Two-Stage Refugee Resettlement Models: Computational Aspects of the Second Stage

Šimon Schierreich[1,2*]
[1]Czech Technical University in Prague
[2]Pennsylvania State University
schiesim@fit.cvut.cz

Abstract

I discuss recent progresses in the analysis of computational aspects of two-stage refugee resettlement methods. I pay special attention to the second stage of these models, as it is arguably understudied compared to the first stage. I also discuss some future challenges for this area that need to be resolved before the models can be deployed and used in practice.

Introduction

Refugee resettlement is indisputably an emerging topic in today's world. The annual reports of the UN High Commissioner for Refugees (UNHCR) show a dramatic increase in the number of displaced persons each year; in May 2022, UNHCR announced that a tragic milestone of 100 million displaced persons had been reached. At the same time, prognoses for the future are not very bright: besides ongoing and new armed and political conflicts, we can also expect migration caused by the consequences of climate change. As illustrated by the previous numbers, we are not very successful in the prevention of forced displacement. Therefore, in practice, we mostly extinguish the consequences in the form of repatriation, resettlement, and integration. The role of social workers, humanitarian and other non-government organizations, and policymakers is incontestable in this context. However, it turns out that computer science and the AI community, in particular, can contribute to even more effective and humane refugee integration processes.

In this work, I focus on two-stage models of refugee resettlement and introduce computational approaches applied or developed to promote these models.

The First Stage

The first stage of refugee resettlement is usually taking place at the national, federal, or even international level. The goal of this phase is to distribute the incoming people between different areas in order to decrease the burden of the most affected communities, such as near-border cities or states.

[*]Part of the work was done while ŠS was visiting PSU as a Fulbright-Masaryk Fellow. ŠS acknowledges the support of the Czech Science Foundation, grant No. 22-19557S, and by the CTU in Prague funded grant No. SGS23/205/OHK3/3T/18.

This stage is usually modeled using a *double-sided matching markets*, as introduced by Delacrétaz, Kominers, and Teytelboym (2023). One side of such market consists of *locations*, each associated with a set of constraints such as the number of refugees the location can accept or qualification requirements. The other side consists of a set of *refugees*, each associated with a set of features such as family size or profession in the home country. The question is then to find a matching between the set of locations and the set of refugees so that all constraints are respected. This model received great attention both from the perspective of theory (Ahani et al. 2024; Aziz et al. 2018) and practice (Ahani et al. 2021; Bansak et al. 2018). The research that arose from this area led to a great improvement in the matching software *Annie*^{TM} MOORE used by the US resettlement agency HIAS (Ahani et al. 2024; Bansak et al. 2018).

The Second Stage

In the second stage of refugee resettlement, the incoming persons are already distributed between different cities, districts, or communities, depending on the scale of the first stage mechanism, and the goal is to integrate them into the target community.

After arriving at the host community, there are usually two most immediate needs for newcomers: to find housing and to get employed. While the latter need is already considered in some of the first-stage mechanisms (see, e.g., the work of Bansak et al. (2018)) and is even used as an important metric for some refugee admission programs, the former one was, until very recently, completely overlooked from the perspective of computer science and AI research.

This changed very recently in the work of Knop and Schierreich (2023). In our paper, we introduced a novel model for *refugee housing* where (a) we can capture the host community and its housing options and (b) when computing matching between the refugees and available housing options, we take into consideration preferences of both the individuals in the host community and the refugees.

Formally, we consider the host community to be modeled as an undirected graph $G = (V, E)$, where V is a set of houses and two houses are connected by an edge if they are considered neighboring. Moreover, a subset $V_I \subset V$ is occupied by a set of inhabitants. Now, our task is to assign a set of refugees to unoccupied houses so that the preferences of both the inhabitants and the refugees are satisfied. In order to accommodate different levels of granularity of preferences and also different phases of housing, we consider three specific models of preferences: anonymous, hedonic, and diversity.

Contribution

So far, in the series of papers of my coauthors and me (Knop and Schierreich 2023; Schierreich 2023; Lisowski and Schierreich 2023), we mainly focused on the computational aspects related to the refugee housing defined in the previous section. More specifically, we, besides introducing the model itself, investigated which variants of the preferences allow for tractable algorithms and in which variant the existence of efficient algorithms is unlikely. Unfortunately, it turns out that even in the simplest setting of anonymous preferences, it is NP-hard to find a matching between refugees and empty houses that would respect the agents' preferences. Therefore, we focused on even more confined versions of our model and investigated which restrictions of the input allow for tractability. On this front, we showed that for certain special cases of the community graph, efficient algorithms are possible.

Future Challenges

In the last section, I introduce several directions for future research related to the second stage of refugee resettlement and the model of refugee housing in particular.

Real-World Data. So far, research on refugee housing is based solely on theoretical foundations. It is not that surprising that there are no datasets capturing moods in communities regarding the integration of newcomers, but we even lack data that would justify our algorithmic results for special cases of community graphs. It is important that before any model that boosts refugee housing can be used in practice, we need to have some solid information about agents' preferences only to be able to test it. This feels like a very challenging task that requires cooperation between many researchers, as there are many ethical and societal challenges related. So, the more immediate task is to collect data about real-world communities and examine their graph-theoretical properties. This could boost future theoretical research.

Dynamic Models. Our model of refugee housing implicitly assumes that we have complete information about all incoming persons in advance. However, in real-life scenarios, this is usually not the case, as the refugees come in smaller groups and at different periods of time. An immediate solution may be to recompute the matching after a new group arrives, but this is clearly a bad solution for both the refugees and the inhabitants. Therefore, it would be very advisable to come, similarly to what is done in some of the first-stage mechanisms, with models that allow for repeated matching. To some extent, our diversity preferences (Knop and Schierreich 2023) may serve as a basic building block for such models, as they also allow us to capture the view of inhabitants on each other and, therefore, partially take into account refugees housed in the past.

Different Solution Concepts. Majority of the research on the second stage of refugee housing focused on housings that perfectly satisfy agents' preferences. However, there is an overwhelming amount of solution concepts studied in the computational social choice literature that may be very desirable in practice. One of the most appealing ones is to employ different fairness notions from the *fair division* literature. Such housing should guarantee to every agent a fair neighborhood. Another direction, partly explored in (Lisowski and Schierreich 2023), is to explore *stability* based on undesirable actions the agents may perform in order to increase their happiness with the outcome.

Beyond Exact Algorithms. Our hardness results clearly indicated that in many situations, it is computationally intractable to find a desirable solution. Therefore, we should take a different perspective and discover the limits of approximation algorithms, machine learning models, and operation research approaches in this area. This first step in this direction was done in (Schierreich 2023), where I study a relaxation of the perfect matching outcomes. This relaxation is one possible approach to approximate perfect matching.

Ask Practitioners. Even the very best model of refugee housing cannot be recast to a practical application and deployed into the wild without a close collaboration between researchers, policymakers, and humanitarian organizations. Without input from all the involved individuals, we cannot ensure that the proposed models fit the real needs of the second stage of refugee resettlement and that algorithmic advancements will translate into practical improvements for vulnerable communities.

References

Ahani, N.; Andersson, T.; Martinello, A.; Teytelboym, A.; and Trapp, A. C. 2021. Placement Optimization in Refugee Resettlement. *Oper. Res.*, 69(5): 1468–1486.

Ahani, N.; Gölz, P.; Procaccia, A. D.; Teytelboym, A.; and Trapp, A. C. 2024. Dynamic Placement in Refugee Resettlement. *Oper. Res.*, 72(3): 1087–1104.

Aziz, H.; Chen, J.; Gaspers, S.; and Sun, Z. 2018. Stability and Pareto Optimality in Refugee Allocation Matchings. In *AAMAS '18*, 964–972.

Bansak, K.; Ferwerda, J.; Hainmueller, J.; Dillon, A.; Hangartner, D.; Lawrence, D.; and Weinstein, J. 2018. Improving refugee integration through data-driven algorithmic assignment. *Science*, 359(6373): 325–329.

Delacrétaz, D.; Kominers, S. D.; and Teytelboym, A. 2023. Matching Mechanisms for Refugee Resettlement. *Am. Econ. Rev.*, 113(10): 2689–2717.

Knop, D.; and Schierreich, Š. 2023. Host Community Respecting Refugee Housing. In *AAMAS '23*, 966–975.

Lisowski, G.; and Schierreich, Š. 2023. Swap Stability in Refugee Housing: A Story About Anonymous Preferences. In *STAIRS '23*.

Schierreich, Š. 2023. Towards More Realistic Models for Refugee Integration: Anonymous Refugee Housing with Upper-Bounds. *CoRR*, abs/2308.09501.