USING CLASSROOM EXPERIMENTS TO TEACH MARKET DESIGN AND MATCHING THEORY*

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Abstract

Market design studies alternative mechanisms to allocate resources when standard markets fail. One application of market design is the study of two-sided matching markets such as the marriage and dating market. Market design and matching theory also relate to the study of platforms (i.e. profit-maximizing intermediaries who serve to connect two (or more) groups of people), such as Amazon, eBay, and Uber. In this paper, we outline two classroom experiments conducted in an undergraduate matching theory class with detailed instructions for readers who may want to implement the experiments in their own curriculum. The first experiment studies market thickness, market segmentation, network externalities, and their use by platforms. The second experiment explores the idea that positive assortative mating in income and education has lead to an increase in income inequality in the U.S. in recent history.

JEL classification: A22, C78

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1 Introduction

The field of market design came into the spotlight when Al Roth and Lloyd Shapley won the Nobel Prize in Economic Sciences in 2012 for "the theory of stable allocations and the practice of market design."[1] Market design is the study of market structures and characteristics with the goal of identifying specific problems so that economists can make them more efficient. The 2012 Nobel Prize catapulted the popularity of the study of two-sided matching markets amongst academics, but the subfield itself started 50 years earlier with the elegant paper by David Gale and Lloyd Shapley titled "College Admissions and the Stability of Marriage" (1962), in which they define the notion of a *stable matching*[2] and develop an algorithm to pair individuals together in a matching market depending on their preferences over potential mates. Recently, Al Roth brought matching markets to the attention of the nonacademic audience with the release of his very accessible book on this topic called "Who Gets What – and Why: The New Economics of Matchmaking and Market Design" (2015).

Market design and matching theory also relate very closely to the study of *platforms*, which is a very interesting and relevant topic for modern-day economics. This is particularly true for undergraduate students who are typically familiar with successful platforms such as Netflix and Google. Platforms are profit-maximizing intermediaries that serve as matchmakers to connect multiple groups of individuals to one another. Some other examples of popular platforms are Visa (matching owners of Visa credit cards to merchants who accept those cards as payment), Amazon (matching buyers and sellers, as well as connecting advertisers to these populations), Uber (matching riders with drivers), and AirBnB (matching individuals who wish to rent vacation or long-term accommodations to those who own or manage them). The platform economy is one that is highly successful – in 2015, estimates were that global revenues from platform consumption in five main sectors – travel, car sharing, finance, staffing and music and video streaming – had the potential to increase global revenues from roughly $15 billion to about $335 billion by 2025.[3] Given the popularity of topics related to market design and matching theory, it is important that an undergraduate economics student at least understands why these markets are so interesting, the strategy behind running successful platforms, and what can be done to improve their overall efficiency.

All this being said, what makes a matching market different than a "normal" market? What makes the

[1] http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/2012/

[2] A stable matching exists in a two-sided matching market when there are no two individuals who are married to other people and who would rather be married to each other.

[3] The Sharing Economy, Consumer Intelligence Series, Price Waterhouse Coopers, 2015. https://www.pwc.com/us/en/technology/publications/assets/pwc-consumer-intelligence-series-the-sharing-economy.pdf

dating market different than the market for Wisconsin cheddar cheese? In a matching markets, there are different *sides* to the market and each side has preferences over individuals on the other sides of the market. For example, in a heterosexual dating or marriage market, there are typically two sides (men and women) and every man and woman has preferences over characteristics of their potential partners. In contrast, markets for consumption goods do not have two-sided preferences – you may prefer Wisconsin cheddar over English cheddar, but the cheese certainly does not care about who ends up buying and consuming it. It is also important to note that prices do not play a strong role in some matching markets but that there are many important matching markets in which prices are a powerful allocation mechanism. For example, wages play a key role in the allocation of doctors to hospitals, whereby economists have studied how price competition works in the labor market for medical residents (Bulow and Levin 2006).

Even though the basic ideas from the field of matching theory are quite intuitive, the level of mathematical maturity needed to study these questions in detail is quite high. This being the case, matching theory and more broadly, market design, is generally not taught to lower-level undergraduate economics majors, and not at all to non-majors. A standard market design class typically requires at least intermediate microeconomics and familiarity with basic set theory and calculus, which is not the norm amongst most sophomore-level college students and below. This is unfortunate since the conclusions derived from the study of market design are extremely useful for real-world applications such as the study and understanding of platforms.

In the spring of 2016, we were given the opportunity by Davidson College, an elite liberal arts college in North Carolina, to design a course on market design that is targeted to undergraduate students who have *only* had introductory economics (micro and macro). In developing this course, we decided to incorporate some experiments as a way to keep the students interested in the material to provide a tangible way of illustrating abstract concepts, and to provide a break for the students so that they can walk around the classroom, not fall asleep, and do something other than listening to lectures on mathematical models. These experiments, including the two described in this paper, were designed to be implemented in *any undergraduate economics classroom* with some modifications, as outlined in the section on classroom implementation.

In summary, our paper has three goals:

1. To add to the growing body of literature in economic education dedicated to documenting experiments in the classroom.

2. To provide instructors with detailed instructions to implement these experiments in any undergraduate economics classroom.

3. To provide an example of a matching theory and market design course that can be taught to undergraduates with little to no mathematical or economics background.

Our paper will focus on the two most successful experiments that we conducted in this market design course that have since been repeated in other classes that we have taught. The first is on the idea of thick markets, network externalities, and the usefulness of market segmentation. The second addresses search frictions, assortative mating, and the rise in income inequality in the US.

2 Literature Review

Many undergraduate economics instructors have documented the use of classroom experiments in their courses to teach particular topics or concepts (Leuthold 1987, Hazlett 1997, Ortmann and Colander 1997, Kaplan & Balkenborg 2010, Perote et al. 2016). The paper that is closest to ours is titled "Choosing Partners: A Classroom Experiment," and was published in the *Journal of Economic Education* (Bergstrom et al. 2013). It provides a case study of a classroom experiment that was used by the authors to teach students about the concept of two-sided markets, stable matching assignments, and the Gale-Shapley deferred-acceptance algorithm outlined in their 1962 paper.

Although our paper does not document or test the effectiveness of using the experiments described in this paper on student learning, the literature on economic education has documented many instances in which experiments have added significant value to student learning in the classroom (Holt 1999). Using multiple sections of the same course, some instructors have been able to experimentally explore the effects of classroom experiments on different dimensions of student learning (Emerson & Taylor 2004, Durham et al. 2007, Grol et al. 2017). Some authors have also found that unlike grade incentives, experiments have the ability to increase learning in introductory microeconomics courses (Dickie 2006). In an article published in 2007, Durham et al. found that the learning benefits that students experience from classroom experiments greatly offset its high implementation costs. Another study found that "students who took part in (a) classroom experiment, as well as those who just watched it, were more successful in answering a multiple-choice test than control groups from the same courses." (Frank 1997).

This paper also adds to the literature devoted to the teaching of "millennials" – that is, students who were born in or after the year 1992 (McGlynn 2005). In particular, many authors have noted that the majority of current-day college students have, by and large, lived the "digital lifestyle" for their entire lives and are

very familiar, and in fact crave, the use of non-lecture methods in the classroom. These include, but are not limited to, the use of media, technology, experiments, games, concrete real-life case studies, and structured debates (Considine et al. 2009; McMahon and Pospisil 2005). This trend is largely inconsistent with how economists teach economics at any level of instruction (Becker et al. 1996, 2001, 2006; Watts & Becker 2008). Thus, this paper also adds to the body of academic papers that document the use and need for innovative ways to present classroom material to students.

3 Course Description

In this section, we will provide an overview of the course so that the reader may situate the experiments within the context of topics covered, as well as to provide an example of a matching theory and market design course that can be taught to undergraduates with little to no mathematical or economics background. There were 34 students in the classroom, which is quite large for Davidson College, where the average class size is 15. Students were mostly sophomores, and most, but not all, were economics majors. The course was designated as a 200-level elective, which means that the only prerequisite for the class was introductory economics.[4] Davidson College is a premier liberal arts college that has consistently ranked within top 10 liberal arts colleges in the U.S. It has an acceptance rate of about 20%, with 85% of the Class of 2021 reporting that they were in the top 10% of their class.[5] We found the students to be remarkably engaged and talented but most had not yet taken intermediate microeconomics. Classes were held every Monday, Wednesday, and Friday for 50 minutes. Since the students did not all come equipped with intermediate micro and the mathematical sophistication needed to study market design at a higher level, our focus for the class was not to teach them how to do quantitative research in matching theory, but to expose them to the useful results that the field has derived that may be used in other aspects of their life and other classes.

The course was divided into two parts. The first part of the course was devoted to learning the basics of market design and matching markets (1.5 weeks), an introduction to rational decision theory and a brief introduction to game theory (1 week), and a more in-depth look at two-sided matching theory, the notion of stability, and a variety of algorithms for finding stable matchings (2 weeks). After we were confident that the students had a sufficiently rigorous foundation in matching theory, we proceeded to look at a variety of applications for matching markets. These included the following markets, each covered for about a week:

[4] At Davidson, ECO 101 (Introductory Economics) covers both micro and macroeconomics.
[5] https://www.davidson.edu/admission-and-financial-aid/class-of-2021-profile

1. The National Residency Matching Program
2. Kidney Exchanges and Repugnant Goods
3. School Choice in Major US Cities
4. Job Search
5. Marriage and Dating Markets

Finally, at the end of the semester, we also discussed other issues related to market design such unraveling, platforms and firm pricing, signaling, and exploding offers.

The students were graded on the following components – two midterm exams (20% of the final grade each), 2 major problem sets (5% each), participation (10%), reading responses to academic and news articles (15%), and a final paper (5% for a written proposal, 5% for final class presentation on the paper, and another 15% for the final paper itself). The method of delivery for the class was mainly lectures with the integration of classroom discussions, debates, and experiments. For example, when we covered kidney exchanges, we read an academic paper that summarized the government-operated market for organs in Iran (Fatemi, 2012). This system is, of course, in contrast to the U.S., where it is illegal for money to be exchanged for a human organ. We then watched the HBO documentary "Tales from the Organ Trade" when we discussed the idea of *repugnant markets* (i.e. markets that do not exist because of prevailing social norms), and debated the existence of organ markets in groups. Some questions that were raised during this debate were: Is it ethical to pay somebody for an organ? Do you see the organ market as the beginning of the commoditization of other goods and services such as sex and children? Should somebody from a developing country be paid less than somebody from a developed country for essentially the same organ? Students prepared questions before each classroom discussion and sent them to us the night before – these questions were then used to spark the initial conversations the next day. Students also provided a 2-3 page writeup on every discussion and class debate on what they had learned from their peers, which was turned in during the subsequent class.

The first experiment described below was conducted at the start of the semester as a classroom activity in the foundations section of the course. We first assigned as required reading for the day the chapter from Al Roth's book that loosely discusses the concept of thick markets and the usefulness of market segmentation. Students came to class prepared and then we played the game. The second experiment was conducted at the end of the course during the topics section of marriage and dating markets. For that experiment, students

were assigned an article from The Economist titled "Sex, brains and inequality: How sexual equality increases the gap between rich and poor households", to read before class.

In both cases, the background material that the students needed to understand were very little. In fact, the experiments themselves were designed to do most of the teaching during the times they were conducted. This being, we have since used these experiments to supplement our curriculum in other economics elective courses that were not dedicated to market design and matching theory. We explain this in more detail in the implementation section below.

4 Experiment 1 - Thick Markets and Market Segmentation

In market design, a *thick market* is a market that is sufficiently saturated with participants such that each participant does not have trouble finding somebody else to transact with. Through this experiment, students learned about the following concepts:

- The costs and benefits of participating in a thick market.
  - Students were introduced to the concept of *market congestion*, which is explained below.
- Preferences and differentiation – both horizontal and vertical.
  - In this experiment, we simulated a two-sided matching market with horizontal preferences. Horizontal preferences are preferences for similarity. In the context of a marriage market, these preferences can be used to model the phenomena where fans of jazz music find it attractive to marry each other or the fact that most individuals marry within their racial group. This is in contrast to vertical preferences, which are preferences over characteristics ranked according to an order that most or all individuals agree on. For example, individuals tend to view income as a vertical trait – the higher a person's income, the more desirable they are seen by their potential mates. Differences in horizontal and vertical traits can also be thought of as *differentiation*. We then discussed some other traits and characterized them by whether they were vertically or horizontally-differentiated. In the context of industrial organization and firm competition, we used the example of quality being a vertically-differentiated trait, whereas color is a horizontally-differentiated trait in the smartphone market.
- Network externalities

- This experiment also allows for discussions regarding externalities in matching markets. Students who have taken introductory economics will have already seen the concept of externalities but may require a quick refresher. We found it useful to do this by going through the simple graphical illustration in Figure 1. Traditional market externalities occur when non-participants of a particular market or transaction experience costs or benefits as a result of other market participants interacting with each other. In matching markets (we will focus on two sides for ease of illustration), network externalities drive a lot of the dynamics between individuals (Armstrong 2006). We characterize these externalities into either a *within-group* or *rivalry* externality, and a *between-group* externality. Rivalry exists when participants on one side of the market compete with each other for the possibility of a transaction or a matching – this externality is heightened with thick markets. Between-group externalities are typically positive externalities that are generated for one side of the market when there are more market participants on the other side of the market. For example, in the case of mobile operating systems such as Apple's iOS, the two sides of the market could be seen as app developers and app users. The more app developers there are, the better it is for app users – users will have a larger array of apps to choose from for their enjoyment.

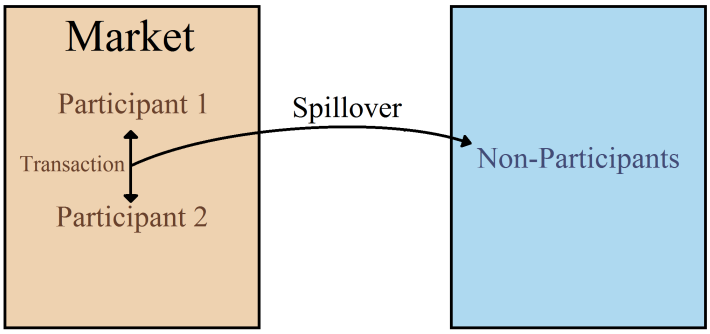

Figure 1: Simple graphical illustration of market externalities.

- Platforms and market segmentation
  - Discussing the benefits of thick markets allowed us to also discuss the idea of platforms, i.e. profit-maximizing matchmakers or intermediaries who function to bring groups of users together. A platform's ability to charge higher prices to its users depends on the quality of potential matches that it provides. (Weyl 2010). For example, a thicker market allows for potentially more (and perhaps even better quality) matches, which means that the platform operating the market is able

to charge higher prices to its users. In the most basic version of this experiment, prices are not modeled. However, we discuss incorporating prices in the modifications subsection below. This experiment also allowed for the discussion of how platforms require large network externalities effects to be successful – without a critical mass of consumers in a market, a platform cannot exploit the benefits of a thick market to attract consumers to join. On the flip side, if there are too many users on a platform, the time to search for a good-quality match increases, which may also negatively affect market participants. The platform then has to balance all of these factors when operating. Additionally, in this experiment, we also explore market segmentation – the idea that it may be better for market participants, depending on their preferences, to be separated into different markets according to their type. There are many ways to segment a market, and some work better than others, as is illustrated in the experiment. When we first taught this course, we used online dating websites as an example of a two-sided matching platforms. We discussed the different between a general interest dating website such as eHarmony in comparison to segmented, "niche" dating platforms such as FarmersOnly (for farmers and individuals who live in rural areas) and MouseMingle (for individuals who love "all things Disney").

4.1 Description of the Experiment

Types: Each student is randomly assigned a "type" – A, B, C or D. If possible, assign an equal number of students to each type.

Preferences: Horizontal – everybody wants to marry their own type.

Number of Iterations: Three, each with different setups.

Time Limit: 90 seconds for each iteration. Time is clearly projected at the front of the room.

Setup for Each Iteration:

- Iteration 1 – The instructor randomly partitions the class into four groups. You may only search and match with individuals in your own group.
- Iteration 2 – Students are free to match to anybody in the class.
- Iteration 3 – The instructor partitions the class into four groups according to their types. You may only search and match with individuals in your group.

Rules and Restrictions

- For each iteration, students search for a match by approaching another student by stating their name, providing one interesting fact about themselves (e.g., "My name is John and I grew up in Germany"), and shaking the other student's hand. The reason for this one-line conversation is to simulate the idea of *costly search* – i.e., the fact that getting to know somebody (in the case of dating and marriage markets) or getting to know a product (in the case of most consumption goods' markets) takes both time and effort. After listening to the other person's introduction, both students reveal their types to each other. If they both happen to be of the same type, they get married and move to the back of the classroom. If they are not of the same type, they must continue the search process with another individual.
- Students are not allowed to shout their type out loud. They must proceed through the search process as outlined above.
- Students are assigned different types for each iteration of the experiment.

Deliverables: On the same day that the experiment was conducted, students participated in an all-class discussion of the experiment, their experiences, their takeaways, and also the reading assigned from the previous class. Students also had to turn in a 1-page writeup on the experiment, its outcomes, and interesting lessons they learned from participating in the experiment or from their peers.

4.2 Outcomes and Takeaways

The first iteration of the experiment (depicted in Figure 1), is meant to illustrate the concept of an anti-thick market, i.e. a *thin market*. A thin market is one in which participants may have trouble finding somebody to match or transact with due to the fact that they have run out of people of their type. In a buyer-seller market, this can be imagined as a difficult situation where you'd like to purchase a specific product but cannot find a seller who can sell that product to you. The cost of a thin market is that some people could end up unmatched, which makes them unhappy. Economists have often studied how market segmentation can improve market efficiency. In the case of the first iteration, we tried to show students that market segmentation, if not done correctly, can actually thin out the market and cause participants to be worse off.

So the question then becomes – can we make markets work better than those in Iteration 1? The second iteration of the experiment (depicted in Figure 2) was meant to show how thick markets increase the chances of successful transactions by providing a wider pool of individuals to pair up and match with. At the end of

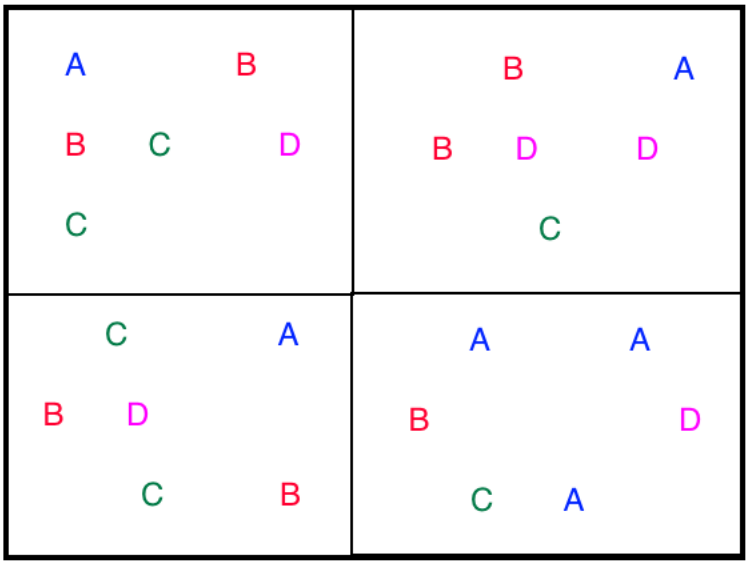

Figure 2: Iteration 1 – Classroom is randomly partitioned into 4 groups. Students may only search within their own group.

the 90 seconds, however, students run into the commonly studied problem of *congestion in a thick market*; that is, the problem where there are simply too many people to search through and hence, many individuals end up unmatched. In a buyer-seller market, this would be a situation where there are too many buyers in line to buy something from a seller and the seller runs out of the good before all of the buyers in line get to buy it.

The question after Iteration 2, in which many individuals still were not able to find a match despite the thickness of the market, is whether or not we can make the market even better. In Iteration 3 (depicted in Figure 3), we have the most ideal situation where every group only has individuals of the same type. In this iteration, the market is thick, there is no congestion because each person matches with the first person they meet, and so the overall payoff in the market is maximized. There may still be individuals who are unmatched if the number of individuals in a group is an odd number, but this market configuration works better in maximizing the amount of matches given the time constraint.

To reiterate a point from earlier, the most important thing that both the instructor and students should take note of is the importance of segmenting the market *in the appropriate way.* As we observed from the results of the experiment, a market designer or a platform can vastly improve efficiency by partitioning markets according to types instead of unsystematically.

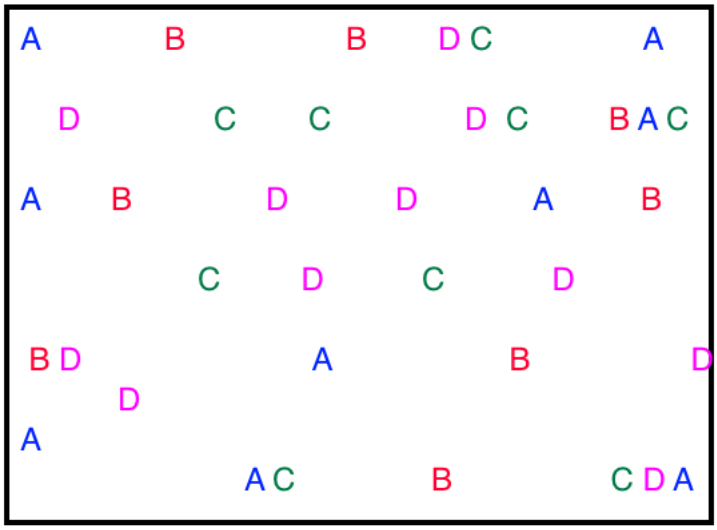

Figure 3: Iteration 2 – Classroom is not partitioned. Students are free to search amongst the entire classroom.

4.3 Possible Modifications

This experiment requires a reasonable amount of physical space in the classroom and an appropriately sized class. Our class had only 34 students in a classroom that could fit 40 students and the experiment worked out very well. In order for the dynamics of a real market to be accurately captured in this experiment, all participants must strictly adhere to the time constraints. Since the experiment includes a search process, it is crucial that the instructor be strict with the amount of time allocated per iteration. Iteration 2 will not produce "good" outcomes that reflect the theoretical results if students are given too much time. If this experiment were to be conducted in a smaller classroom (i.e. 30 and fewer students), the instructor must reduce the time limit for each iteration as he or she sees fit or, alternatively, keep the time limit of 90 seconds per iteration and increase the search costs for each interaction. One easy way to increase search costs is to mandate a certain amount of time of "introduction" to each other beyond the one-line conversation outlined above.

One word of caution is that the network externalities outlined above may be more apparent in larger classes (i.e. 30 and more students). The tradeoff is then that the space logistics become trickier. If you would like to run this experiment in a very large class, we suggest increasing the number of types possible from four to more and correspondingly increase the number of groups as a result of class partitioning.

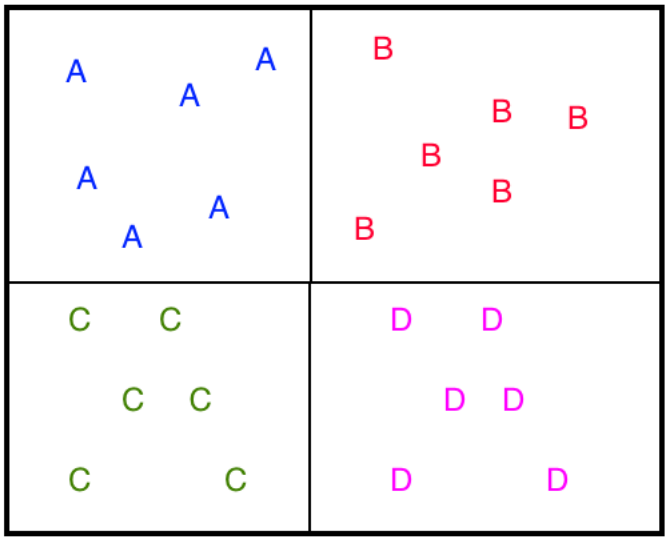

Figure 4: Iteration 3 – Classroom is partitioned into 4 groups according to types. Students may only search within their own group.

Finally, a more advanced version of this experiment could include the addition of a platform as a matchmaker. Students draw an initial endowment of income from a distribution (that is, students do not all have the same initial endowment). The class should be physically "partitioned" into 3 separate markets and students are assigned to one of two types – A or B. The instructor should motivate this exercise by using a particular example of a platform – since students typically find dating markets very interesting, we encourage using online dating websites as an example. The idea is that one market will serve as the outside option for individuals to search on their own (think about this as being the option of searching for a match at a congested bar) and the remaining two markets will be run by profit-maximizing (and fee-charging!) platforms. These two platforms will be "operated" by two students who are chosen before the start of the experiment. The instructor informs all students of the "search time" in all 3 markets, as well as prices charged by the platforms, with the general idea being that the "outside option market" is larger and more congested in types than the two "platform markets", which are segmented into one catering (almost exclusively) for type As and another for type Bs.

An example of the announcement to set up the experiment could be the following:

> "There are 3 dating markets in this game. Preferences are horizontal. The first market is a bar and entrance is free. However, it takes an average of 15 minutes to meet a person of your type.

The remaining two markets are operated by platforms A and B. Platform A charges $\$x$ per entry but it takes an average of 5 minutes to meet a person of type A. Platform B charges $\$y$ per entry but it takes an average of 4 minutes to meet a person of type B. Think about your choice, and move to the market that you would like to join."

The information in the announcement above should also be projected on a screen or written on the board at the front of the class so that all students know it at all times. It is important to note that the platforms must charge all participants on their platform the same fee (i.e. no price discrimination). No collusion is allowed – the two platforms must set prices independent of each other. All students, including platform operators, should be told about the distribution of the endowments (i.e. "Half of you have an income of 50, and the other half have an income of 100") but any individual's initial endowment is private information. Depending on how high the fees are for the platforms, and how congested the outside option market is, students may choose to pay the fee and search on the platform. In this version of the experiment, there should be at least 3 repetitions. After each iteration, some, but not all parameters are changed. For example, the instructor could double the search time for the outside option market, or halve everybody's initial endowment. The platform operators are also allowed to re-optimize given the new information available to them.

This version of the experiment allows the instructor to introduce some additional concepts – the idea of game theory and strategic interactions, the idea of outside options governing optimal choices, and the fact that heterogeneity in income and search costs often drive pricing dynamics in a market. It is also harder to implement than the basic version, so we would advise instructors to start with the basic version and once comfortable with the setup and logistics, consider running this more complicated version.

5 Experiment 2 - Assortative Mating and Inequality

In this experiment, we tried to expose to the students the issue of *assortative mating* and how it could potentially relate to income equality. Assortative mating is simply a term that economists use to describe the phenomenon of "likes marrying likes." Positive assortative mating on income, for example, is when high-income individuals prefer to marry high-income individuals whereas negative assortative mating would be when high-income individuals prefer to marry low-income individuals. An empirical paper published in the American Economic Review used U.S. Census Bureau data to conclude that "if matching in 2005 between husbands and wives had been random, instead of the pattern observed in the data, then the Gini coefficient

would have fallen from the observed 0.43 to 0.34, so that income inequality would be smaller." (Greenwood et al. 2014) This was a very interesting result that was widely covered in popular press, so we made our students read a news article on this finding before they conducted the experiment in class.[6]

Through this experiment, students cemented their understanding of preferences and additionally, learned the following concepts:

- The relationship between micro-level behavior and the economy at large
  - We wanted to expose students to *aggregation* and how micro-behavior can cause macro-trends – that is, the idea that one individual's behavior cannot create macro-changes, but that many individuals behaving similarly can. This is a particularly useful concept to help students form linkages between microeconomics and macroeconomics.
- An introduction to search theory
  - Search processes are crucial to many markets – it explains frictional unemployment resulting from job hunting, the recent shift in consumer purchasing from brick-and-mortar stores to online shopping, and the existence of powerful platform companies that charge a fee in exchange for lessened search costs. Like most events, learning about search processes on paper is very different than experiencing it, which is what we tried to simulate through this experiment.
- The importance of *random matching shocks* and their consequences on individual behavior
  - In this experiment, preferences are not only vertical, but also dependent on a matching shock – a random element drawn from a probability distribution which can dictate whether or not a partnership forms. In practical terms, in a marriage market, a matching shock could be a proxy for "chemistry" – if beauty is a vertical trait, an attractive person may end up choosing a non-attractive person to marry over another attractive person because they share a "special connection" and get along better. In the experiment below, the random matching shock is a proxy for the randomness in life – for example, the child of rich parents could have made terrible investment decisions and lost income, or they could have won the lottery and gained more income as a result.
- Understanding income distributions and trends

[6] The first time we implemented this experiment, we used the following news article from PBS: https://www.pbs.org/newshour/nation/economics-explains-resemble-mate

– In setting up this experiment, we primed students to think about income distributions, which invariably led to some discussions surrounding income inequality. We also discussed the Gini coefficient as a measure of income inequality and briefly talked about country differences across the world, as well as future predicted trends given current economic and social policies.

5.1 Description of the Experiment

Types: Income, ranging from 0-100.

Preferences: Vertical – everybody wants to marry high-income individuals.

Number of Iterations: Two rounds with 3 iterations per round.

Time Limit: 30 seconds for each iteration in Round 1 and 2 minutes for each iteration in Round 2.

Rules and Restrictions

- Without knowing why they are doing so, each student writes down a random 6-digit number on the top of Handout 1 (displayed in the appendix on this paper), where each digit ranges from 0 to 9.
- For each round, the instructor randomly assigns a number between 0 and 100 to each student, which is their income. In each iteration, students must search for a partner to marry, given their preferences. Students search for a match by approaching another student, stating their name, providing one interesting fact about themselves (e.g., "My name is John and I grew up in Germany"), and shaking the other student's hand. After listening to the other person's introduction, both students reveal their incomes to each other. The one-line introduction is meant to simulate search costs of getting to know somebody before deciding whether or not to form a partnership.
- Students then face a choice – should they marry the person they were just introduced to or can they do better by continuing their search? If they find somebody who they consider "sufficiently rich," and hence sufficiently attractive to marry, they marry and move to the back of the room. If not, they must continue searching.
- If they are successful in their search, they must write what their match's income is on Handout 1. The two individuals' incomes then produce a new income, which is

$$\text{New Income } = \frac{\text{Your match's income} + \text{Your income}}{2} + \epsilon$$

where ϵ is a matching shock, and given that you are in the ith iteration of the two rounds (there are 6 iterations, 3 for each round), $\epsilon = 10$ if the ith digit in your number on the top of Handout 1 is an even number, and $\epsilon = -10$ if the number is odd. If you do not find anybody to marry, or equivalently if nobody wants to marry you, your new income for the next iteration will simply be your old income since there was no marriage and hence, no sharing of income.

- Students are not allowed to marry the any of the individuals that they married in a previous iteration. They may marry somebody they met and were introduced to but did not end up marrying.
- As in Experiment 1, students are not allowed to shout their type out loud.

Deliverables: On the same day that the experiment was conducted, students participated in an all-class discussion of the experiment, their experiences, their takeaways, and also the reading assigned from the previous class. Students also had to turn in a 1-page writeup on the experiment and outcomes.

5.2 Outcomes and Takeaways

When we conducted this experiment, we made sure to assign different incomes to each student in both rounds. In other words, if a student was rich in one round, we made sure that they were poor in another. This was done so that students would understand both sides of the coin in terms of the inequality debate.

There were a couple of concepts in real-life searching that we tried to simulate in this experiment. The first was the rather involved search process of getting to know somebody and balancing tradeoff between marrying somebody who maybe isn't the richest person in the classroom now, and continuing the search for a richer person. The distribution of incomes was common knowledge, so every student understood where each person they met stood in terms of the ranking in income. The second was the structure of how income and socioeconomic standing is generally passed down through a family – in each subsequent iteration, a couple gives birth to a child (in this situation, you are your own child), where the child inherits the average of the parents' income plus a random component. Each round had three generations, we deemed a sufficient number of generations to produce the inequality effects, as displayed later in the paper. The second round was much longer than the first round, with 2 minutes for each iteration instead of 30 seconds. This was intended to capture the essence of operating within a time constraint, and also to allow for repetition so that the students could iron out confusions they had regarding the rules of the game in the first round and act more strategically in the second round.

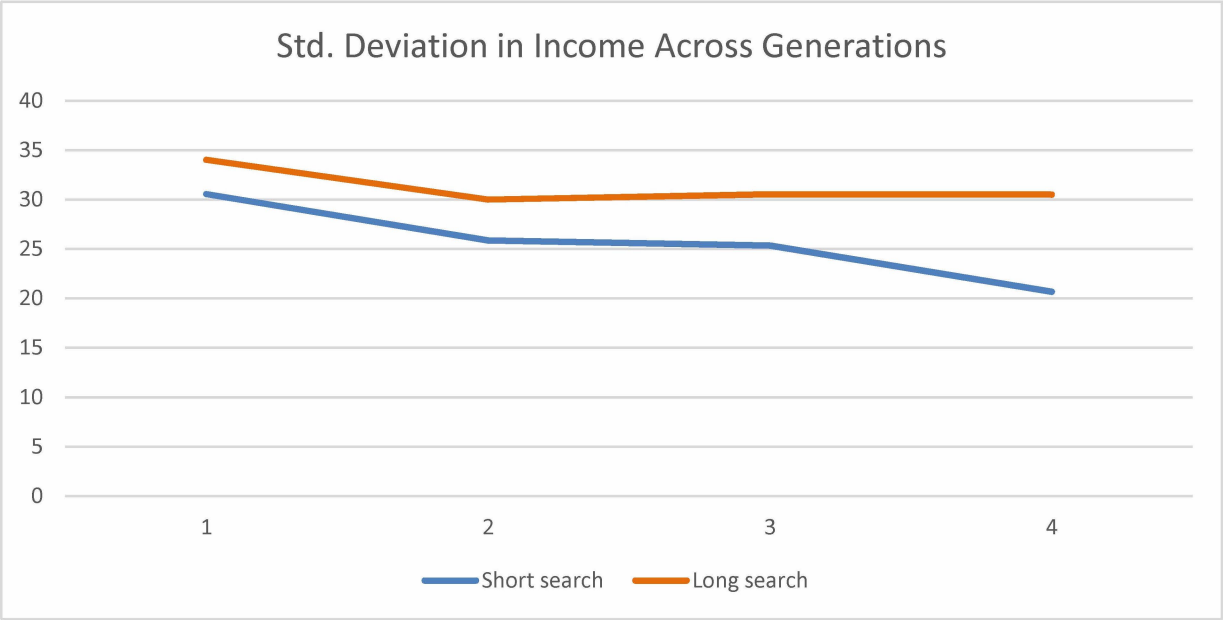

Figure 5: Results from Experiment 2 – Standard Deviation In Income Across Generations

We had a short class discussion right after we did the experiment about the realizations that the students had. The main complaint voiced by the students during this experiment was how unfair it was if you were born very poor. Many "poor" students noted that they were either not able to marry anybody in any iteration or that the only individuals who wanted to marry them were also poor. The students also brought up the issue of "settling," whereby since they knew that they had a time limit, many settled and married somebody who was significantly poorer than them, and in particular, somebody who they would not have married had they been able to search for a longer period.

For the next class period, we showed them the results of the experiment using the data that we obtained. In particular, we showed them three graphs. The first was Figure 4, which depicts the standard deviation in incomes across generations in both rounds (note that "short search" was the first round with 30 seconds and "long search" was the second round with 2 minutes). In Figure 4, note that the long search graph is relatively flat while the short search graph is more downward-sloping, indicating that the standard deviation in the income distribution fell across generations for the short search round but remained fairly constant for the long search round. A smaller standard deviation corresponds to a tighter income distribution; that is, less inequality. The data suggest that when individuals can search for a longer time, they try harder to marry their ideal type (i.e. a richer person), but when they are given a significantly shorter time period to

search, they "settle" and marry somebody who is "middle-class."

Figure 4 of course says nothing about the initial distribution of income and how it compared to the final distribution of income for both rounds. To see this, we also showed the students Figures 5 and 6. As the reader can see from Figure 5, the initial income distributions for both rounds appears to be similar. However, when we look at Figure 6, which shows the income distribution for the final generation, we see the following outcomes:

1. There is clustering about the mean (income of 50) for the short search. This is consistent with the class discussions on individuals settling and marrying somebody who is middle-class when given a very strict time constraint rather than keep on searching for a higher-income individual.

2. There is clustering around low incomes (20) and high incomes (90-100) for the long search, with a relatively constant distribution in the middle, consistent with the findings from Greenwood et al. 2014.

Anecdotally, our students found the experiment very interesting in understanding the dynamics of individual choice and how it may affect the aggregate economy. Through the course evaluations, students expressed appreciation for "the opportunity to stand up and physically move around the room", felt like "the experiment supplemented the theory they learned in class", and introduced them "how people deal with real-life problems".

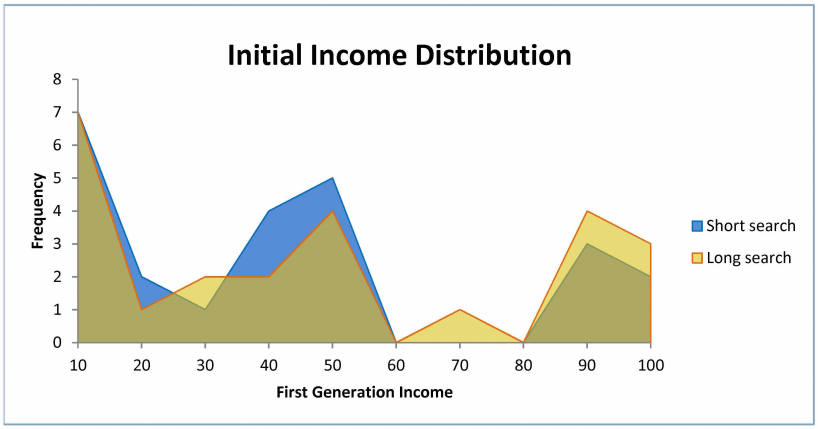

Figure 6: Income Distribution Across the First Generation for Both Rounds

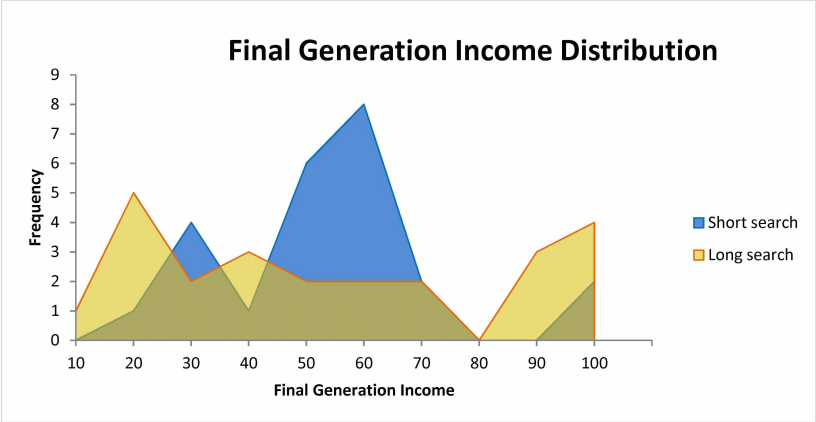

Figure 7: Income Distribution Across the Final Generation for Both Rounds

5.3 Possible Modifications

As the reader may have already noted, the results of this experiment depend on how the utility functions are specified. We chose our particular utility specification because we wanted to incorporate a notion of income-sharing and shocks. One could also imagine a setup where instead of an averaging of incomes, the couple inherits the maximum income between themselves instead. This experiment easily accommodates a variety of utility specifications but we caution against the use of overly complicated setups as to not confuse the students. An interesting consequence of using our income-sharing utility specification was that quite a number of our students, all of whom were in the 90-100 income level, decided not to get married because marriage would lessen the amount of income they would inherit for the next generation. This is similar to a finding in urban economics that in cities with higher male inequality than female, "increasing inequality explains about 25% of the marriage rate decline over the last few decades." (Gould and Passerman 2003)

This experiment also only uses a one-dimensional matching framework — that is, a world in which individuals only care about income. This can be modified to represent a world of multi-dimensional preferences where individuals care about a variety of characteristics in their potential partner such as income, looks, race, education level, etc. If the reader is interested in running an experiment with multi-dimensional preferences, we would caution against using too many dimensions and to limit the number of dimensions to two (perhaps income and a horizontally-distributed characteristic such as physical location in the classroom). In this situation, in order to study inequality as a result of assortative mating in income, the instructor should set income to be the trait that is "dominant" (i.e. the trait that is seen as most important in order to secure a good match) and clearly explain to the student that they could settle for a lower-income individual if they are a very good match in terms of geographical location.

6 Implementation in Other Undergraduate Economics Courses

Even though the two experiments described in this paper were designed for an economics elective on market design and matching theory, they can easily be adapted to other undergraduate economics courses. The reason is that the background information needed to understand, enjoy, and learn from the experiments is insignificant. In particular, given the goals outlined above for both experiments, we can easily see the experiments being used to break up the monotony of lectures and to supplement the teaching of theory in the following undergraduate courses: principles of microeconomics, labor economics, industrial organization,

intermediate microeconomics, public economics, and game theory. To do this, the reader should assign the following background readings to his or her students before the implementation day of the experiment:

- For Experiment 1 – "The Art of Designing Markets" by Al Roth, The Harvard Business Review.[7]
- For Experiment 2 – "Sex, brains, and inequality", The Economist.[8]

We would also like to caution instructors who have never implemented experiments in their classroom to budget at least double the amount of time for the experiments to account for logistical problems. Furthermore, we would also caution against using these experiments in a classroom that has already employed a heavy use of experiments, as "participation in classroom experiments has a positive, but diminishing, marginal benefit on students' final course scores." (Emerson & English 2016)

7 Conclusion

In summary, this paper presents two classroom experiments on matching theory and market design, detailed instructions to implement these experiments in any undergraduate economics classroom, and an example of an entire course on matching theory and market design that could be taught to undergraduates with little to no mathematical or economics background. Due to small class sizes and the lack of multiple sections for courses, we were not able to empirically test any hypotheses related to improved learning outcomes. Unfortunately, we were only able to collect anecdotal evidence and snippets from student evaluations from the course – although these data seemed to suggest that students enjoyed and learned from the experiments, further research projects should be aimed towards rigorously measuring the effectiveness of these experiments in an undergraduate economics elective.

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[7] https://hbr.org/2007/10/the-art-of-designing-markets
[8] https://www.economist.com/united-states/2014/02/08/sex-brains-and-inequality

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Appendix

Handout 1: Assortative Mating Experiment

Your random 6-digit number:

Round 1 - 30 seconds for each iteration. **YOUR INITIAL ASSIGNED INCOME IS _____**

1. Iteration 1
   - Your match's income:
   - Your new income for Iteration 2:
2. Iteration 2
   - Your match's income:
   - Your new income for Iteration 3:
3. Iteration 3
   - Your match's income:
   - The average income in your household:

Round 2 - 2 minutes for each iteration. **YOUR INITIAL ASSIGNED INCOME IS _____**

1. Iteration 1
   - Your match's income:
   - Your new income for Iteration 2:
2. Iteration 2
   - Your match's income:
   - Your new income for Iteration 3:
3. Iteration 3
   - Your match's income:
   - The average income in your household: