade 'ex post.' The ratio-indicator corroborates proposition 1 with respect to the situation with total conflict and limited conflict without trade 'ex post.' Proposition 2, however, is obviously misleading in that the effect of the number of countries on the deterrent effect of trade is generally increasing (and not decreasing). It is not possible to completely replicate the conclusions of proposition 1 for the situation with trade 'ex post.' Simulations reveal that proposition 1 holds for a wide variety of parametric values, but it is relatively easy to find counter-examples.

References

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