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Working Paper
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GLO Discussion Paper, No. 1237

Provided in Cooperation with:
Global Labor Organization (GLO)

Suggested Citation: Ohta, Katsunori; Tamura, Yuji (2023) : Refugee Resettlement, GLO Discussion Paper, No. 1237, Global Labor Organization (GLO), Essen

This Version is available at:
<https://hdl.handle.net/10419/268505>

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Refugee Resettlement*

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February 3, 2023

Abstract

Resettlement is one means of assisting refugees to regain self-reliant living without constant fear. The global total of resettled refugees has remained fractional relative to the need. To contribute to the ongoing effort to increase resettlement, we consider self-enforceable sharing of full resettlement through analysis of a repeated game at the beginning of which host countries bargain over their shares. We find that cooperation opportunities are diminished, or else lost, by cutting the cost of resettlement, whereas they are expanded by heightened pureness in treating refugee protection as a humanitarian public good. Our finding thus makes us reconsider the implications of static-game analysis that both high cost and public-good nature of refugee protection are the sources of insufficient admission. We also show that a wide range of cooperation opportunities may not be conducive to the efficiency of an equilibrium outcome because it allows the bargaining outcome to deviate from the efficient one. We suggest policies for creating cooperation opportunities and improving equilibrium efficiency. Our framework is sufficiently general and is useful for examining other similar problems of public-good provision.

Keywords: International cooperation, International public good, Noncooperative game, Repeated game, Alternate-offer bargaining

JEL classification codes: H41, H87

*We benefited from comments and suggestions by Tim Hatton, Eiichi Miyagawa, Antonio Ruiz-Porrás, Hiroaki Sakamoto, Takashi Shimizu, Ken-ichi Shimomura, and the seminar audiences at Kobe and Guadalajara. We acknowledge financial support from the Japan Society for the Promotion of Science (Grant-in-Aid for Scientific Research, Project ID No. 20K01548) and La Trobe University (Project ID No. RFA CR 2000002948). We also received material support from Wakayama University. All remaining errors are ours.

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1 Introduction

Resettlement of a refugee is the transfer of the person from the country where she had sought protection to another that has agreed to admit her with permanent-resident status (UNHCR, 2019: 7).¹ The need for resettlement arises when voluntary repatriation is impracticable because of ongoing insecurity in her home country and at the same time local integration in the sheltering country is neither possible nor appropriate.² Refugees typically flee into a few neighboring countries that are under-resourced.³ When they do so on a large scale, those countries cannot cope with them adequately. As a result, the refugees are left highly vulnerable both physically and psychologically. They can be even threatened with refoulement, as kindness to non-nationals can easily wear off in overwhelmed countries. The number of individuals in need of resettlement has been increasing, and it is estimated to be as many as over 2 million today (UNHCR, 2022). Yet, the international community has resettled only a small fraction of them (see Table 1 below). This problem has been framed as a product of a lack of cooperation in sharing the humanitarian responsibility, and the latest international agreement on refugee protection—the Global Compact on Refugees (the Compact hereafter)—lists a considerable expansion of resettlement availability as one of its four objectives (UN, 2018: Para. 7). We contribute to the effort to achieve this goal by considering factors that encourage countries to admit all refugees in need of resettlement together.

[Insert Table 1 here]

To study resettlement decisions of potential host countries, we develop a model with three main ingredients: public good, repeated game, and bargaining. In the literature, the first of these is common, but to the best of our knowledge the other two have not been

¹For this reason, it is also called third-country resettlement with the first country being the refugee’s home country from which she fled and the second being the pre-transfer country in which she is located.

²Voluntary repatriation, local integration and resettlement are the three solutions that the United Nations High Commissioner for Refugees (UNHCR) considers to be durable for ending refugee situations (UN, 2018: Para. 85). The full list of qualifying categories for resettlement under the UNHCR auspices is available in the online document, FAQs about Resettlement (www.unhcr.org).

³More recent refugees have travelled longer distances from their home countries and are more dispersed across the world, although the neighboring countries continue to host the largest share of them (Devictor et al., 2021; Fransen and de Haas, 2022).

used. In almost all models of refugee admission, the researchers assume that refugee protection is an international public good (Hatton, 2004; Facchini et al., 2006; Czaika, 2009; Bubb et al., 2011; Fernández-Huertas Moraga and Rapoport, 2014; Tamura, 2018; Hagen, 2022).⁴ We also maintain this assumption because the Compact implicitly takes such a viewpoint in motivating responsibility sharing (UN, 2018: Para. 14). It is well known that voluntary provision of public goods is prone to the problem of free or easy riding and results in an inefficient underprovision, e.g. Cornes and Sandler (1996). Noncooperative theory of public-good provision can thus attribute an insufficient intake of refugees to a lack of international cooperation and has been the workhorse in the literature.

Repeated game-theoretic modeling has been used to examine the possibility of voluntary cooperation by noncooperative agents in various settings, but not in the context of refugee protection.⁵ This second ingredient is appropriate for our purpose because of the following two aspects of the problem. First, refugee protection is a recurrent issue that demands engagement of the international community repeatedly. Second, international agreements cannot be enforced by formal contracts because of the absence of a global institution that can overpower each country's sovereignty. In fact, the Compact acknowledges that it is not legally binding (UN, 2018: Para. 4). We adapt Friedman's (1971) trigger strategy to our infinitely repeated game of refugee resettlement. McMillan (1979) adapted it to public-good provision, and Harstad et al. (2019) to environmental protection. Yet, the literature on refugee protection—another public good—has not utilized the approach.

The third ingredient is bargaining. Repeated game theory (the folk theorem) suggests that, so long as the environment contains some mutually beneficial outcomes, noncooperative players who value the future sufficiently can cooperate with each other to achieve any of those outcomes. However, it remains silent on the question of which mutually beneficial outcome arises in equilibrium. Therefore, it is insufficient for our study of the situation where countries agree that responsibility sharing is important (as articulated

⁴See Suriyakumaran and Tamura (2016) and Tamura (2016) for literature surveys.

⁵In this paper, cooperation does not refer to a cooperative game. Those who are unfamiliar with repeated game theory should note that cooperation by noncooperative agents becomes a possibility if it is mutually more beneficial than noncooperation and no one has an incentive to discontinue it.

in the Compact) but have difficulty in implementing it as they disagree on the distribution of the responsibility.⁶ Since there is no supranational institution that can force each country to resettle a certain number of refugees, we are interested in the distribution that countries can achieve by themselves. This is in line with the Compact’s stance that each country’s contribution is voluntary (UN, 2018: Para. 4). We adapt Rubinstein’s (1982) alternate-offer bargaining to determine a specific distribution of full resettlement when there is a set of distributions achievable by the trigger strategy. The reason for our adaptation of the alternate-offer bargaining is not so much an accurate depiction of the actual negotiation process as an illustration of equilibrium selection through self-interested negotiation. Alternate-offer bargaining has previously been applied to the analysis of one-off provision of a public good, e.g. van den Nouweland and Rusinowska (2020) and the studies cited therein. However, our work is the first that sets up and analyzes an alternate-offer bargaining model in which a repeated public-good game naturally nests and endogenously constrains the set of actions taken by rational bargainers.⁷

One insight of our study results from the repetition of the resettlement game and makes us reconsider the implications of static-game analysis in the literature. Our results imply that both high cost of resettlement and public-good nature of refugee protection are ingredients for admitting more, not less, refugees. We show that the higher the cost of resettlement, the larger the set of cooperation opportunities for full resettlement—the set of mutually beneficial allocations of all refugees in need of resettlement. At first glance, this finding may appear counter-intuitive because the admission cost reduces the net benefit of resettlement in the host country. However, note that the cost reduces the net benefit, whether the country resettles under cooperation or noncooperation. We show that the net benefit is more sensitive to a change in the cost under noncooperation than

⁶The European Union has suffered from the same problem even though its membership is much smaller than that of the United Nations. The EU countries have been battling to reach an agreement for years. See for example Zaun (2019).

⁷On the other hand, models of repeated bargaining exist (Muthoo, 1999: Chap. 10). In our model, bargaining takes place only once before the beginning of the infinitely repeated game. This captures the international community’s attempt to ensure the predictability of the resettlement capacity through long-term commitment (UN, 2018: Para. 92). Harrington (1989) and Miller and Watson (2013) are also concerned with repeated-game equilibrium selection by bargaining, but are different from our study. The former uses Nash bargaining, while the latter allows cheap-talk alternate-offer bargaining before the stage game in every period. See also Abreu and Pearce (2007).

under cooperation. Under noncooperation, a high-cost country resettles a small number of refugees in order to keep the total cost low. As a result, the cost decreases the net benefit through an increase in the total cost and also a decrease in the gross benefit of protecting refugees. On the other hand, under cooperation, the same country must admit an already agreed share of full resettlement, and hence the gross benefit of full resettlement is unaffected by the cost. Accordingly, the net-benefit difference between cooperation and noncooperation is increasing in the resettlement cost. The larger the net-benefit difference, the larger share of full resettlement the country is willing to admit under cooperation, which in turn expands the set of self-enforceable divisions of full resettlement. Existing studies only show that a high cost causes a low level of admission under noncooperation because they study one-off admission only and hence, unlike our study, do not address the effect of the cost on sustainable cooperation. We will show that the effects of externality also go beyond the creation of free- or easy-riding incentives in our dynamic model.

Another insight of our study results from the use of bargaining before the repeated resettlement game and is concerned with the equilibrium efficiency. In existing studies, the total-payoff maximization across host countries determines the ideal level of each country's admission and, as byproducts, the total admission and each country's share of it. This first-best outcome is used as the benchmark to highlight the inefficiency of noncooperative equilibrium. There are two weaknesses in this approach. First, those studies cannot suggest how to improve efficiency because of the static nature of their analyses (which does not yield any cooperation possibility) and also the real-world absence of a supranational institution that can impose the first-best allocation. Second, this efficient level of total admission disregards the need for protection: when it is lower than the need, even if we somehow manage to achieve it, all refugees cannot be admitted.

In our study, the ideal level of global admission is not a result of any optimization by a third party and is exogenously given by the need for resettlement, which is in line with the context of the Compact. As a result, the level of efficiency is determined

by a particular distribution of all refugees across host countries.⁸ We will show that bargained full resettlement could be made more efficient by policies that change the set of mutually beneficial allocations and/or bargaining environments. In other words, instead of merely pointing out inefficiency that is likely to persist in the absence of a supranational authority, our model allows us to consider the issue of efficiency in a constructive manner and offer incentive-based policy implications for an efficiency improvement. For example, we will show that, while the division of full resettlement is more efficient if the country that generates a larger positive externality admits more refugees, bargaining might lead to an inefficient outcome in which it does not have to admit that many. The reason is that the other country that receives the externality is willing to admit more refugees so as to persuade the larger-externality generator to achieve full resettlement together. In such a case, if efficiency is sought, we may consider to arrange bargaining environments in favor of the recipient of the larger externality in order to counter its readiness to admit more refugees under cooperation. Alternatively, we may consider to change the set of mutually beneficial allocations by targetting parameters that influence the incentives of the countries, such as admission costs, so that the bargaining outcome cannot depart from the efficient distribution significantly. Our comparative statics section will imply more ways to promote equilibrium efficiency.

2 Model

Consider two countries indexed by $i, j = A, B$ with $j \neq i$. They repeatedly play a noncooperative game of refugee resettlement an infinite number of times. In each period $t = 0, 1, 2, \dots$, there is a mass of refugees in need of resettlement located outside the countries. We normalize the size of the mass to 1. Each country decides on $a_{i,t} \in [0, 1]$, the number of people it prefers to admit from the mass in period t . We concentrate on

⁸Here, as in the literature, the most efficient outcome is associated with the highest level of the total payoff across host countries. As we will see later on, any equilibrium outcome where full resettlement is achieved is Pareto-efficient in our model, but the bargaining outcome is generally unlikely to maximize the total payoff. Note that our approach is similar to but is not the same as Hagen's (2022). He also examines the allocative efficiency of a fixed total but either at the level that maximizes the global payoff across host countries or, in case utilitarian maximization is infeasible because of factors outside of his model, at some lower level that is yet higher than in Nash equilibrium.

situations where $a_{i,t} + a_{j,t} \leq 1$ holds. Hence each country's decision is the same as the actual resettled number in the country.⁹

The country's payoff from resettlement in period t is given by

$$u_i(a_{i,t}, a_{j,t}) = b_i(a_{i,t}, a_{j,t}) - c_i(a_{i,t}) \quad (1)$$

where $b_i(\cdot) \geq 0$ represents the country's gross benefit from domestic and foreign resettlement and is increasing in each argument with $b_i(0, 0) = 0$. The public-good assumption discussed in the introduction is thus reflected by $\partial b_i(\cdot) / \partial a_{j,t} > 0$.¹⁰ The second term, $c_i(\cdot) \geq 0$, represents the total cost of admitting refugees in the country with $c'_i > 0$ and $c_i(0) = 0$. For example, a rigid labor market with a high minimum wage can fail to absorb many refugees (Dustmann et al., 2017: Section 4), which does not enable them to contribute to the public coffers and, at the same time, increases welfare expenditures to support them. Preparing them for local labor markets by educating and retraining them is essential but costly (Brell et al., 2020; Couttenier et al., 2019). There may also be noneconomic costs, e.g. frictions caused by xenophobia, racism, cultural and religious differences. The function (1) is assumed strictly concave in its own resettlement.¹¹

To explore the model with explicit solutions, let us use the following functional form:¹²

$$u_i(a_{i,t}, a_{j,t}) = a_{i,t} + \beta_i a_{j,t} - a_{i,t}^{\gamma_i} \quad (2)$$

with $\beta_i \in (0, 1)$ and $\gamma_i \in (1, \infty)$. The parameter β_i is the marginal benefit that country i receives from j 's resettlement. The second term thus represents the positive externality from j to i . The parameter restriction implies that refugee protection is an impure pub-

⁹If $a_{i,t} + a_{j,t} > 1$, the countries may compete to attract refugees, which is beyond the scope of our model where refugees are not decision makers.

¹⁰Those who are uncomfortable with the assumption of humanitarian utility from refugee protection could interpret $b_i(\cdot)$ economically. For example, $\partial b_i(\cdot) / \partial a_{i,t} > 0$ holds because of an eased labor shortage in country i , while $\partial b_i(\cdot) / \partial a_{j,t} > 0$ holds because of cheaper imports from country j that enjoys an increased labor force in the country.

¹¹ $\partial^2 b_i(\cdot) / \partial a_{i,t}^2 \leq 0$ and $c''_i \geq 0$ with strict inequality in at least one of those conditions.

¹²Tamura (2018) uses the same. Bubb et al. (2011) also use a combination of a linear benefit and a convex cost for each country's payoff, while they treat refugee protection as a pure public good, i.e. $\beta_i = 1$ in terms of our model.

lic good because domestic resettlement generates a higher marginal benefit than foreign resettlement. Private-good aspects of refugee protection include international prestige resulting from the exhibition of altruistic actions and self-satisfaction from doing it yourself as opposed to reliance on other countries. As for γ_i in the third term, the larger the parameter, the lower the hosting cost when the own resettlement is neither 0 nor 1. The convexity of the cost function can represent, for example, the situation where the risk of domestic socioeconomic instability rapidly rises as its admission exceeds a certain level.¹³

In playing the infinitely repeated game in any period, a country maximizes its continuation payoff (discounted sum of period-specific payoffs from that period onward). Let $\delta_i \in (0, 1)$ denote country i 's discount factor per period. Given the sequence of action profiles $\{a_{i,t}, a_{j,t}\}_{t=0}^{\infty}$, country i 's continuation payoff from the initial period $t = 0$ is

$$v_i = \sum_{t=0}^{\infty} \delta_i^t u_i(a_{i,t}, a_{j,t}). \quad (3)$$

Assuming that each country can observe the opponent's action, a history in period t , denoted by h_t , consists of the sequence of action profiles from the initial period to $t - 1$, that is, $h_t = (a_0, a_1, \dots, a_{t-1})$ where $a_\tau = (a_{i,\tau}, a_{j,\tau})$ with $\tau = 0, 1, \dots, t - 1$. Let H_t denote the set of all potential histories in period t . Because the initial period has no past outcome, we introduce an arbitrary singleton set, $H_0 = \{h_0\}$, as the initial history. A pure strategy, σ_i , is a function that maps each history to an action, that is, $\sigma_i : \cup_{t=0}^{\infty} H_t \rightarrow [0, 1]$. Our solution concept is the subgame perfect equilibrium (SPE). For any t and any $h_t \in H_t$, the SPE strategy profile constitutes a Nash equilibrium (NE) in the continuation games from that period onward. We will focus on the SPE that achieves full resettlement.

We allow the countries to bargain with each other in the Rubinstein (1982) fashion over the share of full resettlement before the beginning of the repeated game. We will examine both finite- and infinite-horizon bargaining, to study how the bargaining outcome

¹³The function (2) assumes $\partial^2 u_i(\cdot) / \partial a_{i,t} \partial a_{j,t} = \partial^2 u_i(\cdot) / \partial a_{j,t} \partial a_{i,t} = 0$ for ease of analysis. If the cross partial derivatives are negative, a decrease in j 's resettlement encourages i to increase its resettlement. If instead they are positive, we have a case of keeping up with the Joneses or a race to the bottom. A combination of a concave benefit and a linear cost does not yield an explicit solution, making analysis unnecessarily complex.

is affected by the number of bargaining stages and the identification of the last proposer. The countries alternately propose a division of full resettlement to each other until they either agree with one or, in the finite-horizon case, reach the last $(S + 1)^{\text{th}}$ stage as a result of failing to reach an agreement whichever comes first. We assume $S \geq 2$, namely, each country has at least one chance to propose if the number of bargaining stages is finite and continues to the last stage. Once an agreement is reached, each country is supposed to host the same agreed share to achieve full resettlement together in every period from then on. Let $\theta_{i,s} \in [0, 1]$ denote country i 's share of full resettlement proposed at stage $s = 1, 2, \dots$. Accordingly, $\theta_{j,s} = 1 - \theta_{i,s}$.

In the finite-horizon case, the order of events is stage by stage as follows:

1. Country i proposes $\theta_{i,1}$. Country j either accepts or rejects the proposal. If it accepts it, bargaining ends, and countries i and j agree to admit $\theta_{i,1}$ and $\theta_{j,1}$ respectively to achieve full resettlement together in every period. If the proposal is rejected, they move to the next stage.
2. Country j proposes $\theta_{i,2}$. Country i either accepts or rejects the proposal. If it accepts it, bargaining ends, and countries i and j agree to admit $\theta_{i,2}$ and $\theta_{j,2}$ respectively to achieve full resettlement together in every period. If the proposal is rejected, they move to the next stage.
3. Country i proposes $\theta_{i,3}$. Country j either accepts or rejects it. ...
- ⋮
- $S + 1$. International negotiation in S stages has ended fruitlessly, and the countries have not reached an agreement. Countries i and j decide to resettle some predetermined levels \hat{a}_i and \hat{a}_j respectively in every period.¹⁴

In the infinite-horizon case, if the countries cannot break a deadlock, the repeated game cannot begin.

¹⁴We will shortly specify those predetermined levels as the NE strategies of the countries.

3 Preliminary analysis

3.1 Structure of the static game

Let us initially concentrate on the situation where full resettlement is not achieved without cooperation but at the same time there remains scope for cooperation to achieve full resettlement.¹⁵ This is equivalent to holding two assumptions in the model. First, the total resettlement in static noncooperative equilibrium is insufficient for accommodating all refugees. Second, the static game of resettlement is prisoners' dilemma.¹⁶ Let us set \hat{a}_i equal to country i 's NE strategy. Using Eq.(2), we get

$$\hat{a}_i = \gamma_i^{\frac{-1}{\gamma_i-1}} \in (0, 1). \quad (4)$$

Thus, each country's NE strategy is its dominant strategy and depends only on its own cost parameter, $\gamma_i \in (1, \infty)$. Since \hat{a}_i is less than 1, neither country resettles everyone on its own initiative.

Let us maintain the following two assumptions from here on.

Assumption 1 (Noncooperation does not achieve full resettlement)

$$\hat{a}_i + \hat{a}_j < 1$$

By holding this assumption, we concentrate on the situation where $\hat{a}_i \in (0, 1 - \hat{a}_j)$ because, if it does not hold, cooperation is unnecessary for achieving full resettlement. That is, cases of $\hat{a}_i + \hat{a}_j \geq 1$ do not concern us in this paper.

Assumption 2 (Scope to cooperate for full resettlement exists)

$$\exists \theta_i \in (0, 1) \text{ that can hold } u_i(\theta_i, \theta_j) > u_i(\hat{a}_i, \hat{a}_j) \quad \forall i$$

¹⁵Later in Sections 5 and 6, we consider cases where such scope is absent.

¹⁶In repeated game theory, the static game that is repeatedly played is usually referred to as the stage game (Fudenberg and Tirole, 1991: 146). As we use the word 'stage' when examining bargaining, we simply call it the static game to avoid confusion.

This assumption implies that each country is potentially better off when both countries cooperate with each other to achieve full resettlement than when they do not. Because \hat{a}_i is country i 's dominant strategy, both $u_i(\theta_i, \hat{a}_j) < u_i(\hat{a}_i, \hat{a}_j)$ and $u_i(\theta_i, \theta_j) < u_i(\hat{a}_i, \theta_j)$ must hold. The countries are thus in prisoners' dilemma when we consider the range of full-resettlement shares that meet the inequality in the assumption.

Assumption 2 also implies that, if cooperated full resettlement is to be mutually beneficial, each country must resettle more refugees than it does in NE, i.e. $\hat{a}_i < \theta_i \forall i$, because any θ_i that meets the inequality of Assumption 2 for both countries must hold both $u_i(\theta_i, \hat{a}_j) < u_i(\theta_i, \theta_j)$ and $u_i(\hat{a}_i, \hat{a}_j) < u_i(\hat{a}_i, \theta_j)$ for all i .

By holding the two assumptions, our interest in the determination of θ_i is narrowed down to the interval $(\hat{a}_i, 1 - \hat{a}_j)$. Mutually beneficial divisions of full resettlement form a subset of this interval.

Lemma 1 There exists an interval $[\theta_i^L, \theta_i^U] \subset (\hat{a}_i, 1 - \hat{a}_j)$ in which $u_i(\theta_i, \theta_j) \geq u_i(\hat{a}_i, \hat{a}_j)$ holds $\forall \theta_i \in [\theta_i^L, \theta_i^U]$ and $\forall i$ with $u_i(\theta_i^U, 1 - \theta_i^U) = u_i(\hat{a}_i, \hat{a}_j)$ and $u_j(1 - \theta_i^L, \theta_i^L) = u_j(\hat{a}_j, \hat{a}_i)$.

Proof. First, $u_i(\theta_i, 1 - \theta_i)$ is monotonically decreasing in $\theta_i > [(1 - \beta_i) / \gamma_i]^{\frac{1}{\gamma_i - 1}}$, and $u_j(1 - \theta_i, \theta_i)$ monotonically increasing in $\theta_i < 1 - [(1 - \beta_j) / \gamma_j]^{\frac{1}{\gamma_j - 1}}$. Since $[(1 - \beta_i) / \gamma_i]^{\frac{1}{\gamma_i - 1}} < \hat{a}_i < 1 - \hat{a}_j < 1 - [(1 - \beta_j) / \gamma_j]^{\frac{1}{\gamma_j - 1}}$ holds, $u_i(\theta_i, 1 - \theta_i)$ is monotonically decreasing in $\theta_i > \hat{a}_i$, and $u_j(1 - \theta_i, \theta_i)$ monotonically increasing in $\theta_i < 1 - \hat{a}_j$.

Second, Assumption 2 guarantees the existence of a θ_i' that can hold both $u_i(\theta_i', 1 - \theta_i') > u_i(\hat{a}_i, \hat{a}_j)$ and $u_j(1 - \theta_i', \theta_i') > u_j(\hat{a}_j, \hat{a}_i)$. Pick any such θ_i' . Since $u_i(1 - \hat{a}_j, \hat{a}_j) < u_i(\hat{a}_i, \hat{a}_j)$ holds and $u_i(\theta_i, 1 - \theta_i)$ is monotonically decreasing in $\theta_i > \hat{a}_i$, there exists $\theta_i^U \in (\theta_i', 1 - \hat{a}_j)$ that holds $u_i(\theta_i^U, 1 - \theta_i^U) = u_i(\hat{a}_i, \hat{a}_j)$. Additionally, we have $u_j(1 - \theta_i^U, \theta_i^U) > u_j(1 - \theta_i', \theta_i') > u_j(\hat{a}_j, \hat{a}_i)$ because $du_j(1 - \theta_i, \theta_i) / d\theta_i > 0 \forall \theta_i < 1 - \hat{a}_j$.

Third, there exists $\theta_i^L \in (\hat{a}_i, \theta_i')$ that holds $u_j(1 - \theta_i^L, \theta_i^L) = u_j(\hat{a}_j, \hat{a}_i)$ because $u_j(1 - \hat{a}_i, \hat{a}_i) < u_j(\hat{a}_j, \hat{a}_i)$ holds and $u_j(1 - \theta_i, \theta_i)$ is monotonically increasing in $\theta_i < 1 - \hat{a}_j$. Also, $u_i(\theta_i^L, 1 - \theta_i^L) > u_i(\theta_i', 1 - \theta_i') > u_i(\hat{a}_i, \hat{a}_j)$ because $du_i(\theta_i, 1 - \theta_i) / d\theta_i < 0 \forall \theta_i > \hat{a}_i$.

Thus, $\forall \theta_i \in [\theta_i^L, \theta_i^U]$, the pair $(\theta_i, 1 - \theta_i)$ Pareto-dominates (\hat{a}_i, \hat{a}_j) . ■

3.2 Condition for long-run cooperation

To examine the possibility of sustainable full-resettlement sharing, we analyze the trigger-strategy equilibrium in the infinitely repeated game. Country i 's strategy is the following

contingent action plan:

$$\sigma_i(h_t) = \begin{cases} \theta_i & \text{if } t = 0 \text{ or } h_t = (\theta, \theta, \dots, \theta) \text{ for any } t \geq 1, \\ \hat{a}_i & \text{otherwise.} \end{cases} \quad (5)$$

Recall $h_t = (a_0, a_1, \dots, a_{t-1})$ where $a_\tau = (a_{i,\tau}, a_{j,\tau})$ with $\tau = 0, 1, \dots, t-1$. Hence $h_t = (\theta, \theta, \dots, \theta)$ means $a_\tau = \theta = (\theta_i, \theta_j) \forall \tau$. Country i will resettle the same θ_i in every subsequent period unless at least one of them deviates from θ . If instead $(a_i, a_j) \neq (\theta_i, \theta_j)$ in some period t , it will resettle only \hat{a}_i every period from period $t+1$ onward. Punishment by the repetition of the static-game NE represents the country's withdrawal from the full-resettlement sharing agreement.¹⁷

Country i 's continuation payoff from cooperated full resettlement in any period is

$$\begin{aligned} v_i^C(\theta_i) &= u_i(\theta_i, 1 - \theta_i) + \delta_i v_i^C(\theta_i) \\ &= \frac{\beta_i + (1 - \beta_i)\theta_i - \theta_i^{\gamma_i}}{1 - \delta_i}. \end{aligned} \quad (6)$$

On the other hand, i 's continuation payoff from optimally deviating from cooperation in any period is

$$\begin{aligned} v_i^D(\theta_i) &= u_i(\hat{a}_i, 1 - \theta_i) + \frac{\delta_i}{1 - \delta_i} u_i(\hat{a}_i, \hat{a}_j) \\ &= \hat{a}_i + \beta_i(1 - \theta_i) - \hat{a}_i^{\gamma_i} + \frac{\delta_i}{1 - \delta_i} (\hat{a}_i + \beta_i \hat{a}_j - \hat{a}_i^{\gamma_i}). \end{aligned} \quad (7)$$

Accordingly, the country cooperates in any period iff $v_i^C(\theta_i) \geq v_i^D(\theta_i)$ or equivalently

$$\delta_i \geq \frac{u_i(\hat{a}_i, 1 - \theta_i) - u_i(\theta_i, 1 - \theta_i)}{u_i(\hat{a}_i, 1 - \theta_i) - u_i(\hat{a}_i, \hat{a}_j)} \quad (8)$$

¹⁷Theoretically speaking, Nash reversion is not the severest punishment because the continuation payoff vector is not an extreme point of the equilibrium payoff set in the game. In other words, we can construct a severer punishment by setting the deviant's continuation payoff to the extreme point that minimizes its payoff in the equilibrium payoff set (Abreu, 1988). However, in our context, Nash reversion is the severest punishment practically implementable, although countries may not implement it in reality for various reasons. For example, imposing sanctions on the deviating country is a severer punishment but is unrealistic because resettlement is a matter of sovereignty and, to our best knowledge, there is no precedent of such a sanction. In a laboratory setting, Dal Bó and Fréchette (2019) found that the grim trigger strategy is one of the most commonly used strategies in the infinitely repeated prisoner's dilemma with perfect monitoring.

or also equivalently

$$\delta_i \geq \tilde{\delta}_i(\theta_i) \equiv \frac{\overbrace{(\theta_i^{\gamma_i} - \hat{a}_i^{\gamma_i})}^{\text{Loss from cooperation}} - \overbrace{(\theta_i - \hat{a}_i)}^{\text{Gain from cooperation}}}{\underbrace{\beta_i(\theta_j - \hat{a}_j)}_{\text{Externality gain from cooperation}}}. \quad (9)$$

Recall that the three bracketed terms which define the threshold for country i 's discount factor in Eq.(9) are all positive for the values of θ_i that hold the inequality in Assumption 2. The expression shows that, if country i is to cooperate, the loss from cooperation resulting from increased hosting costs requires the country to value future payoffs sufficiently highly, that is, to have a sufficiently high discount factor. On the other hand, the gains from cooperation motivate the country to cooperate even if it may not care about future payoffs too much.

Note, for all i , $\tilde{\delta}_i(\theta_i) > 0$ holds because $\theta_i > \hat{a}_i$ for all i implies both numerator and denominator of Eq.(8) are positive, and $\tilde{\delta}_i(\theta_i) \leq 1$ holds for all $\theta_i \in [\theta_i^L, \theta_i^U]$ by Lemma 1. By Expression (8), $\tilde{\delta}_i(\theta_i^U) = \tilde{\delta}_j(\theta_i^L) = 1$ holds, but we have already stated that we ignore the trivial case of $\delta_i = 1$ and assume $\delta_i \in (0, 1) \forall i$. Therefore, we are interested in the open interval (θ_i^L, θ_i^U) .

Lemma 2 The threshold for country i 's discount factor, $\tilde{\delta}_i(\theta_i)$, is strictly increasing in its share of full resettlement over the interval (θ_i^L, θ_i^U) .

Proof.

$$\frac{\partial \tilde{\delta}_i}{\partial \theta_i} = \frac{(\gamma_i \theta_i^{\gamma_i - 1} - 1)(\theta_j - \hat{a}_j) + [(\theta_i^{\gamma_i} - \hat{a}_i^{\gamma_i}) - (\theta_i - \hat{a}_i)]}{\beta_i(\theta_j - \hat{a}_j)^2} > 0 \quad (10)$$

because, by Assumption 2, $\theta_i > \hat{a}_i = \gamma_i^{\frac{-1}{\gamma_i - 1}}$ for any $\theta_i \in (\theta_i^L, \theta_i^U)$, namely, the first term in the numerator is positive. ■

Lemma 3 There exists a unique $\tilde{\theta}_i^*$ that holds $\tilde{\delta}_i(\tilde{\theta}_i^*) = \tilde{\delta}_j(\tilde{\theta}_i^*)$.

Proof. By Lemma 2, $\partial \tilde{\delta}_i / \partial \theta_i > 0$ and $\partial \tilde{\delta}_j / \partial \theta_i < 0$ over (θ_i^L, θ_i^U) . By Expression (8), $\tilde{\delta}_i(\theta_i^U) = \tilde{\delta}_j(\theta_i^L) = 1$, $\tilde{\delta}_i(\theta_i^L) \in (0, 1)$ and $\tilde{\delta}_j(\theta_i^U) \in (0, 1)$. ■

[Insert Fig. 1 here]

In Fig.1, we plot both $\tilde{\delta}_i(\theta_i)$ and $\tilde{\delta}_j(\theta_i)$. Let $\bar{\theta}_i(\delta_i) \equiv \tilde{\delta}_i^{-1}(\delta_i)$ which is country i 's largest self-enforceable share of full resettlement. That is, country i will resettle any $\theta_i \in [0, \bar{\theta}_i(\delta_i)]$ if country j will resettle the corresponding $1 - \theta_i \in [1 - \bar{\theta}_i(\delta_i), 1]$. Similarly, country j will resettle any $\theta_j = 1 - \theta_i \in [0, \bar{\theta}_j(\delta_j)]$ if country i will resettle the corresponding $\theta_i \in [1 - \bar{\theta}_j(\delta_j), 1]$.

Let $\tilde{\delta}^*$ denote the value of $\tilde{\delta}_i(\tilde{\theta}_i^*) = \tilde{\delta}_j(\tilde{\theta}_i^*)$. Now suppose $\delta_i = \delta_j > \tilde{\delta}^*$. In this case, there exists a range of self-enforceable shares, namely, $[1 - \bar{\theta}_j(\delta_j), \bar{\theta}_i(\delta_i)] \subset (\theta_i^L, \theta_i^U)$. If $\delta_i = \delta_j = \tilde{\delta}^*$ instead, the self-enforceable share of full resettlement is unique, i.e. $\tilde{\theta}_i^* = \bar{\theta}_i(\delta_i) = 1 - \bar{\theta}_j(\delta_j) \in (\theta_i^L, \theta_i^U)$.

On the other hand, if $\delta_i = \delta_j < \tilde{\delta}^*$, there is no self-enforceable division of full resettlement because $1 - \bar{\theta}_j(\delta_j) > \bar{\theta}_i(\delta_i)$. However, if $\delta_i > \tilde{\delta}^* > \delta_j$ instead, there may still remain scope for full resettlement, which we will discuss subsequently (Subsection 5.3).

The figure shows that the existence of $\tilde{\delta}^* \in (0, 1)$ at a $\theta_i \in (\theta_i^L, \theta_i^U)$ is a necessary but insufficient condition for sharing full resettlement.

3.3 Benchmark: symmetric countries

If the two countries have the same parameters, β, γ, δ , we have

$$u_i(a_i, a_j) = a_i + \beta a_j - a_i^\gamma, \quad (2')$$

and

$$\hat{a}_i = \hat{a}_j = \hat{a} \equiv \gamma^{\frac{-1}{\gamma-1}}. \quad (4')$$

Here, Assumption 1 can be rewritten as $\gamma^{\frac{-1}{\gamma-1}} < 1/2$ or equivalently (see Appendix B)

$$\gamma \in (1, 2). \quad (\text{Assumption 1}')$$

The threshold for country i 's discount factor is

$$\tilde{\delta}_i(\theta_i) = \frac{(\theta_i^\gamma - \hat{a}^\gamma) - (\theta_i - \hat{a})}{\beta(\theta_j - \hat{a})}, \quad (9')$$

and

$$\left(\tilde{\theta}_i^*, \tilde{\delta}^*\right) = \left(\frac{1}{2}, \left[\frac{\left(\frac{1}{2}\right)^\gamma - \gamma^{\frac{-\gamma}{\gamma-1}}}{\frac{1}{2} - \gamma^{\frac{-1}{\gamma-1}}} - 1 \right] \frac{1}{\beta}\right). \quad (11)$$

If $\delta > \tilde{\delta}^*$, there exists a range of self-enforceable shares of full resettlement, $[1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$.

We now examine which element of this interval emerges as the bargaining outcome.

4 Bargained allocation of full resettlement

First of all, since the bargaining equilibrium depends on off-equilibrium paths, we must know what will happen if the countries agree with a share outside the self-enforceable interval $[1 - \bar{\theta}_j(\delta_j), \bar{\theta}_i(\delta_i)]$. If a country proposes such a θ_i and the other country accepts it, the trigger strategy implies that the countries will resettle (\hat{a}_i, \hat{a}_j) every period from then on. Therefore, the continuation payoffs of the countries when θ_i is accepted are

$$(v_i(\theta_i), v_j(\theta_i)) = \begin{cases} (v_i^C(\theta_i), v_j^C(\theta_i)) & \text{if } \theta_i \in [1 - \bar{\theta}_j(\delta_j), \bar{\theta}_i(\delta_i)] \\ (v_i^N, v_j^N) & \text{otherwise,} \end{cases} \quad (12)$$

where $v_i^C(\theta_i)$ is given by Eq.(6) and, for all i ,

$$v_i^N \equiv \frac{\hat{a}_i + \beta_i \hat{a}_j - \hat{a}_i^{\gamma_i}}{1 - \delta_i}. \quad (13)$$

If the proposal is rejected and it is not the last-stage proposal, the bargaining continues and a counter proposal is made.

It is natural to assume that the time unit associated with bargaining is different from that associated with resettlement. We denote country i 's future discount factor per bargaining stage by $g_i \in (0, 1)$.

4.1 Finite-horizon bargaining

Suppose country i is the last proposer. Country j will accept i 's last-stage proposal $\theta_{i,S}$ and will not deviate from the agreement if and only if both

$$v_j^C(\theta_{i,S}) \geq v_j^D(\theta_{i,S}) \quad (14)$$

and

$$v_j^C(\theta_{i,S}) \geq g_j v_j^N. \quad (15)$$

By Lemma 1, the second inequality is guaranteed for any $\theta_i \in (\theta_i^L, \theta_i^U)$. On the other hand, the first inequality may or may not be satisfied, depending on whether δ_j is at least as large as $\tilde{\delta}_j(\theta_{i,S})$ as shown in Inequality (9). If $\delta_j \geq \tilde{\delta}_j(\theta_{i,S})$, any $\theta_i \in [1 - \bar{\theta}_j(\delta_j), 1]$ can meet the first inequality.

Country i 's most preferred θ_i over the interval $[1 - \bar{\theta}_j(\delta_j), 1]$ is $1 - \bar{\theta}_j(\delta_j)$ so that its share of full resettlement can be minimized and its payoff maximized. The country will propose $1 - \bar{\theta}_j(\delta_j)$ if and only if both

$$v_i^C(1 - \bar{\theta}_j(\delta_j)) \geq v_i^D(1 - \bar{\theta}_j(\delta_j)) \quad (16)$$

and

$$v_i^C(1 - \bar{\theta}_j(\delta_j)) \geq g_i v_i^N. \quad (17)$$

The second inequality is guaranteed by Lemma 1 because the proposal falls within the interval (θ_i^L, θ_i^U) . On the other hand, the satisfaction of the first inequality depends on whether $\delta_i \geq \tilde{\delta}_i(1 - \bar{\theta}_j(\delta_j))$ holds.

Using this logic in backward induction, let us now examine all possible outcomes in the benchmark case of Subsection 3.3. We will not reintroduce parametric heterogeneity until Section 5. Let $g_i = g_j = g$.

Proposition 1 Suppose the two countries are identical.

(i) If $\delta > \tilde{\delta}^*$, they immediately agree to share full resettlement with a $\theta_{i,1} \in [1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$

and do not deviate from the agreement.

(ii) If $\delta = \tilde{\delta}^*$, they immediately agree to share full resettlement equally and do not deviate from the agreement.

(iii) They do not agree to share full resettlement if and only if $\delta < \tilde{\delta}^*$.

Proof. Suppose country i is the last proposer.

(i) If $\delta > \tilde{\delta}^*$, a self-enforceable interval $[1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$ exists. At the last stage S , non-proposer j will obtain either $v_j^C(\theta_{i,S})$ by accepting any $\theta_{i,S} \in [1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$ or v_j^N which is smaller than $v_j^C(\theta_{i,S})$ by rejecting it. Hence it will accept any $\theta_{i,S} \in [1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$. It is indifferent between accepting and rejecting any other $\theta_{i,S}$ because, at the last stage, its payoff is v_j^N regardless of the decision. Given j 's decision rule, proposer i will propose a $\theta_{i,S} \in [1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$ and obtain $v_i^C(\theta_{i,S})$ instead of any other $\theta_{i,S}$ that will result in v_i^N which is smaller than $v_i^C(\theta_{i,S})$. Country i 's optimal proposal at stage S is thus

$$\theta_{i,S}^* \equiv \arg \max_{\theta_{i,S} \in [1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]} v_i^C(\theta_{i,S}) = 1 - \bar{\theta}_j(\delta). \quad (18)$$

At stage $S - 1$, non-proposer i will obtain $gv_i^C(1 - \bar{\theta}_j(\delta))$ if it rejects any proposal. Hence it will accept any $\theta_{i,S-1} \in [1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$ if $v_i^C(\bar{\theta}_i(\delta)) \geq gv_i^C(1 - \bar{\theta}_j(\delta))$. Otherwise, it will accept any $\theta_{i,S-1} \in [1 - \bar{\theta}_j(\delta), \theta'_{i,S-1}]$ where $\theta'_{i,S-1}$ meets $v_i^C(\theta'_{i,S-1}) = gv_i^C(1 - \bar{\theta}_j(\delta))$ and is smaller than $\bar{\theta}_i(\delta)$. In short, country i will accept any $\theta_{i,S-1} \in [1 - \bar{\theta}_j(\delta), \min\{\theta'_{i,S-1}, \bar{\theta}_i(\delta)\}]$. It will accept any $\theta_{i,S-1} \notin [1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$ if $v_i^N \geq gv_i^C(1 - \bar{\theta}_j(\delta))$ and reject it otherwise. If $\theta'_{i,S-1} < \bar{\theta}_i(\delta)$, it will reject any $\theta_{i,S-1} \in (\theta'_{i,S-1}, \bar{\theta}_i(\delta)]$ because $v_i^C(\theta_{i,S-1}) < gv_i^C(1 - \bar{\theta}_j(\delta))$ for such a proposal. However, the accept-reject decision regarding a $\theta_{i,S-1} \notin [1 - \bar{\theta}_j(\delta), \min\{\theta'_{i,S-1}, \bar{\theta}_i(\delta)\}]$ does not matter to the proposal decision because the proposer's payoff is always lower when i 's share falls outside the interval than when it falls within it. Hence the proposer will not propose one outside the interval. Given i 's decision rule, proposer j at stage $S - 1$ will propose

$$\theta_{i,S-1}^* \equiv \arg \max_{\theta_{i,S-1} \in [1 - \bar{\theta}_j(\delta), \min\{\theta'_{i,S-1}, \bar{\theta}_i(\delta)\}]} v_j^C(\theta_{i,S-1}) = \min\{\theta'_{i,S-1}, \bar{\theta}_i(\delta)\}. \quad (19)$$

At stage $S - 2$, non-proposer j will obtain $gv_j^C(\theta_{i,S-1}^*)$ if it rejects any proposal. Hence it will accept any $\theta_{i,S-2} \in [1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$ if $v_j^C(1 - \bar{\theta}_j(\delta)) \geq gv_j^C(\theta_{i,S-1}^*)$. Otherwise, it will accept any $\theta_{i,S-2} \in [\theta'_{i,S-2}, \bar{\theta}_i(\delta)]$ where $\theta'_{i,S-2}$ meets $v_j^C(\theta'_{i,S-2}) = gv_j^C(\theta_{i,S-1}^*)$ and is larger than $1 - \bar{\theta}_j(\delta)$. In short, j will accept any $\theta_{i,S-2} \in [\max\{1 - \bar{\theta}_j(\delta), \theta'_{i,S-2}\}, \bar{\theta}_i(\delta)]$. It will accept any $\theta_{i,S-2} \notin [1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$ if $v_j^N \geq gv_j^C(\theta_{i,S-1}^*)$ and reject it otherwise. If $\theta'_{i,S-2} > 1 - \bar{\theta}_j(\delta)$, it will reject any $\theta_{i,S-2} \in [1 - \bar{\theta}_j(\delta), \theta'_{i,S-2})$ because $v_j^C(\theta_{i,S-2}) < gv_j^C(\theta_{i,S-1}^*)$ for such a proposal. However, the accept-reject decision regarding a $\theta_{i,S-2} \notin [\max\{1 - \bar{\theta}_j(\delta), \theta'_{i,S-2}\}, \bar{\theta}_i(\delta)]$ does not matter to the proposal decision because the proposer's payoff is always lower when i 's share falls outside the interval than when it falls within it. Hence the proposer will not propose one outside the interval.

Given j 's decision rule, proposer i at stage $S - 2$ will propose

$$\theta_{i,S-2}^* \equiv \arg \max_{\theta_{i,S-2} \in [\max\{1 - \bar{\theta}_j(\delta), \theta'_{i,S-2}\}, \bar{\theta}_i(\delta)]} v_i^C(\theta_{i,S-2}) = \max\{1 - \bar{\theta}_j(\delta), \theta'_{i,S-2}\}. \quad (20)$$

In general, consider any stage $s \neq S$ where i is the proposer. By the same argument as above, j will accept any $\theta_{i,s} \in [\max\{1 - \bar{\theta}_j(\delta), \theta'_{i,s}\}, \bar{\theta}_i(\delta)]$ where $\theta'_{i,s}$ meets $v_j^C(\theta'_{i,s}) = gv_j^C(\min\{\theta'_{i,s+1}, \bar{\theta}_i(\delta)\})$, and i will propose

$$\theta_{i,s}^* = \max\{1 - \bar{\theta}_j(\delta), \theta'_{i,s}\}. \quad (21)$$

At the next stage, i will accept any $\theta_{i,s+1} \in [1 - \bar{\theta}_j(\delta), \min\{\theta'_{i,s+1}, \bar{\theta}_i(\delta)\}]$ where $\theta'_{i,s+1}$ meets $v_i^C(\theta'_{i,s+1}) = gv_i^C(\max\{1 - \bar{\theta}_j(\delta), \theta'_{i,s+2}\})$, and j will propose

$$\theta_{i,s+1}^* = \min\{\theta'_{i,s+1}, \bar{\theta}_i(\delta)\}. \quad (22)$$

In sum, whichever country proposes first, the first proposal will fall within the interval $[1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$ and the receiver will accept it. Both countries will not have an incentive to deviate from the agreement.

(ii) If $\delta = \tilde{\delta}^*$, then $\bar{\theta}_i(\delta) = 1 - \bar{\theta}_j(\delta) \iff \bar{\theta}_i(\delta) = \bar{\theta}_j(\delta) = 1/2$ by symmetry. Hence $1/2$ will be accepted. Any other proposal will be either accepted or rejected depending on g , but it is irrelevant to the equilibrium because a proposer does not propose a $\theta_i \neq 1/2$ by the following argument. The optimal proposal (21) implies that, at any arbitrary stage s where i is the proposer, $\theta_{i,s}^* = \max\{1 - \bar{\theta}_j(\delta), \theta'_{i,s}\} = \max\{1/2, \theta'_{i,s}\} = 1/2$ because $\theta'_{i,s} \leq \bar{\theta}_i(\delta) = 1/2$ where $\theta'_{i,s}$ holds $v_j^C(\theta'_{i,s}) = gv_j^C(\theta'_{i,s+1})$. Similarly, using Eq.(22), at any arbitrary stage s where j is the proposer, $\theta_{i,s}^* = \min\{\theta'_{i,s}, \bar{\theta}_i(\delta)\} = \min\{\theta'_{i,s}, 1/2\} = 1/2$ because $\theta'_{i,s} \geq 1 - \bar{\theta}_j(\delta) = 1/2$ where $\theta'_{i,s}$ holds $v_i^C(\theta'_{i,s}) = gv_i^C(\theta'_{i,s+1})$. Hence in SPE the proposer of any stage will propose $1/2$, and the other country will accept it.

(iii) $\delta < \tilde{\delta}^* \iff \delta < \tilde{\delta}_i(\theta_{i,s}) \forall i, s \iff 1 - \bar{\theta}_j(\delta) > \bar{\theta}_i(\delta)$. ■

The SPE outcome for $\delta > \tilde{\delta}^*$ in Proposition 1(i) depends on which country is the first proposer, which one is the last proposer, the number of bargaining stages, the bargaining-stage discount factor, and the bounds of the self-enforceable interval. We examine this dependency in the rest of this subsection and also in Section 5. In any case, unless $\theta'_{i,1}$ happens to be $1/2$, the identical countries will agree with an unequal sharing rule at the first stage, although their SPE proposals will be symmetric in the sense that their equilibrium strategies are mirror images when the assignment of first and last proposing rights is swapped between the countries.¹⁸

¹⁸Tamura (2018) also finds that symmetric countries are more likely to host refugees unequally in number, although in a different context where there is no source of heterogeneity such as the rights to propose first and last. He examines noncooperative outcomes in one shot, and the model allows for asylum-seeking behavior while countries are not allowed to bargain.

First, we examine how the bargaining-stage discount factor affects the equilibrium strategies described in the proof of Proposition 1(i). The next proposition lists all potential cases by describing the strategies for different values of g . Let us continue to suppose that the countries are identical and country i is the proposer at the last stage S . Let

$$\bar{g}_i^N \equiv \frac{v_i^N}{v_i^C (1 - \bar{\theta}_j(\delta))} = \bar{g}_j^N \equiv \frac{v_j^N}{v_j^C (\bar{\theta}_i(\delta))}, \quad (23)$$

$$\bar{g}_{i,S-1} \equiv \frac{v_i^C (\bar{\theta}_i(\delta))}{v_i^C (\theta_{i,S}^*)} = \frac{v_i^C (\bar{\theta}_i(\delta))}{v_i^C (1 - \bar{\theta}_j(\delta))}. \quad (24)$$

Eq.(23) defines the threshold value of the bargaining-stage discount factor at which a country is indifferent between accepting a proposal outside the self-enforceable interval and rejecting it to have its most preferred share of full resettlement accepted at the next stage, e.g. $v_i^N = \bar{g}_i^N v_i^C (1 - \bar{\theta}_j(\delta))$. Under the assumption of identical countries, we have $\bar{g}_i^N = \bar{g}_j^N$. Eq.(24) defines the threshold value at which the last proposer i is indifferent between accepting the least preferred proposal within the self-enforceable interval at the second last stage $S - 1$ and rejecting it to have its optimal counter-proposal accepted at the next stage. As shown in Eq.(18) in the proof of Proposition 1(i), $1 - \bar{\theta}_j(\delta)$ in Eq.(24) is i 's optimal counter-proposal at the last bargaining stage. Note that $\bar{g}_i^N < \bar{g}_{i,S-1}$ holds.

Proposition 2 Suppose the countries are identical and the last proposer is country i . The following strategies then constitute SPE when $\delta > \tilde{\delta}^*$.

(i) Suppose $g \leq \bar{g}_{i,S-1}$. The proposer at any stage proposes to admit the smallest share of full resettlement within the self-enforceable interval $[1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$. The other country accepts any proposal if $g \leq \bar{g}_i^N$. Otherwise, it accepts only those within the interval.

(ii) Suppose $g > \bar{g}_{i,S-1}$.

(ii.a) At the last stage S , country i proposes to admit the smallest share of full resettlement within the self-enforceable interval, i.e. $1 - \bar{\theta}_j(\delta)$. Country j accepts any proposal within the interval and is indifferent between accepting and rejecting any other.

(ii.b) At any proposing stage $s \neq S$, country i proposes to admit $\theta_{i,s}^* \in (1 - \bar{\theta}_j(\delta), \theta_{i,s+1}^*)$ that is never smaller than any of its future proposals. Country j accepts any proposal

within $[\theta_{i,s}^*, \bar{\theta}_i(\delta)]$ and rejects any other.

(ii.c) At any proposing stage $s - 1$, country j proposes country i to admit $\theta_{i,s-1}^* \in (1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$ that is never smaller than any of its future proposals. Country i accepts any proposal within $[1 - \bar{\theta}_j(\delta), \theta_{i,s-1}^*]$ and rejects any other.

(ii.d) Country j 's proposal at any stage is always larger than country i 's proposal at the immediately preceding stage.

Proof. (i) Consider any arbitrary stage at which country j proposes. In equilibrium, country i will accept any $\theta_i \in [1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$ because $g \leq \bar{g}_{i,S-1} \iff v_i^C(\bar{\theta}_i(\delta)) \geq gv_i^C(1 - \bar{\theta}_j(\delta))$, i.e. accepting the least preferred share now is at least as good as having the most preferred share accepted at the next stage. It will accept any other proposal if $v_i^N \geq gv_i^C(1 - \bar{\theta}_j(\delta)) \iff g \leq \bar{g}_i^N$ and reject it otherwise. Hence country j will propose its most preferred share, $\bar{\theta}_i(\delta)$. Now, turn to any arbitrary stage at which country i proposes. Since $\bar{g}_{i,S-1} = v_j^C(1 - \bar{\theta}_j(\delta)) / v_j^C(\bar{\theta}_i(\delta))$ by the symmetric assumption, country j will accept any $\theta_i \in [1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$ in equilibrium. It will accept any other proposal if $v_j^N \geq gv_j^C(\bar{\theta}_i(\delta)) \iff g \leq \bar{g}_j^N$ and reject it otherwise. Hence country i will propose its most preferred share, $1 - \bar{\theta}_j(\delta)$.

(ii) The proof of Proposition 1(i) has shown that, at the last stage S , country j will accept any proposal within the self-enforceable interval and be indifferent between accepting and rejecting any other in equilibrium, and i 's SPE proposal is $1 - \bar{\theta}_j(\delta)$.

At stage $S - 1$, the proof of Proposition 1(i) implies that in equilibrium country i will accept any $\theta_{i,S-1} \in [1 - \bar{\theta}_j(\delta), \theta'_{i,S-1}]$ where $\theta'_{i,S-1} < \bar{\theta}_i(\delta)$ because

$$g > \bar{g}_{i,S-1} \iff v_i^C(\bar{\theta}_i(\delta)) < gv_i^C(1 - \bar{\theta}_j(\delta)), \quad (25)$$

i.e. $\min\{\theta'_{i,S-1}, \bar{\theta}_i(\delta)\} = \theta'_{i,S-1}$ that holds $v_i^C(\theta'_{i,S-1}) = gv_i^C(1 - \bar{\theta}_j(\delta))$ and hence $\bar{\theta}_i(\delta)$ is too high for the country to accept. The country will reject any other $\theta_{i,S-1}$ in equilibrium because $v_i^C(\theta_{i,S-1}) < gv_i^C(1 - \bar{\theta}_j(\delta))$ for such a $\theta_{i,S-1}$. Given i 's decision rule, j 's SPE proposal in Eq.(22) is $\theta_{i,S-1}^* = \theta'_{i,S-1} \in (1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta))$.

At stage $S - 2$, the proof of Proposition 1(i) implies that in equilibrium country j will

accept any $\theta_{i,S-2} \in [\theta'_{i,S-2}, \bar{\theta}_i(\delta)]$ where $\theta'_{i,S-2} > 1 - \bar{\theta}_j(\delta)$ because¹⁹

$$g > \bar{g}_{i,S-1} \implies v_j^C(1 - \bar{\theta}_j(\delta)) < gv_j^C(\theta_{i,S-1}^*), \quad (26)$$

i.e. $\max\{1 - \bar{\theta}_j(\delta), \theta'_{i,S-2}\} = \theta'_{i,S-2}$ that holds $v_j^C(\theta'_{i,S-2}) = gv_j^C(\theta_{i,S-1}^*)$ and hence $1 - \bar{\theta}_j(\delta)$ is too low (equivalently $\bar{\theta}_j(\delta)$ is too high) for the country to accept. Note that $v_j^C(\theta'_{i,S-2}) = gv_j^C(\theta_{i,S-1}^*)$ implies $\theta'_{i,S-2} < \theta_{i,S-1}^*$ because $v_j^C(\cdot)$ is an increasing function. Country j will reject any other $\theta_{i,S-2}$ in equilibrium because $v_j^C(\theta_{i,S-2}) < gv_j^C(\theta_{i,S-1}^*)$ for such a $\theta_{i,S-2}$. Given j 's decision rule, i 's SPE proposal in Eq.(21) is $\theta_{i,S-2}^* = \theta'_{i,S-2} \in (1 - \bar{\theta}_j(\delta), \theta_{i,S-1}^*)$.

At stage $S - 3$, country i will accept any $\theta_{i,S-3} \in [1 - \bar{\theta}_j(\delta), \min\{\theta'_{i,S-3}, \bar{\theta}_i(\delta)\}]$ in equilibrium where $\theta'_{i,S-3}$ holds $v_i^C(\theta'_{i,S-3}) = gv_i^C(\theta_{i,S-2}^*)$. This equality implies $\theta'_{i,S-3} > \theta_{i,S-2}^*$ because $v_i^C(\cdot)$ is a decreasing function. The country will reject any $\theta_{i,S-3} \notin [1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$, and also any $\theta_{i,S-3} \in (\theta'_{i,S-3}, \bar{\theta}_i(\delta)]$ if $\theta'_{i,S-3} < \bar{\theta}_i(\delta)$ because $v_i^C(\theta_{i,S-3}) < gv_i^C(\theta_{i,S-2}^*)$ for such a proposal. Given i 's decision rule, j 's SPE proposal in Eq.(22) is $\theta_{i,S-3}^* = \min\{\theta'_{i,S-3}, \bar{\theta}_i(\delta)\}$. Note that, since $1 - \bar{\theta}_j(\delta) < \theta_{i,S-2}^*$ and

$$\frac{v_i^C(\theta_{i,S-1}^*)}{v_i^C(1 - \bar{\theta}_j(\delta))} = g = \frac{v_i^C(\theta'_{i,S-3})}{v_i^C(\theta_{i,S-2}^*)} \quad (27)$$

where the first equality determines $\theta_{i,S-1}^*$ and the second $\theta'_{i,S-3}$, we must have $\theta_{i,S-1}^* < \theta'_{i,S-3}$. Thus, $\theta_{i,S-3}^* \in (\theta_{i,S-1}^*, \bar{\theta}_i(\delta)]$.

At stage $S - 4$, in equilibrium, country j will accept any $\theta_{i,S-4} \in [\theta'_{i,S-4}, \bar{\theta}_i(\delta)]$ where $\theta'_{i,S-4}$ holds $v_j^C(\theta'_{i,S-4}) = gv_j^C(\theta_{i,S-3}^*)$ which in turn implies $\theta'_{i,S-4} < \theta_{i,S-3}^*$. We also know that $\theta'_{i,S-4} > \theta_{i,S-2}^*$ because we must hold

$$\frac{v_j^C(\theta_{i,S-2}^*)}{v_j^C(\theta_{i,S-1}^*)} = g = \frac{v_j^C(\theta'_{i,S-4})}{v_j^C(\theta_{i,S-3}^*)} \quad (28)$$

where $\theta_{i,S-1}^* < \theta_{i,S-3}^*$ as we have shown earlier. The country will reject any other $\theta_{i,S-4}$ by the same argument used at stage $S - 2$ above. Given j 's decision rule, i proposes $\theta_{i,S-4}^* = \theta'_{i,S-4} \in (\theta_{i,S-2}^*, \theta_{i,S-3}^*)$ in SPE, as in Eq.(21).

At stage $S - 5$, country i will accept any $\theta_{i,S-5} \in [1 - \bar{\theta}_j(\delta), \min\{\theta'_{i,S-5}, \bar{\theta}_i(\delta)\}]$ in equilibrium where $\theta'_{i,S-5}$ meets $v_i^C(\theta'_{i,S-5}) = gv_i^C(\theta_{i,S-4}^*)$ which in turn implies $\theta'_{i,S-5} >$

¹⁹Let us prove (26) by contradiction. Suppose $g > \bar{g}_{i,S-1} \implies v_j^C(1 - \bar{\theta}_j(\delta)) \geq gv_j^C(\theta_{i,S-1}^*)$. Since we have $\theta_{i,S-1}^* = \min\{\theta'_{i,S-1}, \bar{\theta}_i(\delta)\} = \theta'_{i,S-1}$ that holds $v_i^C(\theta'_{i,S-1}) = gv_i^C(1 - \bar{\theta}_j(\delta))$ when $g > \bar{g}_{i,S-1}$, the implied inequality can be rewritten as $v_i^C(1 - \bar{\theta}_j(\delta)) v_j^C(1 - \bar{\theta}_j(\delta)) / v_j^C(\theta'_{i,S-1}) \geq v_i^C(\theta'_{i,S-1})$.

Note that we must have $v_i^C(1 - \bar{\theta}_j(\delta)) + v_j^C(1 - \bar{\theta}_j(\delta)) < v_i^C(\theta'_{i,S-1}) + v_j^C(\theta'_{i,S-1})$ because (i) $\theta'_{i,S-1} \in (1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta))$, (ii) the total payoff under cooperation, $v_i^C(\theta_i) + v_j^C(\theta_i)$, is increasing in θ_i over $[1 - \bar{\theta}_j(\delta), 1/2]$, maximised at $\theta_i = 1/2$ and decreasing over $(1/2, \bar{\theta}_i(\delta)]$, and (iii) $v_i^C(1 - \bar{\theta}_j(\delta)) + v_j^C(1 - \bar{\theta}_j(\delta)) = v_i^C(\bar{\theta}_i(\delta)) + v_j^C(\bar{\theta}_i(\delta))$.

The implied weak inequality in the beginning then implies that we must have

$$v_i^C(1 - \bar{\theta}_j(\delta)) + v_j^C(1 - \bar{\theta}_j(\delta)) < v_i^C(1 - \bar{\theta}_j(\delta)) v_j^C(1 - \bar{\theta}_j(\delta)) / v_j^C(\theta'_{i,S-1}) + v_j^C(\theta'_{i,S-1})$$

which, after a few manipulations, reduces to $v_i^C(1 - \bar{\theta}_j(\delta)) < v_j^C(\theta'_{i,S-1})$. This is a contradiction because we have $v_j^C(\theta_i) < v_j^C(\bar{\theta}_i(\delta)) = v_i^C(1 - \bar{\theta}_j(\delta))$ for all $\theta_i \in (1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta))$. Hence $v_j^C(1 - \bar{\theta}_j(\delta)) < gv_j^C(\theta_{i,S-1}^*)$ must hold if $g > \bar{g}_{i,S-1}$.

$\theta_{i,S-4}^*$. We also know that $\theta'_{i,S-5} > \theta'_{i,S-3}$ because we must hold

$$\frac{v_i^C(\theta_{i,S-3}^*)}{v_i^C(\theta_{i,S-2}^*)} \geq \frac{v_i^C(\theta'_{i,S-3})}{v_i^C(\theta_{i,S-2}^*)} = g = \frac{v_i^C(\theta'_{i,S-5})}{v_i^C(\theta_{i,S-4}^*)}, \quad (29)$$

where $\theta_{i,S-4}^* > \theta_{i,S-2}^*$ as we have shown earlier. Hence $\min\{\theta'_{i,S-5}, \bar{\theta}_i(\delta)\} \geq \theta_{i,S-3}^* = \min\{\theta'_{i,S-3}, \bar{\theta}_i(\delta)\}$. The country will reject any other $\theta_{i,S-5}$ by the same argument used at stage $S-3$ above. Given i 's decision rule, j proposes $\theta_{i,S-5}^* = \min\{\theta'_{i,S-5}, \bar{\theta}_i(\delta)\}$ in SPE, as in Eq.(22).

To summarize, we have

$$\begin{aligned} g &= \frac{v_i^C(\theta'_{i,S-1})}{v_i^C(\theta_{i,S}^*)} = \frac{v_j^C(\theta'_{i,S-2})}{v_j^C(\theta_{i,S-1}^*)} = \frac{v_i^C(\theta'_{i,S-3})}{v_i^C(\theta_{i,S-2}^*)} = \frac{v_j^C(\theta'_{i,S-4})}{v_j^C(\theta_{i,S-3}^*)} = \frac{v_i^C(\theta'_{i,S-5})}{v_i^C(\theta_{i,S-4}^*)} = \dots \\ &= \frac{v_i^C(\theta'_{i,S-1})}{v_i^C(1 - \bar{\theta}_j(\delta))} = \frac{v_j^C(\theta'_{i,S-2})}{v_j^C(\theta'_{i,S-1})} = \frac{v_i^C(\theta'_{i,S-3})}{v_i^C(\theta'_{i,S-2})} = \frac{v_j^C(\theta'_{i,S-4})}{v_j^C(\theta_{i,S-3}^*)} = \frac{v_i^C(\theta'_{i,S-5})}{v_i^C(\theta'_{i,S-4})} = \dots \end{aligned}$$

where, in the second line, we did not change the argument in the denominator of the second last term from $\theta_{i,S-3}^*$ to $\theta'_{i,S-3}$ because $\theta'_{i,S-3}$ may possibly exceed $\bar{\theta}_i(\delta)$, in which case country j 's first proposal will be $\bar{\theta}_i(\delta)$ and remain the same until stage $S-3$.

We have shown that, in general, if country j 's SPE proposal is $\bar{\theta}_i(\delta)$ at a stage s and $\theta_{i,s+2}^* = \theta'_{i,s+2} < \bar{\theta}_i(\delta)$ at its next proposing stage, its equilibrium proposal strategy will consist of

$$\theta_{i,S-1}^* < \dots < \theta_{i,s+4}^* < \theta_{i,s+2}^* < \theta_{i,s}^* = \theta_{i,s-2}^* = \theta_{i,s-4}^* = \dots \quad (30)$$

and correspondingly country i 's equilibrium proposal strategy will consist of

$$\theta_{i,S}^* < \dots < \theta_{i,s+3}^* < \theta_{i,s+1}^* < \theta_{i,s-1}^* = \theta_{i,s-3}^* = \theta_{i,s-5}^* = \dots \quad (31)$$

However, depending on the parameters, j 's SPE proposal may not be as large as $\bar{\theta}_i(\delta)$ at any stage. We have also shown that j 's proposal at any stage is always larger than i 's at the immediately preceding stage, e.g. $\theta_{i,s}^* > \theta_{i,s-1}^*$, $\theta_{i,s+2}^* > \theta_{i,s+1}^*$, \dots , $\theta_{i,S-1}^* > \theta_{i,S-2}^*$. ■

Having examined all potential SPE strategies when $\delta > \tilde{\delta}^*$ holds, let us now examine possible equilibrium outcomes, that is, different SPE first proposals that are accepted. First, let us consider how the equilibrium outcome changes according to the assignment of the right to propose first. Table 2 summarizes the last proposer i 's equilibrium share of full resettlement. The rows present the two cases of Proposition 2. Note that, in case (ii), $\theta_{i,2}^*$ stands for the SPE proposal that will be proposed and accepted at the second stage. It is proposed by country j in the column "First proposer is Last proposer i ", and by i in the last column. The table shows that each country can reduce its share of full resettlement by being the first proposer rather than the second because, in any row, i 's share is smaller in the first column than in the second.

Table 2. SPE outcome, $\theta_{i,1}^*$, by g and the first proposer

$g \in$	First proposer is ...	
	Last proposer i	Second-last proposer j
(i) $(0, \bar{g}_{i,S-1}]$	$= 1 - \bar{\theta}_j(\delta)$	$= \bar{\theta}_i(\delta)$
(ii) $(\bar{g}_{i,S-1}, 1)$	$\in (1 - \bar{\theta}_j(\delta), \theta_{i,2}^*)$	$\in (\theta_{i,2}^*, \bar{\theta}_i(\delta)]$

Next, to understand how the benefit of being the first proposer depends on the bargaining-stage discount factor, let us compare country i 's equilibrium payoff when it is the first proposer with that when it is not. We find that this benefit is decreasing in g . When $g \leq \bar{g}_{i,S-1}$, it is $v_i^C(1 - \bar{\theta}_j(\delta)) - v_i^C(\bar{\theta}_i(\delta))$. This is the largest benefit because the first positive term is the payoff from the most preferred share and the absolute value of the second negative term is the payoff from the least preferred share. Intuitively, with a sufficiently small bargaining-stage discount factor, the impatient country will not reject the proposer's most preferred proposal. By symmetry, this applies to both countries. Therefore, the SPE payoff difference between being the first proposer and being the second proposer is maximum. The same applies to country j 's first-proposer benefit.

With a higher g , the benefit of being the first proposer falls. When $g > \bar{g}_{i,S-1}$, the discount factor is high enough to affect the accept-reject decisions of the countries. At any stage except the last, the second-last proposer j no longer accepts i 's most preferred share $1 - \bar{\theta}_j(\delta)$ because it is patient enough to reject it to counter-propose at the next stage. As a result, i can no longer propose it even if it has the right to propose first. At stage $S-1$, the last proposer i is also patient enough to reject the second-last proposer j 's most preferred allocation $\bar{\theta}_i(\delta)$ to counter-propose at the next stage. As we showed in the last paragraph of the proof of Proposition 2(ii), each country's optimal proposal increases from the last proposer's most preferred $1 - \bar{\theta}_j(\delta)$ as we solve the model backward. The sequence of each country's optimal proposals is thus non-stationary over stages. For a given $g > \bar{g}_{i,S-1}$, the longer the bargaining (or equivalently the larger S), the further the SPE outcome away from country i 's most preferred $1 - \bar{\theta}_j(\delta)$. In other words, the longer the bargaining, the smaller the benefit of being the last proposer. Figure 2 illustrates an example of SPE strategies in Proposition 2(ii).

[Insert Fig. 2 here]

The SPE first proposal also changes according to g within the interval $(\bar{g}_{i,S-1}, 1)$ of case (ii). For a given number of stages, the higher the value of g , the closer the bargaining outcome to the last proposer's most preferred proposal $1 - \bar{\theta}_j(\delta)$. A very high discount factor prevents country j from making a counter-proposal far away from $1 - \bar{\theta}_j(\delta)$ and close to its most preferred proposal $\bar{\theta}_i(\delta)$ because the last proposer i will reject such a proposal in order to move to the next stage. Backward induction suggests that the initial SPE proposal then stays relatively close to the last SPE proposal $1 - \bar{\theta}_j(\delta)$. In other words, patience increases the bargaining power of the last proposer. Table 3 summarizes the last proposer i 's equilibrium share of full resettlement for the shortest bargaining. It shows that when g is close to the lower bound (first row) each country's first proposal is close to its most preferred, indicating that the bargaining power of the first proposer dominates that of the last proposer. On the other hand, when g is close to the upper bound (second row) the first proposals of both countries are close to the last proposer's most preferred, indicating that the bargaining power of the last proposer dominates that of the first proposer.

Table 3. $\theta_{i,1}^*$ by $g > \bar{g}_{i,S-1}$ and the first proposer in the shortest bargaining

g is close to ...	First proposer is ...	
	Last proposer i ($S = 3$)	Second-last proposer j ($S = 2$)
$\bar{g}_{i,S-1}$	More than but close to $1 - \bar{\theta}_j(\delta)$	Less than but close to $\bar{\theta}_i(\delta)$
1	More than but close to $1 - \bar{\theta}_j(\delta)$	More than but close to $1 - \bar{\theta}_j(\delta)$

4.2 Infinite-horizon bargaining

We now turn to the situation where, without a given terminal stage, the countries continue to propose alternately until one of them accepts the other's proposal. It is useful to consider infinite-horizon bargaining in our context. First, we can reasonably assume that most host countries do not end to exist in the foreseeable future. Second, even if the

entire bargaining period is finite, the countries could act as if there is no end because the proposer can expect to have its proposal rejected and receive a counter-proposal instantly and the proposed can expect to have an immediate opportunity to counter-propose after rejecting the opponent's proposal.

Without a terminal stage, we can no longer solve the model by backward induction. Hence we resort to the one-stage-deviation principle, e.g. Fudenberg and Tirole (1991: 108-10). We concentrate on stage-independent strategies, namely, stationary strategy profiles. We first construct a stationary strategy profile that is SPE and then show that it is unique. In this SPE, the optimal proposals of the identical countries are symmetric in the sense that each country proposes to admit the same share of full resettlement.

Let θ_i^i and θ_i^j denote θ_i proposed by i and j respectively. Because of stage independence, the subscript to label the bargaining stage is no longer necessary in this subsection. Let \bar{g} defined by $\bar{g}v_i^C(1 - \bar{\theta}_j(\delta)) = v_i^C(\bar{\theta}_i(\delta))$ and, by symmetry, also $\bar{g}v_j^C(\bar{\theta}_i(\delta)) = v_j^C(1 - \bar{\theta}_j(\delta))$. We note that \bar{g} is the same as $\bar{g}_{i,S-1}$ in Eq.(24) that appeared in analyzing finite-horizon bargaining earlier.

Proposition 3 Suppose the two countries are identical and $\delta > \tilde{\delta}^*$. Then, for any $g > \bar{g}$, there exists a pair of proposals $(\hat{\theta}_i^i, \hat{\theta}_i^j)$ that satisfies $\hat{\theta}_i^i = 1 - \hat{\theta}_i^j$ and makes the following strategy profile an SPE:

$$\begin{aligned}
 \text{Country } i: & \text{ Proposer } i \text{ proposes } \hat{\theta}_i^i \in (1 - \bar{\theta}_j(\delta), 1/2). \\
 & \text{Receiver } i \left\{ \begin{array}{l} \text{accepts any } \theta_i^j \in [1 - \bar{\theta}_j(\delta), \hat{\theta}_i^j]. \\ \text{rejects otherwise.} \end{array} \right. \\
 \text{Country } j: & \text{ Proposer } j \text{ proposes } \hat{\theta}_i^j \in (1/2, \bar{\theta}_i(\delta)). \\
 & \text{Receiver } j \left\{ \begin{array}{l} \text{accepts any } \theta_i^i \in [\hat{\theta}_i^i, \bar{\theta}_i(\delta)]. \\ \text{rejects otherwise.} \end{array} \right.
 \end{aligned}$$

Proof. Suppose there is a pair $(\hat{\theta}_i^i, \hat{\theta}_i^j)$ that makes the strategy profile an SPE. Then, country i will reject any $\theta_i^j \in (\hat{\theta}_i^j, \bar{\theta}_i(\delta)]$, and the one-stage-deviation principle implies

that

$$v_i^C(\theta_i^j) \leq gv_i^C(\hat{\theta}_i^i) \quad (32)$$

holds for such a θ_i^j . By the continuity of $v_i^C(\theta_i)$, this weak inequality is also satisfied at $\theta_i^j = \hat{\theta}_i^j$, i.e.

$$v_i^C(\hat{\theta}_i^j) \leq gv_i^C(\hat{\theta}_i^i). \quad (33)$$

The country will accept any $\theta_i^j \in [1 - \bar{\theta}_j(\delta), \hat{\theta}_i^j]$, and the one-stage-deviation principle implies that

$$v_i^C(\hat{\theta}_i^j) \geq gv_i^C(\hat{\theta}_i^i) \quad (34)$$

holds for such a θ_i^j . Weak inequalities (33) and (34) together imply $v_i^C(\hat{\theta}_i^j) = gv_i^C(\hat{\theta}_i^i)$ or equivalently

$$g = \frac{\hat{\theta}_i^j + \beta(1 - \hat{\theta}_i^j) - (\hat{\theta}_i^j)^\gamma}{\hat{\theta}_i^i + \beta(1 - \hat{\theta}_i^i) - (\hat{\theta}_i^i)^\gamma}. \quad (35)$$

Note that country i will reject any $\theta_i^j \notin [1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$ because such a proposal is not self-enforceable and hence acceptance will result in $v_i^N < gv_i^C(\hat{\theta}_i^i)$.

By the same argument, we have $v_j^C(\hat{\theta}_i^i) = gv_j^C(\hat{\theta}_i^j)$ or equivalently

$$g = \frac{(1 - \hat{\theta}_i^i) + \beta\hat{\theta}_i^i - (1 - \hat{\theta}_i^i)^\gamma}{(1 - \hat{\theta}_i^j) + \beta\hat{\theta}_i^j - (1 - \hat{\theta}_i^j)^\gamma}. \quad (36)$$

Earlier (immediately before this proposition), we defined \bar{g} by $\bar{g}v_i^C(1 - \bar{\theta}_j(\delta)) = v_i^C(\bar{\theta}_i(\delta))$ and, by symmetry, also $\bar{g}v_j^C(\bar{\theta}_i(\delta)) = v_j^C(1 - \bar{\theta}_j(\delta))$. Hence $(\hat{\theta}_i^i, \hat{\theta}_i^j) = (1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta))$ satisfies both Eq.(35) and (36) at $g = \bar{g}$. Besides, because $v_i^C(\theta_i)$ and $v_j^C(\theta_i)$ are continuous and symmetric and both $v_i^{C'}(\theta_i) < 0$ and $v_j^{C'}(\theta_i) > 0$ hold for any $\theta_i \in [1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$, there exists a pair of $\hat{\theta}_i^i \in (1 - \bar{\theta}_j(\delta), 1/2)$ and $\hat{\theta}_i^j \in (1/2, \bar{\theta}_i(\delta))$ that satisfies Eq.(35)-(36) and $\hat{\theta}_i^i = 1 - \hat{\theta}_i^j$ for any $g > \bar{g}$.

We now show that, for any $g > \bar{g}$, proposer i has no incentive to propose a θ_i^i other than $\hat{\theta}_i^i$. First, proposer i has no incentive to propose any $\theta_i^i \in (\hat{\theta}_i^i, \bar{\theta}_i(\delta)]$ because receiver j will accept it and the proposer will end up with $v_i^C(\theta_i^i) < v_i^C(\hat{\theta}_i^i)$. Second, i has an incentive to propose neither $\theta_i^i < \hat{\theta}_i^i$ nor $\theta_i^i > \bar{\theta}_i(\delta)$ because j will reject it and we have already shown that, at the next stage, country i will accept country j 's counter proposal $\hat{\theta}_i^j$ and will hence end up with $v_i^C(\hat{\theta}_i^j)$. The present value of it is $gv_i^C(\hat{\theta}_i^j)$ which is smaller than $v_i^C(\hat{\theta}_i^i)$. In conclusion, proposer i has no incentive to propose θ_i^i other than $\hat{\theta}_i^i$ for any $g > \bar{g}$. The same argument applies to country j 's SPE proposal. ■

Proposition 4 For any given $g > \bar{g}$, the SPE characterized by $(\hat{\theta}_i^i, \hat{\theta}_i^j)$ in Proposition 3 is unique.

Proof. See Appendix A. ■

The SPE strategies are symmetric but always result in unequal sharing of full resettlement because $1/2$ is never proposed in equilibrium. The equilibrium outcome depends on which country is the first proposer. As in the finite-horizon case, each country can reduce its share by being the first proposer rather than the second.

Proposition 5 As g increases from \bar{g} to 1, $\hat{\theta}_i^i$ increases from $1 - \bar{\theta}_j(\delta)$ to $1/2$ and $\hat{\theta}_i^j$ decreases from $\bar{\theta}_i(\delta)$ to $1/2$.

Proof. Monotonicity of $v_i^C(\theta_i)$ and $v_j^C(\theta_i)$ in Eq.(35)-(36) implies this. ■

The proposition suggests that the more patient bargainers the countries are, the smaller the benefit of proposing first becomes and hence the more equally they will share full resettlement. This in turn implies that the total payoff across the countries is higher when they are more patient in bargaining because the total cost of full resettlement is decreasing in g through more efficient cost sharing.²⁰ We will discuss more about efficiency later on (Subsection 6.2).

Now let us consider the SPE for $g \leq \bar{g}$. For convenience, let us denote the ratios in (23) by \bar{g}^N .

Proposition 6 Suppose the two countries are identical and $\delta > \tilde{\delta}^*$. Then, the unique SPE for a given $g \leq \bar{g}$ constitutes

- (i) the proposer proposes to host the smallest share of full resettlement within the self-enforceable interval $[1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$;
- (ii) the receiver with $g \in (\bar{g}^N, \bar{g}]$ accepts any proposal within the same interval and rejects any other; and
- (iii) the receiver with $g \leq \bar{g}^N$ accepts any proposal.

²⁰This implication holds as long as each country's payoff is cardinal and concave. Cardinality is reasonable to assume in the benchmark case of two identical countries. As for concavity, if, unlike our function (2), $b_i(\cdot)$ is concave and $c_i(\cdot)$ is linear, then the total gross benefit of full resettlement is increasing in g through more efficient benefit sharing.

Proof. First, consider any arbitrary subgame in which country i is the proposer. Suppose there exists a $\theta_i^{i'} \in [1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$ which country j rejects. Then, the country rejects any $\theta_i^i \in [1 - \bar{\theta}_j(\delta), \theta_i^{i'}]$. However, j cannot reject such a proposal because $v_j^C(\theta_i^i) \geq v_j^C(1 - \bar{\theta}_j(\delta)) = \bar{g}v_j^C(\bar{\theta}_i(\delta)) \geq gv_j^C(\bar{\theta}_i(\delta))$. A similar argument applies to any subgame in which country j is the proposer. Hence both countries accept any proposal within $[1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$.

Next, when an element outside $[1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$ is proposed the accept-reject decision depends on g . Consider again any arbitrary subgame in which country i is the proposer. If $g \in (\bar{g}^N, \bar{g}]$, country j rejects any $\theta_i^i \notin [1 - \bar{\theta}_j(\delta), \theta_i^{i'}]$ because $gv_j^C(1 - \bar{\theta}_j(\delta)) > \bar{g}^N v_j^C(1 - \bar{\theta}_j(\delta)) = v_j^N$. If $g \leq \bar{g}^N$ instead, it accepts any proposal. A similar argument applies to any subgame in which j is the proposer.

Given the accept-reject decision, a country's optimal proposal is to admit the smallest share of full resettlement, i.e. i proposes $1 - \bar{\theta}_j(\delta)$ and j proposes $\bar{\theta}_i(\delta)$. The strategy profile is optimal for any subgame, and hence the SPE for any $g \leq \bar{g}$ is unique. ■

Proposition 6 implies that a sufficiently small g reduces the incentive to reject a proposal unfavorable to the proposed, and hence the proposer can propose its most preferred within the self-enforceable interval. In equilibrium, the first proposer thus determines the bargaining outcome as it wants.

[Insert Fig. 3 here (summing up Prop.3-6)]

We conclude this section with comparisons of the results between finite- and infinite-horizon bargaining. Our results imply that the influence of the bargaining horizon on the equilibrium distribution of full resettlement depends on patience in bargaining. When the bargainers are not sufficiently patient the equilibrium distribution is the same regardless of the bargaining horizon. In both finite and infinite horizons, each country cannot wait to make a counter proposal in order to reduce its share of full resettlement and hence accepts the current proposal as long as it is within the self-enforceable interval. As a result, the first proposer offers to admit the smallest share in the interval, and the other country accepts to admit the rest. Impatience thus favors the first proposer in both finite- and infinite-horizon bargaining. A small bargaining-stage discount factor may represent, for example, a political situation where the country's government is under pressure to produce an outcome quickly.

On the contrary, when the bargainers are sufficiently patient the bargaining horizon affects the equilibrium distribution. In finite-horizon bargaining, patience favors the

country with the right to propose at the last stage more than the other country. In its turn to propose, the latter must take into account the former's willingness to wait until the end in order to offer to admit the smallest share within the self-enforceable interval. Thus, the effect of patience is to strengthen the bargaining position of the last-proposer country. On the other hand, when the bargaining horizon is infinite and the last proposer is unknown, both countries must consider the other's willingness to reject the current proposal equally. In other words, patience favors both countries equally when they are proposal receivers. Consequently, the more patient bargainers the countries are, the more equal distribution of full resettlement results from infinite-horizon bargaining.

5 Comparative statics

First, we examine the effects of exogenous parameters on the cooperation-opportunity set. Relevant are the marginal externality, admission-cost parameter and resettlement-period discount factor. Second, we consider how the bargaining-stage discount factor may affect the equilibrium distribution of full resettlement, given a cooperation-opportunity set.

5.1 Marginal externality

Cooperation matters more to the country that receives a larger positive externality, i.e. the country for which the public-good nature of resettlement is stronger. When $\beta_i > \beta_j$, country i benefits more from country j 's resettlement of each refugee than j does from i 's. Accordingly, country i is willing to accept a higher share if j cooperates and increases its admission to achieve full resettlement together. On the other hand, since country j does not gain from i 's resettlement as much, it is not prepared to accept a share as high as what i is willing to accept.

Suppose we initially have the benchmark case of two identical countries with $\delta > \delta^*$, i.e. the cooperation-opportunity set exists. We can introduce externality heterogeneity in two ways. First, consider a ceteris paribus increase in β_i . Refer to Fig.1. Eq.(9) implies that the increase will shift $\tilde{\delta}_i(\theta_i)$ down but will not affect $\tilde{\delta}_j(\theta_i)$. This will in turn increase

$\tilde{\theta}_i^*$ and decrease $\tilde{\delta}^*$. As a result, the self-enforceable interval $[1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$ will expand because of the subsequently increased upper bound $\bar{\theta}_i(\delta) = \tilde{\delta}_i^{-1}(\delta)$. Second, consider a ceteris paribus decrease in β_j instead. The decrease will shift $\tilde{\delta}_j(\theta_i)$ up but will not affect $\tilde{\delta}_i(\theta_i)$. This will in turn increase both $\tilde{\theta}_i^*$ and $\tilde{\delta}^*$. Now, because $\tilde{\delta}^*$ will consequently rise, $\delta > \tilde{\delta}^*$ will no longer be guaranteed. If $\delta > \tilde{\delta}^*$ continues to hold, the self-enforceable interval will continue to exist but will shrink because of the subsequently increased lower bound $1 - \bar{\theta}_j(\delta) = \tilde{\delta}_j^{-1}(\delta)$. Either way, $\beta_i > \beta_j$ then ceteris paribus implies $\bar{\theta}_i(\delta) > \bar{\theta}_j(\delta)$. Thus, the highest share that country i is prepared to admit under cooperation is higher than that j is prepared to admit.

If the marginal externality remains identical, a ceteris paribus increase (decrease) in β expands (shrinks and possibly loses) the cooperation-opportunity set by increasing (decreasing) the upper bound and also decreasing (increasing) the lower bound.

5.2 Admission-cost parameter

It seems natural to think that, if admitting a refugee is expensive, the country is reluctant to increase resettlement. Cooperation for full resettlement then appears even more difficult to achieve when the cost parameter is lower because, compared to noncooperation, it requires every country to admit more refugees and hence spend more not only in total but also per admitted refugee. (Recall that the smaller the cost parameter, the higher the cost of admitting a refugee.) However, we show that the opposite is true: countries are more likely to cooperate with each other to achieve full resettlement when admitting a refugee is more expensive. This is because, although the cost parameter applies to both cases of cooperation and noncooperation, the payoff from noncooperative partial resettlement is more sensitive to the admission cost than that from cooperated full resettlement. We also show that one country's cost parameter affects both countries' incentives to cooperate in the same direction through positive externality.

Under cooperation, the cost parameter affects the net benefit from own resettlement, $\theta_i - \theta_i^{\gamma_i}$, (that is, the payoff excluding the positive externality from the other's resettlement) through the admission cost. This benefit is small when γ_i is small because $\theta_i^{\gamma_i}$ is

then large. On the other hand, under noncooperation, the net benefit, $\hat{a}_i - \hat{a}_i^{\gamma_i}$, is affected through not only the admission cost but also the gross benefit. Eq.(4) implies that when γ_i is small not only $\hat{a}_i^{\gamma_i}$ is large but also \hat{a}_i is small because the static-game optimum resettlement adjusts to the cost parameter (see Appendix B: Claims 1-3). Thus, the net benefit from own resettlement is again small when γ_i is small, but the cost parameter affects this benefit under noncooperation more than that under cooperation. As a result, the difference between the net benefits from own settlement under noncooperation and cooperation, i.e. $(\hat{a}_i - \hat{a}_i^{\gamma_i}) - (\theta_i - \theta_i^{\gamma_i})$ in the numerator of Eq.(9), is small when γ_i is small. In other words, the smaller a country's cost parameter, the lower the country's discount-factor threshold $\tilde{\delta}_i(\theta_i)$ and hence the less patience the country needs for cooperating with the other country.

Besides, the smaller a country's cost parameter, the lower the other country's discount-factor threshold as well. This is because, when resettlement in country i is expensive, the difference between the country's admission under cooperation and noncooperation, $\theta_i - \hat{a}_i$, is large and hence the externality difference for the other country, $\beta_j(\theta_i - \hat{a}_i)$, is large. Recall the externality difference is the denominator of the discount-factor threshold—see Eq.(9). In other words, i 's punishment of j 's deviation is severer when γ_i is smaller.

Thus, expensive admission in one country lowers the level of patience required for cooperation by both countries. Equivalently, when admitting a refugee is cheap in one country, both countries must value future payoffs highly if they are to achieve full resettlement together.

Let us introduce $\gamma_i > \gamma_j$ to the benchmark case with $\delta > \tilde{\delta}^*$. That is, the resettlement cost per refugee is lower in country i than in j . A ceteris paribus increase in γ_i will shift both $\tilde{\delta}_i(\theta_i)$ and $\tilde{\delta}_j(\theta_i)$ up and will consequently raise $\tilde{\delta}^*$. As a result, the self-enforceable interval $[1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta)]$ will shrink, assuming that the increased $\tilde{\delta}^*$ does not yet exceed the given δ and hence such an interval still exists. The shrinkage takes place by decreasing the maximum agreeable shares of both countries. That is, the lower bound of the interval rises while the upper bound falls. The rise of the lower bound is smaller than the fall of the upper bound, as $\partial \tilde{\delta}_j(\theta_i) / \partial \gamma_i < \partial \tilde{\delta}_i(\theta_i) / \partial \gamma_i$ holds (see Appendix B). Accordingly,

$\tilde{\theta}_i^*$ falls. Clearly, we can also introduce $\gamma_i > \gamma_j$ by ceteris paribus decreasing γ_j instead, in which case $\tilde{\delta}^*$ must fall. The self-enforceable interval will expand by increasing the maximum agreeable shares of both countries, but the fall of the lower bound is larger than the rise of the upper bound. Accordingly, $\tilde{\theta}_i^*$ falls. Either way, $\gamma_i > \gamma_j$ then ceteris paribus implies $\bar{\theta}_i(\delta) < \bar{\theta}_j(\delta)$. Thus, the highest share that high-cost country j is prepared to admit under cooperation is higher than that low-cost country i is prepared to admit.

If the cost parameter remains the same across the countries, a ceteris paribus decrease (increase) in γ expands (shrinks and possibly loses) the cooperation-opportunity set by increasing (decreasing) the upper bound and also decreasing (increasing) the lower bound.

5.3 Resettlement-period discount factor

When the discount factors differ across the countries, the more patient country is prepared under cooperation to accept a high share that the other country would refuse ceteris paribus. Suppose we initially have the benchmark case of two identical countries with $\delta_i = \delta_j > \tilde{\delta}^*$. Increase δ_i while keeping everything else including δ_j fixed. We must then have $\bar{\theta}_i(\delta_i) > \bar{\theta}_j(\delta_j)$. A ceteris paribus decrease in δ_j can also result in $\delta_i > \delta_j$ which in turn results in $\bar{\theta}_i(\delta_i) > \bar{\theta}_j(\delta_j)$, but the cooperation-opportunity set may no longer exist in this case.

This second way of introducing heterogeneity helps us realize that the existence of a self-enforceable interval does not require both countries to have a discount factor higher than $\tilde{\delta}^*$. The necessary and sufficient condition for the existence, $1 - \bar{\theta}_j(\delta_j) < \bar{\theta}_i(\delta_i)$, must satisfy $\max\{\delta_i, \delta_j\} > \tilde{\delta}^*$ but not necessarily $\min\{\delta_i, \delta_j\} \geq \tilde{\delta}^*$. Note that if $\delta_i > \tilde{\delta}^* > \delta_j$ and $1 - \bar{\theta}_j(\delta_j) < \bar{\theta}_i(\delta_i)$ hold, other things equal, we must have $1 - \bar{\theta}_j(\delta_j) > 1/2$, which means that in SPE the more patient country will always resettle more refugees than the other under cooperation. Harrington (1989) made a similar observation in the context of collusion among firms that have different discount factors.

5.4 Bargaining-stage discount factor

The effect of the bargaining-stage discount factor is purely distributive. Unlike the other parameters discussed above, it does not change the self-enforceable interval and hence does not affect the available opportunities for full-resettlement cooperation. We find that when g is sufficiently large the bargaining outcome is in favor of the more patient of the two in both infinite- and finite-horizon cases. Since we have already discussed the effect in the homogeneous cases in Section 4, we concentrate on the heterogeneous cases here.

5.4.1 Infinite-horizon bargaining

Suppose we initially have the benchmark case of two identical countries with $\delta > \tilde{\delta}^*$, i.e. scope for cooperation exists. If the discount factors of both countries are sufficiently low, or more precisely if neither of them exceeds \bar{g} , the heterogeneity (i.e. $g_i \neq g_j$) does not affect the equilibrium outcome because each country always proposes to resettle the smallest share within the self-enforceable interval and the other country accepts it (Proposition 6). As a result, the first proposer hosts the smallest share of self-enforceable full resettlement, and the other resettles the rest.

If the more patient country has a sufficiently high discount factor instead, or more precisely if $g_i > \bar{g}$, it gains an equilibrium payoff higher than the one obtainable under the symmetric case of $g_i = g_j > \bar{g}$. Recall that, when $g_i = g_j > \bar{g}$ holds in the benchmark, the equilibrium must maintain both

$$v_i^C(\hat{\theta}_i^j) = g_i v_i^C(\hat{\theta}_i^i) \text{ and} \quad (35')$$

$$v_j^C(\hat{\theta}_i^i) = g_j v_j^C(\hat{\theta}_i^j). \quad (36')$$

Let us introduce heterogeneity by reducing g_j from g_i . If g_j still exceeds \bar{g} , i.e. $g_i > g_j > \bar{g}$ holds, both countries' SPE proposals will adjust to maintain Eq.(35')-(36'). A ceteris paribus decrease in g_j violates Eq.(36') by decreasing the right-hand side (RHS). In order to re-establish the equation, $\hat{\theta}_i^i$ must fall. The decrease in $\hat{\theta}_i^i$ in turn violates Eq.(35') by increasing the RHS. To re-establish the equality, $\hat{\theta}_i^j$ must fall. The fall in $\hat{\theta}_i^j$ in turn

violates Eq.(36') by decreasing the RHS. The convergence of $\hat{\theta}_i^i$ and $\hat{\theta}_i^j$ is guaranteed because both g_i and g_j are positive fractions. In short, to hold both equations in the face of a decrease in g_j , both $\hat{\theta}_i^i$ and $\hat{\theta}_i^j$ must fall. The same argument applies to the case where a ceteris paribus increase in g_i leads to a fall in both $\hat{\theta}_i^i$ and $\hat{\theta}_i^j$.

Now, if g_j decreases further and, as a result, $g_i > \bar{g} \geq g_j$ holds, $\hat{\theta}_i^i$ falls to hit the lower bound $1 - \bar{\theta}_j(\delta)$ (Proposition 6(i)) and hence cannot re-establish Eq.(36'). The fall of $\hat{\theta}_i^i$ to $1 - \bar{\theta}_j(\delta)$ in turn violates Eq.(35') by increasing the RHS. In order to re-establish the equality, $\hat{\theta}_i^j$ must fall, but cannot fall enough to re-establish Eq.(36'). Yet, the resulting inequality is compatible with the SPE as it only implies that the less patient country j 's incentive to accept is no longer binding under $g_i > \bar{g} \geq g_j$. In short, both $\hat{\theta}_i^i$ and $\hat{\theta}_i^j$ must be lower under $g_i > \bar{g} \geq g_j$ than under $g_i = g_j > \bar{g}$.

To summarize, compared to the symmetric case, the more patient country resettles less refugees and obtains a higher SPE payoff when its bargaining-stage discount factor is greater than the threshold \bar{g} , whichever country is the first proposer and whether the less patient country's discount factor is greater than \bar{g} .

5.4.2 Finite-horizon bargaining

There are four cases to consider when disagreeing countries cannot continue to bargain forever. The following table summarizes all possible pairs of g_i and g_j when i is the last proposer:

	$g_j \leq \bar{g}_{i,S-1}$	$g_j > \bar{g}_{i,S-1}$
$g_i \leq \bar{g}_{i,S-1}$	W	X
$g_i > \bar{g}_{i,S-1}$	Y	Z

In case W, both countries are impatient enough to accept any proposal within the self-enforceable interval at any stage. As a result, the SPE under $g_i \neq g_j$ does not differ from the symmetric case (Proposition 2(i)).

In case Z, both countries are sufficiently patient, and the sequence of each country's SPE proposals over its proposing stages maintains the same property described in Proposition 2(ii). Compared to the symmetric case, the proposals of both countries will

be closer to the more patient country's most preferred share. That is, they are closer to $1 - \bar{\theta}_j(\delta)$ if $g_i > g_j > \bar{g}_{i,S-1}$, and to $\bar{\theta}_i(\delta)$ if $g_j > g_i > \bar{g}_{i,S-1}$.

In case Y, we have $g_i > \bar{g}_{i,S-1} > g_j$. If country i is the first proposer, the equilibrium outcome will be $1 - \bar{\theta}_j(\delta)$ because the impatient j will accept it. If the first proposer is country j instead, the outcome will be $\theta_{i,1}^* \in (1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta))$ defined by $v_i^C(\theta_{i,1}^*) = g_i v_i^C(1 - \bar{\theta}_j(\delta))$ because the patient i will reject any larger proposal in order to propose $1 - \bar{\theta}_j(\delta)$ and have it accepted by the impatient j at the next stage.

In case X, we have $g_j > \bar{g}_{i,S-1} > g_i$. If country j is the first proposer, the equilibrium outcome will be $\bar{\theta}_i(\delta)$ because the impatient i will accept it. If the first proposer is country i instead, the outcome will be $\theta_{i,1}^* \in (1 - \bar{\theta}_j(\delta), \bar{\theta}_i(\delta))$ defined by $v_j^C(\theta_{i,1}^*) = g_j v_j^C(\bar{\theta}_i(\delta))$ because the patient j will reject any smaller proposal in order to propose $\bar{\theta}_i(\delta)$ and have it accepted by the impatient i at the next stage.

6 Policy implications

6.1 Creating an incentive to cooperate

We have so far concentrated on environments where there is scope for cooperation to achieve full resettlement. We have examined the variation in equilibrium outcomes when there is a range of allocative possibilities that make both bargainers better off under cooperation than under noncooperation. However, the absence of such a possibility may well be the main obstacle to cooperated full resettlement. Therefore, let us now consider cases where scope for cooperation does not exist. The analysis above helps us think of what might be useful for creating an incentive to share full resettlement.

Consider an initial situation characterized by

$$\bar{\theta}_i(\delta_i) + \bar{\theta}_j(\delta_j) < 1.$$

Namely, the self-enforceable interval does not exist initially, which in turn means that full resettlement cannot be divided in a mutually beneficial way and hence there is no scope

for cooperation. Since $\bar{\theta}_i(\delta_i) = \tilde{\delta}_i^{-1}(\delta_i)$ and $1 - \bar{\theta}_j(\delta_j) = \tilde{\delta}_j^{-1}(\delta_j)$, Condition (9) informs us of how to generate such an interval. One way is to raise the resettlement-period discount factor for a given threshold (Subsection 5.3). In our context, the discount factor is best interpreted as representing not only time preference but also the probability of playing the same static game in the next period (Fudenberg and Tirole, 1991: 148). The higher the probability, the larger the discount factor.²¹ In other words, the discount factor is relatively high when the country expects that resettlement sharing is not a one-off but an ongoing issue that must be dealt with the other countries. Promoting the awareness of both ongoing and potential conflicts in the world may help increase the discount factor.

The other way is to lower the threshold for a given discount factor instead. Recall that the threshold $\tilde{\delta}_i(\theta_i)$ in Eq.(9) consists of two components. One is the difference between the net benefits from own resettlement (i.e. excluding the positive externality from the other country's resettlement) under noncooperation and cooperation in the numerator. The other is the difference between the externality gains from the other's resettlement under cooperation and noncooperation in the denominator. The numerator of $\tilde{\delta}_i(\theta_i)$ is a function of γ_i (recall \hat{a}_i is a function of γ_i as shown in Eq.(4)), while the denominator is a function of γ_j and β_i . Hence, to lower the threshold $\tilde{\delta}_i(\theta_i)$, we should increase β_i (Subsection 5.1) and/or decrease either γ_i or γ_j or both (Subsection 5.2). Promoting humanitarianism and at the same time increasing awareness that refugee protection is a global public good may help increase β_i which represents the degree of pureness of the public good. As we mentioned in the introduction, the Global Compact on Refugees takes such an approach in promoting cooperation. The cost parameter could be lowered (that is, admission could be made costlier) by requiring countries to provide the admitted refugees with a welfare standard as high as the one for their citizens through comprehensive integration policies including language and cultural education and employment-related assistance.

Note that if the admission cost can be reduced considerably, each country's noncooperative resettlement could be sufficient for full resettlement because Assumption 1 may

²¹In this interpretation, the discount factor is a function of time preference r and probability p , for example, $\delta = p \exp(\ln p - r)$ with the length of each period normalized to 1.

no longer hold. Yet, full resettlement through drastic cost cutting is unlikely to be a solution for refugee protection. The required cost reduction may be impossible to achieve in reality if countries are to maintain a certain hosting standard. Achieving the cost reduction and consequently deteriorating the hosting quality could induce socioeconomic problems in admitting countries. Difficulty for international cooperation should not be an excuse for cutting the expenditure per admitted refugee.

6.2 Promoting efficiency in cooperation

The existence of cooperation opportunities is necessary for the countries to reach an agreement to share full resettlement. However, we show that having a wide range of cooperation opportunities, as opposed to a limited range, can be suboptimal in terms of equilibrium efficiency—the size of the global payoff in SPE. Since the literature has been concerned with the efficiency of the equilibrium outcome, let us consider it in our model.

Assume that a set of cooperation opportunities exists. Denote the equally weighted global payoff under cooperation by $V^C \equiv v_i^C(\theta_i) + v_j^C(\theta_i)$. Using Eq.(6), the efficient allocation, θ_i^E , is implicitly characterized by $\partial V^C / \partial \theta_i = 0$ or equivalently

$$\frac{1}{1 - \delta_j} + \frac{\beta_i + \gamma_i (\theta_i^E)^{\gamma_i - 1}}{1 - \delta_i} = \frac{1}{1 - \delta_i} + \frac{\beta_j + \gamma_j (1 - \theta_i^E)^{\gamma_j - 1}}{1 - \delta_j} \quad (37)$$

where, on the lefthand side of the equality sign, we have the social marginal cost of resettling θ_i^E in country i and the corresponding marginal benefit on the righthand side.

6.2.1 Homogeneous countries

Let us first consider the benchmark case, for it can show us clearly why a limited range of cooperation opportunities might be preferred to a wide range when efficiency is desired. With two identical countries, Eq.(37) is met by $\theta_i^E = 1/2$, that is, sharing full resettlement equally is the most efficient. Note that, in the benchmark case, this most efficient allocation coincides with the intersection of $\tilde{\delta}_i(\theta_i)$ and $\tilde{\delta}_j(\theta_i)$ denoted by $\tilde{\theta}_i^*$ illustrated in Fig.1 earlier (Subsection 3.2).

Since we assume the existence of a set of cooperation opportunities, δ must be greater than $\tilde{\delta}^*$, and $\tilde{\theta}_i^*$ is always the central element of the self-enforceable interval. We have seen that when the bargaining-stage discount factor is sufficiently small the SPE distribution is given by the interval's lower or upper bound or a distribution close to one of the two bounds (Section 4 and Subsection 5.4). However, when the interval is narrow (i.e. δ does not exceed $\tilde{\delta}^*$ too much), the equilibrium distribution cannot be far from 1/2. This applies to bargaining of both finite and infinite horizons.

On the other hand, when the bargaining-stage discount factor is sufficiently large, the distribution in finite-horizon bargaining equilibrium is ambiguous and depends on a combination of the assignment of the right to propose first and of the right to propose last, the number of bargaining stages and the size of each country's discount factor (see Fig.2, Subsection 4.1 and Subsubsection 5.4.2). The SPE distribution may or may not be close to 1/2, depending on those exogenous variables. Working out a right combination of them to achieve the most efficient allocation is likely to be difficult, if not impossible, while implementation of such a combination is likely to be challenging. However, if the self-enforceable interval is narrow, the equilibrium distribution cannot be far from 1/2, whichever element of the interval is chosen as a result of bargaining.

In infinite-horizon bargaining, the equilibrium distribution approaches 1/2 as the bargaining-stage discount factor approaches to 1, regardless of the interval width (see Fig.3, Subsection 4.2 and Subsubsection 5.4.1). This in turn implies that policies to increase the discount factor contribute to an improvement in equilibrium efficiency. One way to increase the discount factor is to allow the countries to make a counter proposal immediately.²² However, in reality, making a proposal in international negotiation is time-consuming, not least because each government must evaluate and strike a balance between what is best for its country and what is acceptable for the other. Here again, a narrow self-enforceable interval can keep the equilibrium distribution close to 1/2 even if the bargaining-stage discount factor cannot be made very large.

To summarize, if the existing self-enforceable interval is wide, equilibrium efficiency

²²That is, the length of each bargaining stage is kept very short. For example, $g_i = \exp(-r_i\Delta)$ can be increased by decreasing the stage length Δ for a given discount rate r_i .

can be improved by narrowing the interval through policies to reduce δ and/or β and/or increase γ (see Subsections 5.1-3) as long as those policies do not go so far as to eliminate all cooperation opportunities. Efficiency is guaranteed if the interval is reduced to the element $\tilde{\theta}_i^*$. However, when countries are not identical, the relationship between the efficient distribution and the interval width is not as simple as in the benchmark case, as we explain next.

6.2.2 Heterogeneous countries

Let us first consider heterogeneity in the resettlement-period discount factor, while holding β and γ identical. Because the discount factor affects neither $\tilde{\delta}_i(\theta_i)$ nor $\tilde{\delta}_j(\theta_i)$, we continue to have them crossing at $1/2$, i.e. $\tilde{\theta}_i^* = 1/2$. However, the most efficient distribution θ_i^E departs from $1/2$ when $\delta_i \neq \delta_j$. Suppose $\delta_i > \delta_j$. Then, we will have $\bar{\theta}_i(\delta_i) > \bar{\theta}_j(\delta_j)$. That is, assuming $1 - \bar{\theta}_j(\delta_j) < \bar{\theta}_i(\delta_i)$ holds, the more patient country i is prepared to admit a higher share of full resettlement than country j is when they engage in bargaining. Eq.(37) implies $\theta_i^E > 1/2$, namely, efficiency requires the more patient country to resettle more refugees than the other country. Thus, an introduction of heterogeneity in the discount factor moves both the cooperation opportunity set and the efficient allocation of full resettlement in the same direction. The earlier discussion of homogenous countries continues to apply here, except that the target allocation requires the more patient country to admit a higher share. This implies that the bargaining outcome may approach efficiency if the less patient country is placed in a better bargaining position while the cooperation opportunity set is narrowed.

Let us next consider heterogeneity in the marginal externality, while holding δ and γ identical. In this case, both θ_i^E and $\tilde{\theta}_i^*$ depart from $1/2$ and also they depart from each other. Eq.(37) implies that the most efficient distribution θ_i^E is decreasing in β_i and increasing in β_j (see Appendix C). In other words, efficiency requires the country that *generates* a higher marginal externality to resettle more. On the other hand, $\tilde{\theta}_i^*$ is increasing in β_i and decreasing in β_j , indicating that the country that *receives* a higher marginal externality is prepared to resettle more in order to persuade the other to

cooperate (Subsection 5.1). Therefore, when the marginal benefit from the other country's resettlement is not identical, the efficient distribution and the centre of the self-enforceable interval move away from each other. Because of their deviations from $1/2$ in the opposite directions, simply narrowing the interval to $\tilde{\theta}_i^*$ does not achieve efficiency. For example, if $\beta_i > \beta_j$ holds, we will have $\theta_i^E < 1/2 < \tilde{\theta}_i^*$. If θ_i^E is an element of the self-enforceable interval, efficiency can be achieved by narrowing the interval until $\theta_i^E = 1 - \bar{\theta}_j(\delta)$ holds and arranging bargaining to allow country i 's most preferred distribution to arise in SPE. If the interval does not initially contain θ_i^E , it may be expanded until $\theta_i^E = 1 - \bar{\theta}_j(\delta)$ holds. Alternatively, we may attempt to reduce the difference between β_i and β_j so that the difference between θ_i^E and $\tilde{\theta}_i^*$ can decrease and both can approach $1/2$. Efficiency can be achieved by narrowing the interval after that (Subsubsection 6.2.1).

Finally, consider heterogeneity in the cost parameter, while holding δ and β identical. Eq.(37) implies that the impact of the cost parameter on the efficient allocation is not monotonic: the direction of the effect depends on the initial values of the cost parameters. We find that, when resettlement in a country is sufficiently expensive (that is, the country's cost parameter is sufficiently small), making it marginally cheaper will result in the efficient allocation that demands the country to admit less, not more, than before. Here, "sufficiently" indicates whether the cost-parameter value is less than the relevant threshold (see Appendix C). Only when resettlement is sufficiently inexpensive or equivalently the cost parameter is sufficiently large, making it marginally cheaper will lead to the efficient allocation that requires the country to admit more.

To see this clearly, suppose we initially have the benchmark case of two identical countries. Assume that the cost parameter is sufficiently large, that is, resettlement is initially equally inexpensive in the countries. To introduce the heterogeneity in the cost parameter, marginally increase γ_i . Efficiency will then require country i to admit more refugees, resulting in $\theta_i^E > 1/2$. Intuitively, when a country can resettle inexpensively compared to the other country, efficiency requires it to resettle more. Recall that $\tilde{\theta}_i^*$ is decreasing in γ_i regardless of the initial parameter value (Subsection 5.2). Therefore, we will have $\tilde{\theta}_i^* < 1/2 < \theta_i^E$. If θ_i^E is within the self-enforceable interval, efficiency may be

achieved by narrowing the interval until $\theta_i^E = \bar{\theta}_i(\delta)$ holds and arranging bargaining to allow country j 's most preferred distribution to arise in SPE. If the interval does not initially contain θ_i^E , it may be expanded until $\theta_i^E = \bar{\theta}_i(\delta)$ holds. Alternatively, we may attempt to reduce the difference between γ_i and γ_j so that the difference between θ_i^E and $\tilde{\theta}_i^*$ can decrease and both can approach $1/2$. Efficiency can be achieved by narrowing the interval after that (Subsubsection 6.2.1).

Now, assume instead that resettlement is initially equally expensive in the countries, that is, the cost parameter is sufficiently small. In this case, after a ceteris paribus marginal increase in γ_i , efficiency will require country i to admit less, not more, refugees, resulting in $\theta_i^E < 1/2$. This happens because, when γ_i is initially sufficiently small, the marginal cost of resettling one more refugee in addition to $1/2$ in country i rises after marginally increasing γ_i even though the total cost for the country decreases. When resettlement is expensive, the marginal cost starts rising rapidly after admitting a relatively small number. On the other hand, when resettlement is inexpensive (the case we discussed in the immediately preceding paragraph), the marginal cost does not start rising rapidly until a relatively large number is admitted.²³ Clearly, policy implication is different when we have $\theta_i^E < 1/2$, instead of $\theta_i^E > 1/2$, under $\gamma_i > \gamma_j$. Since $\tilde{\theta}_i^*$ is decreasing in γ_i regardless of the initial parameter value (Subsection 5.2), the centre of the self-enforceable interval and the efficient allocation move in the same direction in response to γ_i . This suggests that θ_i^E and $\tilde{\theta}_i^*$ do not distance themselves from each other as much as in the case where resettlement is initially inexpensive. As a result, the interval that takes θ_i^E as a bound is much narrower than in the case of $\theta_i^E > 1/2$ under $\gamma_i > \gamma_j$. Since all elements are not far away from θ_i^E in such a narrow interval, efficiency can be improved by focusing on reducing the interval width, without arbitrary arrangement of bargaining environment.

To summarize, when the countries are heterogeneous, policy intervention to attain efficiency becomes more complex than in the benchmark because the most efficient dis-

²³The impact of the cost parameter on the marginal cost of resettling a given number is not always monotonic, depending on the given number to be resettled. The value of θ_i that equates i 's marginal cost to 1 is increasing in γ_i , namely, $\gamma_i \theta_i^{\gamma_i - 1} = 1 \iff \theta_i = \gamma_i^{\frac{-1}{\gamma_i - 1}}$.

tribution is no longer at the centre of the cooperation opportunity set, which in turn requires the smallest set available to the bargainers to be an interval rather than an element. Arranging bargaining environment to allow the efficient allocation to arise in SPE can be difficult in practice. Yet, understanding the location of the efficient distribution helps us improve on efficiency, if not achieving it, since policies can be targetted to modify the cooperation opportunity set.

7 Extension

Before we conclude, let us extend our model in order to consider one more realistic situation where the number of refugees in need of resettlement can change period by period. For example, the demand for resettlement may be very high in one year due to an outbreak of war somewhere in the world, compared to other relatively peaceful years. We show that the higher the demand for resettlement today, the smaller the set of sustainable cooperation opportunities. When the current demand is too high, there may not be an opportunity to achieve full resettlement together in the long run. We follow Rotemberg and Saloner (1986) in extending our model.

Let us assume there are two possible states, m and M , in each period. Let $q_t \in \{m, M\}$ denote the state in period t . The distribution of the state is identical and independent over time, and $p \in (0, 1)$ denotes the probability of $q_t = m$. The state determines the number of refugees in need of resettlement at the beginning of the period. We denote this number by $Q(q_t)$ and assume that both countries observe it as soon as the state determines it. The size of full resettlement in each period is either $Q(m) = R \in (\hat{a}_i + \hat{a}_j, 1)$ or $Q(M) = 1$, and this is common knowledge among the countries. We thus have $Q(m) < Q(M)$. Note that the lower bound of R implies that an amended version of Assumption 1 holds. That is, full resettlement cannot be achieved without international cooperation even if the state is m .

We now interpret θ_i strictly as country i 's share of full resettlement when cooperating

to achieve full resettlement.²⁴ We then amend Assumption 2 as follows:

$$\exists \theta_i \in (0, 1) \text{ that can hold } u_i(\theta_i R, (1 - \theta_i) R) > u_i(\hat{a}_i, \hat{a}_j) \quad \forall i \quad (\text{Assumption 2'})$$

because $u_i(\theta_i R, (1 - \theta_i) R) < u_i(\theta_i, 1 - \theta_i)$.

Since the countries observe $Q(q_t)$ before resettling in period t , the history in the period is $h_t = ((q_0, a_0), (q_1, a_1), \dots, (q_{t-1}, a_{t-1}), q_t)$ for $t \geq 1$, and the initial history is $h_0 = q_0$. We amend country i 's trigger strategy as follows:

$$\sigma_i(h_t) = \begin{cases} \theta_i & \text{if } t = 0 \text{ and } h_0 = M, \\ & \text{or } t \geq 1 \text{ and } h_t = ((q_0, \theta), \dots, (q_{t-1}, \theta), M); \\ \theta_i R & \text{if } t = 0 \text{ and } h_0 = m, \\ & \text{or } t \geq 1 \text{ and } h_t = ((q_0, \theta), \dots, (q_{t-1}, \theta), m); \\ \hat{a}_i & \text{otherwise,} \end{cases} \quad (5')$$

where $(q_\tau, \theta) \in \{(m, \theta_i R, (1 - \theta_i) R), (M, \theta_i, 1 - \theta_i)\}$ for $\tau = 0, 1, \dots, t - 1$.

We now derive the condition for a country to voluntarily share full resettlement. The derivation process is the same as that for the original model (see Subsection 3.2). When the state in period t is m , country i 's expected continuation payoff from cooperated full resettlement from that period onward is

$$v_i^C(\theta_i | m) = u_i(\theta_i R, (1 - \theta_i) R) + \delta_i E(v_i^C(\theta_i | q_{t+1}))$$

where $E(v_i^C(\theta_i | q_{t+1})) = p v_i^C(\theta_i | m) + (1 - p) v_i^C(\theta_i | M)$. If the state in period t is M instead, it is

$$v_i^C(\theta_i | M) = u_i(\theta_i, 1 - \theta_i) + \delta_i E(v_i^C(\theta_i | q_{t+1})).$$

²⁴Recall that, in our original model, θ_i can be interpreted as both number and share because we normalized the size of full resettlement to one. In this extension, θ_i cannot be interpreted as the number of refugees unless the state is M .

Solving those two equations in two unknowns, we obtain

$$v_i^C(\theta_i|m) = u_i(\theta_i R, (1 - \theta_i) R) + \frac{\delta_i}{1 - \delta_i} E(u_i^C(\theta_i|q_{t+1})) \quad (6'a)$$

and

$$v_i^C(\theta_i|M) = u_i(\theta_i, 1 - \theta_i) + \frac{\delta_i}{1 - \delta_i} E(u_i^C(\theta_i|q_{t+1})) \quad (6'b)$$

where $E(u_i^C(\theta_i|q_{t+1})) = pu_i(\theta_i R, (1 - \theta_i) R) + (1 - p)u_i(\theta_i, 1 - \theta_i)$. Those two equations show that the expected continuation payoff from cooperated full resettlement is larger when the state is M .

Country i will voluntarily share full resettlement in the state m iff $v_i^C(\theta_i|m) \geq v_i^D(\theta_i|m)$ or equivalently

$$\begin{aligned} u_i(\theta_i R, (1 - \theta_i) R) + \frac{\delta_i}{1 - \delta_i} E(u_i^C(\theta_i|q_{t+1})) &\geq u_i(\hat{a}_i, (1 - \theta_i) R) + \frac{\delta_i}{1 - \delta_i} u_i(\hat{a}_i, \hat{a}_j) \\ \iff \delta_i \geq \tilde{\delta}_i(\theta_i|m) &\equiv \frac{u_i(\hat{a}_i, (1 - \theta_i) R) - u_i(\theta_i R, (1 - \theta_i) R)}{u_i(\hat{a}_i, (1 - \theta_i) R) - u_i(\theta_i R, (1 - \theta_i) R) + E(u_i^C(\theta_i|q_{t+1})) - u_i(\hat{a}_i, \hat{a}_j)}. \end{aligned} \quad (8'a)$$

Similarly, in the state M , we have

$$\delta_i \geq \tilde{\delta}_i(\theta_i|M) \equiv \frac{u_i(\hat{a}_i, 1 - \theta_i) - u_i(\theta_i, 1 - \theta_i)}{u_i(\hat{a}_i, 1 - \theta_i) - u_i(\theta_i, 1 - \theta_i) + E(u_i^C(\theta_i|q_{t+1})) - u_i(\hat{a}_i, \hat{a}_j)}. \quad (8'b)$$

Proposition 7 $\tilde{\delta}_i(\theta_i|m) < \tilde{\delta}_i(\theta_i|M)$

Proof. $\tilde{\delta}_i(\theta_i|m) < \tilde{\delta}_i(\theta_i|M) \iff$

$$\begin{aligned} u_i(\hat{a}_i, (1 - \theta_i) R) - u_i(\theta_i R, (1 - \theta_i) R) &< u_i(\hat{a}_i, 1 - \theta_i) - u_i(\theta_i, 1 - \theta_i) \\ \iff \theta_i R - (\theta_i R)^{\gamma_i} &> \theta_i - \theta_i^{\gamma_i} \end{aligned}$$

which holds because $a_i - a_i^{\gamma_i}$ is decreasing in a_i for all $a_i > \hat{a}_i$, and $\theta_i > \theta_i R > \hat{a}_i$. ■

The proof above shows that the threshold difference between the two states arises purely from the difference in the net benefit from the country's own sharing of full resettlement in the current period. This is because, first, the externality gain in the current

period is unaffected whether the country cooperates or deviates regardless of the state and, second, the severity of post-deviation punishment is the same in both states.

The result shows that the smallest discount factor required for voluntarily sharing full resettlement is larger when the current need for full resettlement is larger. For a given share, the larger the total number of refugees in need of resettlement, the more patient each country has to be if cooperated full resettlement is to be achieved. In other words, a set of cooperation opportunities may not exist when the number of refugees is very large. If it does exist, it is likely to be smaller than the set available for a smaller number of refugees.

8 Conclusion

One insight gained from our application of repeated game theory is that both public-good nature of refugee protection and costliness of resettlement encourage the international community to cooperate for achieving full resettlement. Previous studies examine one-off admission by noncooperative countries and focus on their negative effects on total admission. As a result, they find that the public-good nature induces free- or easy-riding behavior and resettlement costs reduce each country's admission. Therefore, if we ignore the recurrence of the need for refugee protection, we might well advise, for example, to lower resettlement costs so as to increase the level of each country's admission even though the resulting total admission will remain short of full resettlement. Such a recommendation can lessen the hosting quality and hinder post-admission integration but also reduces cooperation opportunities for full resettlement in the long run.

Another insight comes from the combination of alternate-offer bargaining and repeated game. It is natural to assume that a more patient country has a high discount factor in general. Therefore, we may reasonably assume that a country with a high resettlement-period discount factor also has a high bargaining-stage discount factor. If this is the case, our analysis suggests that, although a patient country achieves a small share of full resettlement within the mutually-beneficial, self-enforceable set of cooperation options, it

also creates a favorable bargaining environment for the less patient by showing its willingness to resettle a large share and hence expanding the set of cooperation opportunities to the opponent's advantage. Valuing the future highly is conducive to cooperated full resettlement.

We have also considered equilibrium efficiency, as in the literature. We found that, although the existence of cooperation opportunities is essential for achieving full resettlement, a wide range of opportunities may not be conducive to the attainment of efficiency. We argued that, if equilibrium efficiency is desired, we may implement policies to narrow the range while ensuring the efficient distribution to be within the range. Thus, unlike the existing studies, our model was able to suggest policy implications for an efficiency improvement. It should be noted, however, that the formulation and implementation of policies to change the cooperation-opportunity set and bargaining environments are not costless. In our discussion, we ignored those costs that must be deducted from the increased global payoff. Therefore, pursuers of efficiency should carefully evaluate the net gain of achieving it. We also emphasize that, while maximizing the global payoff is ideal, efficiency is not the most important concern of ours in this study. Voluntary achievement of full resettlement is the priority, and we should be prepared to compromise the efficiency of full-resettlement sharing if the pursue of efficiency is likely to delay full resettlement.

Our dynamic analysis extended the existing literature significantly to deal with recurrent needs for refugee protection. We concentrated on resettlement in this paper. However, resettlement is not the only solution for ending refugees' predicament. As we mentioned in the introduction, voluntary repatriation and local integration without resettlement are two other solutions. Those three solutions are linked to each other: for example, local integration is considered when voluntary repatriation is not an option, and resettlement is considered when local integration is inappropriate. Future studies that incorporate different but interconnected means of refugee protection would discover further insights into international cooperation.

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Appendices

A. Proof of Proposition 4 (the uniqueness of the SPE $\forall g > \bar{g}$ given in Proposition 3)

We follow Muthoo (1999) who follows Shaked and Sutton (1984).

Lemma A1 Let $v_j = w(v_i)$ represents the Pareto frontier,

$$\Omega^C = \{(v_i, v_j) : v_i = v_i^C(\theta_i), v_j = v_j^C(\theta_i), \theta_i^L \leq \theta_i \leq \theta_i^U\},$$

of the set,

$$\Omega = \{(v_i, v_j) : v_i \geq v_i^N, v_j \geq v_j^N\}.$$

Then, $\forall v_i \in [v_i^N, w^{-1}(v_j^N)]$, we have $w'(v_i) < 0$, $w''(v_i) < 0$ and $w(v_i^N) > 0$.

Proof. Ω^C is a subset of Ω because $w(v_i^N) = v_j^C(\theta_i^U)$ and $w^{-1}(v_j^N) = v_i^C(\theta_i^L)$ by Lemma 1. Note $w(v_i^N) = v_j^C(\theta_i^U) > 0$.

Since $v_i = v_i^C(\theta_i)$ on the Pareto frontier, $v_i^C(\theta_i) - v_i = 0$. By applying the implicit function theorem to

$$F(\theta_i, v_i) \equiv v_i^C(\theta_i) - v_i = \frac{\theta_i + \beta(1 - \theta_i) - \theta_i^\gamma}{1 - \delta} - v_i,$$

we get

$$\frac{d\theta_i}{dv_i} = -\frac{dF/dv_i}{dF/d\theta_i} = \frac{1 - \delta}{1 - \beta - \gamma\theta_i^{\gamma-1}}.$$

Because $1 - \delta > 0$,

$$\frac{d\theta_i}{dv_i} \leq 0 \iff \left(\frac{1 - \beta}{\gamma}\right)^{\frac{1}{\gamma-1}} \leq \theta_i.$$

Note that $((1 - \beta)/\gamma)^{\frac{1}{\gamma-1}}$ is a quantity smaller than $\hat{a}_i = (1/\gamma)^{\frac{1}{\gamma-1}}$. Because $\hat{a}_i < \theta_i^L$, we have $((1 - \beta)/\gamma)^{\frac{1}{\gamma-1}} < \theta_i$ on the Pareto frontier and therefore

$$\frac{d\theta_i}{dv_i} < 0.$$

Since $v_i = v_i^C(\theta_i)$ and $v_j = v_j^C(\theta_i)$ on the Pareto frontier, $v_j = v_j^C(\theta_i) + v_i^C(\theta_i) - v_i$ or equivalently

$$v_j = \frac{1 + \beta - [\theta_i(v_i)]^\gamma - [1 - \theta_i(v_i)]^\gamma}{1 - \delta} - v_i.$$

Therefore,

$$\frac{dv_j}{dv_i} = \frac{\gamma}{1 - \beta - \gamma\theta_i^{\gamma-1}} [(1 - \theta_i)^{\gamma-1} - \theta_i^{\gamma-1}] - 1.$$

Since the denominator of $d\theta_i/dv_i$ is negative, we have

$$\frac{dv_j}{dv_i} \leq 0 \iff \theta_i \leq 1 - \left(\frac{1 - \beta}{\gamma}\right)^{\frac{1}{\gamma-1}}.$$

Note that $1 - ((1 - \beta) / \gamma)^{\frac{1}{\gamma-1}}$ is a quantity greater than $1 - \hat{a}_j = 1 - (1/\gamma)^{\frac{1}{\gamma-1}}$. Because $\theta_i^U < 1 - \hat{a}_j$, we have $\theta_i < 1 - ((1 - \beta) / \gamma)^{\frac{1}{\gamma-1}}$ on the Pareto frontier and therefore

$$\frac{dv_j}{dv_i} < 0.$$

In conclusion, $\forall v_i \in [v_i^N, w^{-1}(v_j^N)] = [v_i^N, v_i^C(\theta_i^L)]$, $w'(v_i) < 0$. Because

$$\begin{aligned} \frac{d^2v_j}{dv_i^2} &= \frac{(\gamma - 1)\gamma\theta_i^{\gamma-2}}{[1 - \beta - \gamma\theta_i^{\gamma-1}]^2} \left\{ \frac{\gamma}{1 - \beta - \gamma\theta_i^{\gamma-1}} [(1 - \theta_i)^{\gamma-1} - \theta_i^{\gamma-1}] - 1 - \left(\frac{1 - \theta_i}{\theta_i}\right)^{\gamma-2} \right\} \\ &= \frac{(\gamma - 1)\gamma\theta_i^{\gamma-2}}{[1 - \beta - \gamma\theta_i^{\gamma-1}]^2} \left[\frac{dv_j}{dv_i} - \left(\frac{1 - \theta_i}{\theta_i}\right)^{\gamma-2} \right], \end{aligned}$$

we have $dv_j/dv_i < 0 \implies d^2v_j/dv_i^2 < 0$. ■

Let V_i denote the set of country i 's payoffs in any subgame beginning with i 's proposal. Let m_i and M_i denote the infimum and supremum of V_i .

Lemma A2 A country's SPE-payoff infimum is at least as large as its SPE payoff when the opponent's payoff is equivalent to its SPE-payoff supremum at the next period. That is, $m_i \geq w^{-1}(gM_j)$ and $m_j \geq w(gM_i)$.

Proof. Country j accepts any proposal θ'_i that holds $v_j^C(\theta'_i) > gM_j$. Hence $\exists v_i \in V_i$ such that $v_i < w^{-1}(gM_j)$. Otherwise, country i can increase its payoff by proposing θ'_i such that $v_i^C(\theta'_i) = v'_i$ and $v_j^C(\theta'_i) = w(v'_i)$ where $v_i < v'_i < w^{-1}(gM_j)$. Hence $\forall v_i \in V_i$, we have $v_i \geq m_i \geq w^{-1}(gM_j)$. ■

Lemma A3 For any $v_j \in V_j$, the payoff pair on the Pareto frontier, $(w^{-1}(gv_j), gv_j) \in \Omega^C$, is supported by an SPE. Likewise, $\forall v_i \in V_i$, an SPE supports $(gv_i, w(gv_i)) \in \Omega^C$.

Proof. Pick any $v_j \in V_j$. Let ρ denote an SPE that supports the payoff v_j . Let μ_i denote i 's payoff in this SPE. To consider an SPE that supports the payoff pair $(w^{-1}(gv_j), gv_j) \in \Omega^C$, fix a subgame in which country i proposes first. We construct the equilibrium strategy profile in this subgame as follows.

Country i begins by proposing a θ'_i that holds both $v_j^C(\theta'_i) = gv_j$ and $v_i^C(\theta'_i) = w^{-1}(gv_j)$. Such a proposal exists because \bar{g} satisfies both $\bar{g}v_i^C(1 - \bar{\theta}_j) = v_i^C(\bar{\theta}_i)$ and $\bar{g}v_j^C(\bar{\theta}_i) = v_j^C(1 - \bar{\theta}_j)$. Hence $\forall g > \bar{g}$, $gv_j \in (v_j^C(1 - \bar{\theta}_j), v_j^C(\bar{\theta}_i))$ and $w^{-1}(gv_j) \in (v_i^C(\bar{\theta}_i), v_i^C(1 - \bar{\theta}_j))$. Country j accepts a proposal θ_i iff $v_j^C(\theta_i) \geq gv_j$. The game play proceeds according to ρ after the rejection of any proposal.

Because of the SPE ρ in the continuation game, country j obtains gv_j at the next stage if it rejects at this stage. Hence country j has no incentive to deviate from the response behavior. Country i 's first-stage proposal in the subgame is optimal if the proposer does not benefit from any proposal θ_i that satisfies $v_j^C(\theta_i) < gv_j$ because such a proposal will be rejected and i will receive $g\mu_i$ which is less than $w^{-1}(gv_j)$ because $\mu_i = w^{-1}(v_j)$.

By the symmetric argument, an SPE supports the payoff pair $(gv_i, w(gv_i)) \in \Omega^C$. ■

Lemma A4 (i) $m_i \leq w^{-1}(gM_j)$ and $M_i \geq w^{-1}(gm_j)$.

(ii) $m_j \leq w(gM_i)$ and $M_j \geq w(gm_i)$.

Proof. If $m_i > w^{-1}(gM_j)$, then $\exists v_j \in V_j$ that holds $m_i > w^{-1}(gv_j)$, which contradicts Lemma A3, namely, $w^{-1}(gv_j) \in V_i$. Similarly, if $M_i < w^{-1}(gm_j)$, then $\exists v_j \in V_j$ that holds $M_i < w^{-1}(gv_j)$, which contradicts Lemma A3. ■

Lemma A5 $M_i \leq w^{-1}(gm_j)$ and $M_j \leq w(gm_i)$.

Proof. Fix an arbitrary subgame in which country i proposes first. We partition the SPE set of this subgame into two types: (i) the equilibria where country j accepts i 's first proposal and (ii) the equilibria where j rejects it. In any SPE of type (i), i 's first proposal θ_i must satisfy

$$v_i^C(\theta_i) \leq w^{-1}(gm_j)$$

because such a proposal satisfies $v_j^C(\theta_i) \geq gm_j$.

On the other hand, in any SPE of type (ii), the equilibrium payoff pair (μ_i, v_j) satisfies $\mu_i = w^{-1}(v_j)$ which in turn implies $v_i = g\mu_i \leq gw^{-1}(m_j)$, as shown in Lemma A3's proof.

In summary, for any $v_i \in V_i$, $v_i \leq \max\{w^{-1}(gm_j), gw^{-1}(m_j)\} = w^{-1}(gm_j)$. Hence $M_i \leq w^{-1}(gm_j)$. By the symmetric argument, $M_j \leq w(gm_i)$. ■

Proposition 4 For any given $g > \bar{g}$, the SPE characterized by $(\hat{\theta}_i^i, \hat{\theta}_i^j)$ in Proposition 3 is unique.

Proof. Lemmas A2, A4 and A5 together imply

$$\begin{aligned} M_i &= w^{-1}(gm_j), \\ m_i &= w^{-1}(gM_j), \\ M_j &= w(gm_i), \\ m_j &= w(gM_i), \end{aligned}$$

which together in turn imply $m_i = M_i$ and $m_j = M_j$. Hence $\forall g > \bar{g}$, the SPE payoff pair must be unique. Let $v_i^* = m_i = M_i$ and $v_j^* = m_j = M_j$.

To prove the uniqueness of SPE, we first show that any SPE proposal is accepted at the first stage of any subgame. Suppose, to the contrary, there exists an SPE in which the first-stage proposal is rejected. Then, if country i is the proposer, $w(v_i^*) \leq gv_j^*$ must hold for receiver j . This implies $v_i^* \geq w^{-1}(gv_j^*)$ and hence $v_i^* > gw^{-1}(gv_j^*)$. The last inequality implies $v_i^* > gw^{-1}(v_j^*)$, but if this is true proposer i has no incentive to propose a division that will be rejected. Hence there is not an SPE in which the first-stage proposal is rejected. Thus, the first-stage proposal of any subgame will be accepted in an SPE. This result, together with $v_i^* = m_i = M_i$, implies that whenever country i proposes, it proposes $\hat{\theta}_i^i$. By the symmetric argument, j proposes $\hat{\theta}_i^j$ whenever it is the proposer. ■

B. Both $\tilde{\delta}_i(\theta_i)$ and $\tilde{\delta}_j(\theta_i)$ are increasing in γ_i (Subsection 5.2)

Claim 1 $\gamma_i^{\frac{-1}{\gamma_i-1}} < 1/2 \iff \gamma_i \in (1, 2)$.

Note that $\gamma_i^{\frac{-1}{\gamma_i-1}} < 1/2 \iff \gamma_i > 2^{\gamma_i-1}$. Let $f(\gamma_i) \equiv \gamma_i - 2^{\gamma_i-1}$. We show that the range in which $f(\gamma_i) > 0$ is $1 < \gamma_i < 2$. First, we have $f(1) = f(2) = 0$ and $f'(\gamma_i) = 1 - 2^{\gamma_i-1} \ln 2$. Second, $f'(1) > 0$, $f'(2) < 0$, and $f''(\gamma_i) = -2^{\gamma_i-1} (\ln 2)^2 < 0$. Hence $f(\gamma_i) > 0$ iff $1 < \gamma_i < 2$.

Claim 2 $d\hat{a}_i/d\gamma_i > 0$ for $\gamma_i \in (1, 2)$.

Let $g(\gamma_i) \equiv 1 + (\ln \gamma_i - 1)\gamma_i$. Then, $g(1) = 0$, $g(2) > 0$, and $g'(\gamma_i) = \ln \gamma_i > 0$ for $\gamma_i > 1$. Therefore, $g(\gamma_i) > 0$ for $\gamma_i \in (1, 2)$, which in turn implies $d\hat{a}_i/d\gamma_i > 0$ because

$$\frac{d\hat{a}_i}{d\gamma_i} = \left(\frac{\ln \gamma_i}{(\gamma_i - 1)^2} - \frac{1}{(\gamma_i - 1)\gamma_i} \right) \gamma_i^{\frac{-1}{\gamma_i - 1}} = \frac{1 + (\ln \gamma_i - 1)\gamma_i}{(\gamma_i - 1)^2 \gamma_i} \gamma_i^{\frac{-1}{\gamma_i - 1}}.$$

Claim 3 $d\hat{a}_i^{\gamma_i}/d\gamma_i < 0$ for $\gamma_i \in (1, 2)$.

Let $h(\gamma_i) \equiv 1 - \gamma_i + \ln \gamma_i$. Then, $h(1) = 0$, $h(2) < 0$, and $h'(\gamma_i) = -1 + 1/\gamma_i < 0$ for $\gamma_i \in (1, 2)$. Hence, for $\gamma_i \in (1, 2)$,

$$\frac{d\hat{a}_i^{\gamma_i}}{d\gamma_i} = \left(\frac{\ln \gamma_i}{(\gamma_i - 1)^2} - \frac{1}{\gamma_i - 1} \right) \gamma_i^{\frac{-1}{\gamma_i - 1}} = \frac{1 - \gamma_i + \ln \gamma_i}{(\gamma_i - 1)^2} \gamma_i^{\frac{-1}{\gamma_i - 1}} < 0.$$

Claim 4 $\partial \tilde{\delta}_i(\theta_i)/\partial \gamma_i > 0$ and $\partial \tilde{\delta}_j(\theta_i)/\partial \gamma_i > 0$ for $\gamma_i \in (1, 2)$. Moreover, if $\gamma_i = \gamma_j$, then $\partial \tilde{\delta}_i(\tilde{\theta}_i^*)/\partial \gamma_i > \partial \tilde{\delta}_j(\tilde{\theta}_i^*)/\partial \gamma_i$ for $\gamma_i \in (1, 2)$.

From the above Claims 1-3 and because $\theta_i > \hat{a}_i \forall i$, we have

$$\begin{aligned} \frac{\partial \tilde{\delta}_i(\theta_i)}{\partial \gamma_i} &= \frac{1}{(\theta_j - \hat{a}_j)\beta} \left(\theta_i^{\gamma_i} \ln \theta_i - \frac{d\hat{a}_i^{\gamma_i}}{d\gamma_i} + \frac{d\hat{a}_i}{d\gamma_i} \right) > 0; \\ \frac{\partial \tilde{\delta}_j(\theta_i)}{\partial \gamma_i} &= \frac{1}{(\theta_i - \hat{a}_i)^2 \beta^2} [(\theta_j^{\gamma_i} - \hat{a}_j^{\gamma_i}) - (\theta_j - \hat{a}_j)] \beta \frac{d\hat{a}_i}{d\gamma_i} = \frac{\tilde{\delta}_j(\theta_i)}{\theta_i - \hat{a}_i} \frac{d\hat{a}_i}{d\gamma_i} > 0. \end{aligned}$$

The expressions imply $\partial \tilde{\delta}_i(\tilde{\theta}_i^*)/\partial \gamma_i > \partial \tilde{\delta}_j(\tilde{\theta}_i^*)/\partial \gamma_i$ because $\tilde{\theta}_i^* = 1/2$ when $\gamma_i = \gamma_j$ and hence $\hat{a}_i = \hat{a}_j$.

C. Differentiation of the most efficient distribution (Subsubsection 6.2.2)

Since $U = 1 + \beta_i(1 - \theta_i) + \beta_j\theta_i - \theta_i^{\gamma_i} - (1 - \theta_i)^{\gamma_j}$,

$$\partial U/\partial \theta_i = 0 \iff -\beta_i + \beta_j - \gamma_i(\theta_i^E)^{\gamma_i - 1} + \gamma_j(1 - \theta_i^E)^{\gamma_j - 1} = 0$$

which implies that θ_i^E is a function of $\beta_i, \beta_j, \gamma_i, \gamma_j$. Let $F(\theta_i^E, \beta_i, \beta_j, \gamma_i, \gamma_j) = \partial U/\partial \theta_i$. By the implicit function theorem,

$$\begin{aligned} \frac{\partial \theta_i^E}{\partial \beta_i} &= -\frac{\partial F/\partial \beta_i}{\partial F/\partial \theta_i^E} = \frac{1}{-\gamma_i(\gamma_i - 1)(\theta_i^E)^{\gamma_i - 2} - \gamma_j(\gamma_j - 1)(1 - \theta_i^E)^{\gamma_j - 2}} < 0; \\ \frac{\partial \theta_i^E}{\partial \beta_j} &= -\frac{\partial F/\partial \beta_j}{\partial F/\partial \theta_i^E} = \frac{-1}{-\gamma_i(\gamma_i - 1)(\theta_i^E)^{\gamma_i - 2} - \gamma_j(\gamma_j - 1)(1 - \theta_i^E)^{\gamma_j - 2}} > 0. \end{aligned}$$

Additionally,

$$\begin{aligned}\frac{\partial \theta_i^E}{\partial \gamma_i} &= -\frac{\partial F / \partial \gamma_i}{\partial F / \partial \theta_i^E} = -\frac{-(\theta_i^E)^{\gamma_i-1} - \gamma_i (\theta_i^E)^{\gamma_i-1} \ln \theta_i^E}{-\gamma_i (\gamma_i - 1) (\theta_i^E)^{\gamma_i-2} - \gamma_j (\gamma_j - 1) (1 - \theta_i^E)^{\gamma_j-2}} \\ &= \frac{-(1 + \gamma_i \ln \theta_i^E) (\theta_i^E)^{\gamma_i-1}}{\gamma_i (\gamma_i - 1) (\theta_i^E)^{\gamma_i-2} + \gamma_j (\gamma_j - 1) (1 - \theta_i^E)^{\gamma_j-2}};\end{aligned}$$

$$\begin{aligned}\frac{\partial \theta_i^E}{\partial \gamma_j} &= -\frac{\partial F / \partial \gamma_j}{\partial F / \partial \theta_i^E} = -\frac{(1 - \theta_i^E)^{\gamma_j-1} + \gamma_j (1 - \theta_i^E)^{\gamma_j-1} \ln (1 - \theta_i^E)}{-\gamma_i (\gamma_i - 1) (\theta_i^E)^{\gamma_i-2} - \gamma_j (\gamma_j - 1) (1 - \theta_i^E)^{\gamma_j-2}} \\ &= \frac{(1 + \gamma_j \ln (1 - \theta_i^E)) (1 - \theta_i^E)^{\gamma_j-1}}{\gamma_i (\gamma_i - 1) (\theta_i^E)^{\gamma_i-2} + \gamma_j (\gamma_j - 1) (1 - \theta_i^E)^{\gamma_j-2}}\end{aligned}$$

where both $\ln \theta_i^E$ and $\ln (1 - \theta_i^E)$ are negative for $\theta_i^E \in (0, 1)$. The sign of each derivative is the same as the sign of the numerator. We have

$$\frac{\partial \theta_i^E}{\partial \gamma_i} \leq 0 \iff -1 - \gamma_i \ln \theta_i^E \leq 0 \iff \gamma_i \leq \frac{1}{-\ln \theta_i^E};$$

$$\frac{\partial \theta_i^E}{\partial \gamma_j} \geq 0 \iff 1 + \gamma_j \ln (1 - \theta_i^E) \geq 0 \iff \gamma_j \leq \frac{1}{-\ln (1 - \theta_i^E)}.$$

The first line implies that the sign of $\partial \theta_i^E / \partial \gamma_i$ is determined by the initial value of γ_i relative to the positive threshold $-1 / \ln \theta_i^E$. The sign is negative (positive) if γ_i is smaller (larger) than the threshold. It is easy to see that γ_i can initially be either smaller or larger than the threshold. Consider the benchmark case. The efficient allocation is then $1/2$, and hence the threshold is $-1 / \ln (1/2) \simeq 1.44$. Thus, since Assumption 1' requires only $\gamma \in (1, 2)$, the cost parameter can initially be either smaller than, equal to or greater than the threshold.

Note that the threshold is increasing in θ_i^E because the negative number $\ln \theta_i^E$ is increasing in θ_i^E and hence its magnitude (i.e. the absolute value of $\ln \theta_i^E$) is decreasing in it. This in turn implies that the threshold is decreasing (increasing) in γ_i if the cost parameter is smaller (larger) than the threshold.

Also note that γ_i affects the threshold related to the impact of γ_j through its impact on θ_i^E . Since $-1 / \ln (1 - \theta_i^E)$ is decreasing in θ_i^E , it is increasing (decreasing) in γ_i if γ_i is smaller (larger) than the threshold. As a result, γ_i can affect the sign of $\partial \theta_i^E / \partial \gamma_j$.

By the same argument, the second line implies that the sign of $\partial \theta_i^E / \partial \gamma_j$ is positive (negative) if γ_j is smaller (larger) than the threshold $-1 / \ln (1 - \theta_i^E)$. The threshold is decreasing (increasing) in γ_j if the cost parameter is smaller (larger) than the threshold. Also, the threshold $-1 / \ln \theta_i^E$ is increasing (decreasing) in γ_j if the cost parameter is smaller (larger) than the threshold $-1 / \ln (1 - \theta_i^E)$.

Table 1: Global resettlement

Year	#Persons in need of resettlement [†]	#Persons resettled [‡]	% of the Resettled [#]
2009	565,000	84,657	15.0
2010	747,000	72,914	9.8
2011	805,535	61,649	7.7
2012	781,299	69,252	8.9
2013	859,305	71,449	8.3
2014	690,915	73,608	10.7
2015	958,429	81,891	8.5
2016	1,153,296	126,291	11.0
2017	1,190,519	65,108	5.5
2018	1,195,349	55,680	4.7
2019	1,428,011	63,726	4.5
2020	1,440,408	22,800	1.6
2021	1,445,383	39,266	2.7
2022	1,473,156	53,362	3.6

Sources: UNHCR (2008, 2010-2021) & <https://www.unhcr.org/en-au/resettlement-data.html>

[†] UNHCR estimates of the number of persons in need of resettlement for years before 2009 exist but are inconsistent with the figures in the column, as the pre-2009 estimates do not take into account people in protracted situations (UNHCR, 2008: 2).

[‡] The figures do not include persons resettled through applications by non-UNHCR agents. Because some countries resettle through non-UNHCR channels, the actual numbers are larger than the listed in the column. However, resettlement cases through non-UNHCR applications are not many.

[#] The coronavirus-induced pandemic forced many countries to restrict movements of people across their international borders during 2020-2022. The very small percentages reflect this global event.

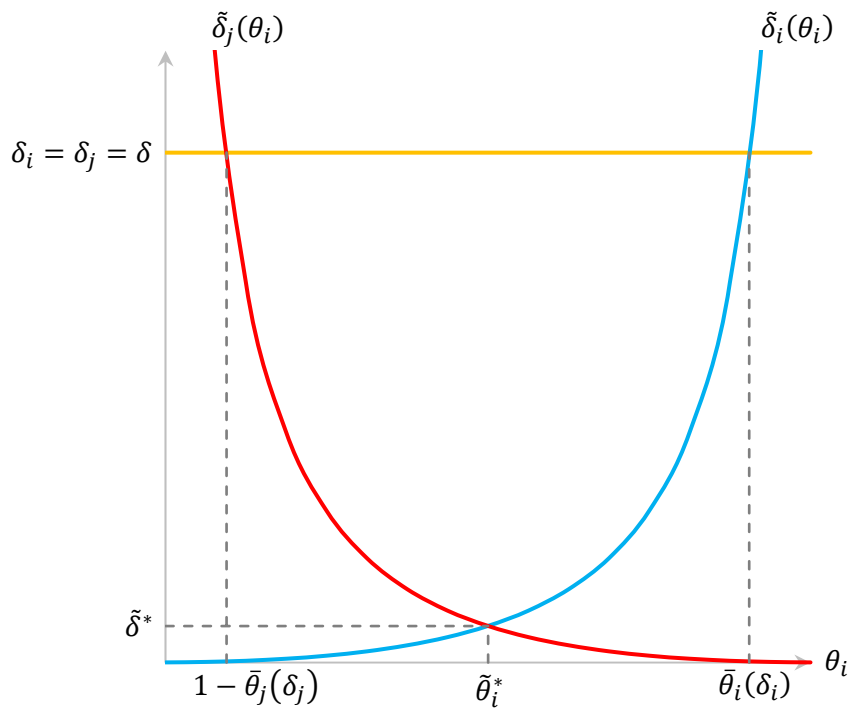


Fig. 1

An illustration of the self-enforceable interval for full-resettlement sharing, $[1 - \bar{\theta}_j(\delta_j), \bar{\theta}_i(\delta_i)]$

Note: $\beta = .8, \gamma = 1.3, \delta = .5$ in this example of two identical countries

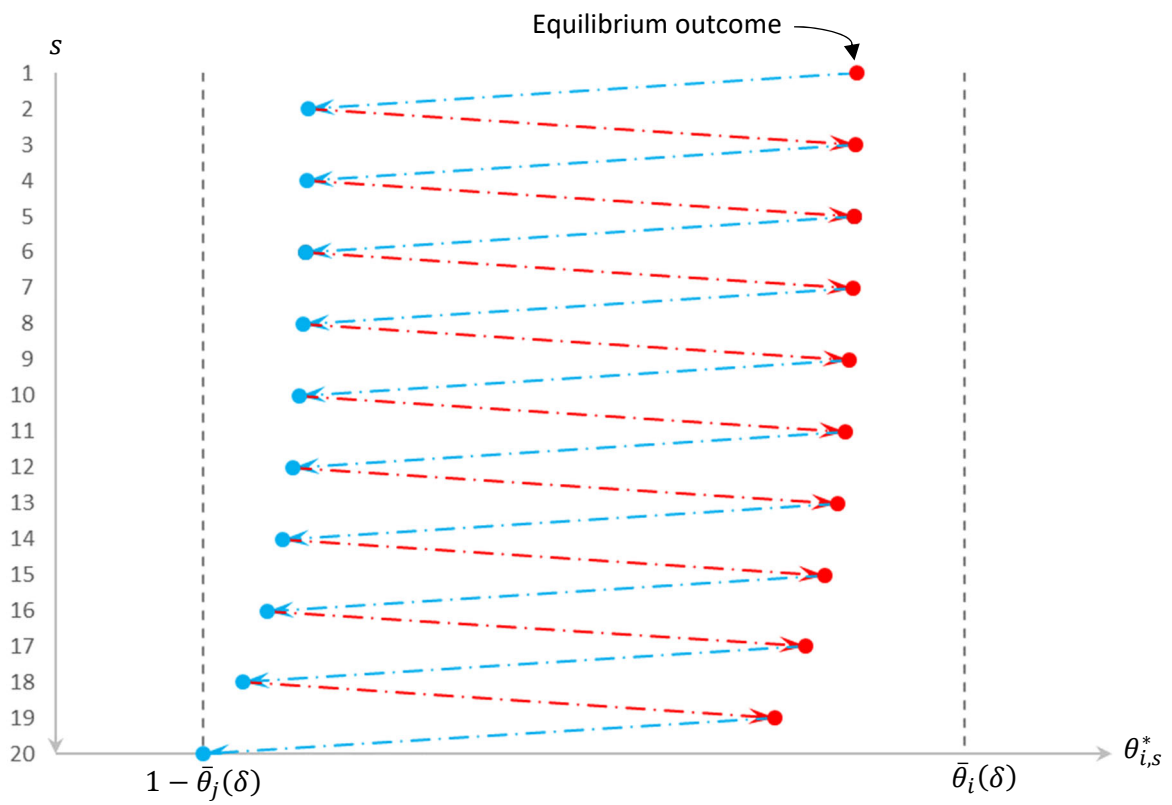


Fig. 2

An illustration of SPE proposals in finite-horizon bargaining by identical countries

with $\delta > \bar{\delta}^*$, $g > \bar{g}_{j,S-2}$, $S = 20$, and country i being the last proposer

Note: $\beta = .8$, $\gamma = 1.3$, $\delta = .5$ as in Fig. 1, and $g = .85$

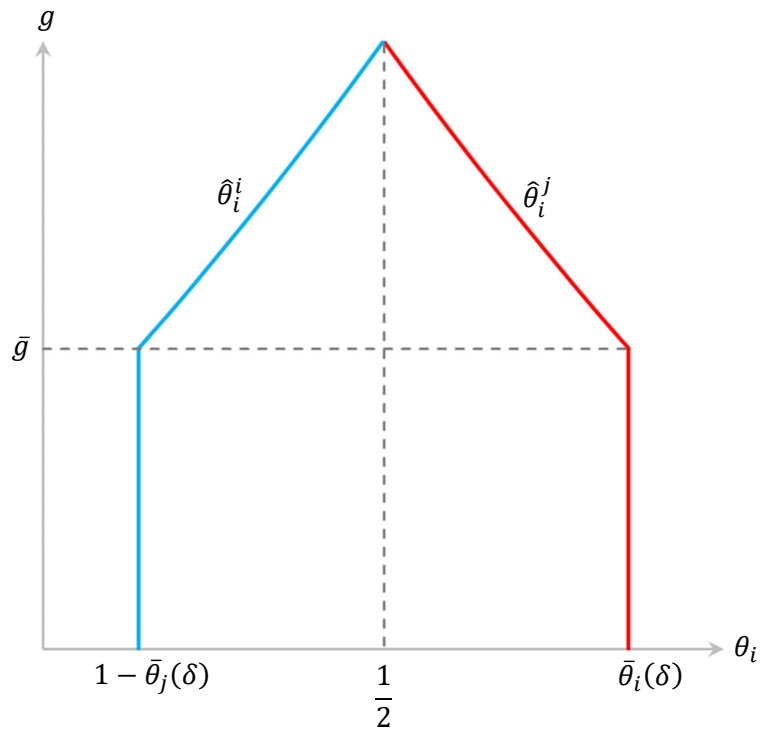


Fig. 3

An illustration of SPE proposals in infinite-horizon bargaining by identical countries with $\delta > \tilde{\delta}^*$

Note: $\beta = .8, \gamma = 1.3, \delta = .5$ as in Fig. 1