

Institution: University of Oxford		
Unit of Assessment: 16 – Economics and Econometrics		
Title of case study: Improving Outcomes for Resettled Refugees		
Period when the underpinning research was undertaken: 2014 - 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Alexander Teytelboym	Research Fellow, Institute for New Economic Thinking, Oxford Martin School.	2014 - present
	Associate Professor, Department of Economics and Economics Fellow, St Catharine's College, University of Oxford	Sept 2017 – present
David Delacretaz	Post-doctoral Research Fellow, Department of Economics and Nuffield College, University of Oxford	Sept 2018 - present
William Jones	Postdoctoral Research Officer, Refugees Studies Centre, Department for International Development, University of Oxford	Oct 2012 – Sept 2015
Period when the claimed impact occurred: 2018 – 31 July 2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact (indicative maximum 100 words)		
<p>Drawing on their research into refugee resettlement as a two-sided matching problem, Alexander Teytelboym, with David Delacretaz and Will Jones, have developed and deployed software designed to optimise resettlement outcomes for refugees. The software package, titled <i>Annie</i>TM MOORE, is the first developed for this purpose. This software has been used by HIAS, a US resettlement agency (www.hias.org), since May 2018 for all of their refugee placements. Since its launch, <i>Annie</i>TM has assisted in the resettlement of 1,105 employable refugees, contributing to a statistically and economically significant improvement in the employment outcomes of refugees and in the quality of refugee integration in their local communities. In addition, it has enabled HIAS to improve the efficiency of its operations and increased the agency's capacity to handle cases. The researchers are in ongoing discussions with other agencies, including the UK Home Office, about the potential use of <i>Annie</i>TM to speed the resettlement process in their jurisdictions.</p>		
2. Underpinning research (indicative maximum 500 words)		
<p>Research by Teytelboym, with Delacretaz, Jones and others, employ insights from market design to derive mechanisms for refugee resettlement that can lead to improved outcomes for both the refugee families and the communities in which they are settled.</p>		

The underlying premise, that refugee resettlement may be modelled as a two-sided matching problem, is set out in papers by Teytelboym with Jones. Two distinct matching problems arise in refugee resettlement: the matching of refugees to states [R1], and the allocation of refugees to localities within states [R2]. From an ethical and an economic welfare perspective, both problems require that the preferences of refugees, states, and local communities are considered. The work by Jones and Teytelboym show how two-sided matching theory can provide an allocation mechanism that takes into account refugees preferences as to where they would like to go, and the views of states or local communities as to which refugees they feel most capable of hosting.

The refugee resettlement problem involves a number of complications that do not arise in other contexts in which matching mechanisms are frequently used – for example, matching children to public schools, or junior doctors to hospitals. Refugees are resettled as families - rather than individuals - and families are of different sizes, with varying needs and integration requirements. Localities vary also in the range and level of services they can provide. Research by Delacretaz and Teytelboym, with Kominers (Harvard University) addresses these additional complications. It builds on classic matching models to develop a new framework incorporating multidimensional constraints that reflect refugee families' needs for multiple units of different services, as well as the service capacities of local areas. Their starting point is the case in which the refugee preferences are not elicited explicitly, but rather the quality of the match is inferred from observable data such as the local employment rate. This basic framework was developed in 2016 when Kominers was a Visiting Fellow at INET, University of Oxford and Delcretaz, then a PhD student at the University of Melbourne, also visited Teytelboym at Oxford. In their working paper [R3], they show that in this case the optimization problem is equivalent to a multiple multidimensional knapsack problem (MMKP). In subsequent work, the analysis is further refined and extended to incorporate the stated preferences of refugee families and also the priorities of localities into the MMKP [R4]. Several matching design approaches are analysed that balance the competing objectives of refugee welfare, respect for localities priorities, and strategy-proofness. In other work, Teytelboym and co-authors investigate whether the efficiency and stability properties of the outcome would be improved by relaxing capacity constraints of localities in ways that are compatible with current US resettlement rules [R5].

Collaborating with Trapp, Martinello, Andersson, and Ahani, Teytelboym combined his expertise in matching models with skills in integer optimisation methods, machine learning and coding to move the analysis from theory to practice [R6]. Integer optimisation methods are used to generalise MMKP to allow for several additional constraints that are important in practice, for example a minimum average family size constraint for different localities. Following the approach of R3, the quality of the match is measured by the probability of employment for the newly arrived refugee and this is estimated from past data using machine learning methods. These techniques are integrated into a software package, Annie™ MOORE (Matching and Outcome Optimization for Refugee Empowerment), based on open-source technologies. It is designed to identify data-driven, optimized matches between refugees and local affiliates while respecting refugee needs and affiliate capacities.

3. References to the research (indicative maximum of six references)

[R1] Jones, W. and A. Teytelboym (2017), 'The international refugee match: A system that respects refugees' preferences and the priorities of states', *Refugee Survey Quarterly.*, 36 (2), 84-109. <https://doi.org/10.1093/rsg/hdx004> [Output type D: Journal Article]

[R2] Jones, W. and A. Teytelboym (2018), 'The local refugee match: Aligning refugees' preferences with the capacities and priorities of localities', *Journal of Refugee Studies*. 31 (2), 152-178. <https://doi.org/10.1093/jrs/fex022>. [Output type D: Journal Article]

[R3] Delacrétaz, D., S. Duke Kominers and A. Teytelboym (2016), 'Refugee Resettlement', Mimeo, <http://www.t8el.com/imp.pdf> [Output type U: Working Paper]

[R4] Delacrétaz, D., S. Duke Kominers and A. Teytelboym (2020), 'Matching Mechanisms for Refugee Resettlement', Mimeo, <http://t8el.com/wp-content/uploads/2019/12/DKT-MMRR-Dec2019.pdf> [Output type U: Working Paper and Resubmitted to the *Quarterly Journal of Economics*].

[R5] Nguyen, H., T Nguyen and A Teytelboym (2019), 'Stability in Matching Markets with Complex Constraints', *Proceedings of the 2019 ACM Conference on Economics and Computation*, <https://doi.org/10.1145/3328526.3329639> [Output type C: Chapter in book]

[R6] Trapp, A.C., A. Teytelboym, A. Martinello, T.Andersson and N. Ahani (2018) 'Placement Optimization in Refugee Resettlement' https://project.nek.lu.se/publications/workpap/papers/wp18_23.pdf, [Output type U: Working Paper and forthcoming in the journal *Operations Research*]

Teytelboym's contribution to the development of the optimization and matching techniques was supported in part by an ESRC New Investigator Grant, entitled "Designing Marketplaces with Complementarities". (GBP243,602, Oct 2018 – Sept 2021)

4. Details of the impact (indicative maximum 750 words)

According to data released by the United Nations High Commissioner for Refugees (UNHCR) of the estimated 1,200,000 refugees in need of resettlement globally, (i.e. permanent relocation to another country) in 2018, only 55,692, just 4.7%, were actually resettled. Moreover, evidence shows that socioeconomic outcomes of refugees depend strongly on the quality of the match with the first community they are resettled to. The pioneering software Annie™ MOORE has been shown to increase the capacity of refugee agencies to match the needs of refugees and their families (e.g. child care or language support) with the service capacities of hosting communities (e.g. housing or places in training programmes), thereby significantly improving socioeconomic outcomes for the resettled refugees and their communities.

Impact on Resettlement Agencies and Refugees

Annie™ MOORE was developed by Teytelboym et al. in collaboration with HIAS, one of nine US refugee resettlement agencies. By identifying data-driven, optimized matches between refugees and local affiliates which take account of refugee needs and community capacities, Annie™ increases the probability of a successful first match. Back-testing using HIAS data on the 496 refugees it resettled during 2017 indicates that using Annie™ to identify matches would have increased the proportion of refugees obtaining employment within a 90-day window by between 22% and 38% [R5, p3]. Commenting on these results, a member of the HIAS team observed that *'the program significantly improves the chances of the refugees settling into, and therefore likely becoming a benefit to, the wider community'* [E1]. HIAS report that the early results of using Annie™ increased the likelihood of employment by at least 20%, in line with the research estimates [E2, p 12].

The subsequent roll-out of Annie™ followed in 2018. Since then it has helped HIAS to resettle over 1,105 refugees who did not previously have any ties with the U.S., and the evidence shows a broad range of benefits. The Associate Vice-President, U.S programs, at HIAS, observed *‘Many people think that once a family has resettled, they continue to be supported by the government...but in the United States this simply isn’t true. Refugees are expected to obtain employment very quickly and start supporting themselves. This technology has been key to helping our regional offices connect relatively straightforward resettlement cases with new homes and communities where they are more likely to thrive in their jobs’* [E1]. In addition, Annie™ has reduced the fraction of refugee families who are placed in communities which cannot provide services to support them, significantly improving the quality of refugee integration in their communities. The HIAS CEO states that Annie™ has *‘completely eliminated any refugee-affiliate service mismatch (for example with respect to single parent support or language support)’* [E3].

Finally the software has enabled HIAS itself to streamline and improve their processes and, by extension, add value to the broader American refugee resettlement programme. As more refugees are able to get into employment more quickly and become self-sufficient, the return on government funding for arriving refugees dramatically increases. HIAS’ Associate Director for Pre-arrival, observes *‘I now spend 80% less time on routine matching, and can focus my time and energy on the more difficult cases, such as those with significant medical conditions, ensuring that their placement is as good as possible’* [E3].

HIAS sees considerable potential to expand the use of Annie™, and is currently negotiating with several other US resettlement agencies about their adoption of this software [E3]. HIAS is hopeful that the forthcoming change in the US administration, coupled with progress in controlling the coronavirus pandemic, will accelerate this process

Ongoing Impact

A report by the UK Independent Chief Inspector of Borders and Immigration (2017-8) highlighted the unacceptable length of time it takes to settle refugees within the UK, and recommended that the Home Office *‘improve the geographical matching process’* of refugees in the Syrian Vulnerable Persons Resettlement Scheme. In its response to the report, the Home Office committed to *‘consider whether there are any changes that could be made to make more effective use of the time between a refugee’s acceptance onto the scheme and their resettlement in the UK’* [E4, para.4.2]. To this end, Teytelboym was invited to present his work on Annie™ at the Home Office in April 2020, though the current pandemic has stalled further development in this area.

Presentations of the Annie™ system have also been made by Teytelboym to the US Department of State (August 2017), the World Bank (May 2017) and the Swedish Ministry of Finance (April 2018). A recent report from the Swedish Equalities Commission recommended the use of statistical matching algorithms to improve the integration of refugees, noting the use of such methods in the US, and referencing the papers by Teytelboym and his co-authors [E5].

Since its launch, Annie™ and the underlying research has been the subject of many media articles and blog posts, including in The Atlantic, Forbes, and Financial Times, helping to shape the discourse around refugee resettlement [E6]. In November 2020, a case study of Annie™ *MOORE: Increasing Employment of Resettled Refugees using Machine Learning and*

Optimisation was featured in the OECD's Observatory of Public Sector Innovation report "Focusing on the Overlooked". [E7, 12-13]

5. Sources to corroborate the impact (indicative maximum of 10 references)

- E1.** HIAS Blog post giving an overview of its new matching software system (Oct 2018) - <https://www.hias.org/blog/new-software-does-hard-work-placing-refugees>
- E2.** HIAS 2018 Annual Report - https://www.hias.org/sites/default/files/10.19_-_hias_ar2019_layoutoptions_v35_web.pdf, p.12
- E3.** Letter of Support for application to Vice-Chancellor's Innovation Award by the CEO of HIAS.
- E4.** The Home Office Response to the Independent Chief Inspector of Borders and Immigrations Report: An Inspection of the Vulnerable Persons Resettlement Scheme, August 2017 – January 2018. (November 2019).
- E5.** The Equality Commission (6 Aug, 2020), "A common concern" Report for the Swedish Ministry of Finance, SOU 2020: 46, p 665, fn. 21 and 22. <https://www.regeringen.se/rattsliga-dokument/statens-offentliga-utredningar/2020/08/sou-202046/>
- E6.** Media Coverage:
- The Atlantic (26 April 2019) <https://www.theatlantic.com/international/archive/2019/04/how-technology-could-revolutionize-refugee-resettlement/587383/>
 - Financial Times (28 November 2018) <https://www.ft.com/content/9332fffc-ec57-11e8-89c8-d36339d835c0>
 - Article in Dagens Nyheter (Swedish leading broadsheet, 10 October 2018) reporting on the announcement by the Swedish Migration Agency that it will use *Annie*TMMOORE for internal relocation of refugees in Sweden
 - Additional articles and blogs about earlier research can be found here: <https://www.refugees.ai/>
- E7.** Observatory of Public Sector Innovation (2020), *Embracing Innovation in Government, Global Trends 2020: Focusing on the Overlooked*, October. <https://trends.oecd-opsi.org/trend-reports/focusing-on-the-overlooked/>