Reseach Proposal: Two-sided-matching with exogenous capacities in the context of refugee allocation

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We develop a model for refugee allocation in the European Union that leverages tradable quotas and two-sided matching mechanisms to address inefficiencies in existing asylum policies. The model introduces a dynamic matching framework where both countries and refugees express preferences, allowing for adjustments through an auction-based system that allocates quotas based on capacity and cost considerations. By incorporating both theoretical and policy dimensions, we evaluate the proposed mechanisms' efficacy and ethical implications, offering insights into more equitable and sustainable refugee distribution strategies.

1 The Problem

Most forecasts agree that the number of people forced to leave their homes will increase in the coming years due to factors like climate change and unforeseen events such as conflicts (e.g., the Russian attack on Ukraine or the conflict in the Middle East; Acostamadiedo et al., 2020; Institute for Economics and Peace, 2020; European Council, 2023). Europe's wealth and geographical location make it a popular destination for refugees, presenting challenges for European countries in accommodating and distributing them effectively.

The 2015 refugee crisis, sparked by the Syrian civil war, highlighted the ineffectiveness of the EU's asylum policies, as they did not account for some member countries' reluctance to accept more refugees (Dinas et al., 2019). This led to diverging political views within Europe and contributed to the rise of populist parties. In response, the Council of the European Union proposed new asylum and migration laws in June 2023. The proposal includes establishing refugee centers at EU borders for processing asylum applications, with accepted migrants distributed among all EU member states. Each country would receive a quota based on its GDP and population size and could choose to accept refugees or pay a fee (€20,000 per refugee) into an EU fund aimed at reducing migration from origin countries (Council of the European Union, 2023).

Therefore, it is important to investigate whether the EU's proposed solution improves upon the status quo, is efficient, and can be enhanced through matching mechanisms that consider the preferences of migrants and possibly even countries.

2 Why the Market Fails Here

The allocation of refugees is an international public good problem. All countries benefit when global poverty and instability are reduced, but individual countries may not account for the positive externalities their actions confer on others. When a country accepts refugees, it alleviates human suffering and provides benefits to other nations, but it bears the costs alone, leading to an undersupply of refugee accommodation.

Comparing this to other public good problems like climate change reveals similarities. Wealthy countries are central to addressing both issues—they are major polluters (Patz et al., 2005) and preferred destinations for refugees. However, refugee allocation differs because it involves human lives, making purely market-based solutions ethically controversial. Additionally, host countries may receive direct benefits from refugees, such as cultural diversity and economic contributions, unlike companies reducing pollution.

Allowing refugees complete freedom to choose their host country can exacerbate the problem. Wealthier nations may become overburdened, while others

contribute little to the collective effort. Without coordinated mechanisms that balance preferences and capacities, the market alone cannot achieve an efficient or equitable allocation, necessitating policy interventions that consider ethical implications and the welfare of both refugees and host communities.[1]

2.1 Notation

Refugees We divide the M refugees into $R \in \mathbb{N} \setminus \{1\}$ groups. We assume that one can easily distinguish refugees and allocate them to one of these groups; we consider these groups as affecting the immigration cost of migrants into society.

We allow refugees to have preferences over countries. These preferences are represented as:

$$w_1 \succ w_2 \succ \cdots \succ w_N$$

Here, w_i denotes country i, and the notation indicates that refugees prefer country w_1 over w_2, and so on. Let

$$u^r\left(w_i\right) \mapsto N - i$$

denote the utility of refugee r from being matched to country w_i. We assume aligned preferences for migrants; that is, they have the same preferences over countries.[2]

Countries Each country has a utility and a cost function. Let m^i denote the intake of migrants of country i, so

$$m^i = \left(m_1^i, \ldots, m_R^i\right)'$$

where m_r^i represents the number of refugees of type r allocated to country i. The utility function for country i is defined as:

$$u^i\left(\sum_{j=1}^{N}\sum_{r=1}^{R} m_r^j\right) \geq 0$$

We assume that it is strictly concave. The idea behind this utility function is that countries receive positive utility from not letting people die at the border but do not care in which country the refugee is matched.

The cost function for country i is given by:

$$c^i\left(\left(m_1^i, \ldots, m_R^i\right)'\right)$$

This function represents the cost of migration for each type of refugee, and we assume the following properties:

1. For those who are interested, the literature review is in section A.
2. It is important to note that there are some migrants who do not have these preferences, e.g., because they like the weather much more in Spain than in Germany, but most refugees will rank countries according to their amenities.

(1) Let $c^i(0) = 0$ for all $i \in N$.

(2) It is strictly increasing; thus, more refugees imply higher costs.

(3) It is strictly convex, and for all m^i, $\lim_{m^i \to 0} c'^i\left(m^i\right) = 0$, and $\lim_{m^i \to \infty} c'^i\left(m^i\right) = \infty$.

(4) Refugees of lower types have lower marginal costs: $\forall m^i,\ c\left(\left(m_1^i + 1, m_2^i, \ldots, m_R^i\right)'\right) < c\left(\left(m_1^i, m_2^i + 1, \ldots, m_R^i\right)'\right) < \cdots < c\left(\left(m_1^i, m_2^i, \ldots, m_R^i + 1\right)'\right)$.

Initially, we allocate each country a quota according to some parameter (e.g., size, population, GDP):

$$q^i := \frac{\sum_{r=1}^{R} m_r^i}{M}$$

From the cost function, we can easily deduce the preferences of countries regarding the type of refugees. All countries will prefer refugees that result in lower costs of immigration:

$$m_1 \succ m_2 \succ \cdots \succ m_R$$

So countries have, as refugees do, aligned preferences.[3]

2.2 Tradable Quotas

The idea of tradable quotas in the context of refugee allocation was introduced first by Fernández-Huertas Moraga and Rapoport (2014a) and extended to one-sided matching by Hagen (2022). In this section, we will introduce a two-sided matching with capacity manipulation games. The main difference is that a country cannot arbitrarily choose some capacity; instead, it has to pay for a lower quota or receive money for a higher quota.

We assume that countries know the distribution of the different refugee types, and preferences are common knowledge.

The total cost function for country i, including transfers, is:

$$\zeta_i\left(\left(m_1^i, m_2^i, \ldots, m_R^i\right)'\right) = c^i\left(\left(m_1^i, m_2^i, \ldots, m_R^i\right)'\right) + t_i$$

3. We will talk about possible relaxation in the discussion of extensions after we introduce both our mechanisms.

2.2.1 The Mechanism.

(1) In the first stage of each period, all countries can trade their quotas based on their expectations, e.g., can choose their capacities.

(2) In the second stage, we compute the matching between countries and refugees.

(3) Payoffs for the countries are thus given by

$$u^i\left(\sum_{j=1}^{N}\sum_{r=1}^{R} m_r^j\right) - \zeta_i\left(\left(m_1^i, m_2^i, \ldots, m_R^i\right)'\right) = u^i\left(\sum_{j=1}^{N}\sum_{r=1}^{R} m_r^j\right) + c^i\left(\left(m_1^i, m_2^i, \ldots, m_R^i\right)'\right) + t_i,$$

and for each migrant by

$$u^M\left(w^i\right) = N - i.$$

We now propose some propositions about our model that should hold after the mechanism but need further investigation and proofs.

Hypothesis 1. *The price of the quota should be equal to the expected marginal cost of taking in* $\left(m_1^i, m_2^i, \ldots, m_R^i\right)'$.

Hypothesis 2. *We propose that there exists a stable matching. The setting of Azevedo and Leshno (2013) is similar to ours and should therefore help to show that it exists here too. Furthermore, we propose that it is a positive assortative matching.*

Hypothesis 3. *We can ensure that it is individually rational for every country. If a country does not want to participate because of too high a starting quota, we could simply lower the quota for this country.*

Hypothesis 4. *Countries that are more preferred will host more refugees, since they should have lower expected marginal costs for hosting the same number of refugees as other countries.*

2.3 An alternative Approch for Refugee allocation

Council of the European Union (2023) proposes that after each country gets a quota allocated, each country can pay a fixed sum per refugee into a pool if it refuses to take one more refugee and rewards countries which then take this refugee.

Let m_D^i denote the number of refugees that country i refuses, and m_A^i the number of refugees which i accepts above its quotas. The EU will help those countries by a transfer t per refugee. Note that we have $\left(m_D^i = m_A^i = 0\right) \oplus \left(m_D^i > 0 \text{ and } m_A^i = 0\right) \oplus \left(m_D^i = 0 \text{ and } m_A^i > 0\right)$. The new cost function for this model is:

$$\zeta_i\left(\left(m_1^i, m_2^i, \ldots, m_R^i\right)', m_D^i, m_A^i\right) = c_i\left(m_1^i, \ldots, m_R^i\right) + price_{\text{migrant}} \cdot m_D^i - t \cdot m_A^i$$

The allocation of refugees works as follows:

First, the quotas for each country are computed with respect to population and GDP size. Each country can choose to take in refugees or not. Assume that countries will always choose rationally and that they know their cost functions. This means they will take in one additional refugee of type r if:

$$c'^{i}_{m_r}\left(m^i\right) < price_{\text{migrant}}$$

and reject if:

$$c'^{i}_{m_r}\left(m^i\right) \geq price_{\text{migrant}}$$

Note that the case where a country is indifferent is incorporated into the second condition. There are now three different possibilities for how the refugee allocation is determined:

(1) For all countries, $c'^{i}_{m_r}\left(m^i\right) < price_{\text{migrant}}$; then each country will take in as many refugees as it should according to its quota.

(2) If for at least one country, the condition $c'^{i}_{m_r}\left(m^i\right) \geq price_{\text{migrant}}$ is fulfilled. This means that they reject some of their allocated refugees and will pay into the EU fund. The remaining refugees will then be allocated to the countries that still accept refugees, according to their quotas.

(3) If at some point, the condition $c'^{i}_{m_r}\left(m^i\right) \geq price_{\text{migrant}}$ is fulfilled for all countries. In this case, the EU can raise $price_{\text{migrant}}$ until at least one country is willing to take in refugees again.[4]

2.3.1 The Mechanism. We will model this game similar to an ascending auction. If the first country claims that it refuses another refugee, let's assume country i is this one:

(1) *First stage:* Calculate the capacities via the following auction (we allocate places and not refugees, thus countries cannot condition on the type):
   a. Choose randomly one country $j \in N \setminus \{i\}$.
   b. If j accepts the refugee place, i has to pay $price_{\text{migrant}}$ to j.
   c. If j rejects the refugee place, select randomly one country in $N \setminus \{i,j\}$ and return to step b.
   d. If no country wants to accept the refugee place, raise the $price_{\text{migrant}}$ and start with i again until the refugee place is allocated.

(2) *Second stage:* We compute the matching between countries and refugees.

4. Then we also could have that $m^i_D > 0$ and $m^i_D > 0$ and we would need to adjust the cost function and payoff function, e.g. have a price vector $price_{\text{migrant}}$ and a vector for $m^i_D > 0$ and $m^i_D > 0$ where the i row correspnds to the i price.

(3) Payoffs for the countries are thus given by

$$u^i\left(\sum_{j=1}^{N}\sum_{r=1}^{R} m_r^j\right) - \zeta_i\left(\left(m_1^i, m_2^i, \ldots, m_R^i\right)', m_D^i, m_A^i\right),$$

and for each migrant by $u^M\left(w^i\right) = N - i$.

As before, we also introduce propositions for the alternative mechanism.

Hypothesis 5. *With a low price$_{migrant}$, the capacities should end up being similar to those under tradable quotas but could be more expensive for countries with a low starting quota.*

Hypothesis 6. *The matching structure is similar to that under tradable quotas.*

Hypothesis 7. *The mechanism is not individually rational.*

Hypothesis 8. *Different prices for the different types of refugees could lead to higher efficiency but should be considered carefully from an ethical standpoint before implementing such a mechanism.*

2.4 Possible Extensions

Possible extensions to this model could involve a more sophisticated approach to the types of refugees. The first idea is to account for whether migrants already speak the language of one of the countries. This would mean that the preferences of countries would no longer be aligned. The same could be done for migrants, as already argued. Furthermore, we could incorporate that the utility function depends also on the intake of refugees; one could argue that countries receive benefits from a more diverse society. It seems reasonable to think about some of these extensions, and thus we have some proposals about characteristics which should be handled with caution.

Hypothesis 9. *There is inefficiency under a one-sided matching where refugees have preferences over countries and we allow for different preferences, where $\varnothing$ means that a migrant prefers not to be matched. Allowing different preferences for refugees will allow for strategic manipulation by countries and thus result in an inefficient solution.*

Example 1. Assume $N = 3$ and a serial dictator matching. The first 6 migrants have $1 \succ 2 \succ 3 \succ \varnothing$ as their preferences, and all other migrants have $3 \succ \varnothing \succ 2 \succ 1$. If country 1 takes 6 refugees, country 2 should never say it rejects a refugee in the auction since it would never have to accommodate one.

Hypothesis 10. *Such strategic behavior should also be possible under a two-sided matching.*

Hypothesis 11. *Under more flexible assumptions regarding the type and the country, there exists a stable matching.*

3 Contribution

I plan to make two separate contributions to the refugee allocation literature with this analysis. The first is theoretical: building a model in an auction setting that allows refugees and countries to express their preferences in a dynamic matching. The second is more relevant for policymakers. I aim to show whether the proposed mechanism will work for the EU and how it can eventually be made more efficient theoretically.

3.1 Remarks: Ethical Concerns

Since this problem involves setting prices on refugee placements, we acknowledge that tradable quotas raise ethical concerns, and ultimately, addressing these issues requires an interdisciplinary approach.

Appendix A Literature Review

The literature on refugee allocation is quite large and has grown rapidly since 2015. There are many different approaches to dealing with refugee allocation.

One idea is to work with a pure matching mechanism that considers the preferences of refugees and countries while simultaneously dealing with constraints, such as families. Aziz et al. (2018) and Delacrétaz, Kominers, Teytelboym, et al. (2019) are some examples of this literature. Most of the pure matching literature deals with static one-sided and two-sided matching.

More empirical contributions come from Bansak, Hainmueller, and Hangartner (2017), who conducted a survey to estimate preferences for refugee allocation in many European countries, and Ahani et al. (2021), who use data from the U.S. and machine learning methods to achieve optimal allocation.

Contributions to the ethical and political constraints in a 'market' for refugees include, for example, Roth (2007) and Huesmann and Wambach (2015). The ethical concerns of the solution proposed by the EU will not be addressed in this analysis.

Fernández-Huertas Moraga and Rapoport (2014a) are the first to propose tradable quotas for refugees. In subsequent papers, Fernández-Huertas Moraga and Rapoport (2014b), Fernández-Huertas Moraga and Rapoport (2015), and Fernández-Huertas Moraga and Rapoport (2016) apply their framework to the EU. The main theoretical framework comes from Hagen (2022), who extends the work of Fernández-Huertas Moraga and Rapoport and adds a welfare-enhancing one-sided matching at the end. He showed that introducing tradable quotas will always shift efficiency upwards relative to the status quo, but this may only be the second-best case. Another significant result is that the mechanism can be designed to make it individually rational to participate, which is a nice property for policy implementation. The property of individual rationality is essential, as some countries have already stated that they will not agree to monetary sanctions or transactions in the context of refugee allocation.

The one-sided matching algorithm allows migrants to have different preferences about their destination, while countries only care about how many refugees they receive. Hagen (2022) showed that if all countries receive as many refugees as they want, this matching can be welfare-improving. Otherwise, popular destinations may be better off than others. He distinguishes between random and deterministic matching. A two-sided matching is not formally incorporated into his model. However, he suggested that it might be the case that some refugees, e.g., PhD economists, are scarce for some countries.

Two-sided matching has already been studied by Sönmez (1997) and Konishi and Ünver (2006), who studied this problem in the context of medical interns in the United States, and by Azevedo (2014) in the context of firms hiring workers.

The crucial difference is that the capacities are not traded but can be set by the firm. They show that in their model a unique stable matching exists.

One approach to allocating refugees with a procurement auction is the model of Gretschko (2019). The country with the lowest cost to host a refugee will host the refugee. All other countries will have to pay some money, which will be used to cover the cost of immigration. He stated that participating in such an auction is not individually rational.

All information about the proposed mechanism will be taken from Council of the European Union (2023) as it is the official document.

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