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Abstract

A terrorist group, based in a developing (host) country, draws unskilled and skilled labor from the productive sector to conduct attacks in that nation and abroad. The host nation chooses proactive countermeasures. Moreover, a targeted developed nation decides its optimal mix of immigration quotas and defensive counterterrorism actions. Even though proactive measures in the host country may not curb terrorism directed at it, it may still be advantageous in terms of national income. Increases in the unskilled immigration quota augment terrorism against the developed country. By contrast, increases in the skilled immigration quota can reduce terrorism in the developed country if skilled migrants have a small marginal impact on terrorism there. When the developed country assumes a leadership role, it strategically should reduce its skilled immigration quota to induce more proactive measures in the host developing country.

Keywords: Transnational terrorism, immigration, counterterrorism policy, developing country, externalities

JEL codes: F22, O10, D74

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Immigration policy and counterterrorism

1. Introduction

Ever since the unprecedented terrorist attacks on September 11, 2001 (henceforth 9/11), economists have focused on myriad aspects of terrorism including its growth impact (Blomberg et al., 2004; Gaibulloev and Sandler, 2008, 2011; Tavares, 2004), its development consequences (Keefer and Loayza, 2008), its economic costs (e.g., Abadie and Gardeazabal, 2003; Eckstein and Tsiddon, 2004), and its counterterrorism implications (e.g., Bandyopadhyay and Sandler, 2011; Bier et al., 2007). Researchers applied game-theoretic tools to investigate the practice of counterterrorism against domestic and transnational terrorism (see, e.g., Arce and Sandler, 2005; Bapat, 2006, 2011; Sandler et al., 1983). Some contributions investigated the demand side in terms of the number and location of terrorist incidents (e.g., Sandler and Siqueira, 2006; Siqueira and Sandler, 2007), while other studies examined the supply side in terms of the roots of terrorism (e.g., Abadie, 2006; Krueger and Maleckova, 2003; Piazza, 2011; Savun and Phillips, 2009). Krueger and Laitin (2008) investigated both sides of terrorism by analyzing what determines whether a nation is a source or a target of transnational terrorism (see, also, Blomberg et al., 2009). Another strand of the terrorism literature relates to trade and/or foreign direct investment (e.g., Abadie and Gardeazabal, 2008; Bandyopadhyay et al., 2011a; Enders and Sandler, 1996; Nitsch and Schumacher, 2004). The empirical findings and methodology of the international trade and terrorism literature are nicely summarized by Mirza and Verdier (2008). In general, terrorism can curb trade and capital flows owing to heightened costs and risks.

Despite these contributions, there is no previous analysis that formally connects immigration policy in a developed country to the supply of terrorism from a developing country in a general equilibrium context. This is an important omission because an exclusive focus on the standard terms-of-trade effects of immigration policy may result in misleading policy recommendations.[1] The purpose of this paper is to fill this void by integrating immigration and counterterrorism policies in a strategic general equilibrium framework. We show that terrorism-related costs and/or benefits, along with terms-of-trade effects, are required when determining an optimal immigration policy. There is a previously unrecognized interplay between proactive counterterrorism measures in a developing country and labor quotas in a developed country. Our analysis can cast light on puzzles, such as why developing countries do not rid themselves of a resident transnational terrorist group when it poses a risk to their interests at home (Bapat, 2011). In particular, we identify circumstances where an unskilled labor-abundant developing country that hosts a terrorist group views skilled labor quotas abroad and its proactive counterterrorism measures as strategic substitutes. Thus, the developing country will reduce its efforts to eradicate the resident terrorists when quotas in the developed country favor skilled laborers. Our analysis addresses other puzzles, such as why a host country will, at times, employ proactive measures against its terrorists when more terrorism results. These enhanced measures are desirable when national income increases as laborers return to the productive sector, which seemed to be the case in Saudi Arabia after its antiterrorist campaign in reaction to a series of al-Qaida attacks in 2003–2005 on Western interests in the country.

There is a small emerging empirical literature that comes to vastly divergent conclusions about the relationship between immigration and transnational terrorism. In particular, studies that focused on known transnational terrorists showed that many were immigrants (e.g., Leiken and Brooke, 2006; Sageman, 2004), while a study that looked at immigrants in general did not find a significant relationship between immigration and terrorism (Dreher and Gassebner, 2010). Based on the World Values Survey on attitudes, Fischer (2011) found that immigrants are more

[1] In this context, terms-of-trade effect refers to the wages of skilled or unskilled immigrants that the developed nation has to pay. A fall in the immigrant's wage is a terms-of-trade gain for the developed nation.

likely than natives to support the application of terrorism. These mixed empirical results indicate that a theoretical analysis of the relationship between terrorism and immigration quotas imposed on the potential host country for terrorists may enlighten not only policymakers, but also empirical researchers.

In our theoretical framework, a transnational terrorist organization, based in a developing country, draws unskilled and skilled labor from the productive sector to attack targets at home and abroad. These two types of laborers join the terrorist group when their anticipated gain exceeds that in the productive sector; this decision is influenced by wages, radicalization, and counterterrorism-induced risks of failure. The ideal factor proportions differ between attacks at home and abroad. Hitting targets abroad in a developed country needs a greater proportion of skilled to unskilled labor, compared with hitting targets at home. This follows because attacks abroad require more complex logistics, language skills, reduced infrastructure, and traversing borders. Given that attacks abroad are more skill-intensive than home attacks, we analyze the effects of counterterrorism policy as well as immigration policy on the supply of terrorism and on the national income of the two countries. The host developing country applies proactive measures to annihilate the resident terrorists, while the targeted developed country relies on defensive measures to deflect attacks abroad. As such, there are elements of positive and negative international externalities. Our theoretical construct is descriptive of transnational terrorism in the post-Cold War era during which terrorist groups – e.g., al-Qaida, al-Qaida in the Arabian Peninsula, Lashkar-e-Taiba, and Jemaah Islamiyah – take refuge in developing countries (e.g., Afghanistan, Pakistan, Yemen, and Indonesia), while attacking host and developed countries' interests at home and abroad.

Given the diverse types of agents in our model (i.e., terrorist recruits, terrorist group, host developing country, and developed country) and the alternative policy instruments, the tradeoffs are subtle and complex. Among other results, we find that the developed country's defensive efforts deflect attacks back to the host country. When the terrorist organization's unskilled labor to skilled labor ratio for terrorist attacks directed at the developed nation exceeds a critical threshold, proactive measures against the resident terrorist group must necessarily reduce the terrorism damage to the developed country, and increase such damage to the developing country. If, however, the critical threshold is between the unskilled to skilled labor ratios for terrorism directed at the two nations, proactive effort must reduce terrorism in both. When the model is simplified with some reasonable parameters, we can identify the circumstances under which a developed country is eager or reticent to allow more skilled immigration from a host country to a terrorist group. Generally, the developed country is more eager when its immigrant pool exercises a relatively small influence on facilitating terrorism there. If, moreover, the developing country is abundant in unskilled labor, then the developed country gains by assuming a leadership role and chooses a smaller skilled labor quota. This strategic action induces the developing country to engage in more proactive counterterrorism measures against its resident terrorists. If, however, the host developing country is better endowed with skilled labor, then a larger skilled labor quota is the desired immigration policy. Our specific cases indicate how relative labor endowments in the host developing country can inform immigration policies in the developed country for the terrorist-haven developing country. Thus, how quotas should differ between skill-scarce Somalia and more skill-abundant Pakistan derives from our analysis.

2. The terrorist organization

Terrorism is the premeditated use or threat to use violence by individuals or subnational groups in order to obtain a political or social objective through intimidation of a large audience beyond that of the immediate victims (Enders and Sandler, 2012). Terrorism is transnational when an incident in one country involves perpetrators, victims, institutions, governments, or citizens of another country – e.g., 9/11 skyjackings. In recent years, transnational terrorist groups often locate their base in a developing country from which they can attack Western interests at home or abroad. Thus, Yemen, Lebanon, Somalia, Syria, Pakistan, Morocco, Algeria, Afghanistan, and other developing countries have been the base for many notorious terrorist groups (Hoffman, 2006; Mickolus, 2008).

The underlying game has two to three stages. In the first variant, the two governments choose their counterterrorism and immigration policies in the first stage, and the terrorist group decides its terrorist campaign in the second stage. In the second variant, the developed country decides its counterterrorism and immigration policies in the first stage, followed by the developing country picking its proactive countermeasures in the second stage. Finally, the terrorist group allocates its attacks at home and abroad in the third stage. We solve both games backwards beginning with terrorist group's decision in the final stage.

The terrorist organization derives benefit from attacking targets in both the host developing nation (say, *F*) and the developed nation (say, *H*). Along the lines of Mirza and Verdier (2008) and Bandyopadhyay et al. (2011b), the terrorist group's utility function is

$$V = \phi^H \left(p^H T^{*H} + p^F \tilde{T}^H \right) + \phi^F p^F T^F \ , \tag{1}$$

where ϕ^j is the terrorists' preference for attacking nation *j* (=*H*, *F*); p^j is the probability of success of a planned attack in nation *j*; T^{*H} is terrorism damage in *H*; and T^F is terrorism damage in nation *F*.[2] In Eq. (1), $\tilde{T}^H$ is *H*'s terrorism damage from an attack in *F*, so that developed countries' interests can be hit at home or abroad. This accords with reality – e.g., very few

[2] We assume that both economies produce the same single good, which serves as the numeraire in this model. Also, the developed nation is assumed to have superior technology, which contributes to its factor returns being strictly larger than the corresponding factor returns in the developing nation. This international factor price difference is possible (in equilibrium) because factor mobility is controlled by immigration quotas imposed by the developed nation.

attacks on US interests occur on US soil in recent years (Enders and Sandler, 2012). As in Bandyopadhyay et al. (2011b), we assume that terror damage for H in F is[3]

$$\tilde{T}^H = \delta^H T^F, \tag{2}$$

where δ^H is a parameter measuring the extent of H's foreign interests in F. The probability of success of a planned attack against H is lowered by its defensive actions, e, although at a diminishing rate, i.e.,

$$p^H = p^H(e),\ p^{H\prime}(e) < 0, \text{ and } p^{H\prime\prime}(e) > 0. \tag{3}$$

Terrorist attacks targeted in a developed nation from foreign bases require a higher degree of sophistication and are produced using a more skill-intensive technology. However, both types of terrorism require a mix of unskilled and skilled labor and exhibit constant returns to scale (CRS). The terrorism production functions in H and F are:[4]

$$T^H = T^H\left(L^{tH}, S^{tH}\right) \text{ and} \tag{4a}$$

$$T^F = T^F\left(L^{tF}, S^{tF}\right), \tag{4b}$$

respectively, where L^{tj} (S^{tj}) is unskilled (skilled) labor used by the terrorists to attack targets in nation j. We also assume without loss of generality that producing terrorism directed against H is more skill-intensive (i.e., $l^{tH} < l^{tF}$, where $l^{tj} = \dfrac{L^{tj}}{S^{tj}}$, $j = H, F$). A natural question is how is

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[3] We note a few things. First, we assume that F has no foreign interests in H, so that attacks in H are attacks against H alone. However, H has foreign interests in F that may be subject to terrorism attacks. In principle, attacks in F against H's or F's interests may be separate. Also, these attack technologies may be distinct, with different skill intensities. If this is the case, then there are three skill intensities, high skill intensity for attacks in H, intermediate skill intensity for attacks against H in F, and low skill intensity for attacks against F. Although this structure is reasonable, it is analytically intractable in this general equilibrium setup. The compromise that we use is that an attack against F has a collateral damage component for H, which is weighted by its foreign interests in F. For example, if the United States has extensive foreign interests in Pakistan, then US interests are more likely to be targeted in Pakistan than in the United States by Pakistan-based groups.

[4] These are standard constant returns to scale (CRS) production functions with positive marginal products T_i^j, negative second-order partials ($T_{ii}^j < 0$), and positive cross partials ($T_{ix}^j > 0$, $i \neq x$). Unless specified otherwise, we will use the standard subscript convention for partial derivatives.

the terrorism that is produced by a developing nation's resources delivered in the developed nation? Although cyber-attacks can be delivered remotely, more traditional terrorist attacks necessitate some physical presence in the target nation. This may require participation by immigrants and/or tourists in the developed nation. For tourist perpetrators, someone may acquire a temporary visa, visit the country, and carry out the attack without any local help, so that immigrants are not involved. If, in contrast, the terrorist group's attack is facilitated by an existing immigrant pool, then the effective terrorism (i.e., T^{*H}) in the developed nation depends on a sympathetic pool of skilled and unskilled immigrants. A simple way to model this is as follows:

$$T^{*H} = A(\alpha,\rho)T^{H}\left(L^{tH},S^{tH}\right),\ A_{\alpha} = \frac{\partial A}{\partial \alpha} \geq 0,\ A_{\rho} = \frac{\partial A}{\partial \rho} \geq 0, \text{ and } A > 0, \tag{5}$$

where α and ρ are unskilled and skilled immigrant pools, respectively, in the developed nation. The partials of A are non-negative because the presence of more skilled or unskilled immigrants potentially improves the delivery capability for terrorism in *H*. Using Eqs. (1)-(5), we express the terrorist group's expected utility as:

$$V = \gamma^{H}T^{H} + \gamma^{F}T^{F},\ \gamma^{H} = \phi^{H}A(\alpha,\rho)\,p^{H}(e), \text{ and } \gamma^{F} = p^{F}\left(\phi^{H}\delta^{H} + \phi^{F}\right). \tag{6}$$

Let the unskilled (skilled) labor supply be inelastically given for *F* at $\overline{L}^{F}$ ($\overline{S}^{F}$). We assume that *H*'s skilled and unskilled wages are sufficiently large relative to their counterparts in *F*, such that given an option to emigrate to *H*, a labor unit (skilled or unskilled) will choose to do so. Thus, the immigration levels, α and ρ, equal the immigration quotas for unskilled and skilled immigration chosen by *H*. The unskilled and skilled labor forces in *F*, net of emigrants, are $\overline{L}^{F} - \alpha$, and $\overline{S}^{F} - \rho$, respectively.

Each unit of unskilled labor has a certain level of radical beliefs, parameterized by θ^{u} , which means that if they succeed in working for the terrorist organization they get a utility equivalent to θ^u units of the numeraire good. Even though units of unskilled labor are homogeneous as inputs in terrorism or in producing goods, they differ in their radical beliefs. The distribution of such beliefs is given by the following probability density and cumulative distribution functions, respectively:

$$\theta^u \sim x\left(\theta^u\right),\ X\left(\bar{\theta}\right) = \int_{-\infty}^{\bar{\theta}} x\left(\theta^u\right) d\theta^u . \tag{7}$$

All unskilled labor units in *F* earn w^{uF} from the productive sector, which equals the marginal product of unskilled labor in producing goods. When they volunteer for the terrorist organization, they know that there is a chance that they may not be able to serve effectively. For example, they may be killed or incarcerated before being able to take part in an attack. They are assumed to succeed in providing their services to the terrorist organization with a probability β, which is a declining function of proactive effort *m* undertaken by the host government. Assuming diminishing returns in the use of such offensive action, we have

$$\beta = \beta\left(m\right),\ \beta'\left(m\right) < 0, \text{ and } \beta''\left(m\right) > 0 . \tag{8}$$

An unskilled labor unit stays in the productive sector if its wage exceeds it expected marginal return from being a terrorist:

$$\theta^u \beta\left(m\right) < w^{uF} \Rightarrow \theta^u < \frac{w^{uF}}{\beta\left(m\right)} . \tag{9}$$

In keeping with the terrorist literature, we assume that the terrorist organization does not pay a wage to its volunteers, who join in order to contribute to the cause (e.g., Barrett, 2011; Sageman, 2004). Volunteers' underlying motive is often to rectify perceived grievances. This is true for unskilled and skilled laborers who join terrorist groups. Eq. (9) describes a margin that is similar to ones used in models of equilibrium migration, where a migrant equates the expected return from migrating to that of the *status quo*.[5] Consider the decision faced by an illegal immigrant (e.g., Ethier, 1986). If, say, someone stays home in Mexico, s/he earns a Mexican wage with certainty. When, however, s/he attempts to migrate illegally to the United States, s/he may be caught and returned home after some penalties are imposed; or s/he may cross successfully and earn a higher wage. The higher the probability of detection at the border and the greater the penalty, the less likely is the individual to migrate. The analogy here is that higher proactive effort reduces the anticipated probability of success for a laborer contemplating a move to the terrorist sector. The associated deterrence effect of proaction provides a more favorable allocation of labor for the productive sector, thereby bolstering national income. Thus, the margin, described in Eq. (9), is critical and endogenous to policy choices.

Based on Eqs. (7) and (9), the fraction of unskilled labor force that stays in the productive sector is $X\left(\frac{w^{uF}}{\beta(m)}\right)$. Thus, $(1-X)\left(\bar{L}^F-\alpha\right)$ labor units volunteer for the terrorist organization, of which a fraction β succeeds in providing their services in terrorist attacks. Thus, the unskilled labor pool L^T for the terrorist organization is

$$L^T=\beta(m)\left[1-X\left(\frac{w^{uF}}{\beta(m)}\right)\right]\left(\bar{L}^F-\alpha\right)=L^T\left(\alpha,w^{uF},m,\bar{L}^F\right). \tag{10}$$

Similarly, let θ^s, $g\left(\theta^s\right)$, and $G\left(\theta^s\right)$, be the radicalization parameter, the probability density function, and the cumulative distribution function for skilled labor, respectively. Therefore, the skilled-labor pool for the terrorist organization is

[5] The legal immigration quotas discussed in this paper are not based on an internal equilibrium relationship. They arise from a corner solution where the migrant's *ex ante* return from emigrating exceeds the return that can be obtained from staying back. However, because immigration is controlled by quotas, this wedge in the returns is sustained in equilibrium.

$$S^T = \beta(m)\left[1 - G\left(\frac{w^{sF}}{\beta(m)}\right)\right]\left(\bar{S}^F - \rho\right) = S^T\left(\rho, w^{sF}, m, \bar{S}^F\right). \tag{11}$$

The terrorist organization maximizes its utility [Eq. (6)], given its supply of skilled and unskilled labor [Eqs. (10)-(11)]. The constrained optimization problem for the terrorist organization is

$$Max\, V = \gamma^H T^H\left(L^{tH}, S^{tH}\right) + \gamma^F T^F\left(L^{tF}, S^{tF}\right) + \lambda_L\left[L^T\left(\alpha, w^{uF}, m, \bar{L}^F\right) - L^{tH} - L^{tF}\right]$$

$$+\lambda_S\left[S^T\left(\rho, w^{sF}, m, \bar{S}^F\right) - S^{tH} - S^{tF}\right], \tag{12}$$

where λ_L and λ_S are the Lagrangian multipliers associated with the unskilled and skilled labor constraints, respectively. The first-order conditions (FOCs) yield the unskilled and skilled labor used by the terrorist organization in attacks at home and abroad and also the shadow prices (i.e., the optimal values of λ_L and λ_S) of these resources for the terrorist organization. Denoting the vector of parameters faced by the terrorist organization by μ, we have

$L^{tj} = L^{tj}\left(\mu\right),\ S^{tj} = S^{tj}\left(\mu\right),\ j = H, F;\ \lambda_i = \lambda_i\left(\mu\right),\ i = L, S$, where

$$\mu = \mu\left(\gamma^H, \gamma^F, \alpha, \rho, w^{uF}, w^{sF}, m, \bar{L}^F, \bar{S}^F\right). \tag{13}$$

Substituting Eq. (13) into (12), we have the envelope function V^*:

$$V^* = V^*\left(\gamma^H, \gamma^F; \alpha, \rho, w^{uF}, w^{sF}, m, \bar{L}^F, \bar{S}^F\right). \tag{14}$$

Using the envelope theorem, we obtain the supply of terrorism aimed at *H*'s and *F*'s interests:

$T^H = V_1^*\left(\gamma^H, \gamma^F; \alpha, \rho, w^{uF}, w^{sF}, m, \bar{L}^F, \bar{S}^F\right)$ and (15a)

$$T^F = V_2^*\left(\gamma^H, \gamma^F; \alpha, \rho, w^{uF}, w^{sF}, m, \bar{L}^F, \bar{S}^F\right). \tag{15b}$$

It is easy to show that V^* is convex and homogeneous of degree one in γ^H and γ^F.[6]

Proposition 1: A rise in *H*'s counterterrorism defense effort (e) reduces terrorism against it while raising the terrorism directed at *F*.

Proof

Based on the FOCs of the optimization problem, it is easy to show that[7]

$$\frac{\partial T^H}{\partial \gamma^H} > 0 \text{ which implies } V_{11}^* > 0 . \tag{16}$$

Given that $\gamma^H = \phi^H Ap^H(e)$, we have

$$\frac{\partial T^H}{\partial e} = \left(\frac{\partial T^H}{\partial \gamma^H}\right)\phi^H Ap^{H\prime} < 0 \text{ which implies } \frac{\partial T^{*H}}{\partial e} = A\frac{\partial T^H}{\partial e} < 0 . \tag{17}$$

Because V^* is homogeneous to degree one, the first-order partial V_1^* is homogeneous of degree zero in γ^H and γ^F. Using Euler's theorem and Eq. (16), we get

$$0 = V_{11}^*\gamma^H + V_{12}^*\gamma^F \text{ which implies } V_{12}^* = -V_{11}^*\frac{\gamma^H}{\gamma^F} < 0 \text{ and } V_{12}^* = V_{21}^* = \frac{\partial T^F}{\partial \gamma^H} < 0 . \tag{18a}$$

Eq. (18a) implies that

$$\frac{\partial T^F}{\partial e} = \left(\frac{\partial T^F}{\partial \gamma^H}\right)\phi^H Ap^{H\prime} > 0 . \tag{18b}$$

Eqs. (17) and (18b) establish the proposition. ■

Proposition 1 confirms the terrorism reduction versus terrorism deflection consequence of defensive measures that dates back to Lapan and Sandler (1988) (see also Bandyopadhyay and

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[6] V^* is similar to the revenue function used in dual models of trade (see Dixit and Norman, 1980). The proofs of convexity and homogeneity are standard and are available from the authors on request.
[7] Proof is in the Appendix.

Sandler, 2011; Bier et al., 2007; Intriligator, 2010; Sandler and Siqueira, 2006). This proposition shows that a general equilibrium framework preserves this result. *H*'s defensive actions reduce the likelihood of successful terrorist incidents in *H*, thereby deflecting them back to the host country *F*. Although *H*'s homeland is now safer for its actions, its interest can still be hit abroad – e.g., attacks against US people or property in Pakistan. Thus, country *H* must weigh these losses against the gains from reduced attacks on its homeland when coming up with an optimal defense policy (see Section 4). Homeland attacks are typically more damaging than foreign attacks on its interests. Recent empirical studies showed a marked shift in terrorist attacks from developed to developing countries following 9/11-motivated security increases (Enders and Sandler, 2006, 2012). Developed countries' interests were more frequently targeted abroad.

We now turn our attention to the effects of proactive policies in the developing country hosting the terrorists. The effect of a rise in proactive measures m on T^H is

$$\frac{\partial T^H}{\partial m} = \frac{\partial V_1^*}{\partial m} = \frac{\partial V_m^*}{\partial \gamma^H}. \tag{19}$$

Using the envelope property of V^* and Eq. (12), we obtain

$$V_m^* = \lambda_L \frac{\partial L^T}{\partial m} + \lambda_S \frac{\partial S^T}{\partial m}. \tag{20}$$

Differentiating Eqs. (10) and (11), respectively, yields

$$\frac{\partial L^T}{\partial m} = L_m^T = \left(\bar{L}^F - \alpha\right)\beta'(m)\left(1 - X + \frac{xw^{uF}}{\beta}\right) < 0 \text{ and}$$

$$\frac{\partial S^T}{\partial m} = S_m^T = \left(\bar{S}^F - \rho\right)\beta'(m)\left(1 - G + \frac{gw^{sF}}{\beta}\right) < 0. \tag{21}$$

Eq. (21) shows that proactive effort must reduce both the unskilled and the skilled labor resources of the terrorist group for two reasons. First, a rise in proactive effort depletes the group's labor resources for a given labor allocation between the productive and terrorist sectors. Second, as proaction rises, the *ex ante* return from joining the terrorist organization must fall [Eq. (9) above], so that fewer laborers become terrorists. This effect complements the direct effect of proaction, leading to fewer terrorists.

Substituting Eq. (21) into (20) and then differentiating, we obtain

$$\frac{\partial V_m^*}{\partial \gamma^H} = L_m^T\left(\frac{\partial \lambda_L}{\partial \gamma^H}\right) + S_m^T\left(\frac{\partial \lambda_S}{\partial \gamma^H}\right). \tag{22}$$

In the Appendix, we show that

$$\frac{\partial \lambda_L}{\partial \gamma^H} = \gamma^F T_{11}^F\left(\frac{\partial l^{tF}}{\partial \gamma^H}\right) < 0 \text{ and } \frac{\partial \lambda_S}{\partial \gamma^H} = \gamma^F T_{21}^F\left(\frac{\partial l^{tF}}{\partial \gamma^H}\right) > 0. \tag{23}$$

From Eq. (12), γ^H is the marginal return of T^H for the terrorist organization. A rise in this return makes the terrorists produce relatively more of this type of terrorism, so that T^H expands, thus requiring more skilled relative to unskilled labor. To supply these additional resources, terrorists must contract unskill-intensive T^F, which releases relatively more unskilled labor. The result is an excess supply of unskilled labor and an excess demand of skilled labor, which leads to a fall in the shadow price of unskilled labor (i.e., λ_L) and a rise in the shadow price of skilled labor (i.e., λ_S).

Applying Eqs. (19)-(23), we find that the sign of $\dfrac{\partial T^H}{\partial m}$ is ambiguous. Proposition 2 throws light on this ambiguity.

Proposition 2: A small rise in *F*'s proactive effort will reduce terrorism in *H* if and only if l^{tF} exceeds a critical level l^0. This critical level depends on the initial proactive level, *H*'s immigration quotas, *F*'s factor endowments and factor prices, and the probability density functions x and g. Terrorism in F will fall if and only if l^{tH} is less than the critical value l^0. It is not, however, possible for terrorism to rise in both nations.

Proof

Given Eqs. (19)-(23), we show in the Appendix that

$$\frac{\partial T^H}{\partial m} < 0 \text{ implies that } \frac{\partial T^{*H}}{\partial m} = A\frac{\partial T^H}{\partial m} < 0 \text{ if and only if } l^{tF} > l^0,$$

where $l^0 = \dfrac{L_m^T}{S_m^T} = \left(\dfrac{\bar{L}^F - \alpha}{\bar{S}^F - \rho}\right)\left[\dfrac{(1-X)\beta + xw^{uF}}{(1-G)\beta + gw^{sF}}\right] = l^0\left(\alpha, \rho, w^{uF}, w^{sF}, m, \bar{L}^F, \bar{S}^F\right).$ (24)

Analogously, we can show that

$$\frac{\partial T^F}{\partial m} < 0 \text{ if and only if } l^{tH} < l^0. \tag{25}$$

From the terrorist organization's FOCs, terrorism labor intensities are entirely determined by γ^H and γ^F. Different possibilities arise depending on these two parameters. We can rule out the possibility that both $\dfrac{\partial T^{*H}}{\partial m}$ and $\dfrac{\partial T^F}{\partial m}$ are positive, because it requires that $l^{tF} < l^0$ and $l^{tH} > l^0$ in violation of the assumed factor intensity ranking $l^{tH} < l^{tF}$. Based on Eqs. (24)-(25), three cases are possible:

Case 1: $\dfrac{\partial T^{*H}}{\partial m} > 0$, $\dfrac{\partial T^F}{\partial m} < 0$, if $l^{tF} < l^0$, $l^{tH} < l^0$.

Case 2: $\dfrac{\partial T^{*H}}{\partial m} < 0$, $\dfrac{\partial T^F}{\partial m} > 0$, if $l^{tF} > l^0$, $l^{tH} > l^0$.

Case 3: $\dfrac{\partial T^{*H}}{\partial m} < 0$, $\dfrac{\partial T^F}{\partial m} < 0$, if $l^{tF} > l^0 > l^{tH}$.

Cases 1 through 3 establish the proposition. ■

From Eq. (21), we know that a rise in proactive effort reduces both the unskilled and skilled labor resources of the terrorist group; however, this does not imply that terrorism must fall in both nations. To see why this is the case, consider a situation where S_m^T tends to zero, while L_m^T is nonzero and finite, which ensures that l^0 is arbitrarily large and must exceed both l^{tH} and l^{tF} (i.e., Case 1). Proactive measures reduce the terrorist organization's unskilled resources, but has a negligible effect on its skilled resources (because $S_m^T \to 0$). The relative scarcity of unskilled resources makes the terrorist group scale back T^F, which releases some skilled labor in the process. If this excess supply of skilled labor is exactly offset by the reduction in skilled resources due to proactive effort, then there is no unemployment of skilled resources. However, given that S_m^T is arbitrarily small, this excess supply cannot be neutralized. The only way for these resources to be fully utilized is to scale up the production of T^H (and hence the supply of T^{*H}). The opposite redistribution of labor happens in Case 2. In Case 3, as unskilled resources decline, the terrorist group scales back T^F, releasing some skilled labor. This excess supply of skilled labor is more than offset by the decline in skilled labor due to proactive measures (i.e., S_m^T is sufficiently large). The result is a shortage of skilled labor, which is resolved by scaling down T^H. Thus, the terrorist group's ability to circumvent *F*'s countermeasures through a change in the mix of terrorism is more limited, so that terrorism directed at both *F* and *H* declines.

2.1. An example with specific functional forms

Let us assume that the probability density functions x and g are independently, identically, and uniformly distributed with supports zero and $\overline{\theta}$, such that

$$x(\theta)=\frac{1}{\overline{\theta}},\ X(\theta)=\frac{\theta}{\overline{\theta}},\ g(\theta)=\frac{1}{\overline{\theta}},\text{ and } G(\theta)=\frac{\theta}{\overline{\theta}}. \tag{26}$$

Substituting this information into Eq. (24) gives

$$l^0=\frac{\overline{L}^F-\alpha}{\overline{S}^F-\rho}. \tag{27}$$

For the terrorist organization to produce both T^H and T^F, their unskilled to skilled endowment ratio must lie between the factor intensities of producing the two types of terror: i.e.,

$$l^{tH}<\frac{L^T}{S^T}<l^{tF}. \tag{28}$$

Substituting for L^T and S^T based on Eqs. (10)-(11) and (26), we have

$$l^{tH}<\psi l^0<l^{tF}\text{, where } \psi=\frac{\beta\overline{\theta}-w^{uF}}{\beta\overline{\theta}-w^{sF}}>1\text{, because } \beta\overline{\theta}>w^{sF}>w^{uF}. \tag{29}$$

Eq. (29) immediately rules out Case 1 where $l^{tF}<l^0$. Case 2 requires that $l^{tF}>l^{tH}>l^0$, which is satisfied for l^{tF}, but not necessarily for l^{tH}. Because ψ exceeds unity, it is possible that

$$l^0<l^{tH}<\psi l^0. \tag{30}$$

If Eqs. (29) and (30) are simultaneously satisfied, we have Case 2. To obtain an explicit range of parameters for this case, we use the following Cobb-Douglas production functions:

$$T^F=\left(L^{tF}\right)^{\sigma}\left(S^{tF}\right)^{1-\sigma},\ T^H=\left(L^{tH}\right)^{\tau}\left(S^{tH}\right)^{1-\tau}, \tag{31}$$

where $\sigma>\tau$ to ensure that $l^{tF}>l^{tH}$. For simplicity, we assume that $A\equiv1$, $p^F=1$, and $\delta^H=0$.[8] The range of parameters that satisfies Eqs. (29) and (30) is

$$\chi<\frac{\phi^H p^H}{\phi^F}<\psi^{\sigma-\tau}\chi\text{, where } \chi=\left(\frac{\sigma}{\tau}\right)^{\sigma}\left(\frac{1-\sigma}{1-\tau}\right)^{1-\sigma}\left(l^0\right)^{\sigma-\tau}. \tag{32}$$

Since ψ exceeds unity and σ exceeds τ, $\psi^{\sigma-\tau}$ is larger than unity. Also, from Eq. (29), the

[8] This set of assumptions is not crucial, but allows the reader to focus on a parameter range that is easier to visualize.

larger is the skilled wage and the smaller is the unskilled wage in *F*, the larger is ψ. This then means that Eq. (32) may permit a substantial range for $\frac{\phi^H p^H}{\phi^F}$. Turning to Case 3, we find the permissible range that satisfies Eq. (29) to be

$$l^{tH} < l^0 < \psi l^0 < l^{tF}. \tag{33}$$

Based on the Cobb-Douglas forms from above, this range is

$$\xi < \frac{\phi^H p^H}{\phi^F} < \chi, \text{ where } \xi = \psi^{\sigma-\tau}\left(\frac{\sigma}{\tau}\right)^{\tau}\left(\frac{1-\sigma}{1-\tau}\right)^{1-\tau}\left(l^0\right)^{\sigma-\tau}. \tag{34}$$

The smaller is ψ, and the larger is σ relative to τ, the larger is the range identified by Eq. (34). If ψ is close to unity, Case 3 is more likely than Case 2, because the range represented by Eq. (32) is small, while that represented by Eq. (34) is correspondingly large. The opposite happens if ψ is large.

Proposition 3: A rise in the terrorist group's target preference for *H* raises T^{*H} and lowers T^F. An increase in the unskilled immigration quota α raises T^{*H} and reduces T^F. However, a rise in the skilled immigration quota ρ may or may not raise T^{*H} and T^F. If skilled immigration has a sufficiently small marginal impact on the delivery of terrorism in *H* (i.e., if A_ρ is small), a rise in the skilled immigration quota reduces T^{*H} and increases T^F. A sufficient condition for this to occur is for skilled immigrants to have no marginal effect in facilitating the delivery of terror in the developed country (i.e., $A_\rho = 0$).

Proof

The proof is in the Appendix. ■

A greater target preference for *H* makes the terrorists devote more of their resources to attacking *H*, which leaves fewer resources for attacks on *F*. Thus, when terrorists fixate on *H*, T^{*H} rises and T^{F} falls. The effect of immigration quotas is more complicated. When α increases, it raises *A* and makes it easier to deliver terrorism in *H*. This creates a greater incentive for the terrorist group to perpetrate terrorism in *H*. The net supply of unskilled labor in *F* (i.e., $\overline{L}^{F} - \alpha$) is also reduced, which decreases the relative supply of unskilled labor for the terrorist group [see Eq. (10)]. This then results in a rise in the supply of skill-intensive terrorism T^{*H} and a reduction in the supply of unskill-intensive terrorism T^{F}. Both the terrorism-delivery facilitation and the factor-intensity effect suggest that a rise in unskilled immigration must augment terrorism in *H* and reduce it in *F*. When, however, we consider the skilled immigration quota, we encounter two opposing effects. On the one hand, a greater pool of skilled immigrants facilitates terrorism delivery in *H*, which tends to raise T^{*H} and reduce T^{F}. On the other hand, a reduction in the relative availability of skilled laborers due to emigration in *F* reduces S^{T} [see Eq. (11)], which limits skill-intensive T^{*H} and augments unskill-intensive T^{F}. Thus, the net effect of an increase in the skilled immigration quota on both T^{*H} and T^{F} is ambiguous. However, as shown in the Appendix, if the effect of skilled immigration in facilitating terror delivery (A_{ρ}) is sufficiently small, then the resource reallocation effects in *F* dominate, and terrorism must fall in *H* and rise in *F*. Indeed, this must occur if $A_{\rho} = 0$.[9]

3. The host (developing) government

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[9] If A_{ρ} is positive, then it has to be below a strictly positive threshold identified in the Appendix, for terrorism to fall in *H* and also to rise in *F*. This threshold depends on terrorism production functions and the terrorist organization's resource endowments in a complicated way. Although the level of *A* affects this threshold, *A*'s partials do not. Thus, for any set of production side parameters in *F*, one can identify functions $A(\alpha, \rho)$, such that A_{ρ} is below this threshold.

In stage 2, *F*'s government decides its proactive measures against the resident terrorist group. We assume that *F* produces a single good, Q^F, using the following CRS production function:

$$Q^F = \eta^F \left(L^F, S^F\right), \tag{35}$$

where L^F and S^F are unskilled and skilled labor used in the production of this good. Recalling that *X* is the share of unskilled labor engaged in productive activity in *F*, we have[10]

$$L^F = \left(\overline{L}^F - \alpha\right) X, \tag{36a}$$

and, similarly,

$$S^F = \left(\overline{S}^F - \rho\right) G. \tag{36b}$$

F's national income, including the earnings of its emigrants and net of terrorism damage, T^F, and counterterrorism spending, is

$$Y^F = \eta^F \left[\left(\overline{L}^F - \alpha\right) X, \left(\overline{S}^F - \rho\right) G\right] + w^{uH}\alpha + w^{sH}\rho - T^F - m, \tag{37}$$

where w^{uH} and w^{sH} are the unskilled and skilled wage rates, respectively, in *H*. In Eq. (37), the price of proactive measures is normalized to be 1.

We assume that *H*'s CRS production function is

$$Q^H = \eta^H \left(L^H, S^H\right). \tag{38}$$

Accounting for the immigrants in *H*'s labor pool, we obtain

$$L^H = \overline{L}^H + \alpha \text{ and } S^H = \overline{S}^H + \rho. \tag{39}$$

The wage rates in the two nations reflect their respective marginal products. Suppressing the factor endowments in the functional forms, we have

$$w^{uH} = \eta_1^H \left(i^H, 1\right) \equiv w^{uH}\left(i^H\right),\ w^{sH} = \eta_2^H \left(i^H, 1\right) \equiv w^{sH}\left(i^H\right),\ w^{uF} = \eta_1^F \left(i^F, 1\right) \equiv w^{uF}\left(i^F\right), \text{ and}$$

[10] We assume that emigration is neutral in terms of affecting the probability distributions of radicalization in *F*'s population of skilled and unskilled labor. Thus, a reduction of the unskilled (skilled) labor pool through emigration does not affect the fraction *X (G)*.

$w^{sF} = \eta_2^F\left(i^F,1\right) \equiv w^{sF}\left(i^F\right)$, where

$i^H = \dfrac{\overline{L}^H + \alpha}{\overline{S}^H + \rho} = i^H\left(\alpha, \rho\right)$ and

$$i^F = \frac{\left(\overline{L}^F - \alpha\right) X\left(\dfrac{w^{uF}}{\beta(m)}\right)}{\left(\overline{S}^F - \rho\right) G\left(\dfrac{w^{sF}}{\beta(m)}\right)} = i^F\left(m, \alpha, \rho\right). \tag{40}$$

Eq. (40) reflects that homogeneity of degree one of the production functions in both nations makes the marginal products and, hence, the factor returns determined entirely by the unskilled labor intensity $i^j\left(j = H, F\right)$. In equilibrium, the unskilled labor intensities reflect the relative abundance of the unskilled labor available in the two nations for productive activities. Clearly, immigration affects this abundance by making more labor available to *H* at the expense of country *F*. For example, a rise in unskilled immigration raises the unskilled labor intensity in *H* and reduces it in *F*. This then reduces the marginal product of unskilled labor and its wage in *H*. In contrast, a rise in *H*'s unskilled labor intensity raises its marginal product of skilled labor and, hence, its skilled wage. For the same reasons, emigration from *F* must move its wages in precisely the opposite direction. Finally, proactive effort can affect the wages in *F* but not in *H*. Wages in *H* are unaffected because i^H is entirely determined by the immigration quotas and *H*'s existing labor stocks, so that proactive measures have no direct effect on it. In contrast, increased proactive measures deplete both types of labor in *F* [see Eq. (21)], possibly changing i^F and wages in *F*. When, however, the proactive response reduces the availability of skilled and unskilled labor in the same proportion, their relative abundance in *F* is unchanged, so that *F*'s wages are unaffected. This issue is addressed below.

Country *F* takes *H*'s immigration quotas (α and ρ) as given when choosing its national-income-maximizing proactive effort.[11] In light of Eq. (40) this fixes i^H and, hence, the skilled and unskilled wages in *H* in terms of *F*'s decision making. Differentiating Eq. (37), we obtain the FOC for *F*'s income-maximizing proactive effort:

$$\frac{\partial Y^F}{\partial m} = Y_m^F\left(m;e,\alpha,\rho\right) = \eta_1^F\left(\overline{L}^F - \alpha\right)\left(\frac{\partial X}{\partial m}\right) + \eta_2^F\left(\overline{S}^F - \rho\right)\left(\frac{\partial G}{\partial m}\right) - \frac{\partial T^F}{\partial m} - 1 = 0. \tag{41a}$$

Eq. (41a) implicitly defines *F*'s Nash reaction function as

$$m = m\left(e,\alpha,\rho\right). \tag{41b}$$

Differentiating the distribution function X with respect to proactive measures yields

$$\frac{\partial X}{\partial m} = \frac{x}{\beta^2}\left[\beta\left(\frac{\partial w^{uF}}{\partial i^F}\right)\left(\frac{\partial i^F}{\partial m}\right) - w^{uF}\beta'\right]. \tag{42}$$

In the Appendix, we show that

$$\frac{\partial i^F}{\partial m} \geq 0 \text{ if and only if } \varepsilon^X \geq \varepsilon^G,\ \ \varepsilon^X = \frac{d\ln X\left(\theta^u\right)}{d\ln\theta^u}, \varepsilon^G = \frac{d\ln G\left(\theta^s\right)}{d\ln\theta^s}, \tag{43}$$

where ε^X and ε^G are the elasticity of the distribution functions *X* and *G* with respect to the radicalization parameters θ^u and θ^s, respectively. The intuition behind Eq. (43) is straightforward. Proactive measures reduce the returns from joining the terrorist group for both skilled and unskilled volunteers [see Eqs. (9)-(11)]. Thus, the proportions of skilled and unskilled labor (i.e., G and X, respectively) that join the productive sector must both rise. If ε^X exceeds ε^G, the proportion X rises faster than the proportion G. In the light of Eq. (40) this suggests that i^F must rise. If the elasticities are equal (as in the specific functional forms for the probability distributions we use below), X and G rise at the same rate, and i^F does not change. Consequently, wages in *F* do not change. For simplicity, we henceforth assume that the

[11] This is consistent with two scenarios: *H* and *F* simultaneously choosing their income-maximizing policies; and *H* choosing its policy at an earlier stage compared to *F*. We analyze both scenarios.

probability density functions are of the form described in Eq. (26) above.[12] Using Eq. (26) and the definitions of ε^X and ε^G from (43), we get

$$\varepsilon^X = \varepsilon^G = 1 \text{ which implies } \frac{\partial i^F}{\partial m} = 0. \tag{44}$$

Substituting Eq. (44) into (42), we have

$$\frac{\partial X}{\partial m} = -\frac{\beta' w^{uF} x}{\beta^2} > 0. \tag{45a}$$

Similarly, we get

$$\frac{\partial G}{\partial m} = -\frac{\beta' w^{sF} g}{\beta^2} > 0. \tag{45b}$$

Proposition 4: Nation *F* chooses its proactive response to reduce its terrorism damages and also to benefit from bringing more of its resources from the terrorist sector into the productive sector. Even when proactive effort raises terrorism in *F*, the government may still choose to employ it.

Proof

Given Eq. (40), we can write Eq. (41a) as

$$w^{uF}\left(\bar{L}^F - \alpha\right)\left(\frac{\partial X}{\partial m}\right) + w^{sF}\left(\bar{S}^F - \rho\right)\left(\frac{\partial G}{\partial m}\right) - \frac{\partial T^F}{\partial m} = 1. \tag{46}$$

The proposition is established from Eq. (46) in light of Eqs. (45a)-(45b) and Proposition 2. ■

A positive $\frac{\partial X}{\partial m}$ in Eq. (45a) reflects the rise in the proportion of productive unskilled labor in *F* as greater proactive measures dissuade some potential terrorist volunteers. The

[12] From Eq. (44), this assumption allows us to focus on the simplest of the three possible cases in Eq. (43), where $\varepsilon^X = \varepsilon^G$. Most of the tradeoffs faced by the governments then come out cleanly. While it is possible to analyze the other two cases (i.e., $\varepsilon^X > \varepsilon^G$, and $\varepsilon^X < \varepsilon^G$), we choose not to do so in this paper for clarity of exposition and space considerations.

ensuing rise in output in F is captured by the first term of Eq. (46). Similarly, the second term in (46) reflects the corresponding rise in output from the return of skilled labor to productive activities. Based on Proposition 2, proactive effort may, however, increase T^F. Even then, national income may increase as long as the first two terms in Eq. (46) dominate (starting from $m = 0$). This is a general equilibrium result, novel to this literature. This finding indicates that the deterrence effect, which keeps more of the population away from terrorism, may be an important determinant of national-income-maximizing counterterrorism policy. It can rationalize the apparently counterintuitive behavior of governments that continue to engage in proactive counterterrorism policies, despite a rise in terrorist attacks due to such policies. Following al-Qaida suicide terrorist attacks on Western residential compounds and other attacks on Saudi oil infrastructure during 2003–2005, Saudi Arabia took a firm proactive stance against terrorism to preserve its income, even though the stance initially resulted in more terrorist attacks (Economist.com, 2008). Such attacks are known as backlash stemming from counterterrorism-induced grievances (Bloom, 2005; Rosendorff and Sandler, 2004; Siqueira and Sandler, 2007). A similar scenario characterized Pakistan following 9/11 and Iraq following the 2007 US military surge.

4. The developed country's government policy choices

Based on Eqs. (38)-(40), H's national income, net of immigrant earnings, terrorism damages, and counterterrorism expenditure, is[13]

$$Y^H = \eta^H\left[\bar{L}^H + \alpha, \bar{S}^H + \rho\right] - w^{uH}\alpha - w^{sH}\rho - p^H(e)T^{*H} - \tilde{T}^H - e, \tag{47a}$$

where the price of defensive effort is normalized at 1. Using Eqs. (2) and (5), we have

[13] Omitting immigrant incomes from the host nation's objective function is a debatable issue. However, for lack of an unambiguously superior alternative, this approach is standard and is used widely in the trade-immigration literature (e.g., see Ethier, 1986).

$$Y^H = \eta^H\left[\bar{L}^H + \alpha, \bar{S}^H + \rho\right] - w^{uH}\alpha - w^{sH}\rho - p^H(e)A(\alpha,\rho)T^H - \delta^H T^F - e\,. \tag{47b}$$

We consider two scenarios – Nash and Stackelberg – for *H*'s choice of its national-income-maximizing combination of defense and immigration policies.

4.1. Nash equilibrium

We have already described the policy choice rule for *F* where it assumes *H*'s policies to be given when choosing its income-maximizing proactive level. Under the Nash assumption, *H* takes *m* as given while choosing its income-maximizing policy variables. The resulting equilibrium is a Nash policy equilibrium. Using Eq. (40), we differentiate Eq. (47b) to obtain *H*'s FOCs for defense and immigration quota choices as:

$$\left(\frac{\partial Y^H}{\partial e}\right)_{|m} = -AT^H p^{H\prime} - Ap^H\left(\frac{\partial T^H}{\partial e}\right) - \delta^H\left(\frac{\partial T^F}{\partial e}\right) - 1 = 0\,, \tag{48a}$$

$$\left(\frac{\partial Y^H}{\partial \alpha}\right)_{|m} = \left(i^H\rho - \alpha\right)\frac{\partial w^{uH}}{\partial \alpha} - p^H\left[A_\alpha T^H + A\left(\frac{\partial T^H}{\partial \alpha}\right)\right] - \delta^H\left(\frac{\partial T^F}{\partial \alpha}\right) = 0\,, \text{ and} \tag{48b}$$

$$\left(\frac{\partial Y^H}{\partial \rho}\right)_{|m} = \left(i^H\rho - \alpha\right)\frac{\partial w^{uH}}{\partial \rho} - p^H\left[A_\rho T^H + A\left(\frac{\partial T^H}{\partial \rho}\right)\right] - \delta^H\left(\frac{\partial T^F}{\partial \rho}\right) = 0\,. \tag{48c}$$

For given levels of the immigration quotas, we see that i^H, w^{uH}, and w^{sH} are all fixed – see Eq. (40). Thus, defense cannot affect the first three terms on the right-hand side of Eq. (47b). Its effect on *H*'s national income is through the expected terrorism damages in *H* and *F* and from its budgetary cost. Using Proposition 1, we know that defense reduces terrorism in *H* and raises terrorism in *F* through transference of attacks. Thus, Eq. (48a) suggests that the benefit from terrorism reduction at home has to be balanced against the damages on *H*'s foreign interests in *F*, as well as against the direct budgetary cost of defense. Turning to Eq. (48b), we see that if the unskilled labor intensity of the immigrant pool (i.e., α / ρ) is larger than the corresponding intensity in production i^H , then unskilled immigration confers terms-of-trade benefits that must be weighed against costs from increased terrorism. When α / ρ is large, the unskilled wage reduction from a relaxation of α confers benefits to *H* because it has to pay a lower amount to the large existing pool of unskilled immigrants. However, from Proposition 3, we know that α augments terror in *H* while reducing it in *F*. These terrorism-related benefits and costs have to be weighed against the terms-of-trade benefits to optimally choose the unskilled immigration quota. The tradeoffs for skilled immigration quota are similar, except that both the terms-of-trade and the terrorism-related effects work in the opposite direction.

4.1.1. Comparative statics of Nash equilibrium in a reduced model

The Nash equilibrium, defined by Eqs. (41a) and (48a)-(48c), is intractable for conducting comparative statics. In this subsection, we use a reduced model where defense and unskilled immigration α are given exogenously, and $A(\alpha, \rho) \equiv 1$. For simplicity, we normalize the given unskilled immigration level at zero. Eq. (48c) then reduces to:

$$Y_{\rho}^{H}(m, \rho) = i^{H} \rho \frac{\partial w^{uH}}{\partial \rho} - p^{H} \frac{\partial T^{H}}{\partial \rho} - \delta^{H} \frac{\partial T^{F}}{\partial \rho} = 0 . \tag{49}$$

Eq. (49) implicitly indicates the Nash reaction function of *H*, and together with Eq. (41a) for the Nash reaction path of *F*, determines the Nash equilibrium levels of m and ρ . In the rest of the analysis, for tractability, we use the earlier Cobb-Douglas functional forms for T^H and T^F , and also apply the following functional forms for Eqs. (35) and (38):

$$Q^{F} = \eta^{F}\left(L^{F}, S^{F}\right) = \left(L^{F}\right)^{k}\left(S^{F}\right)^{1-k} \text{ and} \tag{50}$$

$$Q^{H} = \eta^{H}\left(L^{H}, S^{H}\right) = \left(L^{H}\right)^{z}\left(S^{H}\right)^{1-z} . \tag{51}$$

Lemma 1: F's reaction function is downward sloping (i.e. $Y^F_{m\rho} < 0$) if and only if[14]

$$\left(\frac{w^{sF}}{\beta}\right)^2 > \frac{\bar{\theta}\tau(1-\sigma)}{\sigma-\tau}\left(l^{tF}\right)^{\sigma},\ l^{tF} = \left(\frac{\tau}{\sigma}\right)^{\frac{\tau}{\sigma-\tau}}\left(\frac{1-\tau}{1-\sigma}\right)^{\frac{1-\tau}{\sigma-\tau}}\left(\frac{\phi^H p^H}{\phi^H\delta^H+\phi^F}\right)^{\frac{1}{\sigma-\tau}},$$

which implies $$\frac{(1-k)^{2-k}k^k\left(\frac{\bar{L}^F}{\bar{S}^F-\rho}\right)^k}{\beta^2\bar{\theta}} > \frac{\tau(1-\sigma)}{\sigma-\tau}\left(l^{tF}\right)^{\sigma}. \tag{52}$$

Proof

Note that because defense is held constant, p^H is given, and hence l^{tF} is determined entirely by parameters involving the terrorist organization and nation H. Thus, the second inequality involves parameters except for β and ρ. The probability β is bounded between zero and unity, while ρ has to be between zero and $\bar{S}^F$. If β approaches zero, or ρ approaches $\bar{S}^F$, then the inequality is necessarily satisfied. If, however, $\beta \to 1$ and $\rho \to 0$, the inequality may still be satisfied as long as the other terms on the left-hand side are sufficiently large. The first inequality in (52) suggests that given Cobb-Douglas parameters and $\bar{\theta}$, the inequality is more likely to be satisfied if the skilled wage in F is high. The second inequality reflects the determinants of this skilled wage (derived using the specific functional forms), and reflects the fact that if F is skill-scarce (i.e., if $\frac{\bar{L}^F}{\bar{S}^F-\rho}$ is high), then the inequality is more likely to be satisfied. ■

The intuition is as follows. F's proactive efforts benefit it by encouraging more of its skilled workers to move to the productive sector. If skilled emigration (ρ) increases, then F loses a

[14] The derivation of Eq. (52) is provided in the Appendix. Derivations supporting the rest of this subsection are available on request.

potential skilled worker, who could have been moved from terrorism to productive work. This loss is even greater when the worker possesses a high marginal product (i.e., w^{sF} is high), thus reducing the incentive for *F* to use proactive effort. In other words, $Y_{m\rho}^{F} < 0$, so that proactive measures and the skilled-labor quota in the developed country are strategic substitutes. This suggests that a skill-scarce terrorist haven, such as Yemen or Somalia, would be more reluctant than a more skill-abundant haven, such as Pakistan, to engage in a proactive campaign.

Lemma 2 *H*'s reaction function is downward sloping (i.e., $Y_{\rho m}^{H} < 0$), if and only if

$$p^{H}T_{\rho m}^{H} > \delta^{H}\left|T_{m\rho}^{F}\right|, \text{ where } T_{\rho m}^{H} > 0 \text{ and } T_{m\rho}^{F} < 0. \tag{53}$$

First consider why $T_{\rho m}^{H} > 0$. A rise in ρ reduces terrorism in *H*. This fall in terrorism is proportional to the fraction of skilled labor employed by the terrorist sector. When m rises, this proportion is lower, scaling down the marginal terrorism reduction from ρ (i.e., $T_{\rho m}^{H} > 0$). The term $T_{m\rho}^{F}$ is negative for a similar reason. If the home effect $p^{H}T_{\rho m}^{H}$ is larger than the foreign-interest effect (i.e., $\delta^{H}\left|T_{m\rho}^{F}\right|$), then *H*'s reaction function is downward sloping. ■

Using the second order conditions $Y_{\rho\rho}^{H} < 0$, and $Y_{mm}^{F} < 0$, and the Nash stability condition, $Y_{\rho\rho}^{H}Y_{mm}^{F} - Y_{\rho m}^{H}Y_{m\rho}^{F} > 0$, we get the following comparative static results:

$$\frac{dm}{d\bar{L}^{H}} < 0 \text{ if and only if } Y_{m\rho}^{F} < 0 \text{ and } \frac{d\rho}{d\bar{L}^{H}} > 0, \text{ and} \tag{54a}$$

$$\frac{dm}{d\bar{S}^{H}} > 0 \text{ if and only if } Y_{m\rho}^{F} < 0 \text{ and } \frac{d\rho}{d\bar{S}^{H}} < 0. \tag{54b}$$

The intuition behind Eq. (54a) is that with a larger unskilled endowment for *H*, the terms-of-trade gains from having more skilled immigration is larger. This encourages a higher ρ, shifting out H's reaction function. While ρ rises, m rises or falls in the new Nash equilibrium depending on whether F's reaction function is positively or negatively sloped. Similar intuition applies to Eq. (54b). Turning to F's endowments, we have

$$\frac{dm}{d\bar{L}^F} > 0 \text{ and } \frac{d\rho}{d\bar{L}^F} < 0 \text{ if } Y^F_{m\rho} < 0,\ Y^H_{\rho m} < 0, \text{ and } l^{tH} < \Omega < l^{tF},$$

$$\text{with } \Omega = \frac{(1+k)}{2-k}\sqrt{\frac{(1-k)\bar{L}^F}{k\left(\bar{S}^F - \rho\right)}}; \tag{55a}$$

$$\frac{dm}{d\bar{S}^F} < 0 \text{ and } \frac{d\rho}{d\bar{S}^F} > 0 \text{ if } Y^F_{m\rho} < 0, Y^H_{\rho m} < 0, \text{ and } l^{tH} < \Omega < l^{tF}. \tag{55b}$$

The intuition for the comparative statics of changes in F's endowments is more complicated (compared to H's) because both nations' reaction functions shift in this case. When unskilled labor endowment in F rises, proaction's gains from bringing more people into the productive sector, as well as the terror reduction effect on T^F, are amplified. This leads to a shifting out of F's reaction function. If, on the other hand, the terrorism factor intensities are within the range above, the terrorism-reduction gains from skilled immigration is reduced by $\bar{L}^F$ through its effects on wages in F. This shifts H's reaction function inward. Thus, when both reaction functions are downward sloping, the final Nash equilibrium involves a higher proactive measure and a lower skilled immigration level. The intuition for a change in F's skilled labor is similar.

4.2. Stackelberg equilibrium in the reduced model

This subsection describes the Stackelberg equilibrium in which H chooses its policy one stage ahead of F, so that the underlying game has three stages. For simplicity, we use the reduced model used in the previous subsection. To analyze the Stackelberg equilibrium, we write Eq.

(47b) for the reduced model as

$$Y^{H} = Y^{H}\left(\rho, m\right). \tag{56a}$$

Using (41b), we can write (56a) to represent the payoff of *H* from being a Stackelberg leader, as

$$Y^{HL} = Y^{H}\left[\rho, m\left(\rho\right)\right], \tag{56b}$$

The FOC for the choice of the skilled immigration quota is

$$\frac{\partial Y^{HL}}{\partial \rho} = \left(\frac{\partial Y^{H}}{\partial \rho}\right)_{|m} + \left(\frac{\partial Y^{H}}{\partial m}\right)\left(\frac{\partial m}{\partial \rho}\right) = 0 . \tag{57}$$

Eq. (40) indicates that, for given α and ρ, i^{H} is given and is not affected by *m*; hence, w^{uH} and w^{sH} cannot be directly affected by m. By differentiating (47b) (for given e, α and ρ) with respect to m, we obtain

$$\frac{\partial Y^{H}}{\partial m} = -p^{H}\left(\frac{\partial T^{H}}{\partial m}\right) - \delta^{H}\left(\frac{\partial T^{F}}{\partial m}\right) > 0 , \tag{58}$$

using Case 3 of Proposition 2 (i.e., both T^{H} and T^{F} decline with proactive measures). Recall that Case 1 is ruled for our specific functional forms. Case 2 can potentially lead to ambiguity in the sign of (58), but for simplicity, we assume that the direct effect [i.e., $-p^{H}\left(\frac{\partial T^{H}}{\partial m}\right)$] dominates.

Proposition 5: *H*'s leadership choice of its skilled immigration quota is lower than the Nash level when *F* is sufficiently unskilled labor abundant.

Proof

If we evaluate the marginal leadership payoff at the Nash equilibrium, then the first term on the right-hand side of (57) is zero. Given Eqs. (57)-(58), we have:

$$\left(\frac{\partial Y^{HL}}{\partial \rho}\right)_{|N} = \left(\frac{\partial Y^{H}}{\partial m}\right)\left(\frac{\partial m}{\partial \rho}\right)_{|N} < 0 \text{ if and only if } \left(\frac{\partial m}{\partial \rho}\right)_{|N} < 0\,. \tag{59}$$

Based on Eq. (52), it is clear that because $\beta < 1$, and $0 < \rho < \overline{S}^F$, the following condition is sufficient for F's reaction function to be downward sloping:

$$\frac{(1-k)^{2-k}\, k^k \left(\dfrac{\overline{L}^F}{\overline{S}^F}\right)^k}{\overline{\theta}} > \frac{\tau(1-\sigma)}{\sigma-\tau}\left(l^{tF}\right)^{\sigma}. \tag{60}$$

If (60) is satisfied, then $\left(\dfrac{\partial Y^{HL}}{\partial \rho}\right)_{|N} < 0$, which implies that $\rho^L < \rho^N$, where ρ^L and ρ^N are the leadership and Nash levels of the skilled immigration quota, respectively. ■

The intuition for Proposition 5 follows from our discussion after Lemma 1. When F is sufficiently skill-scarce (i.e., when $\dfrac{\overline{L}^F}{\overline{S}^F}$ is large), it has a high skilled wage. In this situation, losing skilled labor (through emigration) reduces F's incentive for proaction. As a Stackelberg leader, H recognizes this fact, and holds back its skilled immigration quota appropriately.

5. Concluding remarks

Immigration and counterterrorism policies are both central concerns confronting the United States and many other terrorist-targeted developed countries. Moreover, consistent with our model, numerous transnational terrorist groups have taken up residency in developing countries with limited capabilities to root out the groups. This paper is the first general equilibrium analysis with strategic aspects that investigates the interrelationship between immigration quotas and the choice between defensive countermeasures in the developed country and proactive measures in the (host) developing country.

Even though the analysis is complex and ambiguous in places, there are many important and unambiguous insights, especially when specific functional forms are assumed. First, developed countries gain from deflecting attacks back to the developing country despite its own interests in the latter. Second, proactive measures against a resident terrorist group need not reduce terrorism at home *and* abroad. This is a novel result that hinges on labor-intensity considerations in the productive and terrorist sectors in the host developing country and abroad in the developed country. In contrast, the literature views such proactive measures as necessarily reducing terrorism everywhere (e.g., Sandler and Siqueira, 2006). Third, the host country for terrorism may be better off in augmenting proactive measures even if this leads to more attacks at home. This follows when such measures more than compensate for the additional terrorism by augmenting the labor supply in the productive sector so that national income rises. Fourth, we show that a larger unskilled immigration quota raises terrorism against the developed country, while it reduces terrorism against the developing country. If the skilled migrant pool has a limited marginal impact on producing terrorism in the developed country, then a greater skilled labor quota reduces terrorism in the developed country but raises terrorism in the developing country. Fifth, we identify the circumstances for a reduced model where the developed country can gain a strategic advantage through policy leadership. When proactive measures and skilled quotas are strategic substitutes, reduced skilled immigration quotas by the developed country shift the burden of the war on terror to the developing country. Other scenarios would characterize strategic complements. Sixth, we establish that optimal immigration or counterterrorism policies cannot be examined in isolation; thus, there are firm theoretical grounds for including US Immigration and Customs Enforcement (ICE) in the Department of Homeland Security. That is, the margins affecting immigration choices can be greatly influenced by counterterrorism policies at home and abroad.

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Appendix

1. *Derivation of Eq. (16)*

Using the terrorist organization's FOCs, we have

$$\gamma^H T_1^H \left(l^{tH},1\right) - \gamma^F T_1^F \left(l^{tF},1\right) = 0 \text{ and} \tag{M1}$$

$$\gamma^H T_2^H \left(l^{tH},1\right) - \gamma^F T_2^F \left(l^{tF},1\right) = 0 . \tag{M2}$$

Totally differentiating Eqs. (M1) and (M2) and solving using Cramer's rule yield:

$$\frac{\partial l^{tH}}{\partial \gamma^H} > 0 , \ \frac{\partial l^{tF}}{\partial \gamma^H} > 0 , \ \frac{\partial l^{tH}}{\partial \gamma^F} < 0 , \text{ and } \frac{\partial l^{tF}}{\partial \gamma^F} < 0 . \tag{M3}$$

We can write the terrorist group's unskilled labor constraint as:

$$l^{tH} S^{tH} + l^{tF} S^{tF} = L^T \left(\alpha, w^{uH}, m, \overline{L}^H\right). \tag{M4}$$

Totally differentiating Eq. (M4) and the skilled labor constraint, and solving using Cramer's rule give:

$$\frac{\partial S^{tH}}{\partial \gamma^H} = \frac{S^{tH} \dfrac{\partial l^{tH}}{\partial \gamma^H} + S^{tF} \dfrac{\partial l^{tF}}{\partial \gamma^H}}{l^{tF} - l^{tH}} > 0 , \text{ because } \ l^{tF} > l^{tH} . \tag{M5}$$

Using Eq. (4a), we have

$$T^H = S^{tH} T^H \left(l^{tH},1\right) \Rightarrow \frac{\partial T^H}{\partial \gamma^H} = T^H \left(l^{tH},1\right) \frac{\partial S^{tH}}{\partial \gamma^H} + S^{tH} T_1^H \left(l^{tH},1\right) \frac{\partial l^{tH}}{\partial \gamma^H} > 0 . \tag{M6}$$

2. *Derivation of Eq. (23):*

Differentiating the Lagrangian multipliers by using the terrorist organization's FOCs, we get Eq. (23).

3. *Derivation of Eqs. (24) and (25):*

Employing Eqs. (19) and (22), we have

$$\frac{\partial T^H}{\partial m} < 0 \text{ iff } -\frac{L_m^T}{S_m^T} > \frac{\left(\dfrac{\partial \lambda_S}{\partial \gamma^H}\right)}{\left(\dfrac{\partial \lambda_L}{\partial \gamma^H}\right)}. \tag{M7}$$

We first substitute the expressions for L_m^T and S_m^T from Eq. (21) and the expressions for $\left(\dfrac{\partial \lambda_S}{\partial \gamma^H}\right)$ and $\left(\dfrac{\partial \lambda_L}{\partial \gamma^H}\right)$ from Eq. (23) into (M7), and then we use $\dfrac{L_m^T}{S_m^T} = l^0$ [see Eq. (24)]. Given the homogeneity of degree zero of $T_1^F\left(l^{tF}, 1\right)$ and Euler's theorem, we can reduce (M7) to show that:

$$\frac{\partial T^H}{\partial m} < 0 \text{ iff } l^{tF} > l^0. \tag{M8}$$

Analogously, we get Eq. (25):

4. *Proof of Proposition 3:*

(a) To show that $\dfrac{\partial T^{*H}}{\partial \phi^H} > 0$, we proceed as follows. Using Eqs. (15a) and (6), we have

$$\frac{\partial T^H}{\partial \phi^H} = V_{11}^* A p^H + V_{12}^* \delta^H p^F. \tag{M9}$$

From Eq. (18a), we have $V_{12}^* = -\dfrac{V_{11}^* \gamma^H}{\gamma^F} < 0$. Substituting this in (M9) and simplifying yield:

$$\frac{\partial T^H}{\partial \phi^H} = \frac{V_{11}^* A \phi^F p^H}{\phi^H \delta^H + \phi^F} > 0 \Rightarrow \frac{\partial T^{*H}}{\partial \phi^H} = A \frac{\partial T^H}{\partial \phi^H} > 0. \tag{M10}$$

(b) Next we establish that $\dfrac{\partial T^F}{\partial \phi^H} < 0$. Using Eq. (15b), and a similar method as above, we have

$$\frac{\partial T^F}{\partial \phi^H} = -\frac{V_{22}^* p^F \phi^F}{\phi^H} < 0 \text{, because } V_{22}^* = -\frac{V_{21}^* \gamma^H}{\gamma^F} > 0 . \tag{M11}$$

(c) To show that $\frac{\partial T^{*H}}{\partial \alpha} > 0$, we proceed as follows. With Eqs. (5) and (15a), we have

$$\frac{\partial T^{*H}}{\partial \alpha} = A_\alpha V_1^* + A\left(V_{11}^* \frac{\partial \gamma^H}{\partial \alpha} + V_{1\alpha}^* \right). \tag{M12}$$

Differentiating Eq. (6), we get $\frac{\partial \gamma^H}{\partial \alpha} > 0$. Using the envelope theorem and Eq. (12), we get V_α^*.

Differentiating V_α^*, we can then show that $V_{1\alpha}^* > 0$. Thus, (M12) shows that $\frac{\partial T^{*H}}{\partial \alpha} > 0$.

(d) To show that $\frac{\partial T^F}{\partial \alpha} < 0$, we differentiate Eq. (15b) to give:

$$\frac{\partial T^F}{\partial \alpha} = V_{21}^* \frac{\partial \gamma^H}{\partial \alpha} + V_{2\alpha}^* . \tag{M13}$$

Based on Eq. (18a), $V_{21}^* < 0 \Rightarrow V_{21}^* \frac{\partial \gamma^H}{\partial \alpha} < 0$. Using a method similar to above, we can show that

$V_{2\alpha}^* < 0$, so that $\frac{\partial T^F}{\partial \alpha} < 0$ by (M13).

(e) Differentiating T^{*H}, using Eq. (6), and the fact that V_1^* is T^H, we have

$$\frac{\partial T^{*H}}{\partial \rho} = \left(T^H + AV_{11}^* \phi^H p^H \right) A_\rho + AV_{1\rho}^* < 0 \text{ iff } A_\rho < \frac{A\left|V_{1\rho}^*\right|}{T^H + AV_{11}^* \phi^H p^H} . \tag{M14}$$

Using the envelope theorem and Eqs. (11)-(12), we obtain V_ρ^* and, in turn, $V_{1\rho}^* < 0$. Based on Eq. (M14), we see that the sign of $\frac{\partial T^{*H}}{\partial \rho}$ is ambiguous in general, and is negative if A_ρ is sufficiently small. A sufficient condition for this latter case is where skilled immigration has no effect in the facilitation of terror delivery (i.e., if $A_\rho = 0$).

(f) Given Eqs. (15b) and (6), we have

$$\frac{\partial T^F}{\partial \rho} > 0 \text{ iff } A_\rho < \frac{V_{2\rho}^*}{\left|V_{21}^*\right| \phi^H p^H}. \tag{M15}$$

Based on methods similar to above, we can show that $V_{2\rho}^* > 0$. Thus, in general, the sign of $\frac{\partial T^F}{\partial \rho}$ is ambiguous, but is positive if A_ρ is sufficiently small. It is clear from Eqs. (M14) and (M15) that if A_ρ is smaller than the minimum of the two critical values identified in these inequalities, then $\frac{\partial T^{*H}}{\partial \rho} < 0$, and $\frac{\partial T^F}{\partial \rho} > 0$. A sufficient condition for this to occur is $A_\rho = 0$.

5. *Derivation of Eq. (43):*

Given Eq. (40) and the implicit function theorem, we have

$$\frac{\partial i^F}{\partial m} = \frac{N_i}{D_i}, \text{ where}$$

$$N_i = \frac{\beta'}{\beta^2}\left[g w^{sF} i^F \left(\bar{S}^F - \rho\right) - x w^{uF} \left(\bar{L}^F - \alpha\right)\right] \text{ and}$$

$$D_i = \left(\bar{S}^F - \rho\right) G + \left[\frac{i^F \left(\bar{S}^F - \rho\right) g}{\beta}\right]\left(\frac{\partial w^{sF}}{\partial i^F}\right) - \left[\frac{\left(\bar{L}^F - \alpha\right) x}{\beta}\right]\left(\frac{\partial w^{uF}}{\partial i^F}\right). \tag{M16}$$

Based on Eq. (40), $D_i > 0$. Thus,

$$\frac{\partial i^F}{\partial m} \geq 0 \text{ iff } N_i \geq 0 \text{, i.e., iff } g w^{sF} i^F \left(\bar{S}^F - \rho\right) - x w^{uF} \left(\bar{L}^F - \alpha\right) \leq 0. \tag{M17}$$

Using Eq. (40), we have $i^F \left(\bar{S}^F - \rho\right) = \frac{\left(\bar{L}^F - \alpha\right) X}{G}$. Substituting this last expression in Eq. (M17) and simplifying, we get Eq. (43).

6. *Deriving H's policy rules [Eqs. (48a) through (48c)]:*

(a) Derivation of Eq. (48a):

Eq. (40) indicates that $i^H(\alpha,\rho)$ is independent of e. In turn, $w^{uH}(i^H)$ and $w^{sH}(i^H)$ are independent of e. Differentiation of Eq. (47b) with respect to e immediately yields Eq. (48a).

(b) Derivation of Eq. (48b):

Differentiating Eq. (47b) and using $w^{uH} = \eta_1^H$, we have

$$\frac{\partial Y^H}{\partial \alpha} = -\alpha\frac{\partial w^{uH}}{\partial \alpha} - \rho\frac{\partial w^{sH}}{\partial \alpha} - p^H\left[T^H A_\alpha + A\left(\frac{\partial T^H}{\partial \alpha}\right)\right] - \delta^H\frac{\partial T^F}{\partial \alpha}. \tag{M18}$$

Using Eq. (40) and the homogeneity of degree zero of $\eta_1^H(\bullet)$, we can show that

$$\frac{\partial w^{sH}}{\partial \alpha} = -i^H\frac{\partial w^{uH}}{\partial \alpha}. \tag{M19}$$

Based on Eq. (M19), we substitute for $\frac{\partial w^{sH}}{\partial \alpha}$ in (M18) to get Eq. (48b).

(c) Derivation of Eq. (48c):

Derivation of Eq. (48c) follows the same logic as that for Eq. (48b).

7. *Derivation of Eq. (52):*

Using Eqs. (40), (41a), (45a), (45b) and assuming that $\alpha = 0$, we have

$$Y_m^F(m,\rho) = -\frac{\beta'\overline{L}^F\left(w^{uF}\right)^2}{\beta^2\overline{\theta}} - \frac{\beta'\left(\overline{S}^F-\rho\right)\left(w^{sF}\right)^2}{\beta^2\overline{\theta}} - \frac{\partial T^F}{\partial m} - 1. \tag{M20}$$

The zero profit condition in *F*'s productive sector and Sheppard's lemma imply that

$\frac{\partial w^{sF}}{\partial \rho} = -i^F\frac{\partial w^{uF}}{\partial \rho}$. Using this fact and differentiating Eq. (M20) with respect to ρ give:

$$Y_{m\rho}^{F} = -\frac{2\beta' w_{\rho}^{uF}}{\beta^{2}\bar{\theta}}\left[\bar{L}^{F} w^{uF} - \left(\bar{S}^{F} - \rho\right) w^{sF} i^{F}\right] + \frac{\left(w^{sF}\right)^{2}\beta'}{\bar{\theta}\beta^{2}} - T_{m\rho}^{F},$$

$$\text{where, } w_{\rho}^{uF} = \frac{\partial w^{uF}}{\partial \rho},\ Y_{m\rho}^{F} = \frac{\partial^{2} Y^{F}}{\partial \rho \partial m},\text{ and } T_{m\rho}^{F} = \frac{\partial^{2} T^{F}}{\partial \rho \partial m}. \tag{M21}$$

Under the assumed uniform distribution and using $\alpha = 0$, we have

$$i^{F} = \frac{\bar{L}^{F} w^{uF}}{\left(\bar{S}^{F} - \rho\right) w^{sF}} \Rightarrow \bar{L}^{F} w^{uF} - \left(\bar{S}^{F} - \rho\right) w^{sF} i^{F}. \tag{M22}$$

Substituting Eq. (M22) in (M21) gives

$$Y_{m\rho}^{F} = \frac{\left(w^{sF}\right)^{2}\beta'}{\bar{\theta}\beta^{2}} - T_{m\rho}^{F}. \tag{M23}$$

Next, we use (a) the CRS properties of $T^{F}\left(L^{tF}, S^{tF}\right)$, (b) Eqs. (M1) and (M2) (to establish that l^{tj} (*j=H,F*) is independent of m and ρ in the reduced model), and (c) Eq. (M4) and $S^{tH} + S^{tF} = S^{T}$ to obtain an expression for S^{tF} that depends only on l^{tj}, L^{T}, and S^{T}. This then yields:

$$T^{F}\left(L^{tF}, S^{tF}\right) = T^{F}\left(l^{tF}, 1\right) S^{tF} \Rightarrow T_{m\rho}^{F}\left(L^{tF}, S^{tF}\right) = T^{F}\left(l^{tF}, 1\right) S_{m\rho}^{tF} = \frac{T^{F}\left(l^{tF}, 1\right) l^{tH} \beta'}{l^{tF} - l^{tH}}. \tag{M24}$$

Using Eqs. (M23) and (M24), we have

$$Y_{m\rho}^{F} = \beta'\left[\frac{\left(w^{sF}\right)^{2}}{\bar{\theta}\beta^{2}} - \frac{T^{F}\left(l^{tF}, 1\right) l^{tH}}{l^{tF} - l^{tH}}\right] < 0 \text{ iff } \frac{\left(w^{sF}\right)^{2}}{\bar{\theta}\beta^{2}} > \frac{T^{F}\left(l^{tF}, 1\right) l^{tH}}{l^{tF} - l^{tH}}. \tag{M25}$$

Using the Cobb-Douglas forms described in Eqs. (31), (50), and (51), and using Eqs. (M1) and (M2) to derive the expressions for l^{tj} (*j=H,F*), we get Eq. (52).