Implementing distributional constraints in matching markets

by Esteban Peralta

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1 Context and motivation

Since the seminal work of Gale and Shapley (1962), matching markets have been widely studied. This is not surprising given that most of the theoretical analysis has helped to understand the main challenges and improve the performance of real markets [see Kojima (2015) and Roth (2008) for recent surveys]. Among the challenges currently faced by many market designers is their ability to make the market "safe" and able to deal with distributional constraints. As Roth (2008) argues, safeness is crucial to avoid transactions outside the marketplace and has thus played a significant role in the recent success of many markets. Distributional constraints, on the other hand, constitute a response of many markets to increasing distributive concerns like school segregation, shortage of doctors in rural areas and access to state-funded seats at schools and colleges.

While the theoretical treatment of distributional constraints has received a great deal of attention, participation has been largely ignored by much of the theoretical literature.[1] This is surprising given that market participation is voluntary (for many agents) in most real markets. Indeed, some recent examples suggest that market designers might need to worry about agents' incentives to participate. In the Kidney exchange market, for instance, it has been recently observed that some transplant centres do not fully participate of the central exchange centre but rather withhold some of their compatible patient-donor pairs [Roth (2008), Ashlagi and Roth (2014)]. In the U.S. school system, most charter schools do not participate of the clearinghouse of its own district [Ekmekci and Yenmez (2014)] and high-quality private schools do not participate from voucher programs [Abdulkadiroglu, Pathak and Walters, 2015].

Full participation is of the utmost importance since markets where not every agent participates might face important inefficiencies. Indeed, Ashlagi and Roth (2014) showed that transplant opportunities might be lost when a transplant centre withholds some of its compatible pairs and Ekmekci and Yenmez (2014) observed that, since students might be admitted by both public and charter schools, some seats become empty after assignments are produced thus leading to an inefficient decentralized re-assignment. Unfortunately, in a recent working paper – Peralta (2016) – I showed that the current mechanisms employed to implement the desired distributive goals might affect agents' incentives to participate.[2] That paper studies a many-to-one (colleges-students) matching market facing distributional constraints and shows that no deterministic mechanism that produces a feasible matching guarantees full participation whenever agents' preferences are not aligned in a very demanding way. Roughly, every student whose most preferred college lies in some over-demanded region must agree on the most preferred firm. The result might thus help to explain why some institutions – like charter schools and high-quality schools – do not participate from centralized matching programs.

In light of this result, the implementation of distributional constraints seems to be impossible under the current deterministic algorithms used by most clearinghouses. A natural question is thus whether these clearinghouses could be (re-)designed to account for agents' participation incentives. Since clearinghouses are constructed to produce feasible outcomes, full participation would guarantee the implementation of the desired distributional goals. In Peralta (2016) I argue that, indeed, one such re-design might exist. Specifically, I show by example that a random mechanism guarantees full participation in markets where no deterministic mechanism can. Unfortunately, however, this is not a general result.

[1] Indeed, by now there is a vast literature on affirmative action policies in school systems and, recently, an important set of papers by Yuichiro Kamada and Fuhito Kojima offered a detailed analysis of markets dealing with other distributive concerns.

[2] The paper is available upon request.

The goal of this project would then be twofold. First, to understand – i.e., characterize – when random assignments might actually help to enhance participation. In particular, I would investigate if and when random mechanisms implement the desired distributional constraints. Second, the project would study whether this can be achieved by a "simple" re-design of the algorithms currently used. The latter would of course be of particular importance for real markets.

2 Approach

The simplest starting point to capture incentives to participate would be to consider a two-period model where a clearinghouse is ran in the second period but both colleges and students are free to sign contracts during the first. This model would capture the observed feature that, in many markets with distributional constraints – like the residency matching program in Japan or the different voucher programs in the U.S. –, participation is voluntary. The next step would be to propose a game during the first period where colleges and students could agree to sign contracts. For example, colleges could make proposals to students that students could accept or reject.

The details of the game would then depend, crucially, on the particular features of the clearinghouse. For example, does the clearinghouse allow those that have signed some contract in period one to participate? In many matching markets – like the Japanese residency matching program or the National residency matching program in the U.S. –, the answer is negative. On the other hand, does the clearinghouse adjust the desired caps to account for the intake of those not participating? Moreover, are distributional constraints only a feature of the clearinghouse or they apply, more generally, to those not participating as well? All of these features will be crucial since the outcomes produced by the clearinghouse determine the outcomes of the game and, therefore, affect agents' incentives to participate.

I would first focus on the – deterministic – mechanism recently proposed by Kamada and Kojima (2014) for the Japanese residency matching program.[3] This program was recently modified to capture an attempt of the Japanese government to increase the number of residents in rural areas. Since the current program can lead to important inefficiencies, Kamada and Kojima (2014) investigated whether the program could be re-designed. The mechanism they propose is indeed an improvement. They showed that it is (group) strategy-proof and delivers a stable outcome. Given the practical importance of their proposal, focusing on their mechanism seems a natural starting point.

Unfortunately, Kamada and Kojima's (2014) mechanism is deterministic and thus cannot guarantee full participation. As a consequence, the desired distributional constraints might not be implemented. The project would then investigate whether a re-design of Kamada and Kojima's (2014) mechanism could guarantee full participation. Specifically, is there an equilibrium of the above game where no contract is signed during the first period when the clearinghouse randomizes over the set of stable outcomes – those produced by Kamada and Kojima's (2014) mechanism – for those who participate of the clearinghouse in the second period?

Next, I would study whether – and which – random mechanisms can improve upon *any* deterministic one. This would be important not only from a theoretical point of view, but also for potential applications. Indeed, while randomization is widely used in practice – mainly to break ties – it is often under lots of debates.

3 Related literature

While both market participation and distributional constraints have been studied, to the best of my knowledge Peralta (2016) is the first paper that studied their possible relationship. The key reference in terms of distributional constraints is the agenda recently developed by Yiuchiro Kamada and Fuhito Kojima. They introduced novel stability notions and a unified framework to study matching markets facing distributional constraints. However, none of their papers deals with market participation. On the other hand, market participation has been recently studied in the context of Kidney exchange programs – by Ahslagi and Roth (2014) – and school choice – by Afacan (2016) and Ekmecki and Yenmez (2014). None of these papers deals with distributional constraints.

[3] As they argued, the mechanism would be in principle useful to study other makers as well. For example,...

4 References

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Working Papers:

- Participation in Matching Markets with Distributional Constraints.

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Work In Progress:

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Seminar and Conference Presentations:

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Dear Colleagues:

I am writing a letter of recommendation on behalf of Esteban Peralta, a graduate student in the Department of Economics at Yale who is applying for a post-doc in your Innovation Policy program. I know Esteban and his work well. He has been a student in my first-year graduate theory class, he has served as my teaching assistant, and we have talked regularly about his research, culminating in his writing a thesis under my supervision.

I am happy to recommend Esteban. Esteban has excelled in our graduate program, and is developing nicely as a talented and innovative economic theorist. Esteban has a broad set of interests that might usefully be organized under the heading of market design. He began his research working on robust mechanism design. In particular, it is a familiar result in the literature that the set of implementable social choice functions expands if some information is verifiable, i.e., if there are some messages that only some types of agents can send. Esteban develops a topology in information and communication structures, and asks whether the stronger implementation results that appear in the presence of verifiable information are robust in the sense that similar results hold at nearby information and communication structures. His results are subtle, but provide a strong sense in which one should be cautious in interpreting implementation results with verifiable information. This work will be an important addition to this literature.

More recently Estaban has turned to the study of matching markets with distributional constraints. The issue of distributional constraints in matching markets first appeared in the celebrated "rural hospital theorem." This theorem is named to call to mind the comment lament that hospitals in rural locations in the US often have difficulty attracting qualified staff. One's first thought might be that this could be addressed by appropriately designing the matching procedure. Perhaps we need only give these hospitals a higher priority, in some sense. However, the rural hospital theorem shows that this hope is vain, in the sense that if a hospital fails attract enough doctors in a particular stable match, then it does so in every stable match. The practical implication is that it is often difficult to get everyone to participate in a matching procedure, as those who know they will come up shortly simply opt out. For example, a commen lament with kidney exchanges is that it is difficult to get patient/donor pairs into the exchange. A variety of responses have been proposed, typically seen in the imposition of

various distributional constraints (e.g., floors or caps on the number of agents from one side of the market that can be matched with various sets of agents on the other side). It is common in the literature to study the resulting matching procedures and their attendant stable outcomes under the assumption that participation can be taken for granted. Esteban's research instead centers around the participation implications of these procedures. This is a natural step, given the importance of participation decisions in motivating distributional concerns and in the workings of these algorithms. Esteban has already made significant progress on this topic, including a thorough analysis of various stability notions and (more importantly) the demonstration that possibility results for full participation can be achieved if and only if random mechanisms are allowed. Esteban would like to continue this research to identify procedures for implementing the various mechanisms he exams, as well as to achieve a more complete set of welfare results.

Esteban has originally planned to go on the job market this year, and could well have done so. Instead, he elected to wait in order to develop a more complete set of results. A post doc at the NBER would give him a valuable chance to extend his research and broaden the scope of his work. His work may initially appear somewhat of a stretch for inclusion in a group on innovation. However, the question of nurturing innovation is inherently a design question, and it would be quite valuable to bring together people with backgrounds in market design and innovation. Estaban would fit very well in such a group.

Estaban is personable and collegial. He is a frequent and valuable contributor in our seminars and workshops. He is enthusiastic and always eager to talk about research, whether his own or that of someone else. He would be a valuable addition to a working group on innovation, and would enhance the productivity of that group.

Best regards,



Larry Samuelson