

# Scientific proposal

## 1. Project idea and objectives

In many countries (e.g. Sweden, Chile, France, Turkey and the Netherlands) and cities (e.g. New Orleans, New York, and Boston) around the globe, students are assigned to public schools through centralized school choice systems. These are algorithms designed to achieve allocations that holds some desirable properties like stability or Pareto efficiency. Despite the wide implementation of centralized admission systems around the world, most of the Italian school choice system is fully decentralized. If we consider primary school, parents typically register their children to the nearby school. In highly segregated neighbourhoods, this practice can only worsen school segregation, with clear consequences for the future opportunities of the students.

This proposal aims at defining possibly new algorithms to realize fair allocations of students into public schools. In particular, I will investigate the possibility of implementing the well-known Equal Opportunity paradigm (Roemer, 1998) within a many-to-one matching market, where students need to be assigned to schools with limited capacity and heterogeneous quality. In a nutshell, assuming that the central authority can perform an ex-ante assessment of the quality of education each student may receive from being assigned to a give school in the city, I am interested in defining an algorithm that assigns students to school. The main goal of this algorithm is to ensure that the expected educational outcome of a student does not depend on characteristics out of its individual control like gender, place of birth, race, parent socioeconomical status and so on. To do so, I will combine the fairness principles coming from the Equal Opportunity literature and models, with tools and existing results in the matching theory literature.

## 2. Extended synopsis of the scientific proposal

### Introduction

Economists are often concerned with allocation problems and search for mechanisms that realize desirable allocations. Many of such problems can be framed as matching problems in contexts where the price mechanism fails to adequately match demand and supply. Classic examples are the marriage market or the allocation of students to public schools. In this project, we focus on the latter which constitutes a prominent example of many-to-one matching setting, to study allocation mechanisms that equalize outcome opportunities for entities in one side of the market: students, in this case.

Many political philosophers (Rawls, 1971; Sen et al., 1980; Dworkin, 1981) have debated whether all inequalities should be considered unacceptable or if there are certain inequalities that a fair society should tolerate and preserve. Recently, economists (Cappelen et al., 2007, 2013; Alesina et al., 2017) have also investigated preferences for redistribution and tried to identify inequalities that individuals consider unfair. All these scholars converge on the idea that inequalities stemming from individual characteristics out of control or responsibility are unfair and detrimental to socio-economic development. Consequently, a fair society - one that realizes equality of opportunity (EOp) - should aim at levelling the playing field so that the final outcome of each individual is ultimately due to their own choices.



This research project focuses on the prominent interpretations of the EOp paradigm which defines social justice as equality of expected outcomes across groups of individuals with similar circumstances (such as, for example, gender, parents' education, and ethnicity) out of their control. Roemer & Unveren (2017) argue that a key source of observed inequality of opportunity in income is the education premium that some students gain from attending better schools. Other researchers, such as Corak (2013), have emphasized the importance of primary and secondary education in shaping opportunity and social mobility. The school allocation setting is therefore of great interest for the EOp literature, motivating our focus on it for this research project.

In many countries (e.g. Sweden, Chile, France, Turkey and the Netherlands) and cities (e.g. New Orleans, New York, and Boston) around the globe, students are assigned to public schools through centralized school choice systems. A school choice system is a two-sided matching market in which there are students (or their parents) on one side of the market, and public schools on the other side of the market. In this system, students (or their parents) submit to the educational authority their preferences for public schools, and the schools rank students based on certain criteria.

With no (or fixed) tuition fees for public schools, the central authority uses an algorithm to match students with schools while respecting preferences and priorities. The goal of the educational authority is to design an algorithm that finds assignments with desirable properties such as stability and Pareto efficiency. Stability is the central fairness notion in two-sided matching markets; it requires that in the final assignment there exist no student-school pair that would prefer each other to their current matching. Pareto efficiency can be regarded as a welfare concept in matching markets; an assignment is said to be Pareto efficient if there is no other assignment that makes a student better off without hurting some other student. The incompatibility between these properties is well-established in the literature (see Abdulkadiroglu & Sonmez, 2003) and a well-known (compromise) solution to this impossibility is the Deferred Acceptance (DA) algorithm (Gale & Shapley, 1962) used, for example, by the educational authorities in New York City to assign students to public high schools.

To promote disadvantaged groups of students or to reduce school segregation, the matching literature has proposed various affirmative action policies. The three main ones are: majority quotas (Abdulkadiroglu & Sonmez, 2003), minority reserves (Hafalir et al., 2013), and priority-based affirmative action. Majority quotas limit the number of majority students that can be admitted to a school, minority reserves retain seats for minority students, and priority-based affirmative action prioritizes minority students in the admissions process. While it has been shown (see Kojima, 2012; Afacan & Salman, 2016) that these policies may have negative effects on the targeted groups, focusing on few particular minorities may lead us to neglect other disadvantaged groups. For example, Harvard's admission policy has been criticized as one that indirectly favors Afro-America applicants at the expenses of the Asian ones.<sup>1</sup> Although we do not claim here that Harvard implements an affirmative action policy in favor of Afro-America applicants, it is indeed possible for such a policy to harm other disadvantaged groups. Intuitively, this happens because the focus on improving the outcome of a single disadvantaged group, typical of affirmative action policies, imposes no restrictions on who has to lose for this to happen. This research proposal aims to implement a more holistic approach, typical of the EOp paradigm, which takes into account all groups simultaneously.

Abdulkadiroglu et al. (2020) find that parent's preferences do not always align with the quality of education their children can receive from given schools. Therefore, we follow Abdulkadiroglu et al. (2021) in considering the quality of a student-school match as the relevant outcome for the central authority to evaluate assignments. More precisely, we consider match quality to be the potential educational outcome a student can receive by attending a school. Match quality is assumed to be

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<sup>1</sup> See also *Students for Fair Admissions, Inc. v. President and Fellows of Harvard College* (Docket 20–1199).



measured by a central authority for any possible student-school pair. This assumption will not exclude relevant ways of measuring match quality. For example, match quality can mimic individual preferences, so that the better preferred school provides higher match quality than a less preferred one. Such a measure can rely on the assumption that attending the favorite school boosts motivation and potential outcomes of students, as well as on the idea that students (or parents) have sufficient information to assess schools' quality. Another way of defining match quality consists in taking the average income, or higher education achievement, of other students that attended a given school. For example, one may have information on the income of workers, from a particular ethnic group, that attended a given school in the previous years and use it to define the match quality of future students of the same school belonging to the same ethnic group. Another criterion to define match quality may rely on rankings by independent authorities or organization. For example, a quick search on the net can provide future university students with the top-ranked universities and departments worldwide. Similar rankings are likely to exist for smaller geographical areas and other education degrees, so that the educational authority can assign match quality 1 to the worst school in the area, 2 to the second worst, 3 to the next one and so on. This is also in line with the idea that two students attending the same school would get the same educational outcome.

In this research project we focus on the prominent ex-ante approach to the measurement of inequality of opportunity (see Fleurbaey & Peragine, 2013). According to this view, in a fair society, belonging to a given circumstance group should no impact on the expected educational outcome of a student. In line with this simple idea, to realize equality of opportunity in school choice settings, we need to look for allocations that equalize the expected match quality of students belonging to different circumstance groups.

## **The project**

Formally, we will consider the standard school choice setting where we have countable students and schools. Students have complete preferences over schools and schools have complete priority rankings for students. Schools have limited capacity so they cannot always admit all applicants and all students must be assigned to a school, as it is the case in the Italian primary school system. As discussed before, we will consider a measure of the potential educational outcome generated by each student-school pair and, in order to discuss and define EOp, we will augment the standard setting with the partition of students into types (groups of individuals with the same circumstances). Suppose, for example, that we are in a context where we want to equalize student's opportunity, so that their expected educational outcome does not depend on their sex at birth, or whether they belong to a minority or a majority ethnic group. Then, there are four possible types of students: woman from a majority group, woman from a minority group, man from a majority group and man from a minority group. Following the ex-ante approach in the EOp literature (see Fleurbaey & Peragine, 2013; Roemer & Trannoy, 2015; Ramos & van de Gaer, 2016), the inequality between these types is unfair and should be removed as much as possible.

We will consider three desirable properties for a school assignment: stability, efficiency and fairness. While the former corresponds to the standard requirement in matching theory, the second property has already been proposed by Abdulkadiroglu et al. (2021) and consists in finding the allocation that maximizes total match quality. The fairness requirement is, however, new and is based on the idea of minimizing the inequality in types' expected educational outcome. We will investigate the incompatibility between these three requirements and the possibility of providing compromise solutions. Preliminary works on this research project have allowed us to identify Linear Programming



solution that identify a fair and stable assignment. However, because of the incompatibilities between efficiency and fairness, weaker axioms are required in order to define an algorithm.

The main challenge of this research project concerns the difficulty of translating complex ideas of social justice into simple objective functions that are tractable for a computer. An oversimplified way of framing our problem is: “find a stable allocation that satisfies our fairness principle”. Intuitively, if one can list all possible stable allocations of a given school choice instance, then the solution is to simply choose the one that satisfies our requirements. Computer scientists are acquainted with the concept of NP problems, which are problems that cannot be solved by a computer in polynomial time. Unfortunately, among these problems we find the one of “enumerating all stable allocations in a many-to-one matching setting”. To put it differently, we cannot ask a computer to list all the stable allocations, as this may require an exponential amount of time to be done. Therefore, we need to overcome the need of performing this task when identifying the stable allocation that satisfies other desirable properties.

The solution we plan on implementing relies on the concept of rotations and on the algorithm proposed by Cheng et al. (2008) to construct the partially ordered set (poset) of rotations. Starting from a stable allocation, rotations are changes in the assignment of students that preserve stability. As also discussed in Cheng et al. (2008), there is a parallel between the subset of the rotation poset and the set of stable allocations. We plan on using this parallel to identify an algorithm that maximizes an opportunity egalitarian social welfare function, as the one in Peragine (2004), over the set of stable allocation.

The current proposal, which is mainly a theoretical work on the identification of a desirable centralized school admission system, is the continuation of a research idea developed in collaboration with Umutcan Salman: a PhD student at the Université libre de Bruxelles. Progresses toward the definition of an algorithm that assigns students to school, while realizing equality of opportunity, have already been made since the beginning of our collaboration. This reassures me on the feasibility of the current research proposal. Moreover, I have presented this idea in several conferences, including the last SIEP (Società Italiana di Economia Pubblica) and ECINEQ (The Society for the study of Economic Inequality) conferences, receiving enthusiastic interest from several experts in the field.

This project contributes to the literature in three ways. First, to the best of my knowledge, this is the first attempt of introducing the concept of Equality of Opportunity à la (Roemer, 1998) in many-to-one matching settings. Second, despite the well-known and documented importance of public education in enhancing opportunities, the EOp literature has hardly included centralized school admission systems within the set of policy recommendations. Third, we show the possibility of designing school allocation mechanism inspired to opportunity egalitarian fairness principles.

This research project, while having its own identity and goals, is also functional to setting the stage for a more ambitious research agenda, aimed at studying potential benefits and possibility of implementing a new centralized school choice system to manage the allocation of students into primary schools in Italy. The latter will require consistent and new data collection, pilot experiments in local communities, and a longer implementation period, and is likely to be the content of a new research proposal I will submit, at the end of this ERC Seeds, in response to a public call from the ERC Starting Grant program.