

Refugee relocation: A mechanism design approach

Martin Hagen*
CUNEF Universidad

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Abstract

This paper introduces a new mechanism to distribute refugees within the European Union. The usual approach of assigning mandatory refugee quotas has been heavily opposed by several countries. Our mechanism adjusts these quotas to countries' preferences on immigration. All countries become weakly better off, even though they do not exchange monetary transfers, which are ethically controversial. We formally model refugee relocation as a division problem with single-peaked preferences. Our 'quota adjustment mechanism' is the only one satisfying strategy-proofness, Pareto efficiency and a novel concept of fairness that takes account of the asymmetry across countries.

Keywords: refugee relocation, asylum policy, European Union, mechanism design, division problem, single-peaked preferences.

JEL classification: D63, D82, F55.

*CUNEF Universidad, Calle Pirineos, 55, 28040 Madrid, Spain. Email: martin.hagen@cunef.edu. I thank Alexander Westkamp, Yosuke Yasuda, the managing editor and three anonymous referees for helpful comments. Financial support from Fundación Ramón Areces (XXII Concurso Nacional para la Adjudicación de Ayudas a la Investigación en Ciencias Sociales) is gratefully acknowledged.

1 Introduction

The influx of forced migrants¹ is a recurring challenge for the European Union (EU). Following the conflicts in Bosnia-Herzegovina (1992–5), the Kosovo (1998–9) and, most recently, Ukraine, large waves of displaced persons have sought shelter in the EU. The severest ‘refugee crisis’ occurred in 2015 when, mainly due to the Syrian civil war, more than 1.3 million asylum applications were lodged ([Hatton, 2004, 2009, 2020](#)). Most of these migrants entered the EU via Greece and Italy, which were soon overwhelmed with the registration of asylum seekers and the provision of food, health care, temporary housing, etc. In response, the [European Commission \(2015a\)](#) proposed to relocate 40 000 refugees to other EU member states. Each country was assigned a ‘mandatory quota’ that specified how many of these 40 000 persons it ought to take in. The quotas were calculated in proportion to population size, GDP and other measures of reception capacity. Per refugee received, countries were financially compensated with €6 000 out of the EU budget.

How to distribute asylum seekers across member states has become one of the most contentious questions in EU politics. Mandatory quotas are practically appealing because they use objective and easily measurable criteria to define a ‘fair share’ for each country ([Holtug, 2016](#)). Numerous studies have analysed how to select and weigh the variables that enter into the distribution key (e.g. [Thielemann *et al.*, 2010](#); [Wagner and Kraler, 2015](#)). However, little attention has been given to the main downside of mandatory quotas: they disregard national preferences on immigration. Several Eastern European countries opposed the relocation mechanism in 2015 because they were assigned more asylum seekers than they were willing to accept. Hungary and Slovakia even challenged the legality of mandatory quotas, albeit unsuccessfully, at the [Court of Justice of the European Union \(2017\)](#).²

This paper studies how relocation mechanisms could incorporate countries’ willingness to accept refugees. The usual approach in economics

¹Despite subtle differences, the terms ‘forced migrant’, ‘displaced person’, ‘asylum seeker’ and ‘refugee’ are treated as synonyms in this paper.

²Two relocation programmes were agreed on in 2015. The first one concerned 40 000 migrants and, given the resistance to mandatory quotas, eventually made it voluntary for countries to comply. This decision was adopted unanimously. The second programme sought to relocate a further 120 000 migrants via mandatory quotas. This decision was passed by qualified majority against the opposition of Czechia, Hungary, Romania and Slovakia ([Barigazzi and de la Baume, 2015](#)).

would see countries express their preferences through money. For example, [Fernández-Huertas Moraga and Rapoport \(2014, 2015\)](#) propose a market in which quotas can be bought and sold, akin to a cap-and-trade system for pollution. Similarly, [Gretschko \(2019\)](#) suggests a procurement auction that assigns refugees to the countries requesting the lowest financial compensation. There are ethical concerns, however, that such market-based mechanisms denigrate refugees by treating them like commodities (e.g. [Anker *et al.*, 1998](#); [Ortega, 2015](#); [Smith, 2004](#)). While the validity of these moral objections is debated among philosophers (e.g. [Gerver, 2018](#); [Himmelreich, 2019](#); [Kuosmanen, 2013](#); [Sangiovanni, 2023](#)), they do constitute a practical constraint. The question addressed in this paper is what can be done under the EU’s current approach, which limits monetary incentives to a fixed payment per refugee (e.g. €6 000). We show that it is nonetheless possible to design a mechanism that takes countries’ preferences into account and makes all of them at least as well off as under mandatory quotas.

[Table 1](#) illustrates how this mechanism works in the context of the EU’s relocation programme in 2015. Column [1] contains the quotas set by the European Commission in May 2015. Two months later, during a meeting of the Council of the EU, national governments stated how many asylum seekers they would accept voluntarily. These ‘pledges’, which are reported in column [2], summed to 32 256 and thus fell short of the 40 000 goal. For the sake of argument, we treat the pledges as countries’ ideal points, although some countries may have strategically misrepresented their preferences.³

Note that Belgium, Cyprus, Finland, France, Germany, Ireland, the Netherlands, Romania and Sweden accepted their quotas or even wished to host additional migrants (shaded cells). Taken together, these nine countries had quotas of 22 965 and pledges of 25 302. If we replace their quotas by their pledges, then the quotas of the remaining 15 countries can be reduced by a total of $25\,302 - 22\,965 = 2\,337$. Suppose this reduction is done proportionally, that is, all 15 quotas decrease by the same percentage. The resulting distribution is given by column [3]. Luxembourg’s new quota (318)

³The [Council of the European Union \(2015\)](#) did not clearly specify how the remaining 7 744 refugees would be allocated. If a country expected to receive some of them, it may have been optimal to pledge less than its ideal point. On the other hand, [Table 1](#) shows that several countries pledged exactly their quotas. One possible explanation is that their ideal points were lower than their quotas, but they sought to avoid any blame for failing the overall goal of 40 000.

Table 1: Illustration of the quota adjustment mechanism

	[1]	[2]	[3]	[4]	[5]
	Quota adjustment				
Country	Quota	Pledge	Step 1	Step 2	Change
Austria	1213	0	1047	1047	-14%
Belgium	1364	1364	1364	1364	0%
Bulgaria	572	450	494	494	-14%
Croatia	747	400	645	644	-14%
Cyprus	173	173	173	173	0%
Czechia	1328	1100	1146	1146	-14%
Estonia	738	130	637	637	-14%
Finland	792	792	792	792	0%
France	6752	6752	6752	6752	0%
Germany	8763	10500	10500	10500	+20%
Hungary	827	0	714	714	-14%
Ireland	0	600	600	600	N/D
Latvia	517	200	446	446	-14%
Lithuania	503	255	434	434	-14%
Luxembourg	368	320	318	320	-13%
Malta	292	60	252	252	-14%
Netherlands	2047	2047	2047	2047	0%
Poland	2659	1100	2294	2294	-14%
Portugal	1701	1309	1468	1468	-14%
Romania	1705	1705	1705	1705	0%
Slovakia	785	100	677	677	-14%
Slovenia	495	230	427	427	-14%
Spain	4288	1300	3700	3700	-14%
Sweden	1369	1369	1369	1369	0%
Total	39998	32256	40001	40002	0%

Notes: Ireland's quota in column [1] is zero because it is exempted from EU legislation on freedom, security and justice (like Denmark and the UK), yet Ireland opted into the relocation programme. The totals of columns [1], [3] and [4] differ because of rounding.

Sources: Column [1]—[European Commission \(2015a\)](#). Column [2]—[Council of the European Union \(2015\)](#). Columns [3] to [5]—author's own calculations.

now lies below its pledge (320). By assigning Luxembourg its pledge, the 14 countries whose quotas still exceed their pledges can be relieved once more (although only by two units). Column [4] shows the final allocation: since no country's quota is below its pledge, no further adjustments are possible. While some countries inevitably receive more than their pledges, their quotas have decreased by 14%; see column [5].

We mathematically justify this type of 'quota adjustment mechanism'. In our model, which will be thoroughly explained in [Section 3](#), a fixed number of refugees must be distributed among a set of countries. Each country cares only about its own number of refugees and has a unique ideal point. Its utility decreases as we move away from the ideal point. The precise shape of its utility function is each country's private information. Accordingly, our model fits the description of the division problem with single-peaked preferences ([Sprumont, 1991](#)).

Our main result shows that the quota adjustment mechanism is the only one satisfying three appealing properties: strategy-proofness, Pareto efficiency and a novel concept of fairness that takes account of the asymmetry across countries. Strategy-proofness ensures that no country ever gains from misreporting its preferences. Pareto efficiency says that it is impossible to make some country better off without making another country worse off. While there are many existing definitions of fairness (e.g. envy-freeness, anonymity, equal treatment of equals), they implicitly assume that countries differ only in their preferences. EU member states, however, vary greatly in population size, economic performance and other exogenous factors that affect their capacity to absorb refugees. In fact, the European Commission's quotas are meant to reflect these objectively measurable differences.

Our notion of fairness takes the quotas as given but also factors in countries' preferences. A natural desideratum is that no country's final allotment be worse than its quota. While intuitive, this is not a particularly demanding property. Consider column [3] of [Table 1](#), in which the quotas of the 15 countries that are not assigned their pledges decrease by the same percentage. Instead, we could keep the quota of, say, Austria unchanged and lower only those of the other 14 countries. Although Austria's final allotment would not be worse than its initial quota, it could claim to have been treated unfairly compared to the other 14 countries, whose quotas have decreased.

To prevent such discrimination, we extend the definition of quotas from

the EU as a whole to all possible groups of countries. The original quotas in column [1] of [Table 1](#) represent a fair distribution of 40 000 refugees among 24 countries if their preferences are ignored. In column [3], nine countries are assigned their pledges, which sum to 25 302. The other numbers in column [3] can be interpreted as a fair, preference-independent distribution of the remaining 14 698 refugees among the remaining 15 countries. Our notion of fairness, which we call ‘consistent respect for quotas’, requires the final allotment of each country i to be no worse than what i ’s quota would be if the final allotments of any group of countries including i were distributed among them in a fair, preference-independent way.

How the quotas should be set is beyond the scope of our analysis; we take them as exogenously given. But they need to satisfy one assumption: when some countries are assigned their pledges, the remaining countries must not become worse off, that is, their quotas cannot increase. Proportional quota adjustment, as in [Table 1](#), satisfies this assumption, but many of the distribution keys that have been proposed for refugee relocation do not. This undesirable feature will be demonstrated in [Section 6](#), where we also relate our mechanism to the ‘uniform rule’ and other proposals from the mechanism design literature.

2 Related literature on refugee relocation

This paper differs from the existing literature on refugee relocation in three regards. First, our model does not feature externalities. Second, countries are assumed to have private information on their preferences. Third, we take a mechanism design approach.

Externalities usually arise because refugee protection is modelled as a public good with benefits for all countries but costs only for those that host refugees (for a survey, see [Tamura, 2016](#)). Free riding implies that too few refugees are allowed entry into the EU and other safe countries. Several mechanisms have been proposed to increase refugee protection (e.g. [Bubb *et al.*, 2011](#); [Fernández-Huertas Moraga and Rapoport, 2014](#); [Ohta and Tamura, 2023](#)). By contrast, we study the *distribution* of refugees who are already in the EU. There are no externalities because the total number of refugees protected and, thus, the humanitarian benefits that countries may derive are kept constant.

Most of the literature fixes a mechanism, say tradable quotas, and then studies its properties. By contrast, we specify desirable properties and then identify the mechanisms that satisfy them. Such a mechanism design approach has recently been applied to refugee matching, which focuses on the heterogeneity among refugees and asks *who* should go where (e.g. [Andersson and Ehlers, 2020](#); [Aziz et al., 2018](#); [Delacrétaz et al., 2023](#); for a survey, see [Andersson, 2019](#)). Matching is particularly relevant for the assignment of refugees to regions or municipalities within a given country. At the EU level, however, the political debate has mostly revolved around *how many* refugees each member state should take—which is precisely the focus of our analysis.

3 Model

A total of $r \in (0, \infty)$ refugees must be distributed among a set of countries $N := \{1, \dots, n\}$, where $n \in \{1, 2, \dots\}$. An **allocation** is a vector $x := (x_i)_{i \in N} \in [0, r]^n$ such that $\sum_{i \in N} x_i = r$. We refer to $x_i \in [0, r]$, the number of refugees assigned to country i , as i 's **allotment**. The set of allocations is denoted by $X := \{x \in [0, r]^n : \sum_{i \in N} x_i = r\}$. Observe that refugees are assumed to be perfectly divisible. While unrealistic, this assumption is standard in the literature and simplifies the exposition. Our results remain to hold if the allotments are non-negative integers; see [Online Appendix B.3](#).

Countries get a financial compensation of $p > 0$ per refugee. If country $i \in N$ is assigned $x_i \in [0, r]$ refugees, its utility is $u_i(x_i) = px_i - c_i(x_i)$. Following the literature, we assume the cost function $c_i: [0, r] \rightarrow \mathbb{R}$ to be strictly convex: the more refugees a country has already received, the more costly it becomes to host another one.⁴ This assumption can be justified with the difficulty to integrate refugees into the labour market ([Fasani et al., 2022](#)), the hostility among natives ([Hangartner et al., 2019](#)) or the rise of far-right parties ([Dustmann et al., 2019](#)), which tend to increase disproportionately with the size of the incoming refugee cohort. If c_i is strictly convex, then $u_i: [0, r] \rightarrow \mathbb{R}$ is single-peaked. That is, u_i is strictly increasing up to some point $\pi_i(u_i) \in [0, r]$, called the **peak**, and strictly decreasing thereafter. Convexity of c_i further implies that u_i is continuous on $(0, r)$.

⁴See [Bubb et al. \(2011\)](#), [Czaika \(2009\)](#), [Facchini et al. \(2006\)](#), [Fernández-Huertas Moraga and Rapoport \(2014\)](#), [Hagen \(2022\)](#), [Monheim-Helstroffer and Obidzinski \(2010\)](#), [Ohta and Tamura \(2023\)](#), [Tamura \(2018\)](#).

The precise shape of the utility function u_i is country i 's private information. It is commonly known that u_i belongs to a subset U_i of all single-peaked functions on $[0, r]$ that are continuous on $(0, r)$. U_i is country i 's **preference domain** and required to satisfy two 'minimal richness conditions' (Mizobuchi and Serizawa, 2006):

R1. For all $x_i \in [0, r]$, there exists $u_i \in U_i$ such that $\pi_i(u_i) = x_i$.

R2. For all $x'_i, x''_i \in [0, r]$ with $x'_i \neq x''_i$, there exists $u_i \in U_i$ such that $\min\{x'_i, x''_i\} < \pi_i(u_i) < \max\{x'_i, x''_i\}$ and $u_i(x'_i) > u_i(x''_i)$.

R1 says that any country may have any peak. In other words, there is no hard evidence that would allow us to put lower or upper bounds on the number of refugees that countries would like to receive. To understand R2, suppose $x'_i < x''_i$. By R1, there exists a utility function $u'_i \in U_i$ with peak x'_i . Since preferences are single-peaked, u'_i ranks x'_i above x''_i . R2 says that there exists a utility function $u_i \in U_i$ whose peak is slightly above x'_i and which still ranks x'_i above x''_i .

Conditions R1 and R2 are very permissive. They allow the cost function c_i to satisfy other reasonable assumptions, such as monotonicity. We could even consider a quadratic specification like $c_i(x_i) = \frac{1}{2}\theta_i x_i(x_i + 2)$, where $\theta_i \in (0, \infty)$ is country i 's privately known preference parameter. In this case, i 's utility function attains its peak at $\pi_i(\theta_i) = \text{median}\{0, (p/\theta_i) - 1, r\}$. Since π_i is continuous in θ_i , R1 and R2 hold.

A **preference profile** is a vector of utility functions $u := (u_i)_{i \in N}$ such that $u_i \in U_i$ for all $i \in N$. Define $U := \times_{i \in N} U_i$, so $u \in U$. For each group of countries $G \subseteq N$, we write $u_G := (u_i)_{i \in G}$, $u_{-G} := (u_j)_{j \in N \setminus G}$ and $(u_G, u_{-G}) := u$. If $G = \{i\}$, then $(u_{\{i\}}, u_{-\{i\}})$ is shortened to (u_i, u_{-i}) .⁵

Finally, there are exogenously given quotas that represent the allocation that the central planner (e.g. the European Commission) would choose if countries' preferences were ignored. We assume these quotas to be defined not only for the full economy (N, r) but also for any subeconomy (G, r_G) , where a group of countries $G \subseteq N$ must host a total of $r_G \in [0, r]$ refugees. A **quota schedule** q specifies, for each subeconomy (G, r_G) and each country $i \in G$, a quota $q_i(G, r_G) \in [0, r_G]$ such that $\sum_{i \in G} q_i(G, r_G) = r_G$. Examples of quota schedules will be presented in [Section 6](#).

⁵Whenever we consider a group $G \subseteq N$, we implicitly assume that $G \neq \emptyset$.

4 Desirable properties

Throughout the analysis, the following objects are taken as given and commonly known: the set of countries N , the number of refugees in need of relocation r , the vector of preference domains U , and the quota schedule q . The only variable is the preference profile $u \in U$. A mechanism, or ‘rule’, chooses an allocation $x \in X$ for each $u \in U$.

Definition 1. A **rule** is a function $\varphi: U \rightarrow X$. The i -th component of φ is denoted by φ_i , so $\varphi = (\varphi_i)_{i \in N}$.

An ‘ideal’ rule should satisfy three properties: strategy-proofness, Pareto efficiency and fairness. Strategy-proofness says that no country can ever gain by misreporting its preferences, which are its private information.

Definition 2. A rule $\varphi: U \rightarrow X$ is **strategy-proof** if for all $u \in U$, $i \in N$ and $\hat{u}_i \in U_i$, $u_i(\varphi_i(u)) \geq u_i(\varphi_i(\hat{u}_i, u_{-i}))$.

According to Pareto efficiency, it is impossible to find an allocation that makes some country better off and no country worse off compared to the allocation chosen by the rule.

Definition 3. A rule $\varphi: U \rightarrow X$ is (Pareto) **efficient** if for all $u \in U$ and $x \in X$, either $u_i(\varphi_i(u)) > u_i(x_i)$ for some $i \in N$ or $u_i(\varphi_i(u)) = u_i(x_i)$ for all $i \in N$.

It is easy to verify that a rule is efficient if and only if the side of the peak that the allotment lies on is the same for all countries, that is, for all $u \in U$, $\sum_{i \in N} \pi_i(u_i) \leq r$ implies that $\pi_i(u_i) \leq \varphi_i(u)$ for all $i \in N$ and, analogously, $\sum_{i \in N} \pi_i(u_i) \geq r$ implies that $\pi_i(u_i) \geq \varphi_i(u)$ for all $i \in N$.

Our concept of fairness builds on the ‘equal-division lower bound’, which says that no country would become better off if each received the same number of refugees (e.g. Thomson, 2011). In our context, equal division is not an adequate reference point because countries are asymmetric with respect to observable characteristics, like population size or GDP. We can naturally extend the equal-division lower bound by requiring the rule to always choose an allocation that each country weakly prefers to its quota in the full economy, that is, $u_i(\varphi_i(u)) \geq u_i(q_i(N, r))$ for all $u \in U$ and $i \in N$.

Even if this condition holds, some countries may claim to have been treated unfairly—not with respect to *all* other countries, but with respect

to a group of countries. For example, Poland may compare itself to other Eastern European countries. Let i denote Poland, G the group of Eastern European countries, and r_G the total number of refugees that rule φ assigns to Eastern European countries. If the r_G refugees were fairly distributed among group G without taking their preferences into account, then Poland would receive $q_i(G, r_G)$ refugees. Should the allotment $\varphi_i(u)$ be worse than the quota $q_i(G, r_G)$, Poland could claim to have been discriminated against compared to the other Eastern European countries. After all, it would have been possible to give all of them their quotas, but the rule chose not to do so. Based on this idea, our definition of fairness says that no country's allotment should be worse than its quota, regardless of which other countries it is compared to.

Definition 4. A rule $\varphi: U \rightarrow X$ is **consistently respectful of quotas** if for all $u \in U$, $G \subseteq N$ and $i \in G$, $u_i(\varphi_i(u)) \geq u_i(q_i(G, \sum_{j \in G} \varphi_j(u)))$.

5 Quota adjustment rule

We now define the ‘quota adjustment rule’ and then characterise it by strategy-proofness, Pareto efficiency and consistent respect for quotas. The only action that each country $i \in N$ takes in the quota adjustment rule is to report its peak $\pi_i(u_i)$. The rest of the procedure is automatic. Suppose $\sum_{i \in N} \pi_i(u_i) < r$, so the aggregate ‘demand’ for refugees falls short of the target. The reverse case can be treated analogously.

Step 1: The initial quotas are $q_i(N, r)$ for all $i \in N$, which sum to r . If the peaks of all countries are below their quotas, they all receive their quotas and the mechanism ends. Otherwise, each country whose peak is at least as large as its quota receives its peak, that is, $\varphi_i(u) = \pi_i(u_i)$ for all $i \in N$ with $\pi_i(u_i) \geq q_i(N, r)$. Then we move to step 2.

Step 2: Let $N' \subsetneq N$ denote the group of countries that did not receive their peaks in step 1. Let $r' \in [0, r)$ denote the number of refugees that were not assigned in step 1. In subeconomy (N', r') , the quota of each country $i \in N'$ is $q_i(N', r')$, which we call the ‘adjusted quota’. The procedure is as in step 1. If the peaks of all countries in N' are below their adjusted quotas, they all receive their adjusted quotas and the mechanism ends. Otherwise, each country whose peak is at least as large as its adjusted quota receives

its peak, that is, $\varphi_i(u) = \pi_i(u_i)$ for all $i \in N'$ with $\pi_i(u_i) \geq q_i(N', r')$. Then we move to step 3.

Repeating this process, there will be at most n steps (recall that n denotes the number of countries). The reason is that the algorithm only continues if at least one country gets its peak and exits in the current step. That is, at most $n - 1$ countries are left in step 2, at most $n - 2$ countries are left in step 3, and so on. If we reach step n , a single country will be left and receive all refugees that remain unassigned.

Observe that, in step 2 above, the number of refugees r' to be shared among the countries in N' is lower than their aggregate quotas in step 1, that is, $r' = \sum_{i \in N'} q_i(N', r') < \sum_{i \in N'} q_i(N, r)$. Therefore, the quota of at least one country $i \in N'$ will decrease from step 1 to step 2. However, the quota of some other country $j \in N'$ may increase, that is, $q_j(N', r') > q_j(N, r)$. Such an adjustment does not seem fair because j 's quota gets worse, whereas i 's quota improves. The following assumption on the quota schedule ensures that all quotas are adjusted in the same direction.

Assumption 1. Suppose $F \subsetneq G \subseteq N$ and $0 \leq r_F \leq r_G \leq r_N = r$.

- a) If $r_F \leq \sum_{i \in F} q_i(G, r_G)$, then $q_i(F, r_F) \leq q_i(G, r_G)$ for all $i \in F$.
- b) If $r_F \geq \sum_{i \in F} q_i(G, r_G)$, then $q_i(F, r_F) \geq q_i(G, r_G)$ for all $i \in F$.

Assumption 1 expresses a certain notion of ‘solidarity’ (Thomson, 2011): if we remove some countries from group G , the quotas of the remaining countries should either all weakly decrease (part a) or all weakly increase (part b). It follows that the quota schedule is ‘consistent’, that is, if $r_F = \sum_{i \in F} q_i(G, r_G)$, then $q_i(F, r_F) = q_i(G, r_G)$ for all $i \in F$.⁶

Here is our main result.

Theorem 1. *Suppose the quota schedule satisfies Assumption 1. Then there exists a unique rule that is strategy-proof, efficient and consistently respectful of quotas: the quota adjustment rule.*

The proof of Theorem 1 is in [Appendix A](#). We now briefly explain the role of Assumption 1. It is used to show that the quota adjustment rule satisfies strategy-proofness and consistent respect for quotas. Efficiency and

⁶Although the *quota schedule* is consistent under Assumption 1, a *rule* that satisfies consistent respect for quotas may fail to be consistent; see [Online Appendix B.5](#).

uniqueness hold regardless. As already mentioned, Assumption 1 ensures that the quotas of all countries who have not yet received their peaks weakly improve in each step. Hence, none of these countries has incentives to secure its previous quota by reporting a peak equal to that quota. For this reason, the quota adjustment rule is strategy-proof.

The most challenging part of the proof of Theorem 1 is to establish consistent respect for quotas. This property clearly holds for all countries that get their peaks—the best possible outcome—in one of the steps. However, all countries that remain in the last step end up with their final quotas, which are worse than their peaks. Denoting the final subeconomy by (N^*, r^*) , we have that $\varphi_i(u) = q_i(N^*, r^*)$ for all $i \in N^*$. Our proof adds and subtracts countries from N^* in a particular way to show that the quota $q_i(N^*, r^*)$ is at least as good as $q_i(G, \sum_{j \in G} \varphi_j(u))$ for any group G that includes i .

6 Quota schedules

This section presents different quota schedules and analyses whether they satisfy Assumption 1. We also connect the resulting quota adjustment rules to the literature on the division problem with single-peaked preferences.

The question of how to define fair refugee quotas has received considerable attention (e.g. Altemeyer-Bartscher *et al.*, 2016; Angeloni, 2019; Angenendt *et al.*, 2013; Carlsen, 2017; Grech, 2016). Many of the proposed distribution keys violate Assumption 1. Consider, for instance, a simplified version of the formula used by the European Commission (2015b) to calculate the quotas in column [1] of Table 1:

$$q_i(G, r_G) = \left(0.5 \frac{\text{POP}_i}{\sum_{j \in G} \text{POP}_j} + 0.5 \frac{\text{GDP}_i}{\sum_{j \in G} \text{GDP}_j} \right) r_G, \quad (1)$$

where r_G is the total number of refugees to be distributed among group G . The quota of country $i \in G$ is determined by the average of i 's population size and GDP, each relative to group G .⁷

Table 2 considers an example with $G = \{\text{Austria, Romania, Sweden}\}$

⁷The European Commission's (2015b) actual distribution key also contained two inversely weighted 'corrective factors', namely the unemployment rate and the average number of asylum applications over the previous five years. The specific formula was complicated and opaque; see Grech (2016) for an in-depth analysis. Later, the European Commission (2016) adopted the simple average of population size and GDP, as in (1).

and $r_G = 1000$. Equation (1) yields the quotas in column [3]. Austria and Romania together receive 636 refugees. But if we apply (1) to distribute 636 refugees among Austria and Romania, their quotas change; see column [4]. This inconsistency violates [Assumption 1](#).

To grasp the underlying issue, note that Romania’s population is 2.3 times as large as Austria’s, whereas Austria’s GDP is 2.2 times as large as Romania’s. Since both factors are weighted equally, Austria and Romania get roughly the same quota in the two-country subeconomy of column [4]. Adding a relatively rich and unpopulous country like Sweden raises total GDP more than total population size. The effect is as if the weight of GDP had decreased relative to population size, attenuating Austria’s economic advantage over Romania. This results in a lower quota for Austria and a higher quota for Romania, as we see in column [3]. In practice, such reference-group dependence could easily cause disagreement among countries.

Table 2: Quota schedule based on population size and GDP

	[1]	[2]	[3]	[4]
Country	POP (million)	GDP (billion €)	Quota w/ SWE	Quota w/o SWE
Austria	8.5	333	292	314
Romania	19.9	151	344	322
Sweden	9.6	439	364	—
Total	38.0	923	1000	636

Notes: The population and GDP data are for year 2014.

Sources: Column [1]—[Eurostat \(2023b\)](#). Column [2]—[Eurostat \(2023a\)](#). Columns [3] and [4]—author’s own calculations.

An alternative approach was pioneered by [Czaika \(2005\)](#). He defines a Refugee Capacity Index (RCI) based on GDP per capita, population density, ethnic fractionalisation and other variables that depend only on the country in question. The RCI value, which is between 0 and 1, is then multiplied by population size and put in relation to group G :

$$q_i(G, r_G) = \frac{\text{RCI}_i \cdot \text{POP}_i}{\sum_{j \in G} \text{RCI}_j \cdot \text{POP}_j} r_G. \quad (2)$$

It is easy to check that this quota schedule adjusts the initial quotas by the

same proportion, that is, (2) satisfies

$$q_i(G, r_G) = \frac{q_i(N, r)}{\sum_{j \in G} q_j(N, r)} r_G. \quad (3)$$

This formula satisfies [Assumption 1](#). The resulting quota adjustment rule is equivalent to the ‘uniform proportion rule’ ([Zhao and Ohseto, 2022](#)), which is envy-free in the sense that no country prefers the percentage change between allotment and initial quota of another country.

Alternatively, the initial quotas could be adjusted by the same absolute amount instead of the same proportion, that is,

$$q_i(G, r_G) = q_i(N, r) - \frac{1}{|G|} \left[\sum_{j \in G} q_j(N, r) - r_G \right]. \quad (4)$$

This quota schedule also satisfies [Assumption 1](#). The resulting quota adjustment rule is equivalent to the ‘uniform reallocation rule’ ([Klaus *et al.*, 1997, 1998a,b](#)), which is envy-free in the sense that no country prefers the absolute change between allotment and initial quota of another country.⁸

If $q_i(N, r) = r/N$ for all $i \in N$, then (3) and (4) coincide, yielding equal quotas in all subeconomies. In this case, the quota adjustment rule boils down to the ‘uniform rule’ ([Sprumont, 1991](#)), which is envy-free in the standard sense, that is, no country prefers another country’s allotment.⁹

[Table 3](#) compares the three rules in the context of the EU’s relocation programme from 2015. Proportional quota adjustment, column [3], generates the allocation that we already know from [Table 1](#). In comparison, absolute quota adjustment, column [4], tends to favour small countries. For example, Slovenia’s allotment decreases from 427 to 328, whereas Spain’s allotment increases from 3 700 to 4 121. The explanation is that reducing the quotas by the same absolute amount instead of the same relative amount is better for countries whose initial quotas are small. By contrast, the uniform rule favours big countries because it ignores the quotas and treats all countries alike. Since bigger countries are usually willing to accept more refugees, they get their pledges. Smaller countries are rationed uniformly,

⁸For quota schedule (4) to be well-defined, we need to allow for $q_i(G, r_G) < 0$ and $q_i(G, r_G) > r_G$, with the understanding that $u_i(x_i) < u_i(0)$ for all $x_i < 0$ and $u_i \in U_i$. Non-negativity constraints could be incorporated at the cost of more complex notation.

⁹Yet another example of a quota adjustment rule is [Hashimoto and Wakayama’s \(2021\)](#) ‘gross uniform reallocation rule’.

receiving 818 refugees each.

Table 3: Comparison of different quota adjustment rules

Country	[1]	[2]	[3]	[4]	[5]
	Quota	Pledge	Quota adjustment		Uniform rule
			Same %	Same Δ	
Austria	1213	0	1047	1046	818
Belgium	1364	1364	1364	1364	1364
Bulgaria	572	450	494	450	818
Croatia	747	400	644	580	818
Cyprus	173	173	173	173	818
Czechia	1328	1100	1146	1161	1100
Estonia	738	130	637	571	818
Finland	792	792	792	792	818
France	6752	6752	6752	6752	6752
Germany	8763	10500	10500	10500	10500
Hungary	827	0	714	660	818
Ireland	0	600	600	600	818
Latvia	517	200	446	350	818
Lithuania	503	255	434	336	818
Luxembourg	368	320	320	320	818
Malta	292	60	252	125	818
Netherlands	2047	2047	2047	2047	2047
Poland	2659	1100	2294	2492	1100
Portugal	1701	1309	1468	1534	1309
Romania	1705	1705	1705	1705	1705
Slovakia	785	100	677	618	818
Slovenia	495	230	427	328	818
Spain	4288	1300	3700	4121	1300
Sweden	1369	1369	1369	1369	1369
Total	39998	32256	40002	39994	39998

Notes: In column [3] and [4], the quotas are adjusted by the same percentage (%) and by the same absolute amount (Δ), respectively. The totals of columns [1], [3], [4] and [5] differ because of rounding.

Sources: Column [1]—[European Commission \(2015a\)](#). Column [2]—[Council of the European Union \(2015\)](#). Columns [3] to [5]—author’s own calculations.

These three rules also fit the definition of [Barberà *et al.*’s \(1997\)](#) ‘sequential allotment rules’. There are two main differences to our quota adjustment rules. First, the initial quotas of a sequential allotment rule can depend on whether there is underdemand ($\sum_{i \in N} \pi_i(u_i) < r$) or overdemand

($\sum_{i \in N} \pi_i(u_i) > r$). By contrast, the quota schedules that we consider are preference-independent because they are meant to reflect the allocation that the planner would implement if preferences were ignored. The second difference is that our quota adjustment rules need not be ‘replacement-monotonic’ (see [Online Appendix B.7](#)), whereas this property is crucial in [Barberà *et al.*’s \(1997\)](#) characterisation of sequential allotment rules.

7 Conclusion

Mandatory quotas were a key component of the EU’s response to the ‘refugee crisis’ in 2015. They also feature prominently in reform proposals of the EU asylum system (e.g. [European Parliament, 2017](#)). There has been fierce resistance, however, because mandatory quotas ignore member states’ preferences on immigration. We have proposed an alternative mechanism to relocate refugees during a migratory emergency. The main idea is to increase the responsibility of countries willing to do more than their ‘fair share’ so as to alleviate the burden on countries that wish to receive fewer refugees. By incorporating their preferences, this quota adjustment mechanism makes all countries at least as well off as under mandatory quotas, even though no money is exchanged between countries.

The main downside of the quota adjustment mechanism is that some countries may not want to participate. This issue has plagued the implementation of mandatory quotas ([Rios, 2020](#)) and also afflicts other proposals (e.g. [Fernández-Huertas Moraga and Rapoport, 2014](#)). One possible solution would be to raise the monetary compensation that countries get per refugee. To find the lowest price at which all countries wish to participate, their preferences must somehow be taken into account. Apart from creating incentives for countries to exaggerate their reluctance to receive refugees, preference-dependent prices may trigger moral objections against market-based mechanisms (see the [Introduction](#)). Whether, and how, monetary transfers could be incorporated to make refugee relocation individually rational is an important question for future research.

A Appendix: Proof of Theorem 1

A.1 Algebraic definition of the quota adjustment rule

In the main text, the quota adjustment rule was defined algorithmically. We now present an algebraic version of this definition, which will be used to prove [Theorem 1](#).

Consider any preference profile $u \in U$. For the sake of illustration, suppose $\sum_{j \in N} \pi_j(u_j) < r$, that is, refugees are ‘underdemanded’. The set $S^1(u) := \{i \in N : \pi_i(u_i) \geq q_i(N, r)\}$ contains all countries that do not contribute to the underdemand. Removing these countries and their peaks from (N, r) , we obtain the subeconomy $(N \setminus S^1(u), r - \sum_{j \in S^1(u)} \pi_j(u_j))$. The countries whose peaks are at least as large as their quotas in this subeconomy constitute the set $S_+^2(u)$, which is added to $S^1(u)$ to form $S^2(u) := S^1(u) \cup S_+^2(u)$. Removing these countries and their peaks, we reach the subeconomy $(N \setminus S^2(u), r - \sum_{j \in S^2(u)} \pi_j(u_j))$. This process is repeated n times.

In general, the set $S_+^\ell(u)$ contains all countries that exit with their peaks in step $\ell \in \{1, \dots, n\}$. Moreover, $S^\ell(u) := S_+^1(u) \cup \dots \cup S_+^\ell(u)$ is the cumulative set of countries that exit with their peaks in steps 1 through ℓ . The precise definitions, which also cover the case of overdemand, are as follows: $S^0(u) := \emptyset$; for all $\ell \in \{1, \dots, n\}$, $S^\ell(u) := S^{\ell-1}(u) \cup S_+^\ell(u)$ and

$$S_+^\ell(u) := \left\{ i \in N \setminus S^{\ell-1}(u) : \left[\sum_{j \in N} \pi_j(u_j) - r \right] \right. \\ \left. \left[\pi_i(u_i) - q_i(N \setminus S^{\ell-1}(u), r - \sum_{j \in S^{\ell-1}(u)} \pi_j(u_j)) \right] \leq 0 \right\}. \quad (\text{A1})$$

The quota adjustment rule gives all countries in $S^n(u)$ their peaks. The remaining countries get their adjusted quotas in the final subeconomy.¹⁰

Definition A1. A rule $\varphi: U \rightarrow X$ is the **quota adjustment rule** if for all $u \in U$,

$$\forall i \in S^n(u), \quad \varphi_i(u) = \pi_i(u_i), \\ \forall i \in N \setminus S^n(u), \quad \varphi_i(u) = q_i(N \setminus S^n(u), r - \sum_{j \in S^n(u)} \pi_j(u_j)).$$

¹⁰If $S_+^\ell(u) = \emptyset$ for some $\ell \in \{1, \dots, n\}$, then $S^{\ell-1}(u) = S^\ell(u) = \dots = S^n(u)$. Since steps $\ell + 1$ through n are redundant, the algorithm described in the main text stops after step ℓ , whereas the algebraic definition always performs the full n steps.

A.2 Preliminary results

This subsection contains three preliminary results about expression (A1), without using Definition A1 yet. The proofs are in Online Appendix B.1.

Lemma A1 says that *all* countries exit with their peaks if and only if it is feasible to assign all of them their peaks.

Lemma A1. *For all $u \in U$, $S^n(u) = N$ if and only if $\sum_{i \in N} \pi_i(u_i) = r$.*

Lemma A2 concerns the countries in $N \setminus S^n(u)$, which do not exit with their peaks in any of the n steps. Their final quotas are above their peaks if there is underdemand (a) and below their peaks if there is overdemand (b).

Lemma A2. *Consider any $u \in U$ and $i \in N \setminus S^n(u)$.*

- a) *If $\sum_{j \in N} \pi_j(u_j) < r$, then $\pi_i(u_i) < q_i(N \setminus S^n(u), r - \sum_{j \in S^n(u)} \pi_j(u_j))$.*
- b) *If $\sum_{j \in N} \pi_j(u_j) > r$, then $\pi_i(u_i) > q_i(N \setminus S^n(u), r - \sum_{j \in S^n(u)} \pi_j(u_j))$.*

Lemma A3 states the key implication of Assumption 1. In each step of (A1), the quotas of the countries that do not exit weakly improve.

Lemma A3. *Suppose Assumption 1 holds. Consider any $u \in U$, $\ell \in \{1, \dots, n\}$ and $i \in N \setminus S^\ell(u)$.*

- a) *If $\sum_{j \in N} \pi_j(u_j) < r$, then $q_i(N \setminus S^\ell(u), r - \sum_{j \in S^\ell(u)} \pi_j(u_j)) \leq q_i(N \setminus S^{\ell-1}(u), r - \sum_{j \in S^{\ell-1}(u)} \pi_j(u_j))$.*
- b) *If $\sum_{j \in N} \pi_j(u_j) > r$, then $q_i(N \setminus S^\ell(u), r - \sum_{j \in S^\ell(u)} \pi_j(u_j)) \geq q_i(N \setminus S^{\ell-1}(u), r - \sum_{j \in S^{\ell-1}(u)} \pi_j(u_j))$.*

A.3 Main body of the proof

The proof of Theorem 1 is divided into four propositions, which establish efficiency, strategy-proofness, consistent respect for quotas, and uniqueness.

Proposition A1. *The quota adjustment rule is efficient.*

Proof. Consider any $u \in U$. There are three cases. First, suppose $\sum_{i \in N} \pi_i(u_i) = r$. Lemma A1 states that $S^n(u) = N$. Thus, by Definition A1, $\varphi_i(u) = \pi_i(u_i)$ for all $i \in N$. Since every country gets its peak, the allocation is efficient. Second, suppose $\sum_{i \in N} \pi_i(u_i) < r$. By Definition A1 and Lemma A2a, $\varphi_i(u) = \pi_i(u_i)$ for all $i \in S^n(u)$, and $\varphi_i(u) > \pi_i(u_i)$ for all $i \in N \setminus S^n(u)$. Since no country gets less than its peak, the allocation is efficient. The third case, $\sum_{i \in N} \pi_i(u_i) > r$, is analogous to the second. \square

Proposition A2. *Suppose the quota schedule satisfies Assumption 1. Then the quota adjustment rule is strategy-proof.*

Proof. Consider any $u \in U$. By Definition A1, the countries in $S^n(u)$ get their peaks, so they do not have profitable deviations. If $S^n(u) = N$, we are done. Thus, assume $S^n(u) \subsetneq N$. By Lemma A1, $\sum_{j \in N} \pi_j(u_j) \neq r$. Suppose $\sum_{j \in N} \pi_j(u_j) < r$; the reverse case is analogous. Consider any $i \in N \setminus S^n(u)$. By Definition A1 and Lemma A2a,

$$\pi_i(u_i) < \varphi_i(u) = q_i(N \setminus S^n(u), r - \sum_{j \in S^n(u)} \pi_j(u_j)). \quad (\text{A2})$$

First, consider any deviation $\hat{u}_i \in U_i$ with $\pi_i(\hat{u}_i) + \sum_{j \neq i} \pi_j(u_j) \geq r$. For all $j \in N \setminus \{i\}$, efficiency (Proposition A1) implies that $\varphi_j(\hat{u}_i, u_{-i}) \leq \pi_j(u_j) \leq \varphi_j(u)$. Hence, $\varphi_i(\hat{u}_i, u_{-i}) = r - \sum_{j \neq i} \varphi_j(\hat{u}_i, u_{-i}) \geq r - \sum_{j \neq i} \varphi_j(u) = \varphi_i(u)$. Combined with (A2), we get that $\varphi_i(\hat{u}_i, u_{-i}) \geq \varphi_i(u) > \pi_i(u_i)$. By single-peakedness, i does not want to report \hat{u}_i .

Next, consider any deviation $\hat{u}_i \in U_i$ with $\pi_i(\hat{u}_i) + \sum_{j \neq i} \pi_j(u_j) < r$. Since u_{-i} is fixed and $i \notin S^n(u)$, the change from u_i to \hat{u}_i can affect the allocation only if $i \in S^n(\hat{u}_i, u_{-i})$. Let $\ell \in \{1, \dots, n\}$ be the step in which i exits with its peak, that is, $i \in S_+^\ell(\hat{u}_i, u_{-i})$. Then, for all $k \in \{0, \dots, \ell - 1\}$, $S^k(\hat{u}_i, u_{-i}) = S^k(u)$. It follows that

$$\begin{aligned} \varphi_i(\hat{u}_i, u_{-i}) &= \pi_i(\hat{u}_i) \\ &\geq q_i(N \setminus S^{\ell-1}(\hat{u}_i, u_{-i}), r - \sum_{j \in S^{\ell-1}(\hat{u}_i, u_{-i})} \pi_j(u_j)) \\ &= q_i(N \setminus S^{\ell-1}(u), r - \sum_{j \in S^{\ell-1}(u)} \pi_j(u_j)) \end{aligned}$$

Since $\sum_{j \in N} \pi_j(u_j) < r$, Lemma A3a states that

$$\begin{aligned} &q_i(N \setminus S^{\ell-1}(u), r - \sum_{j \in S^{\ell-1}(u)} \pi_j(u_j)) \\ &\geq q_i(N \setminus S^n(u), r - \sum_{j \in S^n(u)} \pi_j(u_j)). \end{aligned}$$

Combined with (A2), we get that $\varphi_i(\hat{u}_i, u_{-i}) \geq \varphi_i(u) > \pi_i(u_i)$. Therefore, i does not want to report \hat{u}_i . \square

Proposition A3. *Suppose the quota schedule satisfies Assumption 1. Then the quota adjustment rule is consistently respectful of quotas.*

Proof. Consider any $u \in U$ and $G \subseteq N$. We must show that $u_i(\varphi_i(u)) \geq$

$u_i(q_i(G, \sum_{j \in G} \varphi_j(u)))$ for all $i \in G$. This condition clearly holds if $G \subseteq S^n(u)$ because then $\varphi_i(u) = \pi_i(u_i)$ for all $i \in G$. Thus, let $G \setminus S^n(u) \neq \emptyset$. By [Lemma A1](#), $\sum_{i \in N} \pi_i(u_i) \neq r$. Suppose $\sum_{i \in N} \pi_i(u_i) < r$; the reverse case is analogous. By [Definition A1](#) and [Lemma A2a](#),

$$\begin{aligned} \forall i \in N \setminus S^n(u), \quad \pi_i(u_i) &< \varphi_i(u) \\ &= q_i(N \setminus S^n(u), r - \sum_{j \in S^n(u)} \pi_j(u_j)). \end{aligned} \quad (\text{A3})$$

We are going to show that

$$\begin{aligned} \forall i \in G \setminus S^n(u), \quad q_i(N \setminus S^n(u), r - \sum_{j \in S^n(u)} \pi_j(u_j)) \\ \leq q_i(G, \sum_{j \in G} \varphi_j(u)). \end{aligned} \quad (\text{A4})$$

By [\(A3\)](#) and [\(A4\)](#), $u_i(\varphi_i(u)) \geq u_i(q_i(G, \sum_{j \in G} \varphi_j(u)))$ for all $i \in G \setminus S^n(u)$.

To prove [\(A4\)](#), we use a variant of [\(A1\)](#) where only the countries in $N \setminus G$, but not those in G , can exit with their peaks. Define $T^0(u) := \emptyset$. For all $\ell \in \{1, \dots, n\}$, $T^\ell(u) := T^{\ell-1}(u) \cup T_+^\ell(u)$ and

$$\begin{aligned} T_+^\ell(u) := \left\{ i \in N \setminus T^{\ell-1}(u) : \right. \\ \left. \pi_i(u_i) \geq q_i(N \setminus T^{\ell-1}(u), r - \sum_{j \in T^{\ell-1}(u)} \pi_j(u_j)) \right\} \setminus G. \end{aligned}$$

Note that $G \subseteq N \setminus T^n(u)$. In three steps, we now move from $N \setminus S^n(u)$ via $N \setminus T^n(u)$ to G . Repeated application of [Assumption 1](#) yields [\(A4\)](#). For visual aid, [Figure A.1](#) illustrates the relationship between G , $S^n(u)$ and $T^n(u)$ in a Venn diagram.

Step 1: From $N \setminus S^n(u)$ to $N \setminus T^n(u)$.

We prove that $T^n(u) \subseteq S^n(u)$ and

$$\begin{aligned} \forall i \in N \setminus S^n(u), \quad q_i(N \setminus S^n(u), r - \sum_{j \in S^n(u)} \pi_j(u_j)) \\ \leq q_i(N \setminus T^n(u), r - \sum_{j \in T^n(u)} \pi_j(u_j)). \end{aligned} \quad (\text{A5})$$

For ease of exposition, we suppress notation of u until the end of Step 1, writing φ instead of $\varphi(u)$, π_i instead of $\pi_i(u_i)$, etc. Moreover, for all $F \subseteq N$ and $i \in N \setminus F$, let $q_i(N \setminus F) := q_i(N \setminus F, r - \sum_{j \in F} \pi_j(u_j))$.

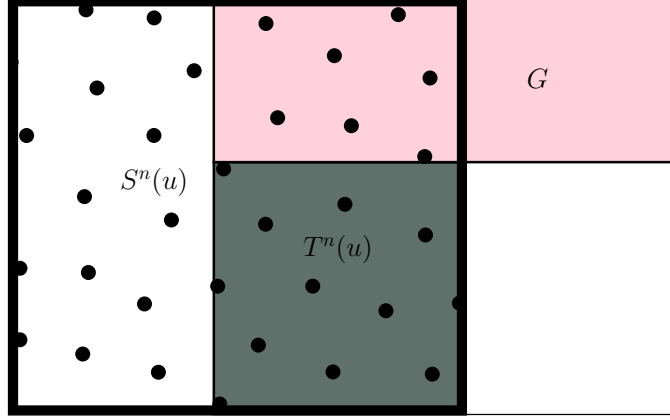


Figure A.1: Proof of [Proposition A3](#)

Notes: The full rectangle is N ; the light-shaded area is G ; the dark-shaded area is $T^n(u)$; the dotted area is $S^n(u)$.

By induction, we establish [\(A6\)](#) to [\(A8\)](#) for all $k \in \{0, \dots, n\}$:

$$T^k \subseteq S^k \tag{A6}$$

and $\forall j \in \{0, \dots, k\}, \forall i \in N \setminus (S^j \cup T^k)$,

$$q_i(N \setminus (S^j \cup T^k)) \leq \begin{cases} q_i(N \setminus S^j), & \text{(A7)} \\ q_i(N \setminus T^k). & \text{(A8)} \end{cases}$$

Note that, by [\(A6\)](#), $S^k \cup T^k = S^k$. Hence, by [\(A8\)](#) with $j = k$,

$$\forall i \in N \setminus S^k, \quad q_i(N \setminus S^k) \leq q_i(N \setminus T^k). \tag{A9}$$

For $k = n$, [\(A6\)](#) and [\(A9\)](#) yield $T^n \subseteq S^n$ and [\(A5\)](#), as desired.

Since $T^0 = S^0 = \emptyset$, [\(A6\)](#) to [\(A8\)](#) hold for $k = 0$, which is the basis of induction. Now consider any $\ell \in \{1, \dots, n\}$ and suppose [\(A6\)](#) to [\(A8\)](#) hold for all $k \in \{0, \dots, \ell - 1\}$. Then

$$\begin{aligned} T_+^\ell &= \{i \in N \setminus T^{\ell-1} : \pi_i \geq q_i(N \setminus T^{\ell-1})\} \setminus G \\ &\subseteq \{i \in N \setminus S^{\ell-1} : \pi_i \geq q_i(N \setminus T^{\ell-1})\} \cup \\ &\quad \{i \in S^{\ell-1} \setminus T^{\ell-1} : \pi_i \geq q_i(N \setminus T^{\ell-1})\} \\ &\subseteq \{i \in N \setminus S^{\ell-1} : \pi_i \geq q_i(N \setminus S^{\ell-1})\} \cup S^{\ell-1} \\ &= S^\ell. \end{aligned}$$

Since $T_+^\ell \subseteq S^\ell$ and $T^{\ell-1} \subseteq S^{\ell-1} \subseteq S^\ell$, it follows that $T^\ell = T_+^\ell \cup T^{\ell-1} \subseteq S^\ell$. Hence, (A6) holds for $k = \ell$.

Next, we establish (A7) for $k = \ell$. Since $T^\ell \subseteq S^\ell$, (A7) holds trivially for $j = \ell (= k)$. Consider any $j \in \{0, \dots, \ell - 1\}$. Note that $T^\ell \setminus S^j = (T_+^1 \cup \dots \cup T_+^\ell) \setminus S^j = (T_+^{j+1} \cup \dots \cup T_+^\ell) \setminus S^j$. We will sequentially remove the sets $T_+^{j+1} \setminus S^j, \dots, T_+^\ell \setminus S^j$ from $N \setminus S^j$ to get $N \setminus (S^j \cup T^\ell)$. First, by definition of T_+^{j+1} and (A8) with $k = j$,

$$\forall i \in T_+^{j+1} \setminus S^j, \quad \pi_i \geq q_i(N \setminus T^j) \geq q_i(N \setminus S^j). \quad (\text{A10})$$

Let us remove the countries in $T_+^{j+1} \setminus S^j$, with their peaks, from $N \setminus S^j$. The remaining set of countries, $N \setminus (S^j \cup T_+^{j+1})$, is equal to $N \setminus (S^j \cup T^{j+1})$ because $T^{j+1} = T^j \cup T_+^{j+1}$ and $T^j \subseteq S^j$. Hence, by (A10) and Assumption 1a,

$$\forall i \in N \setminus (S^j \cup T^{j+1}), \quad q_i(N \setminus (S^j \cup T^{j+1})) \leq q_i(N \setminus S^j), \quad (\text{A11})$$

which is (A7) for $k = j + 1$. If $j + 1 = \ell$, we are done. So, let $j + 1 < \ell$. By definition of T_+^{j+2} and (A8) with $k = j + 1$,

$$\forall i \in T_+^{j+2} \setminus S^j, \quad \pi_i \geq q_i(N \setminus T^{j+1}) \geq q_i(N \setminus (S^j \cup T^{j+1})). \quad (\text{A12})$$

Repeating the above procedure, we remove the countries in $T_+^{j+2} \setminus S^j$, with their peaks, from $N \setminus (S^j \cup T^{j+1})$. The remaining set of countries is $N \setminus (S^j \cup T^{j+2})$. By (A12) and Assumption 1a, their quotas do not increase:

$$\forall i \in N \setminus (S^j \cup T^{j+2}), \quad q_i(N \setminus (S^j \cup T^{j+2})) \leq q_i(N \setminus (S^j \cup T^{j+1})).$$

Combined with (A11), we have (A7) for $k = j + 2$. If $j + 2 = \ell$, we are done. Otherwise, we repeat the argument until we get (A7) for $k = \ell$.

The proof of (A8) for $k = \ell$ is similar; we omit the details.

Step 2: From $N \setminus T^n(u)$ to $N \setminus [S^n(u) \setminus G]$.

In analogy to Lemma A2a, it is easy to verify that

$$\forall i \in [N \setminus T^n(u)] \setminus G, \quad \pi_i(u_i) < q_i(N \setminus T^n(u), r - \sum_{j \in T^n(u)} \pi_j(u_j)). \quad (\text{A13})$$

Let us remove the countries in $[S^n(u) \setminus T^n(u)] \setminus G$, with their peaks, from $N \setminus T^n(u)$. The remaining set of countries is $N \setminus [S^n(u) \setminus G]$. By (A13) and Assumption 1b, their quotas do not decrease:

$$\begin{aligned} \forall i \in N \setminus [S^n(u) \setminus G], \quad & q_i(N \setminus T^n(u), r - \sum_{j \in T^n(u)} \pi_j(u_j)) \quad (\text{A14}) \\ & \leq q_i(N \setminus [S^n(u) \setminus G], r - \sum_{j \in S^n(u) \setminus G} \pi_j(u_j)) \\ & = q_i(N \setminus [S^n(u) \setminus G], \sum_{j \in N \setminus [S^n(u) \setminus G]} \varphi_j(u)), \end{aligned}$$

where the equality is due to Definition A1. Specifically, $\varphi_j(u) = \pi_j(u_j)$ for all $j \in S^n(u)$, so

$$r - \sum_{j \in S^n(u) \setminus G} \pi_j(u_j) = r - \sum_{j \in S^n(u) \setminus G} \varphi_j(u) = \sum_{j \in N \setminus [S^n(u) \setminus G]} \varphi_j(u).$$

Step 3: From $N \setminus [S^n(u) \setminus G]$ to G .

Combining (A3), (A5) and (A14), we get that

$$\begin{aligned} \forall i \in N \setminus S^n(u), \quad & \varphi_i(u) \\ & \leq q_i(N \setminus [S^n(u) \setminus G], \sum_{j \in N \setminus [S^n(u) \setminus G]} \varphi_j(u)). \quad (\text{A15}) \end{aligned}$$

Since $N \setminus [S^n(u) \cup G] \subseteq N \setminus S^n(u)$, (A15) holds for all $i \in N \setminus [S^n(u) \cup G]$. We now remove these countries, with their allotments, from $N \setminus [S^n(u) \setminus G]$. The remaining set of countries is G . By (A15) and Assumption 1b, their quotas do not decrease:

$$\begin{aligned} \forall i \in G, \quad & q_i(N \setminus [S^n(u) \setminus G], \sum_{j \in N \setminus [S^n(u) \setminus G]} \varphi_j(u)) \\ & \leq q_i(G, \sum_{j \in G} \varphi_j(u)). \quad (\text{A16}) \end{aligned}$$

(A5), (A14) and (A16) together yield (A4). \square

It remains to show that the quota adjustment rule is the *only* rule satisfying strategy-proofness, efficiency and consistent respect for quotas. Our proof, like Ching's (1994), uses the fact that any strategy-proof and efficient rule is 'uncompromising' (a term coined by Border and Jordan, 1983).

Lemma A4 (Uncompromisingness). *Suppose φ is a strategy-proof and efficient rule. Consider any $u \in U$, $i \in N$ and $\hat{u}_i \in U$.*

a) If $\pi_i(u_i) < \varphi_i(u)$ and $\pi_i(\hat{u}_i) \leq \varphi_i(u)$, then $\varphi_i(\hat{u}_i, u_{-i}) = \varphi_i(u)$.

b) If $\pi_i(u_i) > \varphi_i(u)$ and $\pi_i(\hat{u}_i) \geq \varphi_i(u)$, then $\varphi_i(\hat{u}_i, u_{-i}) = \varphi_i(u)$.

Proof. See Mizobuchi and Serizawa's (2006) Lemmas 1 to 5. A condensed version of their proof can be found in [Online Appendix B.2](#). This is the only place where we use richness condition [R2](#) and the assumption that the utility functions are continuous on the interior of the domain. \square

Proposition A4. *If a rule satisfies strategy-proofness, efficiency and consistent respect for quotas, then it is the quota adjustment rule.*

Proof. Let φ be any rule that satisfies strategy-proofness, efficiency and consistent respect for quotas. We must show that, for all $u \in U$,

$$\forall i \in S^n(u), \quad \varphi_i(u) = \pi_i(u_i), \quad (\text{A17})$$

$$\forall i \in N \setminus S^n(u), \quad \varphi_i(u) = q_i(N \setminus S^n(u), r - \sum_{j \in S^n(u)} \pi_j(u_j)). \quad (\text{A18})$$

First, we prove [\(A17\)](#). By definition, $S^0(u) = \emptyset$ for all $u \in U$. Hence, vacuously, $\varphi_i(u) = \pi_i(u_i)$ for all $u \in U$ and $i \in S^0(u)$. By induction, consider any $\ell \in \{1, \dots, n\}$ and suppose that

$$\forall u \in U, \forall i \in S^{\ell-1}(u), \quad \varphi_i(u) = \pi_i(u_i). \quad (\text{A19})$$

We will show that

$$\forall u \in U, \forall i \in S_+^\ell(u), \quad \varphi_i(u) = \pi_i(u_i). \quad (\text{A20})$$

Since $S^\ell(u) = S^{\ell-1}(u) \cup S_+^\ell(u)$, it follows that $\varphi_i(u) = \pi_i(u_i)$ for all $u \in U$ and $i \in S^\ell(u)$. For $\ell = n$, we obtain [\(A17\)](#).

To start off the proof of [\(A20\)](#), consider any $u \in U$.

First, suppose $\sum_{i \in N} \pi_i(u_i) = r$. Efficiency implies that $\varphi_i(u) = \pi_i(u_i)$ for all $i \in N$. Moreover, by [\(A1\)](#), $S_+^1(u) = N$ and $S_+^2(u) = \dots = S_+^n(u) = \emptyset$. Regardless of whether $\ell = 1$ or $\ell \in \{2, \dots, n\}$, [\(A20\)](#) holds.

Now suppose $\sum_{i \in N} \pi_i(u_i) < r$; the reverse case is analogous. By [\(A1\)](#),

$$\forall i \in S_+^\ell(u), \quad \pi_i(u_i) \geq q_i(N \setminus S^{\ell-1}(u), r - \sum_{j \in S^{\ell-1}(u)} \pi_j(u_j)). \quad (\text{A21})$$

For all $i \in S_+^\ell(u)$, condition [R1](#) ensures the existence of $\hat{u}_i \in U_i$ such that

$$\forall i \in S_+^\ell(u), \quad \pi_i(\hat{u}_i) \leq q_i(N \setminus S^{\ell-1}(u), r - \sum_{j \in S^{\ell-1}(u)} \pi_j(u_j)). \quad (\text{A22})$$

For all $G \subseteq S_+^\ell(u)$, define $\hat{u}_G := (\hat{u}_i)_{i \in G}$. If $G = S_+^\ell(u)$, then vacuously $\varphi_i(\hat{u}_G, u_{-G}) = \pi_i(u_i)$ for all $i \in S_+^\ell(u) \setminus G$. We will show that this equation remains to hold if we successively shrink the set G . In the end, when $G = \emptyset$, we get that $\varphi_i(u) = \pi_i(u_i)$ for all $i \in S_+^\ell(u)$, which is (A20).

By induction, consider any $G \subsetneq S_+^\ell(u)$ and $i \in S_+^\ell(u) \setminus G$. Define $Gi := G \cup \{i\}$ and note that $Gi \subseteq S_+^\ell(u)$. The induction hypothesis states that $\varphi_j(\hat{u}_{Gi}, u_{-Gi}) = \pi_j(u_j)$ for all $j \in S_+^\ell(u) \setminus Gi$. By (A21) and (A22), $\pi_j(\hat{u}_j) \leq \pi_j(u_j)$ for all $j \in S_+^\ell(u)$. Since $G \subsetneq S_+^\ell(u)$, it follows that $\sum_{j \in G} \pi_j(\hat{u}_j) + \sum_{j \in N \setminus G} \pi_j(u_j) \leq \sum_{j \in N} \pi_j(u_j) < r$. By efficiency, $\pi_i(u_i) \leq \varphi_i(\hat{u}_G, u_{-G})$. We want this to be an equality. To the contrary, suppose

$$\pi_i(u_i) < \varphi_i(\hat{u}_G, u_{-G}). \quad (\text{A23})$$

As $\pi_i(\hat{u}_i) \leq \pi_i(u_i)$, uncompromisingness (Lemma A4a) implies that

$$\varphi_i(\hat{u}_{Gi}, u_{-Gi}) = \varphi_i(\hat{u}_G, u_{-G}). \quad (\text{A24})$$

Since $Gi \subseteq S_+^\ell(u)$, none of the countries in Gi is in $S^{\ell-1}(u)$. Hence, by (A1), their peaks are below their quotas in each of the first $\ell-1$ steps. Given that $\pi_j(\hat{u}_j) \leq \pi_j(u_j)$ for all $j \in Gi$, their peaks do not increase when we move to preference profile (\hat{u}_{Gi}, u_{-Gi}) from u . It follows that $S^{\ell-1}(\hat{u}_{Gi}, u_{-Gi}) = S^{\ell-1}(u)$. Moreover, at (\hat{u}_{Gi}, u_{-Gi}) , (A19) states that $\varphi_j(\hat{u}_{Gi}, u_{-Gi}) = \pi_j(u_j)$ for all $j \in S^{\ell-1}(\hat{u}_{Gi}, u_{-Gi})$. Therefore,

$$\begin{aligned} & q_i(N \setminus S^{\ell-1}(\hat{u}_{Gi}, u_{-Gi}), \sum_{j \in N \setminus S^{\ell-1}(\hat{u}_{Gi}, u_{-Gi})} \varphi_j(\hat{u}_{Gi}, u_{-Gi})) \\ &= q_i(N \setminus S^{\ell-1}(\hat{u}_{Gi}, u_{-Gi}), r - \sum_{j \in S^{\ell-1}(\hat{u}_{Gi}, u_{-Gi})} \varphi_j(\hat{u}_{Gi}, u_{-Gi})) \\ &= q_i(N \setminus S^{\ell-1}(u), r - \sum_{j \in S^{\ell-1}(u)} \pi_j(u_j)) \\ &\geq \pi_i(\hat{u}_i), \end{aligned} \quad (\text{A25})$$

where the inequality is due to (A22). By (A25) and consistent respect for quotas,

$$\begin{aligned} & q_i(N \setminus S^{\ell-1}(\hat{u}_{Gi}, u_{-Gi}), \sum_{j \in N \setminus S^{\ell-1}(\hat{u}_{Gi}, u_{-Gi})} \varphi_j(\hat{u}_{Gi}, u_{-Gi})) \\ &\geq \varphi_i(\hat{u}_{Gi}, u_{-Gi}). \end{aligned} \quad (\text{A26})$$

Combining (A21), (A25), (A26), (A24) and (A23) in this order, we get that

$\pi_i(u_i) > \pi_i(u_i)$. This contradiction concludes the proof of (A17).

To establish (A18), consider any $u \in U$ such that $S^n(u) \subsetneq N$. By Lemma A1, $\sum_{i \in N} \pi_i(u_i) \neq r$. Suppose $\sum_{i \in N} \pi_i(u_i) < r$; the reverse case is analogous. By (A17),

$$r - \sum_{j \in S^n(u)} \pi_j(u_j) = r - \sum_{j \in S^n(u)} \varphi_j(u) = \sum_{j \in N \setminus S^n(u)} \varphi_j(u). \quad (\text{A27})$$

Combined with Lemma A2a, we get that

$$\forall i \in N \setminus S^n(u), \quad \pi_i(u_i) < q_i(N \setminus S^n(u), \sum_{j \in N \setminus S^n(u)} \varphi_j(u)).$$

By consistent respect for quotas,

$$\forall i \in N \setminus S^n(u), \quad \varphi_i(u) \leq q_i(N \setminus S^n(u), \sum_{j \in N \setminus S^n(u)} \varphi_j(u)). \quad (\text{A28})$$

Summing over all $i \in N \setminus S^n(u)$, we get that

$$\sum_{i \in N \setminus S^n(u)} \varphi_i(u) \leq \sum_{i \in N \setminus S^n(u)} q_i(N \setminus S^n(u), \sum_{j \in N \setminus S^n(u)} \varphi_j(u)) = \sum_{i \in N \setminus S^n(u)} \varphi_i(u).$$

Hence, (A28) must hold with equality for all $i \in N \setminus S^n(u)$. Together with (A27), we obtain (A18). \square

References

- Altemeyer-Bartscher, M., Holtemöller, O., Lindner, A., Schmalzbauer, A. and Zeddies, G. (2016). ‘On the distribution of refugees in the EU’, *Intereconomics*, vol. 51(4), pp. 220–228, doi:[10.1007/s10272-016-0606-y](https://doi.org/10.1007/s10272-016-0606-y).
- Andersson, T. (2019). ‘Refugee matching as a market design application’, in (J.-F. Laslier, H. Moulin, M. R. Sanver and W. S. Zwicker, eds.), *The Future of Economic Design*, pp. 445–450, Springer, doi:[10.1007/978-3-030-18050-8_62](https://doi.org/10.1007/978-3-030-18050-8_62).
- Andersson, T. and Ehlers, L. (2020). ‘Assigning refugees to landlords in Sweden: Efficient stable maximum matchings’, *Scandinavian Journal of Economics*, vol. 122(3), pp. 937–965, doi:[10.1111/sjoe.12362](https://doi.org/10.1111/sjoe.12362).
- Angeloni, S. (2019). ‘Improving the distribution of asylum-seekers through a multi-criteria index’, *European Union Politics*, vol. 20(2), pp. 328–337, doi:[10.1177/1465116519831949](https://doi.org/10.1177/1465116519831949).

- Angenendt, S., Engler, M. and Schneider, J. (2013). ‘European refugee policy: Pathways to fairer burden-sharing’, German Expert Council on Integration and Migration, Policy brief, November.
- Anker, D., Fitzpatrick, J. and Shacknové, A. (1998). ‘Crisis and cure: A reply to Hathaway/Neve and Schuck’, *Harvard Human Rights Journal*, vol. 11, pp. 295–310.
- Aziz, H., Chen, J., Gaspers, S. and Sun, Z. (2018). ‘Stability and Pareto optimality in refugee allocation matchings’, *AAMAS 2018: Proceedings of the 17th International Conference on Autonomous Agents and MultiAgent Systems*, pp. 964–972.
- Barberà, S., Jackson, M.O. and Neme, A. (1997). ‘Strategy-proof allotment rules’, *Games and Economic Behavior*, vol. 18(1), pp. 1–21, doi:[10.1006/game.1997.0511](https://doi.org/10.1006/game.1997.0511).
- Barigazzi, J. and de la Baume, M. (2015). ‘EU forces through refugee deal’, *Politico*, 21 September.
- Border, K.C. and Jordan, J.S. (1983). ‘Straightforward elections, unanimity and phantom voters’, *Review of Economic Studies*, vol. 50(1), pp. 153–170, doi:[10.2307/2296962](https://doi.org/10.2307/2296962).
- Bubb, R., Kremer, M. and Levine, D.I. (2011). ‘The economics of international refugee law’, *Journal of Legal Studies*, vol. 40(2), pp. 367–404, doi:[10.1086/661185](https://doi.org/10.1086/661185).
- Carlsen, L. (2017). ‘An alternative view on distribution keys for the possible relocation of refugees in the European Union’, *Social Indicators Research*, vol. 130(3), pp. 1147–1163, doi:[10.1007/s11205-016-1234-4](https://doi.org/10.1007/s11205-016-1234-4).
- Ching, S. (1994). ‘An alternative characterization of the uniform rule’, *Social Choice and Welfare*, vol. 11(2), pp. 131–136, doi:[10.1007/BF00179209](https://doi.org/10.1007/BF00179209).
- Council of the European Union (2015). ‘Outcome of the 3405th Council meeting, Justice and Home Affairs’, Press Release 11097/15, 20 July.
- Court of Justice of the European Union (2017). ‘Judgment in Joined Cases C-643/15 and C-647/15: Slovakia and Hungary v Council’, Press Release No 91/17, 6 September.
- Czaika, M. (2005). ‘A Refugee Burden Index: Methodology and its application’, *Migration Letters*, vol. 2(2), pp. 101–125, doi:[10.33182/ml.v2i2.9](https://doi.org/10.33182/ml.v2i2.9).
- Czaika, M. (2009). ‘Asylum cooperation among asymmetric countries’, *European Union Politics*, vol. 10(1), pp. 89–113, doi:[10.1177/1465116508099762](https://doi.org/10.1177/1465116508099762).

- Delacrétaz, D., Kominers, S.D. and Teytelboym, A. (2023). ‘Matching mechanisms for refugee resettlement’, *American Economic Review*, vol. 113(10), pp. 2689–2717, doi:[10.1257/aer.20210096](https://doi.org/10.1257/aer.20210096).
- Dustmann, C., Vasiljeva, K. and Damm, A.P. (2019). ‘Refugee migration and electoral outcomes’, *Review of Economic Studies*, vol. 86(5), pp. 2035–2091, doi:[10.1093/restud/rdy047](https://doi.org/10.1093/restud/rdy047).
- European Commission (2015a). ‘European Commission makes progress on Agenda on Migration’, Press Release IP/15/5039, 27 May.
- European Commission (2015b). ‘Proposal for a regulation of the European Parliament and of the Council establishing a crisis relocation mechanism and amending Regulation (EU) No 604/2013 of the European Parliament and of the Council of 26 June 2013 establishing the criteria and mechanisms for determining the Member State responsible for examining an application for international protection lodged in one of the Member States by a third country national or a stateless person’, COM/2015/0450 final, 9 September.
- European Commission (2016). ‘Proposal for a regulation of the European Parliament and of the Council establishing the criteria and mechanisms for determining the Member State responsible for examining an application for international protection lodged in one of the Member States by a third-country national or a stateless person (recast)’, COM(2016) 270 final/2, 4 May.
- European Parliament (2017). ‘EU asylum policy: Reforming the Dublin rules to create a fairer system’, Background Note 20171019BKG86403, 19 October.
- Eurostat (2023a). ‘GDP and main components (output, expenditure and income)’, Dataset nama_10_gdp, 14 July, doi:[10.2908/NAMA_10_GDP](https://doi.org/10.2908/NAMA_10_GDP).
- Eurostat (2023b). ‘Population on 1 January’, Dataset tps00001, 13 July, doi:[10.2908/TPS00001](https://doi.org/10.2908/TPS00001).
- Facchini, G., Lorz, O. and Willmann, G. (2006). ‘Asylum seekers in Europe: The warm glow of a hot potato’, *Journal of Population Economics*, vol. 19(2), pp. 411–430, doi:[10.1007/s00148-005-0059-2](https://doi.org/10.1007/s00148-005-0059-2).
- Fasani, F., Frattini, T. and Minale, L. (2022). ‘(The struggle for) Refugee integration into the labour market: Evidence from Europe’, *Journal of Economic Geography*, vol. 22(2), pp. 351–393, doi:[10.1093/jeg/lbab011](https://doi.org/10.1093/jeg/lbab011).
- Fernández-Huertas Moraga, J. and Rapoport, H. (2014). ‘Tradable immigration quotas’, *Journal of Public Economics*, vol. 115, pp. 94–108, doi:[10.1016/j.jpubeco.2014.04.002](https://doi.org/10.1016/j.jpubeco.2014.04.002).

- Fernández-Huertas Moraga, J. and Rapoport, H. (2015). ‘Tradable refugee-admission quotas and EU asylum policy’, *CESifo Economic Studies*, vol. 61(3–4), pp. 638–672, doi:[10.1093/cesifo/ifu037](https://doi.org/10.1093/cesifo/ifu037).
- Gerver, M. (2018). ‘Moral refugee markets’, *Global Justice: Theory Practice Rhetoric*, vol. 11(1), pp. 45–63, doi:[10.21248/gjn.11.1.140](https://doi.org/10.21248/gjn.11.1.140).
- Grech, P. (2016). ‘Undesired properties of the European Commission’s refugee distribution key’, *European Union Politics*, vol. 18(2), pp. 212–238, doi:[10.1177/1465116516649244](https://doi.org/10.1177/1465116516649244).
- Gretschko, V. (2019). ‘A procurement mechanism to assign refugee quotas’, *Journal of Institutional and Theoretical Economics*, vol. 175(1), pp. 53–57, doi:[10.1628/jite-2019-0008](https://doi.org/10.1628/jite-2019-0008).
- Hagen, M. (2022). ‘Tradable immigration quotas revisited’, *Journal of Public Economics*, vol. 208, p. 104619, doi:[10.1016/j.jpubeco.2022.104619](https://doi.org/10.1016/j.jpubeco.2022.104619).
- Hangartner, D., Dinas, E., Marbach, M., Matakos, K. and Xefteris, D. (2019). ‘Does exposure to the refugee crisis make natives more hostile?’, *American Political Science Review*, vol. 113(2), pp. 442–455, doi:[10.1017/s0003055418000813](https://doi.org/10.1017/s0003055418000813).
- Hashimoto, K. and Wakayama, T. (2021). ‘Fair reallocation in economies with single-peaked preferences’, *International Journal of Game Theory*, vol. 50(3), pp. 773–785, doi:[10.1007/s00182-021-00767-z](https://doi.org/10.1007/s00182-021-00767-z).
- Hatton, T.J. (2004). ‘Seeking asylum in Europe’, *Economic Policy*, vol. 19(38), pp. 6–62, doi:[10.1111/j.1468-0327.2004.00118.x](https://doi.org/10.1111/j.1468-0327.2004.00118.x).
- Hatton, T.J. (2009). ‘The rise and fall of asylum: What happened and why?’, *Economic Journal*, vol. 119(535), pp. F183–F213, doi:[10.1111/j.1468-0297.2008.02228.x](https://doi.org/10.1111/j.1468-0297.2008.02228.x).
- Hatton, T.J. (2020). ‘Asylum migration to the developed world: Persecution, incentives, and policy’, *Journal of Economic Perspectives*, vol. 34(1), pp. 75–93, doi:[10.1257/jep.34.1.75](https://doi.org/10.1257/jep.34.1.75).
- Himmelreich, J. (2019). ‘Asylum for sale: A market between states that is feasible and desirable’, *Journal of Applied Philosophy*, vol. 36(2), pp. 217–232, doi:[10.1111/japp.12289](https://doi.org/10.1111/japp.12289).
- Holtug, N. (2016). ‘A fair distribution of refugees in the European Union’, *Journal of Global Ethics*, vol. 12(3), pp. 279–288, doi:[10.1080/17449626.2016.1251483](https://doi.org/10.1080/17449626.2016.1251483).
- Klaus, B., Peters, H. and Storcken, T. (1997). ‘Reallocation of an infinitely divisible good’, *Economic Theory*, vol. 10(2), pp. 305–333, doi:[10.1007/s001990050159](https://doi.org/10.1007/s001990050159).

- Klaus, B., Peters, H. and Storcken, T. (1998a). ‘Strategy-proof division with single-peaked preferences and individual endowments’, *Social Choice and Welfare*, vol. 15(2), pp. 297–311, doi:[10.1007/s003550050106](https://doi.org/10.1007/s003550050106).
- Klaus, B., Peters, H. and Storcken, T. (1998b). ‘Strategy-proof reallocation of an infinitely divisible good’, in (P. L. Butzer, W. Oberschelp and H. T. Jongen, eds.), *Charlemagne and his Heritage: 1200 Years of Civilization and Science in Europe*, pp. 455–470, vol. 2, Brepols Publishers, doi:[10.1484/m.sths-eb.4.2017056](https://doi.org/10.1484/m.sths-eb.4.2017056).
- Kuosmanen, J. (2013). ‘What (if anything) is wrong with trading refugee quotas?’, *Res Publica*, vol. 19(2), pp. 103–119, doi:[10.1007/s11158-012-9198-y](https://doi.org/10.1007/s11158-012-9198-y).
- Mizobuchi, H. and Serizawa, S. (2006). ‘Maximal domain for strategy-proof rules in allotment economies’, *Social Choice and Welfare*, vol. 27(1), pp. 195–210, doi:[10.1007/s00355-006-0112-4](https://doi.org/10.1007/s00355-006-0112-4).
- Monheim-Helstroffer, J. and Obidzinski, M. (2010). ‘Optimal discretion in asylum lawmaking’, *International Review of Law and Economics*, vol. 30(1), pp. 86–97, doi:[10.1016/j.irl.2009.09.004](https://doi.org/10.1016/j.irl.2009.09.004).
- Ohta, K. and Tamura, Y. (2023). ‘Repeated refugee resettlement’, Working paper, 26 November, doi:[10.2139/ssrn.4336195](https://doi.org/10.2139/ssrn.4336195).
- Ortega, A. (2015). ‘The disgrace of trading refugee quotas’, *Real Instituto Elcano Blog*, 22 September.
- Rios, B. (2020). ‘Poland, Hungary and Czechia broke law over refugees relocation system, EU court rules’, *EURACTIV*, 2 April.
- Sangiovanni, A. (2023). ‘The ethics of tradable refugee quotas’, *Politics, Philosophy & Economics*, vol. 22(4), pp. 407–422, doi:[10.1177/1470594X231169210](https://doi.org/10.1177/1470594X231169210).
- Smith, R.C. (2004). ‘Outsourcing refugee protection responsibilities: The second life of an unconscionable idea’, *Journal of Transnational Law & Policy*, vol. 14(1), pp. 137–153.
- Sprumont, Y. (1991). ‘The division problem with single-peaked preferences: A characterization of the uniform allocation rule’, *Econometrica*, vol. 59(2), pp. 509–519, doi:[10.2307/2938268](https://doi.org/10.2307/2938268).
- Tamura, Y. (2016). ‘International coordination in asylum provision’, in (S. N. Durlauf and L. E. Blume, eds.), *The New Palgrave Dictionary of Economics*, Palgrave Macmillan, doi:[10.1057/978-1-349-95121-5_3029-1](https://doi.org/10.1057/978-1-349-95121-5_3029-1).
- Tamura, Y. (2018). ‘Asylum providers: Hawks or doves?’, Working paper, 14 July, doi:[10.2139/ssrn.3067137](https://doi.org/10.2139/ssrn.3067137).

- Thielemann, E.R., Williams, R. and Boswell, C. (2010). ‘What system of burden-sharing between Member States for the reception of asylum seekers?’, European Parliament, Committee on Civil Liberties, Justice and Home Affairs, Study PE 419.620, 22 January.
- Thomson, W. (2011). ‘Fair allocation rules’, in (K. J. Arrow, A. Sen and K. Suzumura, eds.), *Handbook of Social Choice and Welfare*, pp. 393–506, vol. 2, chap. 21, Elsevier, doi:[10.1016/s0169-7218\(10\)00021-3](https://doi.org/10.1016/s0169-7218(10)00021-3).
- Wagner, M. and Kraler, A. (2015). ‘An effective asylum responsibility-sharing mechanism’, International Centre for Migration Policy Development (ICMPD), Thematic paper, October.
- Zhao, Z. and Ohseto, S. (2022). ‘Strategy-proof and fair reallocation with single-peaked preferences’, *Social Choice and Welfare*, vol. 58(4), pp. 791–800, doi:[10.1007/s00355-021-01374-3](https://doi.org/10.1007/s00355-021-01374-3).