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Terms-of-Trade and Counterterrorism Externalities

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Abstract

This paper investigates the interplay of trade and terrorism externalities under free trade between a developed nation that exports a manufactured good to and imports a primary product from a developing nation. A terrorist organization targets both nations and reduces its attacks in response to a nation's defensive counterterrorism efforts, while transferring some of its attacks abroad. Terms-of-trade considerations lead the developed nation to raise its counterterrorism level beyond the "small-country" level, thus compounding its overprovision of these measures. By contrast, the developing nation limits its defensive countermeasures below that of the small-country level. This asymmetry is a novel finding. The analysis is extended to include proactive countermeasures to weaken the terrorist group. Again, the developed country raises its efforts owing to the terms-of-trade externality, which now opposes the underprovision associated with proactive efforts. A second extension allows for several developing-country exporters of the primary product.

JEL Codes: D62, F11, F51

Keywords: free trade neoclassical equilibrium; terms-of-trade externalities; transference externalities; terrorism; defensive counterterrorism; proactive counterterrorism

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1. Introduction

Major trading countries like the United States (US) or trading blocs like the European Union (EU) are targets of terrorist organizations. Typically, these groups [e.g., al-Qaida, Islamic State in Iraq and Syria (ISIS), al-Qaida in the Arabian Peninsula (AQAP)] locate in developing countries that lack the resources to stop them from operating. During the last two decades, this resource scarcity is often complemented by radical ideologies that can be more easily implanted among disaffected people at the margins of these societies, thereby supplying terrorist recruits (Siqueira and Sandler, 2006, 2010). This results in terrorist hotbeds in remote and difficult-to-govern areas in Afghanistan, Pakistan, Somalia, Syria, Yemen, and elsewhere, from which terrorist attacks are often planned. To protect against such attacks, targeted countries deploy defensive counterterrorism measures at home, which deflect attacks abroad.[1] In addition, terrorism disrupts the production of goods and services in an economy, while counterterrorism responses draw on productive resources. These production considerations affect global supply and demand of goods through general-equilibrium linkages, thus changing trade patterns and the international terms-of-trade. Despite these ubiquitous international terror and trade linkages, we are not aware of any article that provides a full-blown, general-equilibrium analysis of optimal counterterrorism policy in this context. This paper fills this gap and uncovers interesting asymmetries between developed and developing countries' counterterrorism strategies.

We consider a developed (e.g., United States) and a developing country (e.g., Pakistan) with two goods – manufactured and primary. The developing country imports the manufactured good and exports the primary product. The developed country's export-import roles are just the reverse. With its limited means, a terrorist organization targets both countries. Greater

[1] The literature on this transference of attacks include Arce and Sandler (2005), Bandyopadhyay and Sandler (2011, 2014), Cárceles-Poveda and Tauman (2011), Enders and Sandler (2012), Rossi de Oliveira *et al*., (2018), Sandler and Lapan (1988), and Sandler and Siqueira (2006)

defensive counterterrorism by either country reduces terrorism at home, but raises it in the other country as the terrorist group redirects its attacks to the relatively softer target.[2] Such defensive measures may take the form of enhanced border security, greater surveillance, or hardening of potential targets.

Counterterrorism limits the production of the manufactured good through demand for closely related resources.[3] When the developing country unilaterally raises its defensive actions, it likely augments the supply of the primary product by containing terrorism at home. Moreover, these larger defensive efforts take up resources used for the production of the manufactured good, thereby depleting its supply. These effects increase the supply of the primary product relative to the manufactured product in the global market and, in so doing, dampen the world price of the primary product. The developing country's defensive countermeasures have additional demand and supply effects due to terrorism deflection to the developed country. If the sum of these aforementioned effects is a net rise in the global excess supply of the primary product, its international market-clearing price falls, leading to a terms-of-trade loss for the developing country. In particular, consider the case of US-Pakistan trade and Pakistan's terms-of-trade since 1997. United States generally exports manufactured goods to Pakistan, which, in turn, exports its primary products to the United States. Furthermore, the United States fostered counterterrorism at home *and* in Pakistan throughout 1997–2014, during which Pakistan's terms-of-trade fell from an index of 118.56 to 58.80 (United Nations Conference on Trade and Development, 2016). This case fits our analysis perfectly. Similarly, Jordan, a major US ally in the Middle East, is a net importer of manufactured goods from the United States and net exporter of primary goods to the United States during 1997–2014. Jordan's terms-of-trade index also fell

[2] This assumes that defensive counterterrorism measures do not directly reduce the terrorists' resources.

[3] For simplicity, think of guns, surveillance cameras, or metal detectors that are required for defensive counterterrorism effort. These deterrent-assisting measures use resources more aligned with manufactured, than with primary, products.

from 112.87 in 1997 to 74.85 in 2014 (United Nations Conference on Trade and Development, 2016).

The counterterrorism policies of the two countries are interdependent as each country's defensive measures affect the other country through terms-of-trade *and* transference externalities. When deciding its Nash level of defensive counterterrorism measures, the developing country must weigh its terms-of-trade loss against its gain from containing terrorism at home. In so doing, the developing country's defensive choice will be less than that associated with the absence of a terms-of-trade externality for the so-called "small-country" case. The opposite is true for the developed country, whose independent defensive choice not only augments the country's terms-of-trade as manufactured goods become relatively more expensive, but also deflects potential attacks abroad. Thus, the developed country is incentivized to exceed the standard hypothesized overprovision of defensive measures (see, e.g., Rossi de Oliveira *et al*., 2018), the opposite holds for the developing country.

In standard trade models, competitive beggar-thy-neighbor terms-of-trade-augmenting policies of individual countries tend to worsen global welfare, which, however, is not necessarily true in our context. As the developing country reduces its Nash defensive counterterrorism below that of the small-country level, this country reduces its overprovision and potentially raises global welfare. By contrast, as the developed country raises its counterterrorism measure above the small-country level, it aggravates its overprovision and potentially reduces global welfare. The final welfare outcome hinges on how these opposing effects net out. The prognosis for global welfare is better if the developing country is more afflicted by terrorism, so that its Nash (small-country) overprovision is relatively greater than that of the developed country.

Next, consider the terms-of-trade externality in light of proactive counterterrorism, which curtails terrorists' prowess, thus making all countries more secure. In the absence of terms-of-trade effects, proactive measures are purely public among targeted countries, thereby resulting in *underprovision* (Sandler and Lapan, 1988; Sandler and Siqueira, 2006). Proactive measures limit production and trade losses due to terrorism in both countries.[4] In this case, the terms-of-trade externality is qualitatively unchanged compared to defensive measures, with the developed (developing) country incentivized to increase (decrease) its proactive efforts relative to the small-country case. However, the global welfare implications are now different as the developed country does more to address its underprovision, which can improve global welfare.

Finally, we return to defensive measures and consider a world where there are multiple exporters of the primary product, while there is one major importer like the United States.[5] If an exporter of a primary product reduces its defensive counterterrorism effort below the small-country level, it can only internalize a *fraction* of the terms-of-trade gain, while other primary-good exporting countries can free ride on this terms-of-trade gain. With such dissipation of gains, there is reduced incentive by each of the primary-good exporting countries to reduce their respective counterterrorism efforts below the small-country level. By contrast, the developed country, the monopoly importer, has the incentive to maintain a higher counterterrorism effort compared to the small-country level. Accordingly, the corresponding Nash counterterrorism equilibrium in this multi-primary-exporter case is likely characterized by overprovision.

Section 2 presents a two-country model of utility-maximizing counterterrorism policy, for which we describe and compare the noncooperative Nash equilibrium of the small-country case with that of the large-country case. Section 3 considers the global cooperative equilibrium

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[4] There is an empirical literature that quantifies these terrorism-induced trade losses – see, e.g., Blomberg and Hess (2006), Bandyopadhyay *et al*., (2018), Egger and Gassebner (2015), and Nitsch and Schumacher (2004). Our paper is not empirical and is not about such losses.

[5] Our analysis can be extended to the multi-importing country case, but we do not do so for two reasons. First, we want to focus on a major importing developed country like the United States that has market power, and on developing countries that may or may not have market power, given competing sources of supply. Second, our multi-country analysis reveals the economic forces at play, which can be easily applied to the multi-importing country case.

of the large-country case, and analyzes the efficiency of the Nash small- and large-country cases. Section 4 considers proactive counterterrorism policy that targets the strength of the common terrorist threat. Section 5 extends the basic model to a multi-country context wherein several developing countries export a primary product to a developed country. Section 6 contains concluding remarks.

2. The baseline defensive counterterrorism model: Noncooperative Nash equilibrium

Consider a two-country world, where developed country *A* and developing country *B* are potential targets of terrorism from a terrorist organization.[6] Two goods, primary good (good 1) and manufactured good (good 2), are competitively produced in both countries. With free trade, country *A* imports the primary good and exports the manufactured good to country *B*, and the opposite holds true for country *B*. Let the incidence of terrorism in country *A* be T^A. This damage may be contained through *defensive* counterterrorism effort, θ^A, measured in terms of the units of the numéraire manufactured good. Country *B* is similarly plagued by terrorism. We consider a two-stage game wherein the governments choose their respective defensive counterterrorism responses in stage 1, while the terrorist group chooses its terrorism attacks targeting the two countries in stage 2. To ensure subgame perfectness, the game is solved by backward induction. Thus, we first describe the behavior of the terrorist organization in stage 2.

2.1 The terrorist organization (stage 2)

The terrorist organization's objective function consists of

[6] The location of the terrorist organization is not critical to our model. The group could be located in either country or in a third country outside this two-country system. The central features are that each targeted country can deploy defensive measures to reduce its incidence and consequences of terrorism, and that the terrorist organization understands that greater defensive measures reduce the amount of terrorism in that targeted country. This then influences the terrorist organization's allocation of resources.

$$V = \alpha T^A + \beta T^B, \tag{1}$$

for which T^A and T^B denote the terrorism levels inflicted by the terrorist organization on countries *A* and *B*, respectively, and α and β capture the respective targeting preferences of the terrorist organization. We assume that this organization has a fixed amount of resources, $\overline{l}$, which it can allocate to attacks in the two countries. Let $l^j \left(j = A, B \right)$ be the extent of its resource earmarked to wreak terrorist-induced havoc in country *j*. Furthermore, let the terrorism production functions, f^j, for the two countries be increasing and concave in the respective terrorists' effort levels. Also, the likelihood of a successful attack, γ^j, in country *j* is reduced by greater counterterrorism effort, θ^j, in that country, but at a diminishing rate. The following formulations reflect these assumptions:[7]

$$T^j = \gamma^j\left(\theta^j\right) f^j\left(l^j\right),\ f^{j\prime}\left(l^j\right) > 0,\ f^{j\prime\prime}\left(l^j\right) < 0,\ \gamma^{j\prime}\left(\theta^j\right) < 0, ,\gamma^{j\prime\prime}\left(\theta^j\right) > 0\ \ j = A, B, \tag{2}$$

Based on eqs. (1)-(2), we can express the terrorist group's objective as:

$$V = \alpha\gamma^A\left(\theta^A\right) f^A\left(l^A\right) + \beta\gamma^B\left(\theta^B\right) f^B\left(l^B\right). \tag{3}$$

The terrorist group chooses l^A and l^B to maximize V, subject to its resource constraint $l^A + l^B = \overline{l}$. The first-order conditions of this constrained optimization problem yields:

$$\alpha\gamma^A\left(\theta^A\right) f^{A\prime}\left(l^A\right) = \beta\gamma^B\left(\theta^B\right) f^{B\prime}\left(l^B\right) \text{ and } l^A + l^B = \overline{l}. \tag{4}$$

Suppressing the parameters α, β, and $\overline{l}$ from the functional forms, and using subscripts to denote partials, we have that eq. (4) yields:

$$l^A = l^A\left(\theta^A, \theta^B\right),\ l^B = l^B\left(\theta^A, \theta^B\right), \text{ with}$$

[7] Defensive counterterrorism, as modeled here, reduces the expected value of a successful attack by limiting the probability of an attack and its consequences. Overall, the modeling reflects that such defensive effort is nationally directed, so that it makes the defending country less attractive from a terrorist organization's viewpoint. This is then associated with negative terrorism spillovers to other countries as potential attacks are deflected abroad.

$$l^A_{\theta^A}\left(\theta^A,\theta^B\right)<0,\ l^A_{\theta^B}\left(\theta^A,\theta^B\right)>0,\ l^B_{\theta^A}\left(\theta^A,\theta^B\right)>0, \text{ and } l^B_{\theta^B}\left(\theta^A,\theta^B\right)<0. \tag{5}$$

Eq. (5) reflects the fact that as *A*'s counterterrorism increases, the terrorist groups' marginal gains fall from allocating its resources to attacking *A*. Accordingly, the terrorist organization reduces its effort in hitting *A*, and shifts its resources to attacking *B*. Greater counterterrorism by *B* has the opposite effect. Given eqs. (2), (4), and (5), we can express the terrorism levels as:

$$T^A\left(\theta^A,\theta^B\right)\equiv\gamma^A\left(\theta^A\right)f^A\left[l^A\left(\theta^A,\theta^B\right)\right] \text{ and } T^B\left(\theta^A,\theta^B\right)\equiv\gamma^B\left(\theta^B\right)f^B\left[l^B\left(\theta^A,\theta^B\right)\right],$$

$$\text{for which } T^A_{\theta^A}\left(\theta^A,\theta^B\right)<0,\ T^A_{\theta^B}\left(\theta^A,\theta^B\right)>0,\ T^B_{\theta^A}\left(\theta^A,\theta^B\right)>0, \text{ and } T^B_{\theta^B}\left(\theta^A,\theta^B\right)<0. \tag{6}$$

2.2 Trade pattern and market clearing

The prices of the primary and manufactured goods are denoted by p^1 and p^2, respectively. We represent the revenue functions of country *j* (= *A*,*B*) by $r^j(\cdot)$. Greater terrorism in a country results in production disruptions that, in turn, lead to a loss in that country's aggregate revenues. In other words, $r^j(\cdot)$ negatively depends on T^j. Furthermore, counterterrorism effort, θ^j, is produced by drawing on country *j*'s productive resources, so that such effort must reduce *j*'s output in either or both goods (e.g., see Mirza and Verdier, 2014; Nitsch and Schumacher, 2004). Accordingly, $r^j(\cdot)$ is a negative function of θ^j. Assuming that the relative price of the primary good is *p* and that the manufactured good is the numéraire, we can, thus, conclude that the revenue functions of the two countries are as follows:[8]

[8]We use the following two notation conventions. First, to highlight the general-equilibrium linkage between markets for the two goods, we show the price of unity for the numéraire good in all the relevant functions. Second, when we have a function in say three variables *x*, *y*, and *z*, $f\left(x,y,z\left(x,y\right)\right)$, then the notation we use is that: $f_x=\left(\dfrac{\partial f}{\partial x}\right)_{|dy=0,dz=0}$. Therefore, $df=\left(f_x+f_z z_x\right)dx+\left(f_y+f_z z_y\right)dy$.

$r^A\left(p^1 = p, p^2 = 1, T^A, \theta^A\right)$ and $r^B\left(p^1 = p, p^2 = 1, T^B, \theta^B\right)$, with

$$r^A_{T^A} < 0,\ r^A_{\theta^A} < 0,\ r^B_{T^B} < 0, \text{ and } r^B_{\theta^B} < 0. \tag{7}$$

We denote the expenditure function of country *j* (= *A*,*B*) by $e^j(\cdot)$. By substituting eq. (6) into eq. (7), we have the expenditure-revenue identities of the two countries:

$$e^A\left(p,1,u^A\right) = r^A\left[p,1,T^A\left(\theta^A,\theta^B\right),\theta^A\right], \tag{8}$$

and

$$e^B\left(p,1,u^B\right) = r^B\left[p,1,T^B\left(\theta^A,\theta^B\right),\theta^B\right]. \tag{9}$$

Eqs. (8) and (9) can each be used to define implicitly the indirect utility functions, u^A and u^B, for each of the countries. Using standard envelope properties of revenue and expenditure functions, we can express the domestic production and consumption of the primary good of country *j* as $r^j_p(\cdot)$ and $e^j_p(\cdot)$, respectively. Thus, country *j*'s net export of the primary good is $X^{1j}(\cdot) = r^j_p(\cdot) - e^j_p(\cdot)$. Given that country *A* imports the primary good and country *B* exports it, we have $X^{1A} < 0$ (since X^{1A} is the negative of the import volume of primary good 1 for *A*). Country *B* exports the primary good, so that $X^{1B} > 0$. Using these definitions and substituting eqs. (6) and (7) into eqs. (8) and (9), we get:

$$u^A = u^A\left(p,\theta^A,\theta^B\right),$$

with

$$u^A_p(\cdot) = \frac{X^{1A}}{e^A_{u^A}} < 0,\ u^A_{\theta^A}(\cdot) = \frac{r^A_{T^A}(\cdot)T^A_{\theta^A} + r^A_{\theta^A}}{e^A_{u^A}}, \text{ and } u^A_{\theta^B}(\cdot) = \frac{r^A_{T^A}(\cdot)T^A_{\theta^B}}{e^A_{u^A}} < 0,^{9} \tag{10a}$$

and

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[9] Note that $e^j_{u^j} > 0$, because it is the inverse of the marginal utility of income for country *j* (*j* = *A*,*B*).

$$u^B = u^B\left(p, \theta^A, \theta^B\right),$$

with

$$u_p^B(\cdot) = \frac{X^{1B}}{e_{u^B}^B} > 0,\; u_{\theta^A}^B(\cdot) = \frac{r_{T^B}^B(\cdot)T_{\theta^A}^B}{e_{u^B}^B} < 0, \text{ and } u_{\theta^B}^B(\cdot) = \frac{r_{T^B}^B(\cdot)T_{\theta^B}^B + r_{\theta^B}^B}{e_{u^B}^B}. \tag{10b}$$

These well-being functions' partials with respect to the terms-of-trade and the two levels of defensive countermeasures have an intuitive interpretation. Consider eq. (10a). At given counterterrorism effort levels $\left(\theta^A, \theta^B\right)$, a rise in the price of the primary good is a terms-of-trade loss for country *A* (which imports this good), which reduces its utility $\left(u_p^A < 0\right)$. Next, at a given relative price level *p* and counterterrorism level θ^B, a rise in θ^A reduces terrorism in *A* and leads to a marginal gain in its revenues of $r_{T^A}^A(\cdot)T_{\theta^A}^A$. When, however, more productive resources are allocated to *A*'s counterterrorism effort, θ^A, there is a loss in national revenues of $r_{\theta^A}^A$. Thus, $u_{\theta^A}^A(\cdot)$, which represents the marginal gains and costs of *A*'s counterterrorism effort, cannot be signed until we define *A*'s counterterrorism choice rule. Finally, at a given *p* and θ^A, a rise in *B*'s counterterrorism effort deflects and, thus, raises terrorism in *A*, thereby reducing *A*'s revenues. This loss in national income is reflected by a fall in *A*'s utility $\left(u_{\theta^B}^A < 0\right)$. Eq. (10b) can be similarly interpreted, after noting that a rise in *p* is a terms-of-trade gain for nation *B*, which is a net exporter of the primary good $\left(u_p^B > 0\right)$.

We now turn to the determination of the equilibrium terms-of-trade. The free-trade price of the primary good is determined by the following international market-clearing condition, for which the global demand for the primary good equals its supply (using Walras law, we know that at this equilibrium price, the international market for the manufactured good also clears), so that

$$e_p^A\left[p,1,u^A\left(p,\theta^A,\theta^B\right)\right]+e_p^B\left[p,1,u^B\left(p,\theta^A,\theta^B\right)\right]$$

$$=+r_p^A\left[p,1,T^A\left(\theta^A,\theta^B\right),\theta^A\right]\quad r_p^B\left[p,1,T^B\left(\theta^A,\theta^B\right),\theta^B\right]. \tag{11}$$

With σ as the slope of the world excess supply function of the primary good, international market stability dictates that $\sigma > 0$. Given this stability condition, eq. (11) implicitly defines

$$p = p\left(\theta^A,\theta^B\right), \tag{12}$$

for which

$$p_{\theta^A}\left(\theta^A,\theta^B\right)=\frac{e_{pu^A}^A u_{\theta^A}^A\left(\cdot\right)+e_{pu^B}^B u_{\theta^A}^B\left(\cdot\right)-r_{pT^A}^A T_{\theta^A}^A-r_{p\theta^A}^A-r_{pT^B}^B T_{\theta^A}^B}{\sigma} \tag{12a}$$

and

$$p_{\theta^B}\left(\theta^A,\theta^B\right)=\frac{e_{pu^B}^B u_{\theta^B}^B\left(\cdot\right)+e_{pu^A}^A u_{\theta^B}^A\left(\cdot\right)-r_{pT^B}^B T_{\theta^B}^B-r_{p\theta^B}^B-r_{pT^A}^A T_{\theta^B}^A}{\sigma}. \tag{12b}$$

The terms in the numerator of the right-hand side of eq. (12a) can be used to unravel the different effects of θ^A on p. The first term reflects the change in *A*'s consumption demand for the primary good as a rise in *A*'s counterterrorism effort alters u^A. The second term indicates the fall in *B*'s consumption demand for the primary good as *B* incurs greater terror spillovers from *A*'s choice of counterterrorism effort. Additionally, the third term reflects the rise in *A*'s supply of the primary good as counterterrorism reduces terror in *A*.[10] In the fourth term, the effect on the supply of the primary good in country *A* follows from a greater diversion of productive (manufacturing) resources to the provision of counterterrorism effort, θ^A. The last term shows the fall in supply of the primary good in country *B* due to a rise in *B*'s terrorism, caused by deflected terrorist attacks from *A*. If the net effect of all of these terms is a decline in the global

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[10] We assume that terrorism reduces production for both goods in both countries, such that $r_{pT^A}^A < 0$, $r_{pT^B}^B < 0$.

excess demand for the primary good, then this good's equilibrium price falls to clear the market, thereby conferring a terms-of-trade gain on country *A*. In an analogous fashion, one can explain eq. (12b). As we discuss below, the terms-of-trade effects, captured by eqs. (12a) and (12b), play a critical role in respective defensive counterterrorism policy choices for the two countries.

By substituting eq. (12) into eqs. (10a)-(10b), we derive the following welfare, *W*, expressions:[11]

$$W^A\left(\theta^A,\theta^B\right) \equiv u^A\left[p\left(\theta^A,\theta^B\right),\theta^A,\theta^B\right] \tag{13a}$$

and

$$W^B\left(\theta^A,\theta^B\right) \equiv u^B\left[p\left(\theta^A,\theta^B\right),\theta^A,\theta^B\right]. \tag{13b}$$

2.3 Unilaterally optimal counterterrorism policy: A Nash policy equilibrium

We invoke the Nash assumption that countries *A* and *B* choose their respective utility-maximizing counterterrorism efforts unilaterally, assuming the other country's effort level given. Based on eq. (13a), the first-order condition of country *A*'s choice of counterterrorism effort and the associated Nash best-response function are as follows:[12]

$$W^A_{\theta^A}\left(\theta^A,\theta^B\right) \equiv u^A_p\left[p\left(\theta^A,\theta^B\right),\theta^A,\theta^B\right]p_{\theta^A}\left(\theta^A,\theta^B\right)+u^A_{\theta^A}\left(\cdot\right)=0 \Rightarrow \theta^A=\theta^A\left(\theta^B\right). \tag{14a}$$

Similarly, the first-order condition and Nash best-response function for country *B* are:

$$W^B_{\theta^B}\left(\theta^A,\theta^B\right) \equiv u^B_p\left[p\left(\theta^A,\theta^B\right),\theta^A,\theta^B\right]p_{\theta^B}\left(\theta^A,\theta^B\right)+u^B_{\theta^B}\left(\cdot\right)=0 \Rightarrow \theta^B=\theta^B\left(\theta^A\right). \tag{14b}$$

Satisfaction of these best-response functions jointly determines the Nash defensive

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[11] Use of $p\left(\theta^A,\theta^B\right)$ in eqs. (13a) and (13b) ensures that any point $\left(\theta^A,\theta^B\right)$ on these welfare functions is consistent with global market clearing.

[12] We assume that there are sufficient diminishing returns to counterterrorism effort [see eq. (2)] for both countries, so that $W^A\left(\theta^A,\theta^B\right)$ and $W^B\left(\theta^A,\theta^B\right)$ are concave in θ^A and θ^B, respectively. This ensures that the respective second-order conditions for utility maximization are satisfied.

countermeasure equilibrium vector, $\left(\theta^{AN}, \theta^{BN}\right)$.

To characterize the effect of international terms-of-trade externalities in this context, we first express the policy vector in the "small-country" case, for which the relative price p is perceived by each country to be invariant to its respective defensive policy choices. Consider the following rules:

$$u_{\theta^A}^A\left(p\left(\theta^A, \theta^B\right), \theta^A, \theta^B\right) = 0 \Rightarrow r_{T^A}^A(\cdot) T_{\theta^A}^A = \left|r_{\theta^A}^A\right| \text{ and} \tag{15a}$$

$$u_{\theta^B}^B\left(p\left(\theta^A, \theta^B\right), \theta^A, \theta^B\right) = 0 \Rightarrow r_{T^B}^B(\cdot) T_{\theta^B}^B = \left|r_{\theta^B}^B\right|. \tag{15b}$$

These equations equate each country's revenue gains from reduced terrorism to its respective cost of counterterrorism effort, ignoring the effect on the terms-of-trade. Let the counterterrorism policy vector that satisfies eqs. (15a) and (15b) be $\left(\theta^{AS}, \theta^{BS}\right)$, for which $p^S = p\left(\theta^{AS}, \theta^{BS}\right)$ is the market-clearing price at $\left(\theta^{AS}, \theta^{BS}\right)$. Then, starting from $\left(\theta^{AS}, \theta^{BS}\right)$, each country believes that the relative price remains at p^S if it unilaterally raises its own counterterrorism effort. Given eqs. (15a) and (15b), each country then perceives that a departure from $\left(\theta^{AS}, \theta^{BS}\right)$ is welfare reducing. In other words, $\left(\theta^{AS}, \theta^{BS}\right)$ is the equilibrium under this small-country assumption.

Proposition 1: A set of sufficient (but not necessary) conditions for country A to raise its defensive measure above that of the small-country level are that: (a) the two countries are targeted equally by the terrorist organization ($\alpha = \beta = 1$); (b) terrorism in the two countries has similar effects on their respective production levels of the primary good; (c) counterterrorism effort in both countries uses resources specific to the production of the manufactured good; and (d) counterterrorism efforts of the two countries are strategic substitutes. Under these same conditions, country *B* reduces its counterterrorism effort below the small-country level. [13]

Comment: Consider Figure 1, where the respective paths are drawn linear for convenience. The small-country equilibrium, $S = \left(\theta^{AS}, \theta^{BS}\right)$, lies at the intersection of the first-order paths representing $u^A_{\theta^A} = 0$ and $u^B_{\theta^B} = 0$. In the large-country case, country *A*, which is the exporter of the manufactured good, considers the terms-of-trade effect of counterterrorism effort. *A* recognizes that an increase in θ^A (intensive in the manufactured good) raises the relative demand of the manufactured good, thereby conferring a terms-of-trade benefit on itself. Accordingly, *A* responds by raising θ^A to the locus defined by eq. (14a), which lies to the right of $u^A_{\theta^A} = 0$. Country *B*, which imports the manufactured good, has the opposite incentive and reduces θ^B to the locus defined by eq. (14b), which lies below the $u^B_{\theta^B} = 0$ line. Given that both curves are drawn to be negatively sloped (strategic substitutes), the outward shift of *A*'s curve and the inward shift of *B*'s curve must move the Nash equilibrium, *N*, to the southeast of point *S*.[14] The Nash equilibrium with endogenous terms-of-trade effects is at $N = \left(\theta^{AN}, \theta^{BN}\right)$, where $\theta^{AN} > \theta^{AS}$ and $\theta^{BN} < \theta^{BS}$.

[Figure 1 near here]

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[13] Proofs of all the propositions are in Appendix A at the end of the paper.

[14] From eq. (15a), the marginal benefit of *A*'s defensive effort is $r^A_{T^A} T^A_{\theta^A}$ at a given *p*. If this marginal benefit falls with an increase in θ^B, then eq. (15a) is downward sloping. As θ^B rises, p falls because counterterrorism is intensive in the manufactured good. Also, recall that terrorism in *A* reduces primary good supply. Thus, $r^A_{T^A p} dp > 0$. In other words, as θ^B rises, the price effect raises $r^A_{T^A}$, and therefore reduces $\left|r^A_{T^A}\right|$ because $r^A_{T^A} < 0$. In turn, at a given $T^A_{\theta^A}$, this means a smaller marginal benefit, and an associated lower level of counterterrorism effort. There are other confounding effects of θ^B such as terror deflection to *A*, which tend to raise the magnitude of $T^A_{\theta^A}$, and therefore induce a rise in θ^A. Accordingly, we cannot rule out the possibility that eq. (15a) may be positively sloped. Similar considerations apply to Eqs. (14a), (14b), and (15b).

There are two income effects of a change in θ^A (on the terms-of-trade) to consider in addition to the effect discussed above. First, when *A* chooses its counterterrorism effort at the small-country outcome, its own income effect of counterterrorism effort is zero (because $u^A_{\theta^A} = 0$). Second, an income effect arises due to terror deflection to *B*, which reduces *B*'s real income (u^B) and hence *B*'s demand for the primary good. This causes the global demand for the manufactured good to rise further, and induces *A* to pursue aggressively its defensive countermeasure beyond that justified in the small-country case, which constitutes a novel result. In so doing, *A*'s overprovision is exacerbated compared to the literature that ignores trade consequences of counterterrorism actions (e.g., Sandler and Lapan, 1988). Precisely opposite incentives apply to country *B*, prompting it to reduce θ^B below the small-country level. As such, a novel asymmetry results in how the targeted countries apply their counterterrorism defensive measures.

A discussion of the relevance of the sufficient conditions is in order. Given the nature of the general-equilibrium model and its associated nonlinearities, we must narrow down the set of possibilities for analytical tractability. These sufficient conditions serve that purpose, and since they are not necessary conditions, their violations do not necessarily invalidate Proposition 1. Targeting symmetry, condition (a), limits one consideration and may hold when countries possess assets at home and abroad that may attract attacks. It may also hold when diverse, but strongly held, grievances (e.g., religious differences in developing countries or foreign policy decisions in developed countries) motivate a similar intensity of terrorist attacks. For example, many fundamentalist Islamic groups attack rival religious sects with the same fervor that they attack US, Israeli, or other Western interests. Condition (b) is reasonable from a technology perspective in a globalized world, where foreign direct investment and information flows lead to a convergence of technologies. If primary good production technology is similar between the two countries, then the effect of terror disruptions on the production of these goods should be, *ceteris paribus*, symmetric. Condition (c) is most central and intuitively defendable. Counterterrorism effort is apt to be intensive in guns, drones, capital-intensive surveillance systems, advanced technology-based barriers using manufactured goods relative to primary goods. Condition (d) ensures that strategic effects along the curves in Figure 1 complement the effect of the shifts of these curves. This is a technical condition, which, if violated, can still allow Proposition 1 as long as the shifts of the curves dominate the movements along the curves.

3. Globally optimal counterterrorism policy

Until now, the discussion focuses on what is unilaterally optimal for the trading countries in light of a common terrorist threat; however, terms-of-trade and terrorism deflection externalities imply that the free-trade equilibrium is likely globally inefficient. After first defining a global optimum, we evaluate the Nash equilibrium of counterterrorism policy choices for the small- and large-country cases in regards to global efficiency.

Let W^G represent the global welfare level as the sum of the utility levels of the two countries, so that

$$W^G\left(\theta^A,\theta^B\right) = W^A\left(\theta^A,\theta^B\right) + W^B\left(\theta^A,\theta^B\right)$$

$$= u^A\left[p\left(\theta^A,\theta^B\right),\theta^A,\theta^B\right] + u^B\left[p\left(\theta^A,\theta^B\right),\theta^A,\theta^B\right]. \tag{16}$$

Differentiating eq. (16), we get:

$$dW^G = \left(u_p^A + u_p^B\right)dp + \left(u_{\theta^A}^A + u_{\theta^A}^B\right)d\theta^A + \left(u_{\theta^B}^A + u_{\theta^B}^B\right)d\theta^B. \tag{17}$$

For simplicity, we assume that the two countries' representative consumers possess identical and homothetic preferences. Insofar as preferences are preserved through monotonic transformations, we represent homothetic preferences by a homogeneous of degree one utility function; hence, the expenditure function can be expressed as:

$E(p,1,u) = E(p,1,1)u \Rightarrow E_u = E(p,1,1)$. In turn, this implies that $e^A_{u^A} = e^B_{u^B} = E(p,1,1)$. Given eqs. (10a) and (10b), we have:

$$u^A_p + u^B_p = \frac{X^{1A} + X^{1B}}{E(p,1,1)} = 0, \tag{18}$$

because market clearing, eq. (11), implies that the net exports of the two countries must sum to zero. By substituting eq. (18) in eq. (17), we have:

$$dW^G = \left(u^A_{\theta^A} + u^B_{\theta^A}\right)d\theta^A + \left(u^A_{\theta^B} + u^B_{\theta^B}\right)d\theta^B. \tag{19}$$

We assume that $W^G\left(\theta^A,\theta^B\right)$ is a strictly concave function of the counterterrorism vector. Hence, second-order conditions of a maximum are satisfied, and eq. (19) yields the first-order conditions of global welfare maximization as:

$$W^G_{\theta^A}\left(\theta^A,\theta^B\right) = u^A_{\theta^A}\left[p\left(\theta^A,\theta^B\right),\theta^A,\theta^B\right] + u^B_{\theta^A}\left[p\left(\theta^A,\theta^B\right),\theta^A,\theta^B\right] = 0 \tag{20a}$$

and

$$W^G_{\theta^B}\left(\theta^A,\theta^B\right) = u^A_{\theta^B}\left[p\left(\theta^A,\theta^B\right),\theta^A,\theta^B\right] + u^B_{\theta^B}\left[p\left(\theta^A,\theta^B\right),\theta^A,\theta^B\right] = 0. \tag{20b}$$

Eqs. (20a) and (20b) jointly determine the global welfare-maximizing counterterrorism effort vector $\left(\theta^{A*},\theta^{B*}\right)$.

Proposition 2: A sufficient condition for both countries' defensive efforts to be overprovided in the small-country case, compared to the global optimum, is that $W^G_{\theta^A\theta^B} \geq 0$.

Comment: This global welfare cross partial reflects the effect of country *B*'s defensive effort on the marginal global welfare effect of *A*'s defensive effort (and *vice versa*). The non-negativity of this effect is sufficient but not necessary for Proposition 2. Indeed, as indicated in Appendix A, even if $W^G_{\theta^A\theta^B} < 0$, Proposition 2's overprovision still holds if the spillover effects of defensive countermeasures between the two countries are reasonably symmetric. Figure 2 can provide an intuitive guide to this proposition. Point $G^* = \left(\theta^{A*}, \theta^{B*}\right)$ represents the global optimum. Accordingly, departures from G^* in any direction must be associated with lower global welfare, W^G. We prove in Appendix A that $S = \left(\theta^{AS}, \theta^{BS}\right)$ lies to the northeast of G^* when $W^G_{\theta^A\theta^B} \geq 0$. The circular iso-welfare curve passing through *S* has lower welfare compared to G^*, and any southwest movement from *S* is a movement to a higher iso-welfare curve. This follows because lower counterterrorism by either country alleviates terror-deflecting externalities. In other words, counterterrorism effort is overprovided by both countries at the small-country equilibrium compared to the global optimum.

[Figure 2 near here]

This overprovision result is in keeping with the literature for the alternative case of an absence of trade, an active terrorist group, and two or more targeted countries (e.g., Rossi de Oliveira *et al*., 2018; Sandler and Siqueira, 2006). However, this overprovision would be attenuated somewhat if the targeted countries have foreign interests that limit their deflection gains (Bandyopadhyay and Sandler, 2011).

Corollary to Propositions 1 and 2: Under the sufficient conditions for Propositions 1 and 2, *A*'s defensive countermeasures are more overprovided at the Nash equilibrium compared to the outcome at the small-country case.

This follows immediately since by Proposition 1, $\theta^{AN} > \theta^{AS}$, and by Proposition 2 $\theta^{AS} > \theta^{A*}$, so that $\theta^{AN} > \theta^{AS} > \theta^{A*}$. Thus, A's Nash defensive behavior and its use of terms-of-trade-augmenting policy distorts A's choice further from the global optimum when compared with the small-country case, representative of the literature. By noteworthy contrast, given $\theta^{B*} < \theta^{BS}$, the terms-of-trade-augmenting policy of B depresses its defensive countermeasure *below* that for the small-country level (recall from Proposition 1 that $\theta^{BN} < \theta^{BS}$). There is, thus, a novel asymmetry between the defensive choices of targeted countries when trade-induced influences are taken into account. We now discuss whether there are any direct comparison between θ^{B*} and θ^{BN}.

Proposition 3: If $W^{G}_{\theta^A\theta^B} = 0$, counterterrorism effort by B is overprovided at the Nash equilibrium relative to the global optimum, provided that B's terror-deflecting effect to A dominates the terms-of-trade spillover to country A.

Comment: Country B's countermeasure's incentives create opposing externalities. First, to gain a terms-of-trade advantage, B reduces its counterterrorism effort. Second, to contain terrorism-related damages, B pushes its counterterrorism effort too high by ignoring the terror-deflecting externality on A. When the latter dominates, B's counterterrorism is overprovided $\left(i.e.,\ \theta^{BN} > \theta^{B*}\right)$. Hence, we have $\theta^{B*} < \theta^{BN} < \theta^{BS}$, so that the terms-of-trade-augmenting θ^{BN} is less distortionary compared to the small-country level, θ^{BS}. This terror-deflecting dominance is more likely to characterize the situation of many such exporters as explored in Section 5. A zero cross partial of global welfare is satisfied when W^{G} is separable, so that each country's welfare depends on its own counterterrorism measure. This condition can be satisfied in other non-separable scenarios.

4. Proactive counterterrorism measures targeting the terrorist group

Next, we turn to proactive counterterrorism measures (e.g., raids on terrorist assets, attacks on state sponsors, and group infiltration) that directly confront the terrorist group's operatives and operations (Enders and Sandler, 2012). Let the proactive measure of country j $\left(\text{i.e., } \mu^j, j = A, B\right)$ deplete the group's global resources, $\overline{l}$, so that

$$\overline{l} = \overline{l}\left(\mu^A, \mu^B\right),\ \overline{l}_{\mu^A}\left(\mu^A, \mu^B\right) < 0, \text{ and } \overline{l}_{\mu^B}\left(\mu^A, \mu^B\right) < 0. \tag{21}$$

To foster clarity and avoid repetition, we focus on the global resource-reducing effect of proactive or offensive measures and, hence, amend eqs. (2)-(4) as follows:[15]

$$T^j = f^j\left(l^j\right),\ f^{j\prime}\left(l^j\right) > 0,\ f^{j\prime\prime}\left(l^j\right) < 0,\ \ j = A, B. \tag{22}$$

Using $\alpha = \beta = 1$ in eq. (1) and applying eq. (22), we get:

$$V = f^A\left(l^A\right) + f^B\left(l^B\right). \tag{23}$$

The terrorist group's optimization problem is to maximize V by choosing l^A and l^B, subject to its resource constraint $l^A + l^B = \overline{l}\left(\mu^A, \mu^B\right)$. The associated first-order conditions are:

$$f^{A\prime}\left(l^A\right) = f^{B\prime}\left(l^B\right) \text{ and } l^A + l^B = \overline{l}\left(\mu^A, \mu^B\right). \tag{24}$$

Eq. (24) implies that

$$l^A = l^A\left(\mu^A, \mu^B\right) \text{ and } l^B = l^B\left(\mu^A, \mu^B\right),$$

[15] This is a special case of eq. (2), where $\gamma^j\left(\theta^j\right) \equiv 1$. A model that preserves that formulation and adds the current formulation in eq. (21) can be easily developed. However, for the sake of clarity, we restrict our attention to the novel aspect of this section, which is the global public good aspect of proactive policy.

with $l^{A}_{\mu^{A}}\left(\mu^{A},\mu^{B}\right)<0$, $l^{A}_{\mu^{B}}\left(\mu^{A},\mu^{B}\right)<0$, $l^{B}_{\mu^{A}}\left(\mu^{A},\mu^{B}\right)<0$, and $l^{B}_{\mu^{B}}\left(\mu^{A},\mu^{B}\right)<0$. (25)

Eq. (25) reflects the fact that, as proactive measures by any of the two countries reduce $\overline{l}$, the terrorist group possesses fewer resources that can be allocated to terrorism in the two countries. Eqs (22) and (25) imply that

$T^{A}\left(\mu^{A},\mu^{B}\right)\equiv f^{A}\left[l^{A}\left(\mu^{A},\mu^{B}\right)\right]$ and $T^{B}\left(\mu^{A},\mu^{B}\right)\equiv f^{B}\left[l^{B}\left(\mu^{A},\mu^{B}\right)\right]$,

with $T^{A}_{\mu^{A}}\left(\mu^{A},\mu^{B}\right)<0$, $T^{A}_{\mu^{B}}\left(\mu^{A},\mu^{B}\right)<0$, $T^{B}_{\mu^{A}}\left(\mu^{A},\mu^{B}\right)<0$, and $T^{B}_{\mu^{B}}\left(\mu^{A},\mu^{B}\right)<0$. (26)

Eq. (26) shows that more proactive countermeasures by either country reduce terrorism in both countries, thereby yielding positive transnational external benefits.

The rest of the analysis is procedurally identical to that of Section 2 with the vector $\left(\mu^{A},\mu^{B}\right)$ replacing $\left(\theta^{A},\theta^{B}\right)$. Accordingly, we have:

$$W^{A}_{\mu^{A}}\left(\mu^{A},\mu^{B}\right)\Big|_{u^{A}_{\mu^{A}}\left(p,\mu^{A},\mu^{B}\right)=0} \Rightarrow \frac{X^{1A}\left[e^{B}_{pu^{B}}u^{B}_{\mu^{A}}\left(\cdot\right)-r^{A}_{pT^{A}}T^{A}_{\mu^{A}}-r^{A}_{p\mu^{A}}-r^{B}_{pT^{B}}T^{B}_{\mu^{A}}\right]}{\sigma e^{A}_{u^{A}}\left(\cdot\right)} \quad 0 ,$$

if and only if $e^{B}_{pu^{B}}u^{B}_{\mu^{A}}\left(\cdot\right)-r^{A}_{pT^{A}}T^{A}_{\mu^{A}}-r^{A}_{p\mu^{A}}-r^{B}_{pT^{B}}T^{B}_{\mu^{A}}<0$. (27)

If we retain the assumption of Proposition 1 that $r^{A}_{p\mu^{A}}>0$ (i.e., counterterrorism uses the factor specific to the manufactured good), and if $r^{j}_{pT^{j}}<0, j=A,B$, (i.e., terrorism in either country reduces its production of the primary good), then, as long as the income effect captured by the term $e^{B}_{pu^{B}}u^{B}_{\mu^{A}}\left(\cdot\right)$ in eq. (27) is not too large, we have $e^{B}_{pu^{B}}u^{B}_{\mu^{A}}\left(\cdot\right)-r^{A}_{pT^{A}}T^{A}_{\mu^{A}}-r^{A}_{p\mu^{A}}-r^{B}_{pT^{B}}T^{B}_{\mu^{A}}<0$. In this case, even with this different counterterrorism environment, we replicate the qualitative results of Proposition 1, for which the terms-of-trade consideration incentivizes the importing (exporting) country of the primary good to raise (reduce) its counterterrorism effort relative to the small-country level. However, because counterterrorism is now associated with positive spillovers, one can safely surmise that the small-country counterterrorism effort is underprovided (see, e.g., Sandler and Lapan, 1988). When, therefore, the developing country, which exports the primary good, reduces its proactive counterterrorism below the small-country level to improve its terms-of-trade, global welfare worsens. In contrast, as the primary good importing country raises its proactive effort, global welfare improves as long as the importing country does not overshoot its globally efficient counterterrorism level. If the developed country is the dominant supplier of proactive measures (the likely scenario), then global welfare is apt to increase as country *A* augments its proactive measures. Again, there is a novel asymmetry among the two trading countries owing to the terms-of-trade externality, so that corrective policy must account for the different incentives among trading partners in a proactive counterterrorism scenario.

5. Defensive countermeasures: Large importing country and many symmetric exporting countries of the primary good

Developing countries are typically not monopoly suppliers of a primary product to a large developed country, so that these primary good exporters' market power is more limited than previously presupposed. Thus, we now consider a situation where there is one large primary good importing country like the United States (denoted by *A*) and several primary good exporting countries like Pakistan and Indonesia (denoted by $k = 1, 2, ..., n$). Given the Nash assumption, the first-order condition of country *j*'s choice of defensive counterterrorism and the associated Nash best-response function are as follows:[16]

$$\frac{\partial W^j}{\partial \theta^j} = u_p^j\left[p\left(\theta^A, \theta^1, ..., \theta^n\right), \theta^A, \theta^1, ..., \theta^n\right]\frac{\partial p}{\partial \theta^j} + \frac{\partial u^j}{\partial \theta^j} = 0 \Rightarrow \theta^j = \theta^j\left(\theta^{-j}\right), \tag{28}$$

[16] See eq. (B10) of Appendix *B*, which provides modeling and mathematical details supporting this section.

where θ^{-j} is the counterterrorism vector excluding θ^j $\left(i.e., \theta^{-j} = \left(\theta^A, \theta^1, ..., \theta^n\right)\Big|_{\theta^i \neq \theta^j}\right)$. Eq. (28) determines the multi-country Nash counterterrorism policy equilibrium vector $\left(\theta^{AN}, \theta^{1N}, ..., \theta^{nN}\right)$. If eq. (28) is evaluated at the small-country level of counterterrorism policy for *A*, then eq. (29a) follows:

$$\left(\frac{\partial W^A}{\partial \theta^A}\right)\Bigg|_{\frac{\partial u^A}{\partial \theta^A}=0} = u_p^A(\,)\left(\frac{\partial p}{\partial \theta^A}\right)\Bigg|_{\frac{\partial u^A}{\partial \theta^A}=0} \frac{X^{1A}\left[\sum_{k=1}^{n} e^k_{pu^k}\left(\frac{\partial u^k}{\partial \theta^A}\right) - r^A_{pT^A}\left(\frac{\partial T^A}{\partial \theta^A}\right) - \sum_{k=1}^{n} r^k_{pT^k}\left(\frac{\partial T^k}{\partial \theta^A}\right) - r^A_{p\theta^A}\right]}{\sigma e^A_{u^A}(\cdot)} > 0,$$

$$\text{if and only if } \sum_{k=1}^{n} e^k_{pu^k}\left(\frac{\partial u^k}{\partial \theta^A}\right) < r^A_{p\theta^A} + r^A_{pT^A}\left(\frac{\partial T^A}{\partial \theta^A}\right) + \sum_{k=1}^{n} r^k_{pT^k}\left(\frac{\partial T^k}{\partial \theta^A}\right). \tag{29a}$$

Consider the last inequality of eq. (29a). The left-hand side is negative because the income normality of the primary good implies that $e^k_{pu^k} > 0$, and eq. (B7) of the Appendix indicates that $\frac{\partial u^k}{\partial \theta^A} < 0$. The first term on the right-hand side of eq. (29a) is the effect on the production of the primary good in *A* as more resources are allocated to counterterrorism. Recall from Section 2 that if factors specific to the manufactured good are used in counterterrorism, then the supply of the primary good must increase with enhanced counterterrorism action. Given that $r^A_{p\theta^A} > 0$, the inequality in (29a) is satisfied if $r^A_{pT^A}\left(\frac{\partial T^A}{\partial \theta^A}\right) + \sum_{k=1}^{n} r^k_{pT^k}\left(\frac{\partial T^k}{\partial \theta^A}\right) \geq 0$. The first of these two terms is positive because it represents the increase in primary good production in *A* as terrorism is reduced by θ^A. By contrast, the second term is negative as terrorism is deflected to countries other than *A*, thereby reducing production of the primary good abroad. If these two effects largely offset each other, then the inequality is satisfied, and we have that

$\left(\frac{\partial W^A}{\partial \theta^A}\right)_{\left|\frac{\partial u^A}{\partial \theta^A}=0\right.} > 0 \Rightarrow \theta^{AN} > \theta^{AS}$. This inequality *also* holds if the two right-hand positive terms in the last inequality of eq. (29a) dominate the terrorism-deflecting-induced fall in the primary good production abroad.

Next, we consider the effect of defensive countermeasures by the exporting countries of the primary good. The import of this good by *A*, say $M^{1A}\left(= -X^{1A} \quad 0\right)$, must equal the sum of the exports by the collective of developing countries, $k = 1, 2, ..., n$. Given the assumed symmetry of primary good exporting countries, we have that $nX^{1k} = M^{1A} \Rightarrow X^{1k} = \frac{X^{1A}}{n}$. Therefore, based on eq. (B13) of Appendix B, the following welfare implication holds:

$$\left(\frac{\partial W^k}{\partial \theta^k}\right)_{\left|\frac{\partial u^k}{\partial \theta^k}=0\right.} = -\frac{\left(\frac{X^{1A}}{n}\right)\left[\sum_{\substack{j \neq A,1 \\ j \neq k}}^{n} e^j_{pu^j}\left(\frac{\partial u^j}{\partial \theta^k}\right) - r^k_{pT^k}\left(\frac{\partial T^k}{\partial \theta^k}\right) - \sum_{\substack{j \quad A,1 \\ j \neq k}}^{n} r^j_{pT^j}\left(\frac{\partial T^j}{\partial \theta^k}\right) - r^k_{p\theta^k}\right]}{\sigma e^k_{u^k}(\cdot)}. \tag{29b}$$

Comparing eq. (29a) to eq. (29b), we see that the marginal effect for each primary good exporting country is smaller (approximately) by a factor of n, relative to the effect in country *A*. Thus, we assert that

$$\left(\frac{\partial W^k}{\partial \theta^k}\right)_{\left|\frac{\partial u^k}{\partial \theta^k}=0\right.} \to 0, \text{ as } \frac{X^{1A}}{n} \to 0 \text{ and } n \to \infty, \text{ while } X^{1A} \text{ is finite.} \tag{29c}$$

Eq. (29c) implies that the terms-of-trade motive for reducing defensive countermeasures by the primary good exporters is negligible when there are a large number of developing-country exporters. But, as we argue above, the developed country has the incentive to raise its effort level above the small-country level. If, therefore, the developing countries' effort levels are strategic complements (to the effect level of the developed countries), then they will react by raising their counterterrorism level. This Nash equilibrium will involve greater counterterrorism effort by all countries compared to the small-country case. Since the small-country equilibrium is characterized by overprovision (see Proposition 2) compared to the global optimum, the Nash equilibrium of this multi-country case will surely be associated with overprovision under strategic complementarity. However, the overprovision is somewhat moderated if developing countries' effort levels are strategic substitutes to the developed country's defensive measures.[17]

6. Concluding remarks

This paper presents a general-equilibrium analysis of the interplay of terms-of-trade and terrorism-deflecting externalities in various game-theoretic scenarios involving targeted trading countries and a common terrorist group. The associated two-stage games have the trading countries going first in choosing their counterterrorism and the terrorist group then deciding its distribution of attacks among targeted countries. In the baseline defensive counterterrorism case, there are two trading countries, developed and developing, that are targeted by the same terrorist group. The developed (developing) country imports (exports) the primary good. The trading roles are reversed for the manufactured good, which is used intensively in supplying counterterrorism. In this scenario, a terms-of-trade effect, involving the relative price fall in the primary good, induces the developed country to defend beyond the overprovision small-country level, common to the literature, where there is no terms-of-trade effect. In contrast, the developing country reduces its defensive action below that of the small-country case in order to limit the adverse terms-of-trade influence as its exported primary good falls in price. This

[17] Under strategic substitutability, developing nations will react to greater θ^A by cutting back θ^k. If this strategic effect is small, global overprovision is still the likely outcome, where the terror-deflection externalities (discussed in Propositions 2 and 3) make for effort levels of developing nations that are still "too high" relative to the global optimum.

asymmetry between the defensive actions of the targeted countries highlights how trade adds a novel consideration that results in somewhat more optimistic welfare findings if the developing country's decreases to defensive measures are substantial compared to the developed country's increases to its measures. More pessimistic welfare findings occur when the developed country's terms-of-trade-induced increase to defensive measures is more substantial.

We also consider the possibility that the countries' proactive countermeasures may reduce the global resource availability for the terrorists. Such measures reduce terror in all countries and are, thus, associated with positive transnational spillovers. At a given terms-of-trade, the Nash proactive policy equilibrium tends to be characterized by underprovision of counterterrorism effort by both countries. However, the terms-of-trade externalities are qualitatively unaltered compared to the previous defensive analysis. Therefore, the developed country's terms-of-trade-driven rise in counterterrorism effort helps alleviate this country's underprovision. The opposite is true for the developing country, where underprovision is worse compared to the small-country case. In terms of welfare consequences, the asymmetry switches with the developed country ameliorating the inefficiency compared to the defensive case. Since the developed country is generally the main supplier of proactive measures, the terms-of-trade effect is likely to improve global welfare compared to cases examined in the literature.

Finally, we return to the defensive counterterrorism case to consider multiple exporters of the primary good and single developed country importer of this good. When several symmetric developing countries compete to export the primary good to the developed country, the terms-of-trade underprovision incentives for these countries dissipate in proportion to the number of exporters. As a consequence, there is a tendency in this case for greater overprovision of defensive effort and enhanced terror deflection across countries, thus adversely affecting global welfare.

A potential extension could allow for many developed countries that export the manufactured good to many developing countries, the source of the primary good. Another extension could permit the joint determination of defensive and proactive counterterrorism in a trade setting.

Appendix A: Proofs of Propositions 1-3

Proof of Proposition 1:

Let us evaluate eq. (14a) at the small-country level of counterterrorism policy. Using $u^A_{\theta^A} = 0$ in eq. (14a) along with eqs. (10a) and (12), and noting that $X^{1A} < 0$, we have

$$W^A_{\theta^A}\left(\theta^A, \theta^B\right)\Big|_{u^A_{\theta^A}=0} \Rightarrow \frac{X^{1A}\left[e^B_{pu^B} u^B_{\theta^A}(\cdot) - r^A_{pT^A} T^A_{\theta^A} - r^A_{p\theta^A} - r^B_{pT^B} T^B_{\theta^A}\right]}{\sigma e^A_{u^A}(\cdot)} \quad 0 \ ,$$

if and only if $e^B_{pu^B} u^B_{\theta^A}(\cdot) - r^A_{pT^A} T^A_{\theta^A} - r^A_{p\theta^A} - r^B_{pT^B} T^B_{\theta^A} < 0$. (A1)

By appealing to eqs. (4) through (6), we can show that, when $\alpha = \beta = 1$,

$$\frac{\partial\left(T^A + T^B\right)}{\partial \theta^A} = T^A_{\theta^A} + T^B_{\theta^A} = \frac{T^A \gamma^{A\prime}\left(\theta^A\right)}{\gamma^A\left(\theta^A\right)} < 0. \qquad \text{(A2)}$$

The inequality in eq. (A2) indicates that, while greater defensive measures in *A* reduces its terrorism as terrorism is shifted to *B*, the global effect is a reduced overall terrorism, $T^A + T^B$. Thus, *B*'s increase in terrorism does not completely offset *A*'s fall in terrorism. Faced with greater counterterrorism in *A*, the terrorist organization incurs some efficiency loss as it allocates more resources to attacks in *B*, because of diminishing returns in terrorism production in any particular location. Defining *B*'s marginal propensity to consume the primary good out of income as mpc^{1B}, we can use eqs. (A1) and (A2) to get:

$$e^{B}_{pu^{B}}u^{B}_{\theta^{A}}\left(\cdot\right)-r^{A}_{pT^{A}}T^{A}_{\theta^{A}}-r^{A}_{p\theta^{A}}-r^{B}_{pT^{B}}T^{B}_{\theta^{A}}$$

$$=\left[mpc^{1B}r^{B}_{T^{B}}\left(\cdot\right)-r^{B}_{pT^{B}}+r^{A}_{pT^{A}}\right]T^{B}_{\theta^{A}}-\frac{r^{A}_{pT^{A}}T^{A}\gamma^{A\prime}\left(\cdot\right)}{\gamma^{A}\left(\cdot\right)}-r^{A}_{p\theta^{A}}\text{, where } mpc^{1B}=\frac{e^{B}_{pu^{B}}}{e^{B}_{u^{B}}}. \tag{A3}$$

When terrorism in the two countries have similar effects on their respective production levels of the primary good, then $\frac{\partial r^{A}_{p}\left(\cdot\right)}{\partial T^{A}}\cong\frac{\partial r^{B}_{p}\left(\cdot\right)}{\partial T^{B}}\Rightarrow r^{A}_{pT^{A}}\cong r^{B}_{pT^{B}}$. Also, when counterterrorism effort of country *A* uses resources specific to the manufactured good, there is either no effect or a positive effect on the production of the primary good. Suppose that the manufactured good uses a capital-specific input and also labor. If counterterrorism depletes some of this sector-specific capital (and no labor), then productivity of labor falls in the manufacturing sector, and labor flows to the primary sector, which raises the output of the primary good. Consequently, we have $\frac{\partial r^{A}_{p}\left(\cdot\right)}{\partial\theta^{A}}=r^{A}_{p\theta^{A}}\geq 0$. Therefore, under sufficient conditions (a)-(c) in Proposition 1, we have:

$$e^{B}_{pu^{B}}u^{B}_{\theta^{A}}\left(\cdot\right)-r^{A}_{pT^{A}}T^{A}_{\theta^{A}}-r^{A}_{p\theta^{A}}-r^{B}_{pT^{B}}T^{B}_{\theta^{A}}$$

$$=mpc^{1B}r^{B}_{T^{B}}\left(\cdot\right)T^{B}_{\theta^{A}}\left(\theta^{A},\theta^{B}\right)-\frac{r^{A}_{pT^{A}}T^{A}\gamma^{A\prime}\left(\theta^{A}\right)}{\gamma^{A}\left(\theta^{A}\right)}-r^{A}_{p\theta^{A}}<0.\text{[18]} \tag{A4}$$

Using eq. (A4) in eq. (A1) yields:

$$W^{A}_{\theta^{A}}\left(\theta^{A},\theta^{B}\right)\Big|_{u^{A}_{\theta^{A}}=0}>0. \tag{A5}$$

This suggests that starting from the small-country level of counterterrorism effort, there is a marginal gain in utility for country *A* from an increase in its defensive countermeasures when it endogenizes the effect of θ^{A} on the market-clearing price, which raises θ^{A} above θ^{AS}. Given concavity of the welfare function, *A*'s Nash reaction function, which endogenizes the terms-of-

[18] We assume that both goods are normal in consumption in both countries, such that $mpc^{ij}>0,\ i=1,2;\ j=A,B.$

trade effects, lies to the right of θ^{AS}.

For country *B*, the analysis is identical, except that *B* is the exporter of the primary good, good, such that $X^{1B} > 0$; hence, we have:

$$W^B_{\theta^B}\left(\theta^A,\theta^B\right)\Big|_{u^B_{\theta^B}=0} = < \frac{X^{1B}\left[mpc^{1A} r^A_{T^A}(\cdot) T^A_{\theta^B}\left(\theta^A,\theta^B\right) - \frac{r^B_{pT^B} T^B \gamma^{B\prime}\left(\theta^B\right)}{\gamma^B\left(\theta^B\right)} - r^B_{p\theta^B} \right]}{\sigma e^B_{u^B}(\cdot)} \quad 0. \qquad \text{(A6)}$$

Thus, country *B* will want to reduce its θ^B below θ^{BS}. Hence, under strategic substitutability, $\theta^{AN} > \theta^{AS}$ and $\theta^{BN} < \theta^{BS}$. Q.E.D.

Proof of Proposition 2:

Case 1: $W^G_{\theta^A\theta^B} = 0$.

Refer to Figure 2, where global welfare is maximized at G^*. Consider eq. (20a), $W^G_{\theta^A}\left(\theta^A,\theta^B\right) = 0$, which implicitly defines

$$\theta^A = \theta^A\left(\theta^B\right)\Big|_{W^G_{\theta^A}=0}, \text{ where } \frac{d\theta^A}{d\theta^B} = -\frac{W^G_{\theta^A\theta^B}}{W^G_{\theta^A\theta^A}} \quad 0, \text{ when } W^G_{\theta^A\theta^B} = 0. \qquad \text{(A7)}$$

As such, eq. (20a) defines a locus that is a vertical line through G^*. Similarly, eq. (20b) implies

$$\theta^B = \theta^B\left(\theta^A\right)\Big|_{W^G_{\theta^B}=0}, \text{ where } \frac{d\theta^B}{d\theta^A} = -\frac{W^G_{\theta^A\theta^B}}{W^G_{\theta^B\theta^B}} \quad 0, \qquad \text{(A8)}$$

so that eq. (A8) implies that eq. (20b) defines a locus that is a horizontal line through G^*.

Now, consider the circle passing through *C*, vertically above G^*. The welfare at point C is $W^G\left(\theta^{AC},\theta^{BC}\right) = \bar{W}^{GC}$. Consider the following global iso-welfare curve and its slope,

$$W^G\left(\theta^A,\theta^B\right) = \bar{W}^{GC} \qquad \left(\frac{d\theta^B}{d\theta^A}\right)_{W^G(\cdot)=\bar{W}^{GC}} \qquad \frac{W^G_{\theta^A}}{W^G_{\theta^B}}. \qquad \text{(A9)}$$

Given that C lies vertically above G^*, eqs. (20a) and (A7) imply that $W^G_{\theta^A} = 0$ at C, while eqs. (20b) and (A8) imply that $W^G_{\theta^B} \neq 0$ at C. Thus, eq. (A9) implies that the slope of the iso-welfare curve at C is zero. Similarly, appealing to eqs. (20b), (A8), and (A9), we can infer that the slope of the iso-welfare curve tends to infinity at point D, which is directly to the right of point G^*. Consider the segment of the iso-welfare curve between C and D that is to the right of $W^G_{\theta^A} = 0$ and above $W^G_{\theta^B} = 0$. Under the assumption of strict concavity of $W^G\left(\theta^A, \theta^B\right)$ and $W^G_{\theta^A\theta^B} = 0$, points between C and D are associated with levels of $\left(\theta^A, \theta^B\right)$ for which $W^G_{\theta^A}$ and $W^G_{\theta^B}$ are both negative. Eq. (A9) thus implies that the slope of the iso-welfare curve between C and D is negative (as displayed in Figure 2). Following the same logic, we can infer that the iso-welfare curve is also negatively sloped in the segment to the southwest of G^*, but is positively sloped in the segments to the northwest and southeast of G^*.

Evaluating $W^G_{\theta^A}$ and $W^G_{\theta^B}$ at the small-country equilibrium $\left(\theta^{AS}, \theta^{BS}\right)$ and using eqs. (10a) (10b), (20a), and (20b), we get:

$$W^G_{\theta^A}\Big|_{u^A_{\theta^A}=0} = \lessdot u^B_{\theta^A}\left[p\left(\theta^A, \theta^B\right), \theta^A, \theta^B\right] \quad 0 \tag{A10}$$

and

$$W^G_{\theta^B}\Big|_{u^B_{\theta^B}=0} = \lessdot u^A_{\theta^B}\left[p\left(\theta^A, \theta^B\right), \theta^A, \theta^B\right] \quad 0. \tag{A11}$$

Substituting (A10) and (A11) into (A9), we have the slope of the iso-welfare curve passing through $\left(\theta^{AS}, \theta^{BS}\right)$ as $\left(\frac{d\theta^B}{d\theta^A}\right)_{W^G(\cdot)=\bar{W}^{GC}} - = \frac{W^G_{\theta^A}}{W^G_{\theta^B}} \quad 0$. This immediately rules out $\left(\theta^{AS}, \theta^{BS}\right)$ being on the positively sloped segments of the iso-welfare curve. Next, consider the point S' in Figure 2 that is southwest of G^* and also on a negatively sloped portion of the iso-welfare curve. If

S' is the small-country equilibrium, then eq. (A10) indicates that $W^G_{\theta^A}\big|_{u^A_{\theta^A}=0} < 0$, which, given the strict concavity of W^G, means that the $W^G_{\theta^A} = 0$ line must lie to the left of S'. This, however, contradicts our supposition that S' is to the southwest of G^*. In other words, S' cannot be an admissible small-country equilibrium. Thus, $S = \left(\theta^{AS}, \theta^{BS}\right)$ in Figure 2, drawn to the northeast of G^*, is the only possible small-country equilibrium. Thus, if $W^G_{\theta^A\theta^B} = 0$, we must have $\theta^{AS} > \theta^{A*}$, $\theta^{BS} > \theta^{B*}$.

Case 2: $W^G_{\theta^A\theta^B} > 0$.

The strict concavity of W^G means that $W^G_{\theta^A\theta^A}$ and $W^G_{\theta^B\theta^B}$ are both strictly negative, so that $W^G_{\theta^A\theta^B} > 0$ implies that the slope of the paths defined in (A7) and (A8) are positive at all points. Also, strict concavity and $W^G_{\theta^A\theta^B} > 0$ imply that

$$W^G_{\theta^A\theta^A} W^G_{\theta^B\theta^B} - \left(W^G_{\theta^A\theta^B}\right)^2 > 0 \Rightarrow -\frac{W^G_{\theta^A\theta^A}}{W^G_{\theta^A\theta^B}} > -\frac{W^G_{\theta^B\theta^A}}{W^G_{\theta^B\theta^B}} \Rightarrow \left(\frac{d\theta^B}{d\theta^A}\right)_{W^G_{\theta^A}=0} > \left(\frac{d\theta^B}{d\theta^A}\right)_{W^G_{\theta^B}\;0} > 0. \quad \text{(A12)}$$

Eq. (A12) implies that the locus (not drawn) representing eq. (20a) is positively sloped and steeper relative to the locus representing eq. (20b). In other words, in Case 2, *S* lies in a narrower segment northeast of G^* than the *C-D* segment that corresponds to Case 1. Therefore, in Case 2, we again have: $\theta^{AS} > \theta^{A*}, \theta^{BS} > \theta^{B*}$.

Combining Cases 1 and 2, we prove our assertion that $\theta^{AS} > \theta^{A*}, \theta^{BS} > \theta^{B*}$ when

$W^G_{\theta^A\theta^B} \geq 0$.[19] Q.E.D.

Proof of Proposition 3:

Using eq. (17) and noting that the Nash equilibrium defensive vector $\left(\theta^{AN}, \theta^{BN}\right)$ must satisfy eq. (14b), we get:

$$\frac{\partial W^G}{\partial \theta^B} = u_p^A p_{\theta^B} + u_{\theta^B}^A + u_p^B p_{\theta^B} + u_{\theta^B}^B \Rightarrow \frac{\partial W^G}{\partial \theta^B}_{|Nash} = u_p^A p_{\theta^B} + u_{\theta^B}^A . \tag{A13}$$

From eq. (10a), we know that both u_p^A and $u_{\theta^B}^A$ are negative. Also, using eqs. (14b) and (15b), we can show that $p_{\theta^B}\left(\theta^A, \theta^B\right) < 0$.[20] This, in turn, means that

$$\frac{\partial W^G}{\partial \theta^B}_{|Nash} < 0 \text{ if and only if } u_p^A p_{\theta^B} < \left|u_{\theta^B}^A\right|. \tag{A14}$$

Recall from Figure 2 that when $W^G_{\theta^A\theta^B} = 0$, $W^G_{\theta^B} = 0$ is a horizontal line passing through point G^* (i.e., the locus $\theta^B = \theta^{B*}$). From (A14), $\left(W^G_{\theta^B}\right)_{|Nash} < 0$ if and only if $u_p^A p_{\theta^B} < \left|u_{\theta^B}^A\right|$. Therefore, in this case, strict concavity implies that θ^{BN} has to exceed θ^{B*} and must lie above the horizontal line through G^*. Similarly, if $u_p^A p_{\theta^B} \geq \left|u_{\theta^B}^A\right|$, then $\theta^{BN} \leq \theta^{B*}$. Recall from eq. (10a) that the term $u_{\theta^B}^A \left(= r_{T^A}^A T_{\theta^B}^A / e_{u^A}^A\right)$ represents the decline in *A*'s utility from terrorism deflected to *A* from greater defensive measures by *B*. In contrast, higher counterterrorism effort by *B* reduces terror and

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[19] If $W^G_{\theta^A\theta^B} < 0$, the paths defined in (A7) and (A8) are negatively sloped, with concavity implying that (A7) is steeper than (A8) (not drawn in Figure 2). Even in this case, overprovision is the likely outcome if countries are not too asymmetric (proof available upon request).

[20] Eq. (14b) yields $p_{\theta^B} = -u_{\theta^B}^B \big/ u_p^B$. From eq. (10b), we know that $u_p^B > 0$. Now, the small-country's first- and second-order conditions for *B*'s choice of θ^B require that $u_{\theta^B}^B = 0$ and $u_{\theta^B\theta^B}^B < 0$ [see eq. (15b)]. Thus, as θ^B is reduced below the small-country level (recall Proposition 1) toward θ^{BN}, $u_{\theta^B}^B$ must turn positive. Thus, at an interior Nash equilibrium, p_{θ^B} is negative.

raises the global supply of the primary good, thus conferring a terms-of-trade gain to *A*, captured by $u_p^A p_{\theta^B} > 0$. Eq. (A14) suggests that if this latter positive terms-of-trade effect is dominated by the negative terror-deflection effect, then there is a global gain from reducing θ^B below θ^{BN}. If, therefore, the second inequality in eq. (A14) is satisfied, then counterterrorism effort by *B* is overprovided at the Nash equilibrium. Q.E.D.

Appendix B: The multi-country case

If the terrorist organization targets all countries equally, then its objective function is:

$$V = T^A + \sum_{k=1}^{n} T^k . \tag{B1}$$

Using similar modeling strategy and notation as in Section 2.1, we have the following terrorism relationships:

$$T^j = \gamma^j\left(\theta^j\right) f^j\left(l^j\right),\ f^{j\prime}\left(l^j\right) > 0,\ f^{j\prime\prime}\left(l^j\right) < 0,\ \gamma^{j\prime}\left(\theta^j\right) < 0,\ \gamma^{j\prime\prime}\left(\theta^j\right) > 0,\ j = A,1,2,...,n \tag{B2}$$

Given eqs. (B1)-(B2) and the resource constraint, $l^A + \sum_{k=1}^{n} l^k = \bar{l}$, the terrorist group optimally chooses its attack levels in the different countries to satisfy the following first-order conditions:

$$\gamma^A\left(\theta^A\right) f^{A\prime}\left(l^A\right) = \gamma^1\left(\theta^1\right) f^{1\prime}\left(l^1\right) = \gamma^2\left(\theta^2\right) f^{2\prime}\left(l^2\right) = \ldots = \gamma^n\left(\theta^n\right) f^{n\prime}\left(l^n\right), \text{ and } l^A + \sum_{k=1}^{n} l^k = \bar{l}. \tag{B3}$$

When $\bar{l}$ is suppressed from the functional forms, eq. (B3) can be expressed as:

$$l^j = l^j\left(\theta^A, \theta^1, ..., \theta^k, ..., \theta^n\right), \text{ where } \frac{\partial l^j}{\partial \theta^j} < 0 \text{ and } \frac{\partial l^j}{\partial \theta^i} > 0\left(i \neq j\right) \text{ for } j,i = A,1,2,...,n.$$

Based on eqs. (B1)-(B4), terrorism in the respective countries can be re-expressed as:

$$T^j = \gamma^j\left(\theta^j\right) f^j\left[l^j\left(\theta^A, \theta^1, ..., \theta^n\right)\right] \equiv T^j\left(\theta^A, \theta^1, ..., \theta^n\right), \text{ with } \frac{\partial T^j}{\partial \theta^j} = f^j \gamma^{j\prime} + \gamma^j f^{j\prime} \frac{\partial l^j}{\partial \theta^j} < 0,$$

$$\frac{\partial T^j}{\partial \theta^i} = \gamma^j f^{j\prime} \frac{\partial l^j}{\partial \theta^i} > 0\left(i \neq j\right), \text{ where } j,i = A,1,2,...,n. \tag{B5}$$

The expenditure-revenue identities of the countries are:

$$e^j\left(p,1,u^j\right) = r^j\left[p,1,T^j\left(\theta^A,\theta^1,...,\theta^n\right),\theta^j\right], \; j = A,1,2,...,n. \tag{B6}$$

Eq. (B6) yields:

$$u^j = u^j\left(p,\theta^A,\theta^1,...,\theta^n\right), \text{ where } u_p^j\left(\cdot\right) = \frac{X^{1j}}{e_{u^j}^j\left(\cdot\right)}, \; \frac{\partial u^j}{\partial \theta^j} = \frac{r_{T^j}^j \frac{\partial T^j}{\partial \theta^j} + r_{\theta^j}^j}{e_{u^j}^j} \text{ and}$$

$$\frac{\partial u^j}{\partial \theta^i} = \frac{r_{T^j}^j \frac{\partial T^j}{\partial \theta^i}}{e_{u^j}^j} < 0\left(i \neq j\right) \text{ for } j,i = A,1,2,...,n. \tag{B7}$$

The market-clearing equation corresponding to eq. (11) equals:

$$e_p^A\left[p,1,u^A\left(p,\theta^A,\theta^1,...,\theta^n\right)\right] + \sum_{k=1}^{n} e_p^k\left[p,1,u^k\left(p,\theta^A,\theta^1,...,\theta^n\right)\right]$$

$$= r_p^A\left[p,1,T^A\left(\theta^A,\theta^1,...,\theta^n\right),\theta^A\right] \quad \sum_{k=1}^{n} r_p^k\left[p,1,T^k\left(\theta^A,\theta^1,...,\theta^n\right),\theta^k\right]. \tag{B8}$$

As before, if the slope of the excess supply function is denoted by $\sigma > 0$, then eq. (B8) yields:

$$p = p\left(\theta^A,\theta^1,...,\theta^n\right), \text{ where } j,i = A,1,2,...,n, \; i \neq j, \text{ and}$$

$$\frac{\partial p}{\partial \theta^j} = \frac{e_{pu^j}^j\left(\frac{\partial u^j}{\partial \theta^j}\right) + \sum_{\substack{i=A,1\\ i\neq j}}^{n} e_{pu^i}^i\left(\frac{\partial u^i}{\partial \theta^j}\right) - r_{pT^j}^j\left(\frac{\partial T^j}{\partial \theta^j}\right) - \sum_{\substack{i\ A,1\\ i\neq j}}^{n} r_{pT^i}^i\left(\frac{\partial T^i}{\partial \theta^j}\right) - r_{p\theta^j}^j}{\sigma}. \tag{B9}$$

Based on eqs. (B7) and (B9), country *j*'s utility function can be written as:

$$W^j\left(\theta^A,\theta^1,...\theta^n\right) = u^j\left[p\left(\theta^A,\theta^1,...\theta^n\right),\theta^A,\theta^1,...\theta^n\right]. \tag{B10}$$

The "small-country" model where price *p* is invariant to whatever defensive policies any country chooses implies:

$$\left(\frac{\partial W^j}{\partial \theta^j}\right)_{|p} = \frac{\partial u^j}{\partial \theta^j} = 0 \,. \tag{B11}$$

By substituting eq. (B7) into eq. (B11), the small-country defensive levels satisfy:

$$\frac{\partial u^j}{\partial \theta^j} = 0 \Rightarrow r^j_{T^j} \frac{\partial T^j}{\partial \theta^j} = \left| r^j_{\theta^j} \right|, \; j = A, 1, 2, ..., n \,. \tag{B12}$$

Let the counterterrorism policy vector that satisfies eq. (B12) be $\left(\theta^{AS}, \theta^{1S}, ..., \theta^{nS}\right)$, where θ^{jS} represents the optimal counterterrorism policy for country *j* in the small-country case.

For primary good exporting countries, $X^{1k} > 0$ for $k = 1, 2, ..., n$. Using eqs. (B9)-(B11), we get the following expression:

$$\left(\frac{\partial W^k}{\partial \theta^k}\right)_{\left|\frac{\partial u^k}{\partial \theta^k}=0\right.} = u^k_p(\cdot)\left(\frac{\partial p}{\partial \theta^k}\right)_{\left|\frac{\partial u^k}{\partial \theta^k}=0\right.} = \frac{X^{1k}\left[\sum_{\substack{j=A,1\\ j\neq k}}^{n} e^j_{pu^j}\left(\frac{\partial u^j}{\partial \theta^k}\right) - r^k_{pT^k}\left(\frac{\partial T^k}{\partial \theta^k}\right) - \sum_{\substack{j=A,1\\ j\neq k}}^{n} r^j_{pT^j}\left(\frac{\partial T^j}{\partial \theta^k}\right) - r^k_{p\theta^k}\right]}{\sigma e^k_{u^k}(\cdot)} < 0 \,,$$

$$\text{if and only if } \sum_{\substack{j=A,1\\ j\neq k}}^{n} e^j_{pu^j}\left(\frac{\partial u^j}{\partial \theta^k}\right) < r^k_{p\theta^k} + r^k_{pT^k}\left(\frac{\partial T^k}{\partial \theta^k}\right) + \sum_{\substack{j=A,1\\ j\neq k}}^{n} r^j_{pT^j}\left(\frac{\partial T^j}{\partial \theta^k}\right). \tag{B13}$$

Let W^G represent the global welfare level as the sum of the utility levels of all the countries:

$$W^G = \sum_{j=A,1}^{n} W^j\left(\theta^A, \theta^1, ..., \theta^n\right) = \sum_{j=A,1}^{n} u^j\left[p\left(\theta^A, \theta^1, ..., \theta^n\right), \theta^A, \theta^1, ..., \theta^n\right]. \tag{B14}$$

Differentiating eq. (B14), we get the following change in global welfare:

$$dW^G = \left(\sum_{j=A,1}^{n} u^j_p(\cdot)\right) dp + \left(\sum_{j=A,1}^{n} \frac{\partial u^j}{\partial \theta^A}\right) d\theta^A + \left(\sum_{j=A,1}^{n} \frac{\partial u^j}{\partial \theta^1}\right) d\theta^1 + ... + \left(\sum_{j=A,1}^{n} \frac{\partial u^j}{\partial \theta^n}\right) d\theta^n \,. \tag{B15}$$

Using the market-clearing equation for the primary good, we have: $\sum_{j=A,1}^{n} u^j_p(\cdot) = \frac{\sum_{j=A,1}^{n} X^{1j}}{E(p,1,1)} = 0$.

Therefore, eq. (B15) becomes

$$dW^G = \left(\sum_{j=A,1}^{n} \frac{\partial u^j}{\partial \theta^A} \right) d\theta^A + \left(\sum_{j=A,1}^{n} \frac{\partial u^j}{\partial \theta^1} \right) d\theta^1 + \dots + \left(\sum_{j=A,1}^{n} \frac{\partial u^j}{\partial \theta^n} \right) d\theta^n . \tag{B16}$$

At the global optimum, the following holds:

$$\frac{\partial W^G}{\partial \theta^i} = \left(\sum_{j=A,1}^{n} \frac{\partial u^j}{\partial \theta^i} \right) = 0 \text{ for } i = A,1,...,n . \tag{B17}$$

Evaluating the marginal change of global welfare with respect to defensive measures of any country *i* (*i=A,1,2….n*) at the small-country equilibrium, we have:

$$\left(\frac{\partial W^G}{\partial \theta^i} \right)\Bigg|_{\frac{\partial u^i}{\partial \theta^i}=0,\forall i} = \left(\sum_{\substack{j=A,1 \\ j \neq i}}^{n} \frac{\partial u^j}{\partial \theta^i} \right) < 0 . \tag{B18}$$

Strict concavity of W^G implies that θ^i is overprovided relative to the global optimum.

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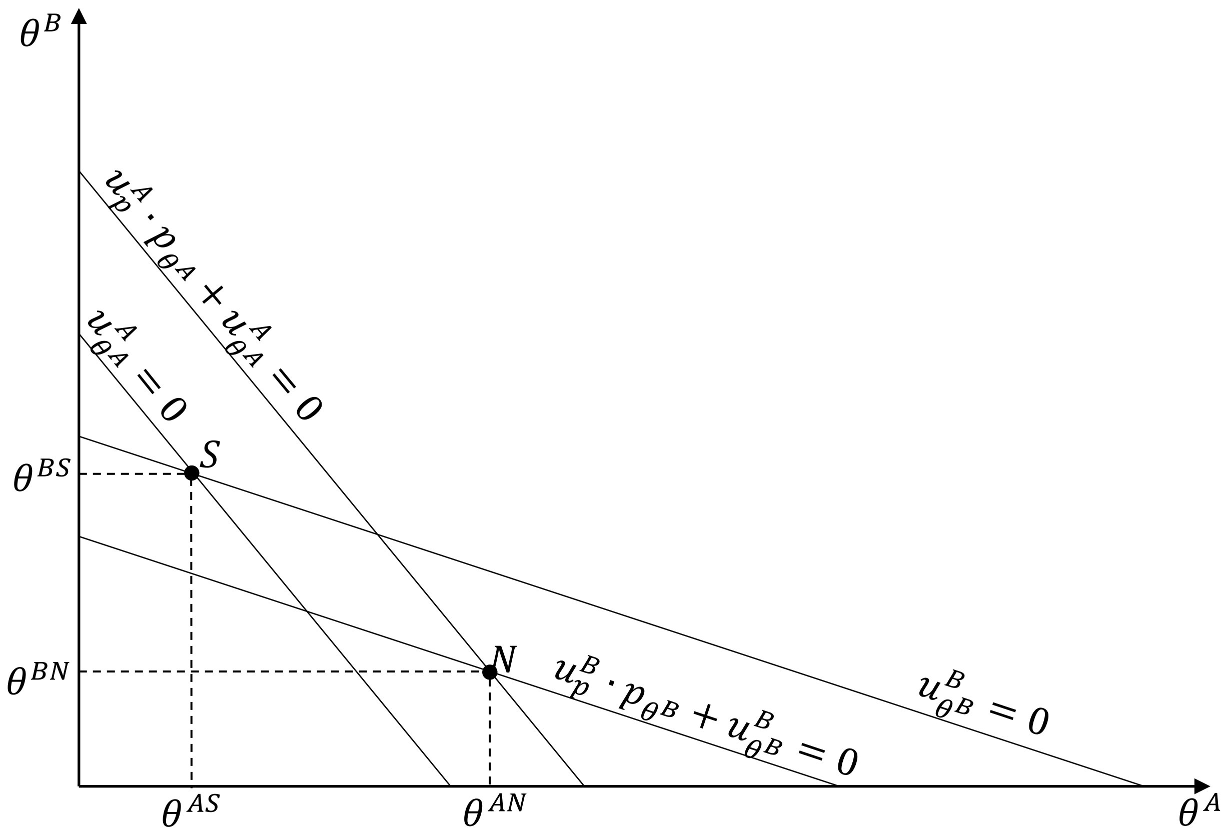

Fig. 1. Equilibrium comparison between Nash and small country case+

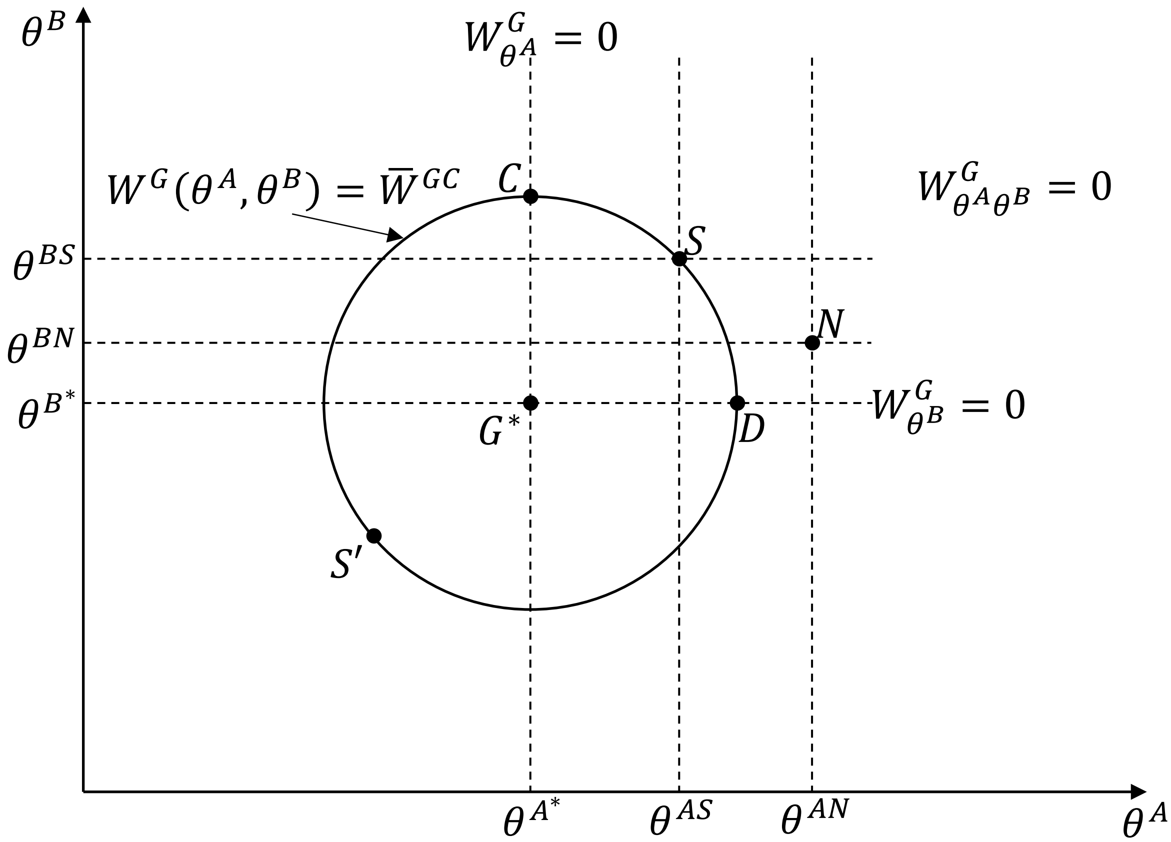

Fig. 2. Welfare comparisons of optimum and alternative equilibriums