

Making Markets Thick: Designing Rules for Offers and Acceptances

Muriel Niederle and Alvin E. Roth

May 30, 2007

Abstract: Many markets encounter difficulty establishing or maintaining sufficient thickness to allow participants to consider many possible transactions, and in restoring such thickness once it has been lost. Often this is because transactions are made quickly and at dispersed times, sometimes inefficiently early. To address such problems, many markets have organizations that try to establish norms concerning when offers can be made, accepted and rejected. Examining some of these markets suggests it is difficult to establish (or re-establish) a thick market at an efficient time when it is acceptable for firms to make exploding offers, and unacceptable for workers to renege on commitments they make, however early. But this evidence is only suggestive. Laboratory experiments allow us to isolate the effects of exploding offers and binding acceptances. In a simple experiment, in which uncertainty about applicants' quality is resolved over time, we find inefficient early contracting when firms can make exploding offers and applicants' acceptances are binding. Relaxing either of these two conditions causes matching to take place later, in a thicker market. These results have implications for market design, which we explore in the context of two contemporary design problems facing the markets for gastroenterology fellows, and federal court clerks.

Muriel Niederle: Department of Economics, Stanford University and NBER, <http://www-econ.stanford.edu/~niederle>, and Alvin E. Roth: Department of Economics, Harvard University, and Harvard Business School, <http://www.economics.harvard.edu/~aroth/alroth.html>.

Acknowledgements: This work has been partially supported by a grant from the National Science Foundation. We are grateful to Uri Gneezy for important early conversations that helped shape the experiment reported here, and Debbie Proctor with whom we were lucky to collaborate on redesigning the policies governing the gastroenterology fellows market to organize a new centralized clearinghouse.

I. Introduction

Many markets have experienced difficulty in maintaining a thick market in which transactions are made at a time and in a manner that promote efficiency. One obstacle in a number of markets has been the use of exploding offers. In such markets, firms make offers to which applicants must respond very quickly, and these markets often clear very fast, with firms as well as applicants having little opportunity to consider many alternatives. Sometimes, from year to year, firms seek to begin the offer process earlier, and so these markets often clear not only before participants can consider many alternatives, but also before useful information about applicants is available (see e.g. Roth and Xing 1994 for an account of a number of such “unraveled” markets).

Partly for these reasons, different markets have different rules, norms, and expectations about how and when offers will be made, accepted, and rejected. For example, in some labor markets, exploding offers are rare. Similarly, norms differ concerning the circumstances under which a candidate may honorably change her mind about an offer she has accepted. These differences--whether they are enshrined in legally enforceable rules, or simply in expected behavior, and whether they are dictated by the larger market environment, or constitute different equilibria within a given market—can influence who makes offers to whom, at what time (and hence in how thick a market), and what outcome is produced.

These are issues of considerable practical importance. A case in point is the entry level labor market for American gastroenterologists, which as we began the work reported here was suffering from just the kinds of unraveling mentioned above. Offers, often exploding offers, were made to aspiring gastroenterologists two years before employment would begin (while they were still engaged in their internal medicine residency). This had caused a number of problems for the market (see Niederle and Roth, 2003a), and the gastroenterology professional organizations were interested in trying to reestablish a thick market that would seek to hire applicants only one year in advance. But many employers (fellowship program directors) were concerned that, even though they would like the market to be later and thicker, they could be harmed if they waited for an orderly market, and their competitors continued to lock up the best candidates early with exploding offers. So the question arose, what policies could the gastroenterology

organizations adopt to make it safe for employers to wait and participate in a thick market at an efficient time?

It turns out that in many markets, formal market organizations exist that seek to regulate how and when offers are made, accepted, and rejected (see Table 1). Because these markets are all different, it is difficult to make simple comparisons of the effects of the various institutions they have created to shape offers and acceptances. But examining these markets together, in terms of their rules about offers and acceptances, suggests a pattern that we will discuss below. Markets that have suffered from unraveling and have been successful in reversing it and restoring a thick market have done so either by preventing firms from making exploding offers, or by establishing rules and conventions that allow candidates who accept early offers to under some circumstances change their minds.¹ Of course, it is hard to draw any firm conclusion about the effects of particular rules and customs from these field observations. Each of the markets in Table 1 is different in complex ways from each of the others, and the rules and customs in each market arise out of their special circumstances.

This paper reports an experiment in a simple laboratory environment, designed to investigate the interplay between the rules by which offers are made, accepted, and rejected, and the timing, thickness, and efficiency of the resulting market. Note that the simple experimental environment is quite different from the markets in Table 1. The laboratory environment, because it is so simple, is different from each of these markets in more transparent ways than they are different from one another. And in the experiment, the rules are an exogenous experimental variable, so that their influence can be readily observed. Thus the experiment adds two things to the evidence from the markets in Table 1. First, it adds a clean comparison of the effects of various rules, when they are varied exogenously, holding all else constant. Second, while it is always somewhat risky to draw inferences about the effect of a rule change in one market from the effects in a different market, the inferences may be clearer when one of the markets is simple.

¹ See Avery et al. 2003, 2001, 2007; Frechette et al. forthcoming, Mongell and Roth 2001; Niederle et al. 2006; Roth 1984, 1991; Roth and Xing 1994, 1997 for descriptions of the markets in Table 1 that are not described here.

Table 1: Some Institutions to regulate offers, acceptances, and rejections

Market	Institution that tries to regulate timing and other aspects of offers	Description
Graduate School Admissions	Council of Graduate Schools (CGS)	Exploding offers discouraged, and acceptances before April 15 non-binding (see text)
Undergraduate College Admissions	National Association for College Admission Counseling (NACAC)	Binding early decision, non-binding early action
U.S. , Canadian, and British Medical Residencies	National Resident Matching Program (NRMP), Canadian Resident Matching Service (CaRMS), various regional matches in Britain.	Centralized clearinghouse
Medical Fellowships	Specialty Matching Services (SMS)	Centralized clearinghouse
Clinical Psychology	Association of Psychology Postdoctoral and Internship Centers (APPIC)	Centralized clearinghouse
Lawyers (particularly in large law firms)	National Association for Law Placement (NALP)	Principles and Standards for Law Placement and Recruitment Activities
Federal Judicial Clerkships	Judicial Conference of the United States (and various ad hoc committees of judges)	Law Clerk Hiring Plan (http://www.cadc.uscourts.gov/lawclerk/)
Canadian Lawyers (articling positions)	Regional Law Societies (e.g. Law Society of Upper Canada)	Articling Recruitment Procedures (centralized match abandoned for 2004-5 articling term)
Japanese University Graduates	The Japan Federation of Employers' Associations (Nikkeiren), Labor Ministry	Establishes guideline dates before which contracts should not be signed, and rules about interviewing.
Recruitment of MBA graduates	Individual business school recruiting offices	Regulations of on campus interviews, dates and duration of offers, etc.
US College Graduates—on campus recruiting	National Association of Colleges and Employers (NACE) www.nacweb.org/about/principl.html	Guidelines for good conduct that discourage renegeing of acceptances by students and undue time pressure of acceptance and encouragement to renege on another offer.
Postseason college football bowls	Bowl Championship Series (BCS)	Confederation of bowls and conferences
Sororities	National Panhellenic Conference	Regulates bidding procedure

Our experimental results confirm the pattern suggested by our reading of the field evidence. In the laboratory, markets that are initially inefficiently early and thin move towards later, thicker markets if firms cannot make exploding offers, but can only make open offers. The same thing is observed when firms can make exploding offers, if candidates can subsequently change their minds without too much cost if they receive more desirable offers later. However unraveled markets remain inefficiently unraveled when firms can make exploding offers and acceptances are binding.

After reporting the experiment, we will examine its implications for the design of decentralized markets, including the decentralized markets that precede the start of a centralized market in which participation is voluntary. In particular, we will describe the successful intervention in the market for gastroenterology fellows in which we recently took part, and we will discuss recent developments in the market for law school graduates who become appellate court clerks.

When designing policies for markets, note that different market organizations such as those in Table 1 may have different degrees of authority. It may not be possible for them to compel members; in many cases these organizations are simply voluntary associations that serve to codify how the majority of members would like to see the market organized. This is the case of the market for gastroenterology, which involves four overlapping professional organizations. Because of this, it may not be possible to prevent gastroenterology program directors from making exploding offers, but it may nevertheless be possible to enable applicants who have accepted such offers to later change their minds, by making clear the circumstances in which applicants can do so. That is, even when it is not possible to enforce rules against exploding offers, it may be possible to establish norms and expectations that will make exploding offers less profitable, and minimize how much they disrupt the market. This is the approach eventually adopted by the various gastroenterology professional organizations.

In the next section we first look in some detail at a market from Table 1 that will be familiar to most of our readers, the market for graduate admissions to American universities. This will motivate the experiment we report, and help explain the new market design for the gastroenterology market that we will discuss later. Before

concluding, we also consider the market design problem presently arising in the market for federal court clerks.

II. Graduate admissions

One market in which a good deal of effort has been spent shaping and discussing the timing of offers and acceptances is the market for graduate students. The Council of Graduate Schools has, since the mid 1960's, attempted to establish norms concerning how graduate students are recruited. Over 350 American universities subscribe to its resolution, which is distributed to applicants by graduate programs, and states in part:

“Students are under no obligation to respond to offers of financial support prior to April 15; earlier deadlines for acceptance of such offers violate the intent of this Resolution. In those instances in which a student accepts an offer before April 15, and subsequently desires to withdraw that acceptance, the student may submit in writing a resignation of the appointment at any time through April 15. However, an acceptance given or left in force after April 15 commits the student not to accept another offer without first obtaining a written release from the institution to which a commitment has been made.”

(<http://www.cgsnet.org/pdf/resolution.pdf>)

The resolution is accompanied by some explanatory discussion of how the resolution should be honored in the breach, which reads in part as follows (www.cgsnet.org/PublicationsPolicyRes/resolutions.htm#resolution1):

“Students may be waiting for offers from several institutions so that they can compare and make a decision. One of the complaints we hear is that some departments make offers quite early and insist that students respond quickly or lose the offer. According to the Resolution, the option available to the student in this situation who wishes to review several offers is to accept each one and then, by April 15, resign from all but one. But this places the student in an awkward position and really violates the spirit of the Resolution, that is, that acceptances should not be made casually.

“A better approach is for institutions to give students until April 15 to make decisions regarding appointments. Students often consider multiple offers, and this option provides a reasonable opportunity for them to do so. This would not preclude institutions asking students to accept or reject offers in a timely manner.”

Note that the resolution attempts to foster a market culture under which exploding offers are discouraged directly, and also indirectly by being made less enforceable. That is, the resolution suggests that a student who accepts an exploding offer with a deadline before

April 15, but subsequently declines it before April 15, should not be thought of as behaving badly. This reduces the cost of renegeing on (and hence also of accepting) an exploding offer, in a world with opportunities for repeated interactions, in which social norms may have some force.

Similar concerns, and attempts to alter market culture, have played large roles in the organization of entry level labor markets for doctors, for lawyers, and college admissions at the undergraduate level. For example, doctors engage in a centralized labor clearinghouse, the medical “match,” to which doctors and program directors submit rank order lists after they interviewed one another. While a match guarantees that all participants face a thick market (they can consider anyone they have ranked), the main concern is therefore to try to have widespread participation, and make it safe for participants to submit rankings reflecting their underlying preferences (Roth, 1984, 1991, Roth and Peranson 1999). One norm of participation is that employers are not supposed to ask applicants to make commitments prior to the match, which, as we will see can be a real concern when starting a match and moving the timing of a market, such as in the market for gastroenterologists. Another norm is that employers are not supposed to indicate how they will record their preferences or try to entice applicants to commit to rank them highly in the match (to prevent pre-match negotiations over rank order lists making the market thin by making rank order lists very short). Surveys of medical students reveal that when they are nevertheless asked for such indications and commitments on rank order lists, they feel free to answer encouragingly, without constraining their subsequent behavior in the match (see e.g. Anderson et al., 1999; Carek et al., 2000; Pearson and Innes, 1999; Teichman et al., 2000). In the medical resident market, like the graduate admissions market, the rules of the market and the corresponding market culture result in current operations of those markets in which early matches seem not to be very common, and in which participants face a thick market in which they can consider many options.

In contrast, law students who apply for appellate court clerkships are frequently given exploding offers, and are almost never reported to renege on them. And indeed in contrast to the graduate student and medical resident market, the market for law clerk

positions has in recent years cleared very early, despite numerous attempts to control and push back the timing of the market (Roth and Xing 1994; Avery, Jolls, Posner, and Roth, 2001, 2007).²

Even in a given market, commitments made at different times may have different force. In the undergraduate college admissions process in recent years, students who applied in the Fall to a college through a “binding early decision” program were considered to have made a binding commitment to attend that college if admitted, while acceptance of offers later in the year was much less binding.³

These examples, along with those mentioned in Table 1, suggest some support for the hypothesis that markets clear later and become thick when firms do not make exploding offers (i.e. offers which must be accepted or rejected before other offers can be considered), or, in case they do, applicants are able to remain eligible for more desirable offers, and can accept them at a low cost.⁴ However, all these markets differ in many ways, not only their culture regarding exploding offers and the degree to which a commitment is binding. Some markets are very large (college admission), some are much smaller (law clerks or college football bowls), in some markets monetary compensation plays a big role in clearing the market (new associates of large law firms and college football bowls) in others, wages are set exogenously (law clerkships). Furthermore, the

² The latest attempt to control dates of clerkship appointments was begun in 2003, and will be discussed in the conclusion. Although it has been somewhat successful in controlling dates, it has not succeeded in restoring thickness (Avery et al. 2007).

³ Avery Fairbanks, and Zeckhauser (2003) describing the situation before 2002, note that most selective colleges set a regular application deadline on or about January 1, and an early application deadline on or about November 1. Colleges typically choose one kind of early application program, called either “Early Decision,” or “Early Action.” Students who apply to an Early Decision program can only submit one early application, and sign a contract that they will attend if accepted. Students who apply Early Action do not sign a contract, i.e. they retain the option of applying elsewhere also. These colleges then notify early applicants of a decision, “Admit,” “Reject,” or “Defer”, by early-to-mid December. Early Decision colleges submit lists of their early admits to rival colleges with a note that those ED admits are expected to withdraw all other applications. The rule that students could submit only one early decision application was enforced in part through actions of the high school guidance counselors, while the binding nature of early acceptances was enhanced by the practice of other colleges not to consider applications from other colleges’ early admits. Many of the rules and customs regulating early admissions have been in flux, since the Fall of 2001, after the National Association for College Admission Counseling (NACAC) suggested changes that had the unintended effect of making binding early decision less reliably binding. Most recently, Harvard University abolished its early action program and decided to process all applications at one time, and was followed in this by several other competitive colleges and universities.

⁴ However, not all markets that use exploding offers and binding agreements suffer from unraveling. For example, in the market for junior economists, at some point many departments impose short deadlines, though the market as a whole has been stable in matching after the winter meetings.

rules in the markets are endogenous, i.e. they arise from the special circumstances in each market.

An ideal test for the effects of rules concerning offers and acceptances and rejections on the timing and thickness of the market would be a set of markets that differ only in how offers are made and responded to, but not in any other way. Markets created in the laboratory offer us the possibility of making just such comparisons.

In what follows, we consider a simple environment, in which early matches are unambiguously inefficient, because information about the applicants' quality, which determines the efficient matching, is only known in later periods. The efficiency of an outcome in our environments will be measured as the total welfare of market participants.⁵

We consider three kinds of markets. In the first, firms can make exploding offers, and acceptances are binding. We compare this with two alternative environments. In one of these, applicants may renege on their acceptance of an exploding offer at a small cost, and in the other, only open offers may be made, that is, offers without a constraining deadline.⁶ Furthermore, our environment is simple enough that participants have enough time to match to each other once all uncertainty about the applicants' quality is resolved. That is, we try to eliminate congestion as an important factor in our experiments.

These environments allow for many equilibria, including some in which all matches are agreed upon inefficiently early. However, all environments have a sequential equilibrium that induces efficiently late matches. Nevertheless, the late matching equilibrium may be less robust, more fragile to the presence of applicants who deviate from equilibrium behavior when offers are exploding and acceptances are binding. Similarly, early matching equilibria may be less robust in the case of open offers and non-binding acceptances.

⁵ While early matches may benefit some participants (such as lower quality firms that manage to hire higher quality applicants) total overall welfare will be reduced by early matchings in our experimental environment. For a discussion of the problems of measuring efficiency in naturally occurring labor markets, see Niederle and Roth (2003a), which shows that early transactions in the market for gastroenterologists decreased mobility in the market. (See also Niederle and Roth 2003b, 2004). In the market for college football bowls, Frechette et al. (forthcoming) show increased efficiency of late matching as measured by television viewership.

⁶ In natural markets, the behavior of participants is often guided both by fixed rules and norms and expected behavior, the whole culture of the market. Formal rules and informal rules often impose equally

Experiments will allow us to make controlled comparisons between these different regimes, and also to investigate issues about which theory is still relatively silent, namely the multiplicity of equilibria. We test the hypothesis that in an environment in which exploding offers and binding agreements lead to a market which is thin and unraveled, either open offers, or the possibility to renege on early acceptances can lead the market to operate at a later time and more efficiently. That is, we test the fragility of early matching equilibria when firms can make only open offers or applicants can renege.

We will see that, in the environments we explore, the market results in inefficiently early contracts when firms are free to make exploding offers and acceptances are binding. But both the prevention of exploding offers, and the facilitation of reneges, change the market dynamics in a way that promotes later offers, a thicker market, and greater efficiency.

When we turn from the experiment to the labor market for gastroenterologists, we will see that this conclusion had immediate application in the market design that reversed the unraveling of hiring decisions that market had suffered.

II. Experimental Matching Markets

The experimental markets consisted of 5 firms and 6 applicants. Firms have a fixed quality, from 1 to 5, and applicants will eventually have a quality from 1 to 6. (The qualities of firms are simply their assigned ID number from 1 to 5, the qualities of applicants are revealed over time.) In each market a firm can hire one applicant and an applicant can work for one firm. A matched firm and applicant each earn the product of their qualities, unmatched market participants earn zero.⁷

Each market lasts 9 periods. In periods 1, 4 and 7 each applicant receives an integer signal from 1 to 10 (uniform iid). The quality of each applicant is determined in period 7 through the relative ranking of the sum of their three signals. Note that while signals across periods are uncorrelated, because the final quality is determined by the sum of signals, the relative quality after two signals is heavily influenced by the quality of the

strong restrictions on possible and acceptable behavior of market participants. We model these formal and informal rules about offers and responses as strict rules in these experiments.

⁷ There are no monetary transfers between firms and applicants, they each receive the mutual gains of matching, equally.

first signal, that is the relative quality (the sum of signals) is correlated over time. The applicant with the highest sum receives a quality of 6, the second highest a quality of 5, the lowest a quality of 1 (ties are broken randomly). Firms see all the applicants' signals as they become available over time, but applicants only receive information about their own signals.⁸ Having three periods in which new information is revealed allows us to observe several “degrees” of inefficiency of early matching.⁹

Each information state lasts for 3 periods in which firms can make offers, and applicants decide whether to accept or reject them. This helps avoid exogenously imposed congestion, which occurs when firms may run out of time to make offers they would have liked to make. In pure strategy equilibria, congestion does not occur, by assumption. However, in laboratory markets, even a small amount of coordination failure would lead to congestion, and potential congestion in late periods would provide an additional reason for firms to make early offers, and an additional source of inefficiency. (In naturally occurring markets, congestion is common; see the discussion in Roth and Xing 1997. Kagel and Roth (2000) report an experiment in which early matching arises in response to congestion.) Since we are interested here in early matching for reasons other than congestion, the experimental markets will allow 3 periods in which offers can be made and accepted, whenever new information is revealed.¹⁰ This is sufficient in our environment, because once information about applicants' qualities is revealed, the assortative matching, even among a subset of firms and applicants, is apparent.

We consider two types of offers that can be made by firms:

An *exploding* offer is an offer that the applicant can only accept right away, i.e. in the same period in which it was made; if it is not accepted immediately, it is rejected.

⁸ This feature of the experimental environment is motivated by the situation in many markets, in which firms see a whole pool of applicants, but applicants may have difficulty knowing how they compare with other applicants

⁹ In this environment, it is possible that, after two signals, the applicant of the highest quality, or the applicant of the lowest quality, though not both, can be deduced by the firms, but not by the applicants (who do not see others' signals).

¹⁰ While this avoids exogenously imposed congestion, congestion may develop endogenously, if applicants hold offers until late, or firms delay making offers. Roth and Ockenfels 2002 discuss congestion arising endogenously in an auction market, in which bidders delay making bids until near the close of the auction. Markets that use centralized clearinghouses avoid congestion, and often have adopted the clearinghouse for this reason.

An *open* offer is an offer the applicant can also hold (until period 9). That is, an applicant who receives an open offer may accept or reject it immediately, or may hold it, to accept or reject at a later period. An applicant must reject a held offer if he wishes to hold or accept another offer.¹¹

In a given period, first all the firms decide what offers they will make. Each firm that is unmatched, and has no open offer being held by an applicant, may decide to make at most one offer. Then each applicant learns of all offers he receives in that period before having to decide how to respond to each of them. If an applicant accepts the offer of a firm, the applicant and the firm are matched, and all market participants are informed about this. Offers are made in private; i.e. until they have been accepted they are not announced to the other firms and workers.

We consider three environments, characterized by different rules governing offers and acceptances.

Treatment 1: Exploding and Open offers

Each firm can decide whether to make each offer open or exploding. Once an applicant accepts an offer, the acceptance is binding, and firms cannot make subsequent offers to an applicant who has already accepted an offer.¹²

Treatment 2: Open Offers Only

Firms can only make open offers. Once an applicant accepts an offer, the acceptance is binding, and firms cannot make subsequent offers to an applicant who has already accepted an offer.

Treatment 3: Renege

In this treatment, firms can again decide whether to make open or exploding offers. However, an applicant who accepted an offer may still receive further offers. An

¹¹ This is not an onerous constraint for the applicants, since they have strict, unchanging preferences over the firms. In our experimental environment, it reduces the cost to a firm of making an open offer, since it reduces the likelihood that an open offer will be held by an applicant who has no intention of taking it.

¹² One can think of the applicants' ability to make binding agreements as an agreement among firms to not make offers to applicants who accepted another firm's offer. Recall for example colleges' practice of honoring other colleges' early decision acceptances (footnote 3).

applicant can renege on initial acceptances and accept a new offer at a cost of 1 point (that is subtracted from his final payment).¹³

All three treatments allow for a whole array of Bayesian Nash equilibria. For example, in each treatment, there is an equilibrium in which, after the first period, all the firms are matched. For example, the following strategies constitute an equilibrium in which all firms are matched in Period 1.

Strategies of firms: Each firm i makes an open offer in period 1 to applicant i . A firm whose offer is rejected never makes another offer.

Strategies of applicants: Each applicant i in period 1 accepts an open offer from firm i and rejects any other offers (i.e. exploding offers, offers from other firms, and offers received in other periods).

These strategies constitute an equilibrium, as no firm has an incentive to deviate, given the strategies of applicants and vice versa. However, this equilibrium has the unattractive property of using weakly dominated strategies.

However, in each of the different conditions, when firms and applicants are risk neutral there is a sequential equilibrium that yields late matching and the efficient outcome. But the possibility of late matching is less robust in the case of exploding offers and binding agreements than in the other two conditions.¹⁴

In particular, since a strategy is a function that specifies an agent's actions at each of his information sets, we can (even in the renege condition) speak of an agent as adopting a strategy of "locking in" an offer at some point of any of the experimental treatments by accepting (and not just holding) the offer, and not later renegeing on it. We can now state the following.

Proposition:

In the open offer and the renege treatments, it is a weakly dominated strategy for applicants to lock in firms early, before period 7. (Applicants always do at least as well,

¹³ This fee is smaller than the minimum improvement from accepting a match with a higher quality firm, since matches pay each applicant the product of his quality and the quality of the firm to which he is matched.

¹⁴ The proofs, and statements of equilibrium strategies and beliefs are straightforward but tedious; they can be found in a technical addendum to the paper at www.stanford.edu/~niederle.

and sometimes better, if they hold the best offer they have received, or remain willing to renege on their acceptance, respectively, as long as better firms remain unmatched.) In the exploding offer treatment, it is *not* a weakly dominated strategy for the applicant to accept an exploding offer early (before period 7), which means it is not a weakly dominated strategy to lock in a firm early, before period 7.

This suggests that the firms' behavior may be different in the different conditions. In the case of exploding offers and binding acceptances, (risk neutral) firms are always prepared to make early offers to applicants who have an expected quality that is higher than the one the firm receives in the stable match.¹⁵ In the open offer and renege condition, firms may not be prepared to make any early offers, as applicants would simply use the offer's option value, which can only reduce the firms' profits.

This difference may affect the robustness of the various equilibrium refinements to deviations from equilibrium, e.g. to random or other non-equilibrium behavior of some participants. For example, suppose there are some applicants who do not want to reject offers without a better offer in hand.

In the case of exploding offers and binding acceptances, such applicants will accept early (exploding) offers. This implies that firms will have an incentive to make early offers to applicants with an expected quality higher than the firms' equilibrium match and there will be early transactions in such markets.

Furthermore these early matched applicants (and firms) impose a negative externality on (higher quality) firms that do not make an early offer, but which may want to hire them later on. The reason is that these applicants irreversibly accepted an early offer from a lower quality firm. If this negative externality is high enough, high quality firms will be well advised to also start making early offers (to applicants whose expected value is *lower* than the quality they would receive in an assortative match in period 7), only to prevent high quality applicants from being captured early by low quality firms. These early offers are in turn accepted by rational applicants as well, which implies that an even bigger portion of the market moves early. So, a few applicants who do not reject early offers can affect the incentives of all firms and applicants, such that matching late is

¹⁵ In the late matching equilibrium, applicants reject such offers.

not an equilibrium any more. By this mechanism a few applicants can affect the timing of a much bigger portion of the market, and cause the market to transact early.¹⁶

In contrast, in the open offers and renege treatment, applicants who do not want to reject offers (without having another offer in hand) can merely hold on to the offer, and use it as an option. Such applicants would not differ from rational applicants, who would also use the option value of an offer. So, in the open offers and renege treatments (and again, in contrast to the exploding offer treatment) even when faced with these kinds of applicants, firms do not benefit from making early offers, and indeed have a strict incentive *not* to make early offers. Furthermore, suppose there were a few applicants who would not only hold, but accept early offers in the open offer treatment, or never renege upon accepting an early offer in the renege treatment, that is applicants who “lock in” an offer early. Even in this case the incentives for firms to make early offers are considerably weaker than in the exploding offer case, since other applicants would still use firms’ early offers as an option. This makes equilibria with early matching less likely to be robust when firms can make only open offers or when acceptances are not binding.

Thus, each of the treatments has multiple equilibria, including a sequential equilibrium with efficient late matching. However, the late matching equilibrium appears to be less robust in the exploding offer (with binding agreements) treatment, than in both the open offer and renege treatment. Similarly, early matching seems less robust in these two treatments than in the case of exploding offers and binding agreements.

We conducted 7 sessions of the exploding offer treatment, and 6 sessions of the open offer and 6 of the renege treatment. Subjects participated in only one session, each of which consisted of twenty consecutive markets. Participants kept their role, firm or applicant, for the whole experiment, and, for firms, also the firm ID and hence quality (from 1 to 5). The experiment was conducted at the Harvard Business School, with students, using z-Tree software (Fischbacher, 2007). Firms 1 and 2 received an additional

¹⁶ However, it cannot be the case that in a pure strategy equilibrium all firms match before the uncertainty is resolved, as then, for example, the worst firm among the ones that make offers in the last period in which there are unmatched firms would have an incentive to not make the offer, and rather hire the best of the remaining 2 applicants once the uncertainty is resolved.

amount of \$5,¹⁷ and each participant received \$0.10 for each point earned. All participants received a \$10 show up fee.

III. Results of the Experiment: Unraveling, Thickness, and Efficiency

First we investigate whether different rules concerning offers and acceptances affect the timing of the market. How long do firms wait to extend offers, and hence how much information about an applicant's quality do firms have when extending the offers that were eventually accepted?

A market experiences no unraveling if final offers, i.e. offers that were eventually accepted, are all made after period 7, once all the uncertainty about applicants' qualities is resolved.. Figure 1 shows the timing of final offers for all treatments over all 20 markets (In our experiment, subjects participated in 20 markets.) The timing is presented in terms of how many signals had been revealed before the offers were made. So a value of 1 corresponds to offers made when only one signal was available (periods 1-3), 2 denotes offers made after 2 signals, i.e. offers made in periods 4-6, and 3 signals corresponds to the final quality of applicants being known, that is offers made in periods 7-9. For the renege treatment, we only consider an offer to be final if it was accepted and not renegeed upon. The results are presented in blocks of five markets.

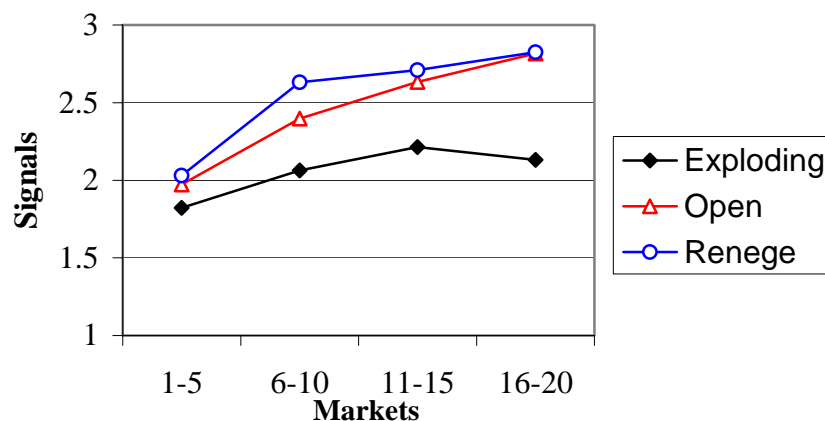


Figure 1. For each treatment and blocks of markets, the time at which final offers were made (i.e. offers that eventually result in a match) measured in the number of available signals about the applicants' quality.

¹⁷ The instructions stated that some participants, already determined in advance, would receive some additional fixed payment (see instructions).

The first 5 markets in all treatments look similar, there is no significant difference in the average number of signals observed before firms make their final offers (that is offers that result in a match).¹⁸ However, as participants gain experience, matches come to be made later in the open offer and the renege treatments, but not in the exploding offer treatment. In the last five markets (markets 16-20), final offers in the exploding offer treatment are made with significantly fewer signals than in the renege treatment ($p = 0.003$, $n=13$) and the open offer treatment ($p = 0.003$, $n=13$),¹⁹ while the renege and the open treatment are not significantly different ($p = 0.63$, $n=12$). Thus we see that open offers and the applicants' ability to renege help the market to defer the timing of contracts, even when the market begins with early appointments (as in the first five markets of Figure 1). In the analyses that follow, we'll show that the markets in the exploding offer condition are not only earlier than the others, but that they also exhibit the other classic symptoms of unraveling.

III.A: Transaction Times and Market Thickness:

From now on we focus our attention on the last 5 markets in each experiment, when conditions seem to have stabilized. We now investigate the timing of offers in more detail. Figure 2 shows, for each treatment, in the last five markets, the percentage of offers that were made when one, two or all three signals (3 signals = final quality) about the applicants' quality were available.

¹⁸ A two sided Mann Whitney U test on session averages on the average number of signals observed when making a final offer in the first five markets, gives p values of 0.63 when comparing Open to Renege ($n=12$), 0.32 when comparing Renege to Exploding ($n=13$) and 0.316 when comparing Open to Exploding ($n=13$).

¹⁹ Furthermore, we can compute for each of the last five markets in any session the average number of signals the five firms had when making their final offer. The exploding offer market with the *highest* such number among the 35 such markets (that is, the one where on average the five firms saw the most signals before making their final offer), is lower than the market with the *lowest* average number of signals used by the five firms in any of the last five markets in any session of either the open or the renege treatments.

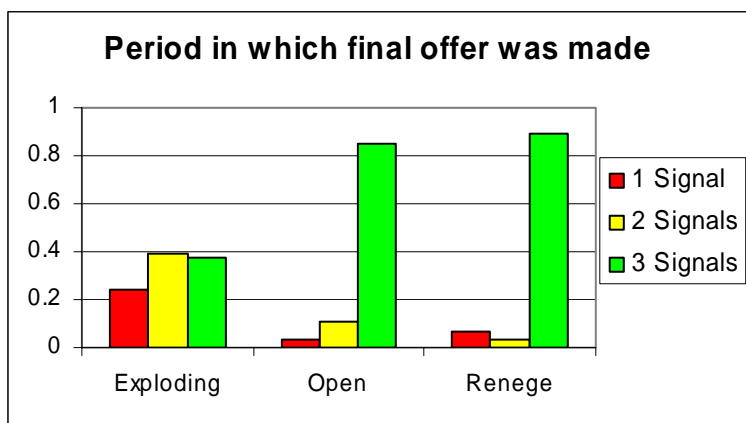


Figure 2. For each treatment, in the last five markets (markets 16-20), the proportion of final offers that were made when one, two or all three signals (and hence the final quality) about applicants' quality were available.

Like Figure 1, Figure 2 shows that unraveling occurs when firms can make exploding offers and acceptances are binding. When firms are forced to make open offers, or when applicants can renege on their acceptance, the markets experience almost no unraveling. Furthermore, it is the high quality firms, firms 4 and 5, that make early final offers. In the exploding offer treatment, only about 20% of firms 4 and 5 make final offers after 3 signals are available (and 34% after 1 signal), compared to 88% and 90% in the open offer and renege treatment.

The fact that the open offer treatment and the exploding offer treatment are so different suggests that firms make exploding offers when they are given the opportunity to do so. Indeed, in the last five markets of the exploding offer treatment, only firm 1 makes an open offer in more than 10% of the markets (while firm 5 makes no open offers at all). Except for firms 3 and 4, every firm made an exploding offer in every one of the last five markets in each of the seven sessions of the exploding offer treatment (and firms 3 and 4 made exploding offers in 34 of these 35 markets). In the renege treatment, firms make somewhat more open offers, but the vast majority of firms (at least 67%) make an exploding offer in each of the last five markets.

Thus when firms could make open and exploding offers, the majority of offers were exploding. Firms made use of their ability to make exploding offers to put pressure on applicants. However, this effect was more pronounced when acceptances were binding. When applicants can renege on their acceptance the value of making an exploding offer is smaller, and firms made less use of that option.

So far we examined the timing of offers averaged across different markets, now we explore the timing within markets. A transaction is made (and announced to the market) only when an offer is accepted. The following table shows for each treatment the timing of first acceptances in each of the last five markets (where we use only final acceptances that were not renege upon for the renege treatment).

	1 Signal (1-3)	2 Signals (4-6)	3 Signals (7-9)
Exploding	.71	.29	0
Open	0	.23	.77
Renege	.30	.10	.60

Table 1: For each treatment (in the last five markets) the proportion of markets whose first acceptance (which as not renege upon in the renege treatment) was made when only one signal, 2 signals, or 3 signals (and hence the final quality) about applicants' quality were available.

Markets with exploding offers not only experience early contracting on *average*, 71% of the markets have their first acceptance with only signal 1 available. All 35 markets (the last five markets of all 7 sessions of the exploding offer condition) have their first acceptance before the final quality of applicants becomes available. In contrast, when firms can only make open offers, or when acceptances by applicants are not binding, 77% and 60% of the markets, respectively, experience their first acceptance only after all the uncertainty about applicants' quality is resolved.²⁰

A further piece of evidence for strategic causes of unraveling comes from examining the length of the market, i.e. the timing between the first and the last acceptance. In the exploding offer treatment, 32 out of 35 markets last for 5 or more periods (with 10 lasting exactly 5 periods). In the open offers only and the renege treatment, the first final offers are made later, and the markets also last for a shorter time. In the renege treatment, 40% of the markets last for 5 or more periods, and for the open offer treatment, the number is 23%. The fact that the markets in the exploding offer treatment last so long shows that unraveling in this treatment is not caused simply by a desire to avoid congestion.

²⁰ Even though markets with different rules concerning exploding offers experience a difference in timing of the first accepted offer, their *last* accepted offer is predominately in periods 7-9. In the open and renege treatment, not a single market (of the last five markets) ends before period 7, and in the exploding offer treatment, 89% (31 out of 35) of the last five markets finish after period 7. Note that, in each treatment, the last firm to be unmatched has strong incentives to wait and see which of the two remaining applicants is of higher quality.

To put it another way, in the unraveled markets the offers are not just earlier, but also dispersed, making the market less thick in any period. Figure 3 shows the cumulative distribution of offers that were finally accepted, and makes clear that in the last three periods, when all information is available, the market is much thicker in the open and renege conditions than in the exploding offer condition with binding acceptances.

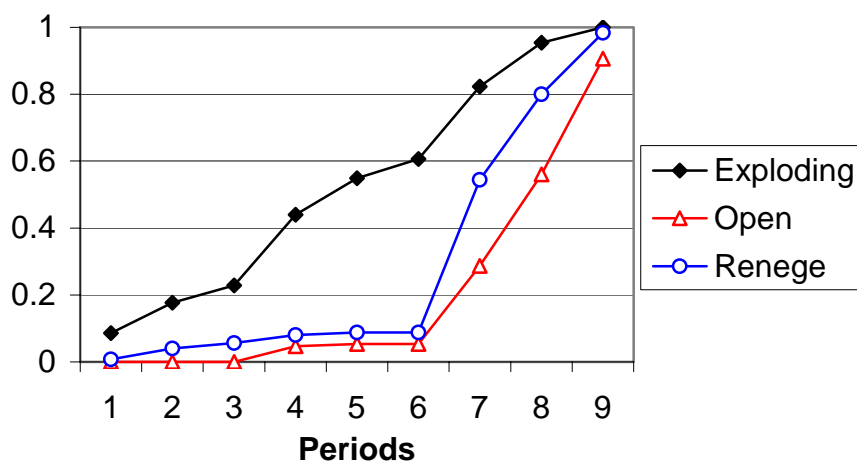


Figure 3: Cumulative acceptances within a market: For each treatment, for the last five markets, the cumulative proportion of final acceptances up to the end of each period.

III.B. What are the costs of unraveling?

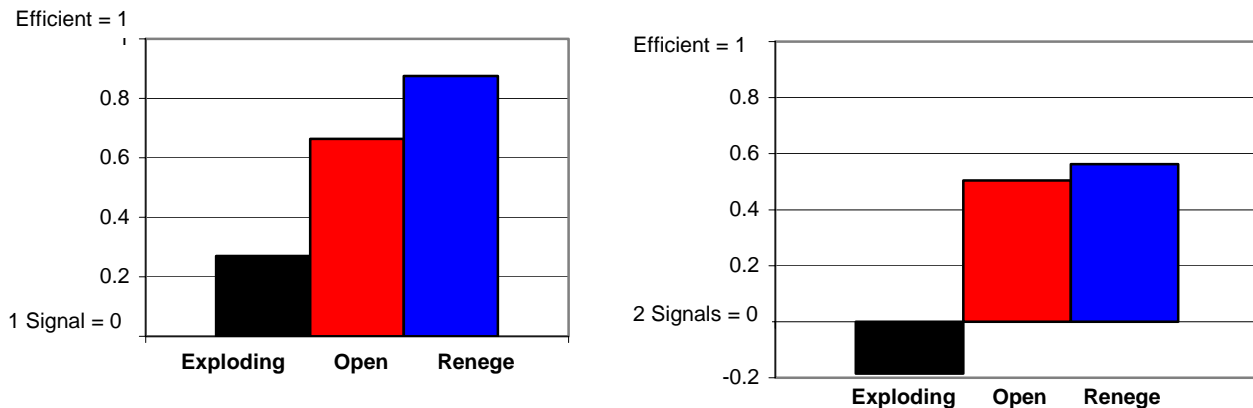
From this point on, we eliminate from our main analysis one outlier session of the renege treatment. In that particular session there was one applicant who *never* accepted an offer. No other applicant in any session of any treatment behaved in this way. In footnotes we will show the analysis that includes all renege sessions.

We have seen that the market unravels and lacks thickness when firms can make exploding offers and acceptances are binding. Now we investigate the costs of unraveling.²¹ We evaluate the different treatments according to the quality of the resulting matches. How much use do firms make of the information about applicants that becomes available over time? We consider three benchmarks: assortative matching when

²¹ Of course, these costs would be different in different environments. One way to interpret the results in this section, therefore, is that they demonstrate that unraveling of transactions occurs even when it is quite costly in terms of the information lost.

only signal 1 is available, assortative matching with 2 signals, and assortative matching once all the uncertainty about applicants' qualities is resolved (the efficient outcome).

We calculate the value of the assortative match after the 1st signal by producing an assortative match between firms and applicants according to the applicants' first signal. We use the actual quality of applicants determined during the experiment to compute the value of this match.²² The value of the assortative match with 2 signals is computed analogously. Let "1 Signal" and "2 Signals" denote the value of the assortative match after the first and after the second signal respectively, and "Efficient" the value of the unique stable and efficient match once all signals are known. Figure 4 shows the averages across sessions and markets of $(\text{Actual Profits} - 1 \text{ Signal})/(\text{Efficient} - 1 \text{ Signal})$, and $(\text{Actual Profits} - 2 \text{ Signals})/(\text{Efficient} - 2 \text{ Signals})$. That is it shows the relative gains of the outcome of the experimental market towards efficiency compared to assortative matching after 1 signal and after 2 signals.



Profits compared to assortative matching after

4a: 1 Signal

4b: 2 Signals

Figure 4a and 4b. 4a shows for each treatment the value of $(\text{Actual Profits} - 1 \text{ Signal})/(\text{Efficient} - 1 \text{ Signal})$ averaged across sessions. That is it shows the relative gains of the actual match towards efficiency compared to assortative matching after 1 signal. Figure 4b shows the similar results for 2 signals.

Figure 4a shows that all treatments achieve on average a social surplus higher than assortative matching with one signal. Efficiency gains are significantly lower in the exploding offer treatment than in the open ($p=0.063$) and the renege treatment

²² In case of ties in the first signal between two applicants, we take the average of the two possible outcomes.

($p=0.004$).²³ Assortative matching based on 2 signals (the second signal becomes available at period 4) would have resulted in a higher efficiency than the exploding offer treatment, but both the Open and Renege treatment achieve higher efficiency levels than assortative matching after two signals. Furthermore, both the open offer and renege treatment achieve significantly higher efficiency gains than the exploding offer treatment ($p=0.007$ and $p=0.06$ ²⁴ respectively), while they are not significantly different from each other ($p=0.465$). When we look at final absolute efficiency levels, the efficiency of the exploding offer treatment is significantly lower than of the open offer treatment ($p=0.03$) and the renege treatment ($p=0.009$), while the renege and the open offer treatment are not significantly different ($p=0.116$ using a two sided Mann-Whitney U test with session averages).^{25 26}

A different way to measure the functioning of a market is to count the number of “disruptive” blocking pairs, these are a firm and a worker, at least one of whom is matched, who are currently not matched to each other, but would both prefer to be so, instead of remaining with their current match (or being unmatched).²⁷ For the last 5 markets, the exploding offer treatment has, on average, in each market 3 such (firm, applicant) pairs, which is significantly higher than the about 1 such pair in the open ($p=0.003$) and renege treatment ($p=0.004$).^{28 29}

²³ When we include the outlier session in the renege treatment, the value of the proportion of gains from assortative matching after one signal towards efficiency is 0.69 (instead of 0.88). The exploding offer treatment still achieves significantly lower proportionate gains in efficiency starting from the assortative match after 1 signal than all the sessions in the renege treatment: $p=0.032$.

²⁴ When we include all renege sessions, the value of the proportion of gains from assortative matching after two signals towards efficiency is 0.14 (as opposed to 0.56). The p -value when we include all renege sessions and compare them to the efficiency gains in the exploding offer treatment is $p = 0.25$.

²⁵ All treatments achieve high levels of efficiency (compared to the alternative of no firm being matched). The efficiency in the exploding offer treatment is 93% compared to 96% in the open offer treatment and 98% in the renege treatment. However, even a random allocation of the six applicants to the five firms achieves an efficiency of 75%. Average efficiency of assortative matching after one signal is 88% and after two signals it is 93%. We’ll see below that even small changes in efficiency can be associated with big changes in payoffs to differently ranked participants.

²⁶ When we include all renege sessions, the comparison with the exploding offer treatment has a p -value of 0.07, the comparison to the open offer treatment yields $p = 0.37$.

²⁷ These are blocking pairs that would disrupt the outcome of the market, had they the chance. (Blocking pairs that simply involve unmatched participants are much less disruptive, and in naturally occurring markets they often have a subsequent opportunity to match to one another.)

²⁸ The open offer and renege treatment, do not differ significantly in the number of blocking pairs ($p = 0.2245$). When we use all the renege sessions, the p -values are 0.002 and 0.46, when comparing it to the exploding and open treatment respectively.

²⁹ The maximum feasible number of disruptive blocking pairs is 15 and achieved by anti-assortative matching. Then the matched firm 5 generates 5 blocking pairs (4 of which use matched applicants), firm 4 generates 4, firm 3 generates 3, firm 2 generates 2 and firm 1 generates only 1.

III.C. Individual level consequences of unraveling

We have seen the loss of social surplus when firms can make exploding offers that are binding, compared to when offers have to be open or applicants can renege on their acceptance. Now we investigate the value of the match for each applicant and each firm separately, for the last five markets of each treatment.

The Firms

The following graph shows for each firm the average quality of the applicant they are matched to and the average quality of the applicant that remains unmatched.

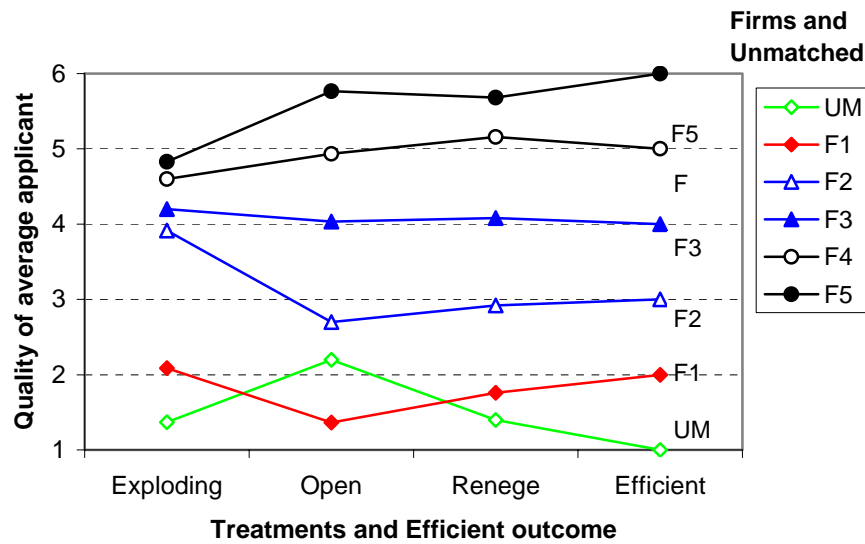


Figure 5: The average quality of the applicant each firm is matched to in the last five markets of each treatment. UM shows the quality of applicants who remain unmatched. Efficient shows for each firm the quality of the applicant in the unique stable and socially efficient match.

The exploding offer treatment significantly lowers the payoff of the highest quality firm, firm 5, by 16% compared to the open ($p = 0.0056$) and by 15% compared to the renege ($p = 0.046$) treatment. But the low quality firms, firm 2 and firm 1, achieve a significantly *higher* payoff in the exploding offer treatment, compared to the open offer treatment ($p=0.062$ and $p=0.07$ for firm 2 and firm 1 respectively) and the renege treatment ($p=0.001$ and $p=0.099$).³⁰ In the exploding offer treatment, firm 2 gains 45% compared to the open offer and 34% compared to the renege treatment.

³⁰ When we include all renege sessions, the p-values for firm 5, when comparing the exploding offer to the renege treatment is $p=0.023$, while it is $p=0.025$ for firm 2 and $p=0.05$ for firm 1.

The difference in the quality of applicants between firm 2 and firm 5 is 0.92 in the exploding offer treatment, which is significantly lower than in the open offer treatment, 3.07 ($p=0.0025$) and the renege treatment, 2.76 ($p=0.026$).^{31,32}

The Applicants

The following figure shows for each applicant the average quality of the firm they are matched to in the last five markets for each treatment.

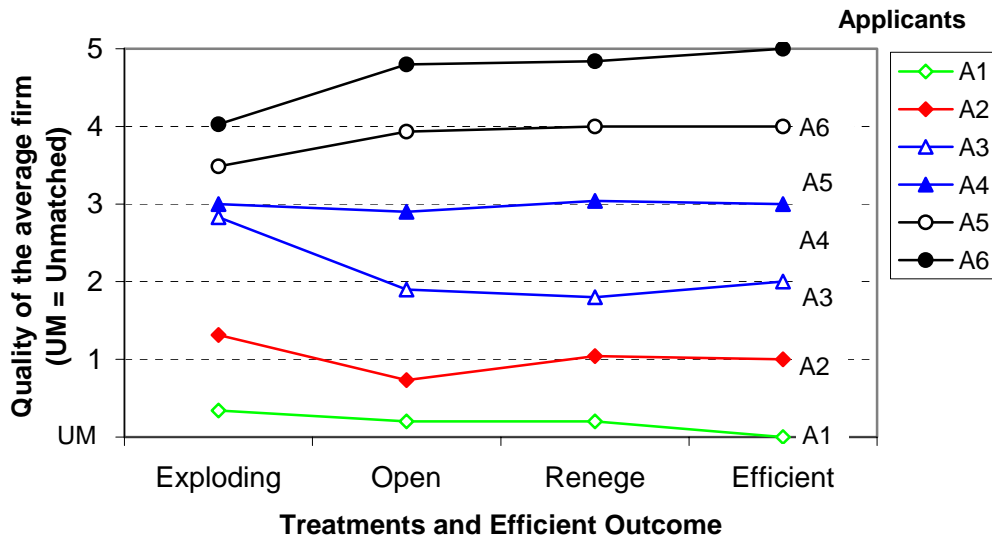


Figure 6: The average quality of the firm the applicant is matched to in the last five markets of each treatment, where UM is unmatched. “Efficient” shows for each applicant the quality of the firm in the unique stable and socially efficient match.

As for the firms, it is the high quality applicants, applicant A6 and A5 that receive a significantly lower match in the exploding offer treatment than in the open offer treatment (by 10% and 11% with $p=0.045$ and $p=0.049$ for applicant 6 and 5 respectively) and the renege treatment (by 17% and 13% with $p=0.019$ and 0.023). And it is a medium quality applicant, applicant 3, who significantly gains from unraveling (by 49% and 57% with $p=0.026$ and 0.041 compared to the open and renege treatment respectively).³³ In all treatments higher quality applicants are hired by higher quality firms, on average. The difference in the quality of firms between applicant 3 and

³¹ When we include all renege sessions the p-value is $p = 0.014$

³² In all treatments higher quality firms hire higher quality applicants, on average, but not in each session.

³³ When we include all renege sessions, the p-values are for applicants 6, 5 and 3: $p=0.009$, $p=0.108$ and $p=0.037$ respectively.

applicant 6 is 1.2 in the exploding offer treatment, which is significantly lower than in the open offer treatment, 2.9 ($p=0.0034$) and the renege treatment, 3.04 ($p=0.0044$).³⁴

The inefficient matchings in these markets are costly for the highest quality firms and applicants, while some lower quality firms and applicants tend to *gain* from early matches.³⁵

IV. Implications for market design

Gastroenterology Fellows

From 1986 to the mid 1990's, the labor market for gastroenterology fellows (entry level gastroenterologists) was organized through a centralized match that operated one year before employment would begin. The match collapsed following a shock to the market that caused fellowship programs and applicants to make early contracts before the match (McKinney, Niederle, and Roth, 2005). Following the collapse of the match, the market unraveled, and the hiring of fellows became increasingly early and dispersed, with exploding offers, eventually moving almost two years before employment would begin (Niederle, Proctor, and Roth, 2006). One consequence was that the scope of the market collapsed, and what had been a national market was replaced by more local markets, in which gastroenterologists were more likely to be recruited from the local pool of applicants (Niederle and Roth 2003a).

As these facts became increasingly well known to gastroenterologists, there was a growing interest in reestablishing a match, to move the date of hiring nearer the date of employment, and to make the market thicker. However, doing so would require fellowship directors to refrain from early hiring prior to the first use of the match (as well as in subsequent years). With the memory of the collapse of the match clearly in mind, many program directors who were themselves interested in participating in a well

³⁴ When we include all renege sessions, the p -value is $p = 0.0026$.

³⁵ For this reason, it is sometimes difficult to achieve consensus in markets that suffer from unraveling about what steps, if any, to take to address the problem. See Niederle and Roth (2005) for discussion of the situation facing gastroenterologists as they started to consider whether to organize a centralized clearinghouse.

organized market at a later date were concerned that their competitors would gain an advantage over them by making early exploding offers in an effort to “capture” promising candidates before the match.³⁶

In reply to this concern, we related the experience of the market for new Ph.D.’s, and shared the result of the experiment reported above. The American Gastroenterology Association subsequently published a policy statement containing a resolution modeled after that of the Council of Graduate Schools (Niederle, Proctor, and Roth, 2006). A modified version of this was adopted by all four major Gastroenterology professional organizations, the American Gastroenterological Association (AGA), the American College of Gastroenterology (ACG), the American Society for Gastrointestinal Endoscopy (ASGE) and the American Association for the Study of Liver Diseases (AASLD), regarding offers made before the (new) match. It states, in part

The general spirit of this resolution is that each applicant should have an opportunity to consider all programs before making a decision and be able to participate in the Match. ... It therefore seeks to create rules that give both programs and applicants the confidence that applicants and positions will remain available to be filled through the Match and not withdrawn in advance of it.

This resolution addresses the issue that some applicants may be persuaded or coerced to make commitments prior to, or outside of, the Match. ... Any applicant may participate in the matching process ... by ... resigning the accepted position if he/she wishes to submit a rank order list of programs ... The spirit of this resolution is to make it unprofitable for program directors to press applicants to accept early offers, and to give applicants an opportunity to consider all offers ...

The gastroenterology match for 2007 fellows was held June 21, 2006, and succeeded in attracting 121 of the 154 eligible fellowship programs (79%). 98% of the positions offered in the match were filled through the match, and so it appears that the gastroenterology community succeeded in changing the timing and thickness of the market.

³⁶ In June 2005, our colleague Debbie Proctor, the gastroenterologist who took the lead in reorganizing the match, sent us an email saying, in part “I’m answering 3-4 emails per day especially on this issue. ‘I want to make sure MY competition is in the match and that they don’t cheat.’ Well, this is another way of saying that if they cheat, then I will too!...Have you ever seen this before? The distrust amongst program directors? I find it hard to believe that we are unique. Maybe this is [a] social science phenomenon?”

Part of the success of the gastroenterology match was due to the fact that early movers couldn't impose a big negative externality on those who waited for the match, since pre-match exploding offers would not necessarily remove candidates from the market. This made it easier for everyone to wait for the match. Not every attempt to facilitate a thick market by constructing an orderly marketplace takes this approach, and the market for new law clerks is instructive in its similarities and differences from the market for gastroenterologists.

Law Clerks

The market for clerks for Federal appellate judges has periodically suffered serious market failures in which clerks are sometimes hired two years in advance, i.e. at the beginning of the second year of law school (Avery et al. 2001). Roth and Xing (1994) discussed 5 attempts to fix this market, starting in the 1970's, in which organizations of judges and law schools attempted to control the time at which offers could first be made. This is a market in which exploding offers are the mode, and in which verbal acceptances seem to be completely binding (law students are reluctant to renege on promises to Federal judges). In the most recent (8th) effort to repair the market, in March of 2002, a large majority of Federal appellate judges voted to approve a proposal stating that "...the hiring of law clerks in the Fall after the first year of law school is an unacceptable practice," and that they therefore endorsed "a moratorium on law clerk hiring during the Fall of 2002..."³⁷, with hiring to resume only after Labor Day 2003, and be restricted to third year law students. That is, like the gastroenterology fellows market, the law clerk market sought to replace early and diffuse hiring with hiring at a specified time a year later than had become customary.

While the first four years of operation of the market under the new proposal succeeded in moving the hiring date, it appears that there has been substantial cheating on the precise opening time of the market³⁸, and an increase in offers that explode immediately (Avery et al. 2007). Some of this can be traced to the fact that the proposal

³⁷ Letter to law school deans, March 11, 2002, signed by Chief Judge Edward R. Becker, and Judge Harry T. Edwards.

³⁸ Avery et al. (2007) report that approximately a third of the judges acknowledge that they sometimes don't comply with the rules on timing.

calls for no changes regarding exploding offers, and in fact a FAQ accompanying the letter by Judges Becker and Edwards included the following question and answer .

“Q Are judges forbidden from making "exploding offers," i.e., offers that require an applicant to respond promptly to an offer?

A The Plan does not purport to address how an offer is given by a judge. This is for each judge to determine. However, no applicant is obliged to act on an offer if the terms are unacceptable, nor is an applicant obliged to accept the first offer that he or she receives.”

And exploding offers are widespread: the modal respondent to the student survey reported in Avery et al. (2007) accepted an offer on the first day that offers were allowed.³⁹ So, although the market has so far largely succeeded in controlling the dates of appointment, for many participants the market remains very thin, and applicants can often consider no more than a single offer.

Given that law students are almost never reported to renege on promises made to senior Federal judges (Avery et al 2001), the results of the present experiment give us a clear prediction: the problem of early contracting will not be solved by the current attempt to change the date of the market while leaving the market rules and customs intact. Rather, more fundamental changes in the market culture of judges and law clerks will be needed.⁴⁰

Lessons for Market Design

The main result of our experiment is that open offers by firms, or the flexibility for applicants to change their minds about early acceptances lead to late, efficient hiring. Firms could not permanently capture applicants early through exploding offers. Note that this is the case because our market is uncongested. Firms that wait until the efficient time to make offers can make as many offers as they might need, so they don't run an unacceptable risk of remaining unmatched.

³⁹ A representative quote about exploding offers from the Avery et al. (2007) surveys: “I received the offer via voicemail while I was in flight to my second interview. The judge actually left three messages. First, to make the offer. Second, to tell me that I should respond soon. Third, to rescind the offer. It was a 35 minute flight.”

⁴⁰ On this point, see also the discussion in Haruvy, Roth, and Unver (2006), concerning other aspects of the market culture in the law clerk market. That experiment focuses on a different aspect of offers in the law clerk market, namely that applicants may not feel able to refuse the first offer they receive.

In an environment in which congestion is a large problem (i.e. an environment in which many offers would have to be made before the market clears) exploding offers have the potentially positive effect of combating congestion by increasing the number of offers a firm can make, and some early matching may be important to allow the market to clear.⁴¹ However, exploding offers are also often used strategically to make the market thin for applicants, and in many cases this leads to markets that operate well before employment begins. That is, while exploding offers can sometimes be an efficiency-enhancing response to congestion, they lead to the problems discussed in this paper, which often leads to unraveling beyond what seems warranted by congestion problems.⁴²

This helps explain why the rules for offers and acceptances in the market for graduate students works well for that market. Graduate programs admit relatively large numbers of students, and are not too sensitive to the precise numbers who enroll. So graduate programs can make many offers at once, and the successful control of the dates of appointment via policies that effectively prevent exploding offers goes a long way towards establishing the orderly and stable decentralized market that has persisted for many years.⁴³

This is also why such a policy for discouraging early offers worked well in the market for gastroenterology fellows. By using a match, they solved the congestion problem. The remaining problem is therefore, whether gastroenterology programs and fellows can safely wait for the match. This is exactly the problem that our experimental results indicate can be solved with appropriate policies about offers and acceptances.

This also helps explain why, before the adoption of a match, such a policy worked less well for medical residencies and fellowships. Those are markets in which it is hard to tolerate uncertainty about the number of residents and fellows. (Accreditation requirements generally prevent fellowship and residency programs from offering even one more than their target number of positions.) So residency programs can't offer more positions than they have, they have to make sequential offers. In the 1940's (for residency

⁴¹ Previous experiments have looked at matching in congested decentralized markets in which early, exploding offers arise in part as firms seek to avoid being unmatched.

⁴² Note that in our experiment too, in the treatment with exploding offers and binding agreements, many markets lasted for more than 5 periods (the number of firms to be matched) and the first match often occurred before period 4, that is, with more than 6 periods left in the market. Our experiment is designed to show that exploding offers with binding agreements can lead to unraveling even in the absence of congestion.

⁴³ Despite the congestion around April 15 which may make the size of entering classes uncertain.

programs, and in the 1980's for fellowship programs) policies were tried that attempted to encourage program directors to make offers that would remain open for a longer period of time. However, these markets experienced large congestion problems, and these policies did not help the market, were abused, changed, and eventually replaced by a centralized match (Roth, 1984, 2003). The policies that worked well in our experiments did not succeed in the absence of a solution to the congestion problem.

Whether a policy of open offers would work in the market for law clerks is hard to assess, as it is not clear how severe the congestion problem is. What is clear is that the current policy in that market fails to address not only the congestion problem, but also incentives for judges to make markets thin for applicants by using exploding offers.

V. Discussion

A striking feature of many markets is that market participants spend a good deal of effort addressing how and when offers are made, accepted, and rejected. The formal and informal rules, customs, and norms that result are a critical element of the widely different ways that the matching processes in these markets are organized. In some markets, exploding offers are the norm, and applicants for positions find themselves faced with offers that must be accepted or rejected before other offers may be considered or even received. In others, exploding offers are discouraged, or made more difficult to use to advantage.

Observation of these markets suggests the hypothesis that exploding offers with binding acceptances are potent facilitators of inefficiently early matching. But because these many markets are also quite different from one another in other respects than their norms concerning offers and acceptances, it is natural to look to the laboratory for an investigation that seeks to isolate the effects of different rules and customs concerning exploding offers.

The laboratory environment makes it easy to manipulate these factors. The results of the experiment confirm the hypothesis motivated by the natural markets, that exploding offers together with binding acceptances make it difficult to avoid early and

dispersed transactions. In the same environment, late and thick markets are achieved by either allowing only open offers, or allowing applicants to renege on early acceptances.

The problem facing applicants who receive early exploding offers when acceptances are binding is that, to reject such an offer, an applicant must hope for a better offer later in the market, hence hope not only that he will be highly ranked in the later market, but also that high quality firms will not fill their positions early. Once some applicants are ready to accept early offers, they impose a negative externality on high quality firms, making the whole market move early. We have seen in other environments that to successfully halt unraveling, a major factor is that applicants must be willing to reject early offers (Kagel and Roth 2000, McKinney, Niederle and Roth 2005, Unver 2001, Haruvy et al. 2006). When offers are open, or when applicants can renege on their acceptances, then the market does not have to depend on applicants' willingness to reject early offers to have most of its transactions happen efficiently late.⁴⁴

The market for gastroenterology fellows was faced with a problem as it sought to reverse the market failure that had followed the collapse of the gastroenterology match in the 1990's. To move from a decentralized early market, to a centralized one that would operate a year later, market participants had to feel confident that other participants would not move early, or if they did, that this would not have negative effects on those who waited. That is, before the gastroenterology market could once again enjoy the benefits of a centralized match operating at a relatively late time, they first had to find a way to control behavior in the decentralized market that had replaced the match, when fellowship programs started defecting from the match in the 1990s. And they had to do this at a time when the memories of those defections, and the ripple effects throughout the market, were still fresh, so that mutual trust was not high.

The gastroenterologists solved this problem by adopting a policy, modeled on the market for new Ph.D.s and on the results of the experiments reported here, that (in the words of their joint resolution), made it "unprofitable for program directors to press

⁴⁴ Although early transactions are inefficient in the environments we study because of the information about match quality that is lost, we do not mean to imply that there are no circumstances in which early matching, and even exploding offers, may be efficient. Prominent among these would be markets in which there is congestion, so that there isn't enough time to make many open offers, but in which exploding offers might allow more possible transactions to be considered.

applicants to accept early offers.” In contrast, federal appellate judges are presently trying to control the timing of their market without interfering with the profitability of exploding offers. The results of the present experiment suggest reasons to believe that the gastroenterologists will succeed, and the judges will fail.

More generally, market design is about the details of how markets work, and so designs for different markets may sometimes be quite different. But it appears that there may be quite a bit of generality across markets about some kinds of details that are important. In particular, the details of the sometimes informal rules and practices governing how offers are made, compared, and accepted or rejected are can be critical elements of a market’s design.

Bibliography:

Anderson, K. D., Jacobs, D. M., Blue, A. V. (1999), "Is Match Ethics an Oxymoron?" *American Journal of Surgery*, 177:237-239.

Avery, Christopher, Andrew Fairbanks and Richard Zeckhauser, *The Early Admissions Game: Joining the Elite*, Harvard University Press, Cambridge, MA 2003.

Avery, C., Jolls, C., Posner, R. A., and Roth, A. E. (2001), "The Market for Federal Judicial Law Clerks," *University of Chicago Law Review*, 68:793-902.

Avery, C., Jolls, C., Posner, R. A., and Roth, A. E. (2007), "The New Market for Federal Judicial Law Clerks," *University of Chicago Law Review*, Spring, forthcoming.

Carek, P. J., Anderson, K. D., Blue, A. V., and Mavis, B. E. (2000), "Recruitment Behavior and Program Directors: How Ethical Are Their Perspectives about the Match Process?" *Family Medicine*, 32:258-260.

Chen, Yan, and Tayfun Sonmez, (2006), "School Choice: An Experimental Study", *Journal of Economic Theory*, 127: 2002-231.

Fischbacher, U. (1999), z-Tree: Zurich Toolbox for Ready-made Economic Experiments, 2007, *Experimental Economics* 10(2), 171-178.

Fréchette, Guillaume, Alvin E. Roth, and M. Utku Ünver, "Unraveling Yields Inefficient Matchings: Evidence from Post-Season College Football Bowls," *Rand Journal of Economics*, forthcoming.

Haruvy, E., Roth, Alvin E., and Ünver, Utku, "The Dynamics of Law Clerk Matching: An Experimental and Computational Investigation of Proposals for Reform of the Market", *Journal of Economic Dynamics and Control*, 30, 3, March 2006, Pages 457-486.

Kagel, J.H., Roth, A.E., 2000. The dynamics of reorganization in matching markets: a laboratory experiment motivated by a natural experiment. *Quarterly Journal of Economics* 115 (1), 201-235.

McKinney, C. Nicholas, Muriel Niederle, and Alvin E. Roth, (2005) "The collapse of a medical labor clearinghouse (and why such failures are rare)," *American Economic Review*, 95, 3, June, 2005, 878-889.

Mongell, S. and Roth, A.E. "Sorority Rush as a Two-Sided Matching Mechanism," *American Economic Review*, vol. 81, June 1991, 441-464.

Niederle, Muriel, Deborah D. Proctor and Alvin E. Roth, "What will be needed for the new GI fellowship match to succeed?", *Gastroenterology*, 130, January 2006, 218-224.

Niederle, Muriel and Roth, A. E., (2003a) "Unraveling reduces mobility in a labor market: Gastroenterology with and without a centralized match", *Journal of Political Economy*. 111, 6, December, 1342-1352.

Niederle, Muriel, and Alvin E. Roth, (2003b), "Relationship Between Wages and Presence of a Match in Medical Fellowships", *JAMA, Journal of the American Medical Association*, vol. 290, No.9, September 3, 1153-1154.

Niederle, Muriel and Alvin E. Roth (2004), "The Gastroenterology Fellowship Match: How it failed, and why it could succeed once again," *Gastroenterology*, 127, 2 August 2004, 658-666.

Niederle, Muriel, and Alvin E. Roth (2005), "The Gastroenterology Fellowship Market: Should there be a Match?", *American Economic Review Papers & Proceedings*.

Pearson, R. D. and Innes, A. H. (1999), "Ensuring Compliance with NRMP Policy," *Academic Medicine*, 74:747-748.

Roth, A.E. "The Evolution of the Labor Market for Medical Interns and Residents: A Case Study in Game Theory", *Journal of Political Economy*, Vol. 92, 1984, 991-1016.

Roth, A.E. "A Natural Experiment in the Organization of Entry Level Labor Markets: Regional Markets for New Physicians and Surgeons in the U.K.", *American Economic Review*, vol. 81, June 1991, 415-440.

Roth, Alvin E. "The origins, history, and design of the resident match," *JAMA. Journal of the American Medical Association*, vol. 289, No. 7, February 19, 2003, 909-912.

Roth, Alvin E. and Axel Ockenfels "Last-Minute Bidding and the Rules for Ending Second-Price Auctions: Evidence from eBay and Amazon Auctions on the Internet," *American Economic Review*, 92 (4), September 2002, 1093-1103.

Roth, A. E. and Elliott Peranson, "The Redesign of the Matching Market for American Physicians: Some Engineering Aspects of Economic Design," *American Economic Review*, 89, 4, September, 1999, 748-780.

Roth, A.E. and X. Xing "Jumping the Gun: Imperfections and Institutions Related to the Timing of Market Transactions," *American Economic Review*, 84, September, 1994, 992-1044.

Roth, A.E. and X. Xing "Turnaround Time and Bottlenecks in Market Clearing: Decentralized Matching in the Market for Clinical Psychologists," *Journal of Political Economy*, 105, April 1997, 284-329.

Teichman, J. M., Anderson, K. D., Dorough, M. M., Stein, C. R., Optenberg, S. A., and Thompson, I. M. (2000), "The Urology Residency Matching Program in Practice," *Journal of Urology*, 163:1878-1887.

Unver, Utku, "Backward Unraveling over Time: The Evolution of Strategic Behavior in the Entry-Level British Medical Labor Markets," *Journal of Economic Dynamics and Control* (2001), 25 (6-7), 1039-1080

Online Appendix: Instructions for the exploding offer treatment, the other instructions are adapted accordingly.

WELCOME

Thank you for participating in this experiment about economic decision making. It is important that during the experiment you remain silent. If you have any questions, or need assistance of any kind, please raise your hand, and I will come to assist you. Thank you for your cooperation.

The decisions made in this experiment are hiring decisions. Accordingly, your role will be either “firm” or “applicant.” Your role, firm or applicant, will stay the same throughout the experiment. In other words, if you begin as a FIRM, you will remain a FIRM until the end of the experiment. Similarly, if you begin as an APPLICANT, you will remain an APPLICANT until the end of the experiment.

The experiment will have many “markets,” which will last nine “periods” each.

If you are a “firm,” to get a positive payoff in a given market of the experiment you will need to hire one, and only one, applicant in that market.

If you are an “applicant” you will need to accept one, and only one, job offer in each market of the experiment.

In each group, there are five firms and six applicants. The firms are numbered 1 through 5, and the applicants are numbered 1-6.

The firms and applicants are assigned “qualities.” Your payoff as a firm is your quality multiplied by the quality of the applicant you have hired. Similarly, your payoff as an applicant is the product of your quality and your employing firm’s quality. For example, if a firm of quality 3 hires an applicant of quality 4, both firm and applicant will receive a payoff of $3 \times 4 = 12$ points each.

Firms’ qualities are simply their assigned participant number. In other words, if you are firm 3, your quality is 3. If you are firm 4, your quality is 4.

Applicants’ “qualities,” in contrast, have nothing to do with their assigned ID number and depend solely on the applicant’s “grades” and “scores.”

Exactly how are applicants’ qualities determined?

In period 1, 4 and 7, each applicant receives a “grade,” which is a number between 1 and 10, with 10 being the best possible grade and 1 being the worst possible grade. The computer generates these grades randomly, with each of 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 having an equal chance of occurrence.

So, in period 1, each applicant has a grade between 1 and 10, which is the applicant’s “1. score.” In period 4 the applicant receives a second grade from 1 to 10. The sum of the

first grade (from period 1) and the second grade (from period 4) is the applicant's "2.score." In period 7 each applicant receives a third grade between 1 and 10. The sum of the first, second and third grade is the applicant's "3. score."

The "3. score" determines the applicant's final quality, through its ranking relative to the other applicants' "3. scores". The applicant with the highest "3. score" has a quality of 6. The applicant with the second highest "3. score" has a quality of 5, and so on. The applicant with the lowest "3. score", has a quality of 1. In case of ties, that is, when two applicants have the same "3. score," the computer will break ties and randomly give one a higher quality than the other.

For example, let's say that applicant 5 receives in period 1 a grade of 2, so the "1. score" is 2. In period 4 applicant 5 receives 6, so the "2. score" is $2+6=8$. In period 7 the applicant receives a grade of 9 which means the "3. score" is $2+6+9=17$. Let's say that the other 5 applicants have "3. scores" of 22, 15, 15, 12 and 7. Then, our applicant 5 has the second highest "3. score" and is assigned quality 5. The two applicants with "3. score" 15 get qualities 4 and 3 (they are the third and fourth highest). The computer will randomly determine which of the two receives quality 4 and which quality 3.

In the experiment you will see only the scores (not the grades from which they are composed), but now you know how they are determined. The "1. score" will be available at the beginning of period 1, the "2. score" will become known in period 4, and the final "quality" of each applicant will be known starting in period 7.

Making and accepting offers

Firms can make two types of offers:

An *exploding* offer is an offer that the applicant can only accept or reject right away, in the same period as the offer was made.

An *open* offer is an offer that the applicant can accept, reject or "hold". An open offer can be held by the applicant until the last period, when he has to decide whether to accept or reject the offer. An open offer will remain open as long as the applicant holds it. (Each applicant who hasn't already accepted an offer can hold no more than one offer at a time.) A firm with an open offer that is being held cannot make another offer: a firm can only have one offer outstanding at any time.

Firm's decisions in each period

A firm that has not yet hired an applicant, and has no open offer being held by an applicant, has to decide whether to make an offer, and, if so, to which applicant. A firm may make at most one offer in a period. Once the firm types in the ID number of the applicant to whom the offer is made, the firm has to decide whether to make an open or exploding offer. An exploding offer is one the applicant has to accept or reject in this period. If the offer is open, the applicant can also choose to hold the offer, and postpone the decision whether to accept or reject it. A firm can only have one offer outstanding in each period, so a firm with an open offer that is held by an applicant cannot make another offer.

Applicants' decisions in each period.

In each period the applicant sees all the offers she has received that period, including possibly an open offer she decided to hold from the previous period. The applicant has to decide whether to accept or reject her offers. If the offer is an open offer, the applicant can decide to hold this offer, which means this offer will be available for her also next period. (An open offer that was held from the previous period must be held again at this period if the applicant wants to continue to hold it.) In any period the applicant can only hold one offer. All the offers that are not accepted or held are automatically rejected. (In the last period, period 9, the applicant can only accept or reject offers). When an applicant accepts an offer from a firm, we say the applicant and the firm are matched to each other.

Once a firm and an applicant are matched, the firm cannot make any further offers, and the applicant cannot accept any further offers. The firms cannot make offers to applicants who are matched, so a matched applicant will not receive any further offers.

The information on the Screen of Applicants and Firms:

In the top left box you can see whether you are a firm or an applicant. Let's start by looking at a sample screen for one of the firms: we are looking at a screen of Firm 2.

The screen shot is from period 7, at which point all the information about applicants, their "1. score", their "2. score" and their final "quality" is available. (In periods 1-3 only the "1. score" is available, in periods 4-6 the "1. score" and the "2. score" are available, and the final quality is only available starting at period 7.)

If you are a firm, your ID number (and hence your quality) will remain fixed across markets.

In the top right you can see the current period in the market. Each market has 9 periods, and new information about the applicants becomes available in periods 1, 4 and 7. Any firm (and applicant) who is not matched by the end of period 9, remains unmatched in this market, and earns zero points.

On the bottom right there is a box called "Applicant's Scores". In this box is a list of applicants' scores and qualities as they become available over time. The ordering is according to the applicants' ID numbers (which are randomly assigned in every market). In the sample screen you can see that Applicant 1 has quality 5, while applicant 3 has quality 2.

On the top left the firm has a box called "Matchings" which shows which of the firms have already hired which applicant, at what period and with what score or quality. The entries are ordered by year of acceptance of the offer by the applicant. For firm 2, the entry that corresponds to firm 2, is marked by ** 2 ** instead of just 2 in the column labeled "hired by firm".

On the bottom right the firm has a box that reminds them of the points they receive for a match.

All the boxes we discussed so far, are also available on the screen of the applicants. Now we discuss the part that is specific to firms.

The box headed “List of Applicants” shows for each applicant the relevant score or quality, and by which firm they are hired (where 0 means they are not hired by any firm yet). Note that on this list, applicants are listed in order of quality (or, before period 7, in order of their most recent score, with the highest scoring applicant listed at the top of the list, etc.). Thus on this screen, applicant 4 is listed first, with a quality of 6, applicant 1 is next, and so forth.

In the box below, the firm can choose to make an offer. To make an offer, the firm types in the ID of the applicant to whom the offer is directed, and then clicks on the choice of an “exploding” or “open” offer. To make the offer the firm has to click the “make offer” button. The firm cannot make an offer to an applicant who is already matched to another firm.

If the firm does not want to make an offer, or is already matched or has an open offer held by an applicant, the firm has to click the “No Offer” button.

On the left, in the middle, the firm can see if she is already matched (has already hired an applicant) and which one. The second line shows if the firm has an open offer and to which applicant. In period 7 the last line appears that shows the points the firm receives in this market, if she is already matched (it shows 0 points if she is unmatched). In our example, firm 2 and applicant 1 (of quality 5) are matched to each other, and hence firm 2 (and applicant 1) earn each $2 \times 5 = 10$ points in Market 1.

Below, on the bottom left, is a table that shows each firm all her offers that were rejected in this market. For example, Firm 2 made an exploding offer in period 1 to applicant 1 that was rejected in period 1.

The Applicant:

The screen shot is from applicant 2 in period 7 (as can be seen in the top 2 boxes). Each applicant will receive a new ID number in every market, which has nothing to do with the final quality that is determined throughout the market.

The table headed “The scores” lists your scores and qualities as they become available over time. Applicant 2 turns out to have quality 4 in this example; this means he has the third highest quality (the highest is 6, the lowest is 1).

The applicant has a box called “Matchings,” showing which of the firms have already hired which applicant, at what period. The entries are ordered by year of acceptance of the offer by the applicant.

Now we discuss boxes and choices that are only available to applicants.

On the right side the applicant has a table called “Your offers” that shows all the offers available (for this applicant) this period and whether the offer is exploding or open. (By

the time you see this screen, firms have finished making their offers for this period, so this screen shows all the offers you will receive in this period.) In the example, applicant 2 has one exploding offer, from firm 1. (Applicant 2 has to decide what to do with this offer, but he has no need to wait for further offers in this period, as all the firms have already finished making offers.) To accept an offer, the applicant has to first *click on the offer* and then the “Accept offer” button. Once an applicant accepted an offer, he is matched to that firm (i.e. hired by that firm) for this market, and will not receive any subsequent offers. The applicant can also decide to hold at most one open offer, by typing in the firm’s ID number (and hence the firms’ quality) that made him such an offer, and click the “Hold Offer” button. In that case the applicant will have this offer available in the next period. If an applicant holds an offer, all the other offers are automatically rejected. The applicant can also decide to reject all offers by clicking the Reject / Continue button. If the applicant received no offers, he nevertheless has to click the “Reject / Continue” button so the experiment can proceed. *Once you have made your decision, click the necessary button promptly, in order that the experiment will not take an excessively long time.*

The table in the middle left shows whether and to whom the applicant is matched, whether the applicant decided to hold an offer and from which firm. In period 7 the last line appears that shows the points the applicant receives in this market, if he is already matched (otherwise it shows 0 points).

The box in the bottom left shows the offers the applicant rejected in this market, ordered by the year in which they were rejected.

PAYMENT:

The payment you receive in this experiment has two components.

The first is based on your performance in the experiment: For each point you accumulate in the experiment, you receive \$ 0.10. The second component is independent of your performance in the experiment, and already determined in advance. It consist of the \$10 show up fee, and for some types of players (already determined) another fixed payment that is already determined now. That is, your behavior in the experiment influences your payoff only through the points you accumulate in the markets.

SUMMARY:

At the beginning of the experiment you learn whether you are a firm or an applicant. If you are a firm, you also learn your quality, which is your ID number that you will have throughout the whole experiment. If you are an applicant, you receive a new ID number in every market, and your ID number has nothing to do with your quality. In each Market there are 5 firms and 6 applicants.

Information about Applicants’ qualities is revealed over several periods:

- Period 1: Each Applicant receives a grade between 1 and 10 (with each of 1,2,3,4,5,6,7,8,9,10 having an equal chance to occur) that is his “1. score”.
- Period 4: each applicant receives another grade of 1,...,10, (each having the same chance of occurring) and the sum of the two grades constitute the “2. score”.
- Period 7: Each applicant receives a third grade between 1,...,10 (each having the same chance of occurring), and the sum of all three grades constitute the “3.

score”. The applicant with the highest score receives the highest quality of 6, the applicant with the second highest receives quality 5, and so on, until the applicant with the lowest score who receives quality 1.

To earn points in a market, a firm will need to hire one, and only one, applicant in that market, and an “applicant” will need to accept one, and only one, job offer. How is this done?

- In each period, each firm that has not yet hired an applicant, and has no open offer being held by an applicant, has to decide whether to make an offer, and, if so, to which applicant, and whether the offer should be exploding or open. Each firm can only have one outstanding offer in each period.
- An exploding offer is an offer to which the applicant must respond immediately. If he does not accept it right away (i.e. in the same period that it was made), the offer expires, and it is as if he had rejected it.
- An open offer is an offer the applicant can accept, reject, or hold. At most one offer can be held, in which case it will remain available in the next period.
- Once all the firms have made their offers, the applicants see the screen showing all the offers they received this period. (Once an applicant sees his offer screen, there will not be any further offers arriving in that period.)
- In each period, applicants who receive offers have to decide whether to accept the offer, reject the offer, or, if the offer is an open offer, the applicant can decide to hold (no more than one) offer.
- Once an applicant accepted an offer, he cannot accept another offer in the same market, and will no longer receive offers.
- Firms and Applicants that are not matched by the end of period 9 in a market remain unmatched and earn zero points.
- Firms and applicants that are matched to each other each earn points equal to the product of the applicant’s quality and the firm’s quality.
- After period 9, a completely new market begins, and everyone is free to try to match once again.

Screen of Firm 2

You are Firm 2	Applicants' ID numbers: 1, 2, 3, 4, 5, 6 Firms' ID (=quality): 1, 2, 3, 4, 5	You are in Period 7 in Market 1																																								
Matchings		List of all Applicants																																								
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">Applicant</th> <th style="width: 15%;">hired by firm</th> <th style="width: 15%;">in period</th> <th style="width: 15%;">Quality</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">** 2 **</td> <td style="text-align: center;">6</td> <td style="text-align: center;">5</td> </tr> </tbody> </table>	Applicant	hired by firm	in period	Quality	1	** 2 **	6	5	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 33%;">Applicant</th> <th style="width: 33%;">Quality</th> <th style="width: 33%;">Hired by firm</th> </tr> </thead> <tbody> <tr><td style="text-align: center;">4</td><td style="text-align: center;">6</td><td style="text-align: center;">0</td></tr> <tr><td style="text-align: center;">1</td><td style="text-align: center;">5</td><td style="text-align: center;">2</td></tr> <tr><td style="text-align: center;">2</td><td style="text-align: center;">4</td><td style="text-align: center;">0</td></tr> <tr><td style="text-align: center;">6</td><td style="text-align: center;">3</td><td style="text-align: center;">0</td></tr> <tr><td style="text-align: center;">3</td><td style="text-align: center;">2</td><td style="text-align: center;">0</td></tr> <tr><td style="text-align: center;">5</td><td style="text-align: center;">1</td><td style="text-align: center;">0</td></tr> </tbody> </table>		Applicant	Quality	Hired by firm	4	6	0	1	5	2	2	4	0	6	3	0	3	2	0	5	1	0											
Applicant	hired by firm	in period	Quality																																							
1	** 2 **	6	5																																							
Applicant	Quality	Hired by firm																																								
4	6	0																																								
1	5	2																																								
2	4	0																																								
6	3	0																																								
3	2	0																																								
5	1	0																																								
<p>You are matched to Applicant 1. You have no open offer</p> <p>Your profits in this market are 10 points.</p>		<p>Make an offer to Applicant <input style="width: 150px;" type="text"/></p> <p>The type of the offer is <input type="radio"/> exploding (only open this period) <input type="radio"/> open (until the end of this market)</p> <p style="text-align: right;">Make Offer</p>																																								
Your offers that were rejected in this market		No Offer																																								
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">Period</th> <th style="width: 15%;">offer to</th> <th style="width: 15%;">Deadline</th> <th style="width: 15%;">Rejected in</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">1</td> <td style="text-align: center;">exploding</td> <td style="text-align: center;">1</td> </tr> </tbody> </table>	Period	offer to	Deadline	Rejected in	1	1	exploding	1	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="4" style="text-align: left;">Applicant's Scores</th> </tr> <tr> <th style="width: 10%;">Appl.</th> <th style="width: 10%;">1. Score</th> <th style="width: 10%;">2. Score</th> <th style="width: 10%;">Quality</th> </tr> </thead> <tbody> <tr><td style="text-align: center;">1</td><td style="text-align: center;">10</td><td style="text-align: center;">16</td><td style="text-align: center;">5</td></tr> <tr><td style="text-align: center;">2</td><td style="text-align: center;">3</td><td style="text-align: center;">12</td><td style="text-align: center;">4</td></tr> <tr><td style="text-align: center;">3</td><td style="text-align: center;">2</td><td style="text-align: center;">6</td><td style="text-align: center;">2</td></tr> <tr><td style="text-align: center;">4</td><td style="text-align: center;">8</td><td style="text-align: center;">17</td><td style="text-align: center;">6</td></tr> <tr><td style="text-align: center;">5</td><td style="text-align: center;">10</td><td style="text-align: center;">11</td><td style="text-align: center;">1</td></tr> <tr><td style="text-align: center;">6</td><td style="text-align: center;">3</td><td style="text-align: center;">7</td><td style="text-align: center;">3</td></tr> </tbody> </table>		Applicant's Scores				Appl.	1. Score	2. Score	Quality	1	10	16	5	2	3	12	4	3	2	6	2	4	8	17	6	5	10	11	1	6	3	7	3
Period	offer to	Deadline	Rejected in																																							
1	1	exploding	1																																							
Applicant's Scores																																										
Appl.	1. Score	2. Score	Quality																																							
1	10	16	5																																							
2	3	12	4																																							
3	2	6	2																																							
4	8	17	6																																							
5	10	11	1																																							
6	3	7	3																																							
		<p>Points for a Match: 2 x Applicant's final quality.</p> <p>The Applicant's final quality (from 1 to 6) is determined in Period 7.</p> <p>Unmatched firms earn 0 points.</p>																																								

Screen of Applicant 2

You are Applicant 2		Applicants' ID numbers: 1, 2, 3, 4, 5, 6		You are in Period 7 in Market 1				
		Firms' ID (=quality): 1, 2, 3, 4, 5						
The Scores			Matchings			Your offers		
Applicant	Quality	2. Score	1. Score	Applicant	hired by firm	in period	Firm	offer deadline
** 2 **	4	12	3	1	2	6	1	exploding
<p>You are not matched yet.</p> <p>Last period you decided to hold no offer</p> <p>Your profits in this market are 0 points.</p>						<div style="text-align: right; margin-bottom: 10px;"><input type="button" value="Accept Offer"/></div> <div style="text-align: right; margin-bottom: 10px;"> Hold offer from Firm <input style="width: 50px; height: 20px;" type="text"/> <div style="text-align: right; margin-top: 5px;"><input type="button" value="Hold Offer"/></div> </div> <div style="text-align: right;"><input type="button" value="Reject / Continue"/></div>		
The offers you rejected in this market								
Period of offer	from Firm	Deadline	Rejected in period					
<p>The points you earn from a match are the quality of the firm with whom you are matched (from 1 to 5) x your final quality (from 1 to 6), which is determined in period 7.</p> <p>If you are not matched you earn 0 points.</p>								