NBER WORKING PAPER SERIES

THE COLLAPSE OF A MEDICAL
LABOR CLEARINGHOUSE
(AND WHY SUCH FAILURES ARE RARE)

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NBER Working Paper No. 9467
January 2003
JEL No. I0, J0

ABSTRACT

The collapse of the clearinghouse for the entry-level gastroenterology labor market offers a unique opportunity to study how stable clearinghouses succeed and fail.

To explore the reasons for the failure of the clearinghouse (and why failures of this kind of clearinghouse have been so rare), we conduct an experimental investigation of demand shocks of the kind that occurred in the gastroenterology market. We find that a reduction in demand for positions leads to the collapse of the match only when it is detectable by firms before being detected by workers (as in the unexpected shock that took place in 1996, which could be seen by firms in their reduced applicant pools). Simple demand and supply imbalances do not seem to interfere with the operation of the centralized match.

Our results suggest an affirmative answer to the question posed by market participants about whether the clearinghouse could be successfully restarted, and that this would relieve some of the distress now reported in that market, by allowing it to operate later, at a more uniform time, and with more national scope.

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1. Introduction

Many entry level labor markets have at some point in their history suffered from the "unraveling" of hiring decisions. Unraveling is typically a dynamic process, in which offers are made earlier from year to year, and can come to be written quite far before actual employment starts. In markets that experience unraveling, applicants typically receive "exploding" offers that must be accepted or rejected before (sometimes any) other offers can be received and considered (see e.g. Niederle et al. 2002). In such a market, any firm that makes an offer late, either because the firm wants to wait for additional information about applicants, or because the firm leaves its offers open for even a little time, and is eventually rejected, will often find that desirable candidates have already accepted offers elsewhere. Therefore, firms have an incentive to make early exploding offers themselves, and the trend towards making exploding offers becomes self reinforcing.[1]

In many markets there have been vigorous and sustained efforts to halt the unraveling of appointment dates. However, efforts to simply impose uniform appointment dates have most often been unsuccessful. Some markets have successfully reorganized themselves around a centralized clearinghouse, which permits uniform matching at an efficient time (Roth and Xing 1994). (Niederle and Roth 2002, looking at the market for gastroenterologists in a companion paper to the present study, observed that a clearinghouse also increased the scope of that market. During the time that gastroenterology was organized by a clearinghouse, the market was more national, compared to before and after the clearinghouse, when candidates tended to come from local hospitals.)

Not all centralized clearinghouses have been successful. There is a good deal of empirical evidence (see e.g. Roth 1984, 1990, 1991, Roth and Xing 1994) that a key

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[1] Roth and Xing, 1994, describe several dozen such markets and submarkets. Two markets that have recently been experiencing this kind of unraveling are the market for law clerks for Federal appellate judges (cf. Avery, Jolls, Posner and Roth 2001), in which offers have been made almost two years in advance of employment, and the market for college admissions (cf. Avery, Fairbanks and Zeckhauser 2001), in which elite colleges admit a high percentage of their entering classes through "early decision" programs that require applicants to commit in advance to one college that they will accept its offer if they are admitted early.

element of the design of a successful clearinghouse is whether it produces matches that are stable in the sense that there exists no firm and worker who are not matched to one another but who would both prefer to be matched to one another rather than accepting the results of the centralized clearinghouse (cf. Gale and Shapley, 1962, Roth and Sotomayor, 1990).[2] However, some unstable matching mechanisms have been observed to persist for years (cf. Roth, 1991; Mongell and Roth, 1991), and a very few stable matching mechanisms have been observed to fail.[3]

Table 1 shows a variety of centralized clearinghouses that employ a stable matching mechanism. As the table makes clear, the failure of such a clearinghouse is a rare event. We know of about 100 markets and submarkets organized via a stable clearinghouse (often simply called a "match"), and of these we know of only three markets in which such a clearinghouse was abandoned after operating for several years. Each of these failures occurred in a submarket of a larger complex of markets in which the stable clearinghouse otherwise continues to be used.

1. The clearinghouse for gastroenterology fellowships, begun in 1986, started to fail in 1996 and was formally abandoned in 2000, while other Internal Medicine subspecialties continue to use a centralized match that uses the stable matching algorithm employed by the larger resident match.

2. The dental specialties of periodontics and prosthodontics abandoned a centralized match in 1997 and 2000 respectively, while other postdoctoral dental programs continue to employ a stable matching procedure.

3. In Canada, the entry level market for lawyers is for what are called articling positions, and a stable clearinghouse system for these positions was abandoned in Vancouver in 1996, while remaining in use in Toronto and Calgary.

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[2] This is a bit of an oversimplification. Many labor markets have special features that complicate the definition of stability: see e.g. Roth and Peranson, 1999, for a description of the implications of stability in the market for medical residents. The market for gastroentrologists is both much smaller and considerably simpler than the resident match, and the definition of stability given here is sufficient.
[3] And in theory, stability is neither a necessary nor a sufficient condition for the success of a match (see Roth and Xing, 1994, Li and Rosen, 1998, Li and Suen, 2000, and Suen, 2000).

The internal medicine subspecialty of gastroenterology is the only market for which we have been able to gather evidence that suggests that the demise of the match is primarily related to events within the market itself.[4] It therefore provides us with a unique opportunity to investigate why a stable centralized mechanism failed, while so many others continue to be successfully used.

Table 1: Stable Centralized Matching Mechanisms

Market	Successful (still in use)
National Resident Matching Program (NRMP) (over 40 specialty markets and submarkets for first year postgraduate positions, and 15 for second year positions)	yes (new design in '98)
Regional medical markets in Britain (Edinburgh '69 and Cardiff)	yes
Specialty Matching Services (SMS) (over 30 subspecialty markets and submarkets for advanced medical residencies and fellowships)	yes (**except Gastroenterology since 2000**)
Canadian Lawyers: articling positions (multiple regions)	yes (**except British Columbia since 1996**)
Dental Residencies (5 specialties)	yes (**except for periodontists since 1997 and prosthodontists since 2000**)
Osteopaths (> '94)	yes
Pharmacists	yes
Reform rabbis (first used in '97-98)	yes
Clinical psychologists (first used in '99)	yes

To address this question, after considering the history of the market leading up to the collapse of the match, we will turn to laboratory experiments. The available field data, while suggesting hypotheses about the cause of the collapse (some of them put forward by market participants), do not allow these hypotheses to be distinguished, because they are all consistent with the history of the market. Experiments in the laboratory will allow us to reproduce and vary on a small scale different conditions of supply and demand, and also the kind of shocks experienced by the gastroenterology labor

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[4] In contrast, for example, the failure of the clearinghouse in the legal labor market for articling positions in British Columbia appears to have a lot to do with the interaction with the markets in other provinces in Canada, and to some degree with the market for new lawyers in the United States (cf. Roth and Xing, 1994).

market just prior to the collapse of the match, in ways that the single observation of the history of the market cannot.

This paper will be organized as follows. Section 2 will recount the history of the gastroenterology labor market. Section 3 will describe and analyze the experiments we conducted. In the conclusion, we will discuss both the policy implications of these results for the gastroenterology market, and also what they suggest about the broader class of markets that sometimes experience the unraveling of appointment dates.

2. The Gastroenterology Market

The history of the market for GI fellowship positions (so called because of the older name of Gastro-Intestinal disease) is similar to that of many medical markets and submarkets (Roth, 1984, Roth and Xing, 1994). Before 1985, it suffered from the unraveling of appointment dates, and a number of solutions were attempted prior to the adoption of a centralized match.[5] In 1986 the Medical Specialties Matching Program (MSMP) was initiated by the NRMP as part of the Specialty Matching Services at the request of the Association of Professors of Medicine, the Association of Program Directors in Internal Medicine and the Council of Sub-Specialty Societies of the American College of Physicians. Starting in 1989, the match was conducted for Gastroenterology, Cardiovascular Disease, and Pulmonary Disease, and since 1994 also for Infectious Disease (all of these are internal medicine subspecialties.) The goal was to establish a uniform appointment date for internal medicine fellowship positions and permit applicants to complete at least two years of their residency before making a decision as to which sub-specialty to pursue. The fellowship clearinghouse was

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[5] For example, Dr. David Brenner, then Chair of the AGA's Manpower and Training Committee, in an interview in Spring 1999, in the Trainee and Young GI News of the American Gastroenterology association: "Before the match, an approach of setting guidelines for interviewing candidates and negotiating positions was tried, and it was unsuccessful. Some applicants and programs received calls asking them for decisions three months before the deadline. Since it was only a recommended policy, directors say, it was terribly abused, which is why the training directors developed the match. Many felt that there was a chaotic atmosphere." See Roth and Xing (1997) for a similar prehistory to a match.

conducted a year in advance, i.e. after two years of internal medicine residency, and one year before employment would begin (NRMP 1999).[6]

In such a clearinghouse, applicants and fellowship programs submit rank order lists over positions and applicants, respectively. Then the lists are processed to produce a stable match.

However, in the years 1997 to 1999 the centralized match broke down, and was abandoned. The collapse of the match can be clearly seen in the number of positions that were filled through the match each year: While in 1996 around 300 positions participated in the match, by 1999 there were only 14, and in 2000 no centralized match for Gastroenterologists was even attempted.

The demise of the match seems to have been set in motion in 1993-1994, when, as part of general discussions of health care reform, the subspecialty of Gastroenterology subjected itself to a manpower analysis. The resulting study was published in 1996 in the Journal of the American Medical Association (Meyer et al 1996). Its main conclusions are that the US health care system and gastroenterologists would benefit from a reduction in gastroenterology Fellowship programs. The Gastroenterology Leadership Council endorsed a goal of 25% to 50% reduction in the number of GI fellows over 5 years. Furthermore, an additional year of training was mandated: starting in the summer of 1996, three years of training were required to be board eligible, instead of two.

That is, in 1996 the *supply* of gastroenterology fellowships was sharply reduced, by administrative decision of the specialty board, and the time needed to become a gastroenterologist was increased by a year (although some three-year fellowship programs had already existed before 1996).

However, this announced (and hence expected) reduction in supply triggered an *even larger reduction* in the number of residents who applied for GI fellowship positions. This seems to have been the start of the demise of the match. In 1996, for the first time, and despite the reduction in the number of positions offered, there were fewer applicants for GI fellowship positions than there were positions offered in the match. That is, despite the considerable reduction in the supply of positions, the market in fact

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[6] So a typical GI fellow will, after graduating from medical school, have been employed for 3 years as a resident in internal medicine (qualifying to be a Board certified specialist in internal medicine), before starting a GI fellowship, at the end of which he will be eligible to be a Board certified subspecialist.

experienced a shortage in demand for fellowship positions, as internal medicine residents stayed away from the market. This seems to have triggered a scramble among fellowship programs. Dr. David Brenner, then Chair of the AGA's Manpower and Training Committee, in an interview in Spring 1999, AGA: Trainee and Young GI News, described that demise in part as follows:

> *"Last year, several applicants complained because many training programs did not use the match. Many applicants were un-aware of this change and they felt that they had missed opportunities. Training-program directors who used the match felt that they had lost applicants to programs that had secured fellows before the match. Many applicants and a large percentage of the fellowship programs stopped using the match, which made choices more difficult for the remaining applicants and programs and created a vicious circle. Many training directors were very disappointed a few years ago when they didn't fill their slots because the applicants they thought were interested accepted positions before the match."*

Once the match broke down, and the commitment to uniform late appointment dates vanished, the market for Gastroenterology fellows once again experienced unraveling and exploding offers.

For example, GI Fellows Bauer, Fackler, Kongara, Matteoni, Shen and Vaezi, 1999, comment in a letter on the effects of the demise of the match.

> *"Of recent concern is the deterioration of the match process for candidates applying for fellowship positions over the past two years. Our junior colleagues are concerned that they may not be able to wait safely to interview with the institution of their choice while a position is offered elsewhere early in the decision process. The absence of the match benefits the programs a great deal more than their applicants."*

Hypotheses about the demise of the centralized matching procedure for gastroenterologists

One hypothesis about what caused the demise of the gastroenterology match, put forward by market participants in the gastroenterology literature, is that a centralized match can only work when there is a surplus of applicants.[7]

Gorelick, 1999, in a Comment from the Editors, speculates about the reasons of the demise of the match, and discusses the subsequent unraveling, as follows.

> *"The reasons for the decline of the match include fewer applicants to the Gastroenterology Match, and the inopportune timing of interviews and the Match. This year the reduced applicant pool led to earlier interviews and the virtual abandonment of the Match.*
>   *This downward trend in applicants to GI programs may have reversed this year and may remain stable for the foreseeable future. However, the movement toward earlier interview dates is likely to continue. Indeed some programs will be conducting their interviews almost 2 years before the trainee's start date".[8]*

Of course, there may be different kinds of perceived shortages of applicants. There may simply be fewer applicants than positions, as in 1996. A more subtle kind of shortage is that there may not be enough "high quality" applicants to fill the high quality positions. The best programs want to hire the best internal medicine residents. Thus, regardless of the actual number of applicants, perceived shortages arise. Indeed, the perception among some GI fellowship directors is that, even though there are now once again more applicants than positions, there are not enough high quality applicants available[9]. Of course, such perceived shortages can also arise in the eyes of applicants, regardless of the number of positions available. In many markets there appears to be a perception among participants on both sides of the market that they are on the short side (i.e. there are never enough high quality opportunities on the other side of the market).

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[7] For example, Dr. Phillip Toskes, former President of the American Gastroenterology Association writes "After all, it is probably true that the match only works well when there are numerous applications for limited positions" (1999)

[8] Furthermore, applicants are usually in the midst of difficult and sleep-depriving rotations characteristic of their second year residency. In an interview with the authors of this paper, one fellowship director indicated that an additional disadvantage of interviewing so far in advance is that applicants tend to fall asleep during the interview.

[9] This perceived shortage was the cornerstone of Dr. Phillip Toskes' presidential address at the 1998 meeting of the AGA. He says "It is time to step back and bring the best and the brightest back to gastroenterology."

The matching algorithm used by the NRMP to conduct the medical matches generates a stable outcome regardless of any shortages of positions or applicants. However, the incentives for programs and applicants to participate in the centralized match, or strike a deal outside the match, may change in response to changes in supply and demand.

Before we present further hypotheses about the demise of the GI match, we first need to consider a little more carefully the difference in the strategic options facing firms and workers when markets are centralized and when markets are decentralized.

When a centralized labor clearinghouse is working smoothly, it gives at least a superficial appearance of symmetry between firms and workers, since they both participate in a similar way (i.e. they both submit lists of preferences). But in a decentralized market, and in a centralized market from which firms may choose to defect by making early offers, there are some important asymmetries between firms (fellowship programs in the gastroenterology market) and job applicants (Internal Medicine residents). Two asymmetries seem particularly important in the present instance: the first involves the actions that participants take, and the second involves their information.

1. Asymmetry of actions: In both centralized and decentralized markets, applicants apply to firms to be considered for a position (e.g. apply for an interview). In decentralized markets, or when firms do not wait for a centralized market, firms then make offers, and applicants decide whether to accept or reject them.
2. Asymmetry of information following a shock: Receipt of applications gives firms an informational advantage; they know if they are getting many or few applications, and hence they have an early indication of shifts in the demand for positions. In contrast, information about the *supply* of positions is common to both firms and applicants, since available positions are announced well in advance. And in the absence of a shock, historical information will be a reliable guide to both firms and applicants.

This suggests three related hypotheses about why the shortage of applicants for gastroenterology positions in 1996 set off the collapse of the match. In fact each new

hypothesis will be a special case of the former hypothesis, starting with the simple supply and demand hypothesis expressed in the gastroenterology literature.

Three hypotheses:

1. The success of this kind of match depends on there being more applicants than positions: the centralized match fails when there are fewer applicants.
2. The match failed because there was a shock that reduced the demand for positions below the supply, but the match could have recovered from this shock if given the chance, once supply and demand stabilized.
3. The match failed because there was a shock that reduced the demand for positions below the supply, and because firms knew this (because they could see their reduced applicant pool) and applicants didn't. However, the match could have recovered from this shock if given the chance, once supply and demand stabilized, since then applicants would no longer be at an information disadvantage to firms.

While all three hypotheses take as their basis the fact that the gastroenterology match started to unravel the first year in which demand for positions was less than supply, the three hypotheses differ in their implications for a reorganization of the gastro match, for what we should expect to find in other markets with and without successful centralized clearinghouses, and for how such supply and demand shocks might be managed in the future.

3. Experiments

The goal of these experiments is to create a simple matching environment, in which we can study the effects of both stationary imbalances in supply and demand, and of shocks that create a shortage of applicants. In each experimental condition, subjects first gain experience of unraveling by participating in fifteen decentralized markets. They then participate in fifteen markets in which a centralized matching facility is available to subjects who choose to wait and use it. In the treatments that involve a

shock, the shock occurs after the 30th market, and subjects participate in an additional 15 markets after the shock, with centralized matching available for those who wait to use it. Firms and applicants are both always fully informed about the number and types of firms in the market. We will vary the information that applicants have about other applicants, and examine markets either with full information, in which firms and applicants have the same information about supply and demand, or partial information, in which only firms are directly informed about the number of applicants. (The partial information condition is intended to let us observe the market in conditions like that of the 1996 shock to the gastro market, which unexpectedly reduced the number of applicants.)

The Environment

Participants in the experiment are assigned the role of either a firm or a worker (i.e. an applicant for work), of one of two types, High or Low. Each subject maintained the same role (e.g. as a High firm) throughout all the markets in an experimental session, and no subject participated in more than one session. In each market, firms can match to at most one worker, and each worker can match to at most one firm. For each participant, a match to a High type is worth 150 points plus or minus a private value between 0 and 10 points. A match to a Low type is worth 50 points plus or minus a private value between 0 and 10 points.

Markets are divided into three periods, and in each period, firms that are not yet matched can make up to one offer. After all the firms make offers (or choose not to make an offer), workers accept or reject offers. A worker who receives several offers only sees them one at the time, in a random order. That is, a worker must choose to accept or reject each offer without knowing whether he has any more offers coming in that period.[10] Workers can only accept one offer per market. Once an offer is accepted, the worker must reject any other offers he received in that period. Accepted offers are announced to all participants in any subsequent periods, while unaccepted offers remain private. Matched firms are no longer allowed to make offers and unmatched firms cannot make offers to matched workers.

In the gastroenterology labor market, costs of unraveling consist of many components for both firms and workers, including uncertainty about the quality of the match and loss of planning flexibility. In our experiment, we model these various costs simply, by imposing a fixed cost of contracting early (as in Kagel and Roth, 2000). In particular, each market lasts for 3 periods, denoted periods -2, -1 and 0. To model costs of unraveling each participant who matches in period –2 incurs a cost of 20 points and each applicant who matches in period –1 incurs a cost of 10 points. The penalties for matching early are deducted from the participants' earnings. Subjects who failed to match by the end of period 0 receive 0 points for that market. Participants receive $.008 for each point plus a $10 show-up fee.

There are two kinds of markets:

1. In a *decentralized* market, firms have 3 periods to match by making offers to workers, who can chose to accept or reject the offers.
2. In a *centralized* market, the first two periods are as in the decentralized market. But in the last period, period 0, all firms and workers who have not already matched in periods
   -2 and -1 are matched using the firm-optimal deferred acceptance algorithm.[11]

In each of the experimental treatments, subjects first participated fifteen decentralized markets, and then fifteen or thirty centralized markets.

In each experimental treatment there are 3 low type firms and 3 low type workers. We vary the number of high type firms and workers to induce demand and supply imbalances and the kinds of demand shocks as experienced by the gastroenterology market.

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[10] Thus these are exploding offers, each of which has a deadline that expires before other offers may be received or considered.

[11] When the MSMP was operating the gastroenterology match, a version of the firm-proposing deferred acceptance algorithm was used. For ongoing matches, the MSMP subsequently followed the NRMP in adopting a new algorithm built around an applicant-proposing deferred acceptance algorithm (Roth and Peranson, 1999).

Fixed Demand treatments:

To test for effects of demand and supply imbalances, we have 3 treatments, determined by the number high type firms and workers. 3Firms – 3Workers is the treatment in which there are 3 high type firms and 3 high type workers (in addition to the 3 low type firms and workers). We compare the outcome of this balanced treatment to one in which there is excess supply of workers and one in which there is an excess supply of firms. In 2Firms – 3Workers, there are only 2 high type firms for 3 high type workers, that is there is a shortage of firms. In 3Firms – 2Workers, there is a shortage of one high worker for the 3 high type firms.

In all three treatments, both firms and workers are informed about demand and supply. We have 2 sessions of 3Firms – 3Workers and 7 sessions for each of 3Firms – 2Workers and 2Firms – 3Workers, each having 15 decentralized markets followed by 15 centralized markets. [12]

The Shock Treatments:

The shock treatments started out with 3 High type firms and 4 High type workers. Then, after market 30, there was a single shock, eliminating 2 High type workers and hence resulting in a shortage of workers from markets 31 to 45. [13]

The shock conditions were conducted under one of two information conditions, Full or Partial information. (The conditions without a shock were all conducted under Full information.) In both information conditions, firms and workers are both fully informed about the number and types of firms in the market. Firms also know the number and

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[12] Three of the seven sessions for each unbalanced condition continued for an additional 15 markets: see the Appendices.

[13] Under the Full Information design, the two workers who drop out after market 30 collect their payments and leave while the others finish the last 15 markets. In the partial information condition, these two workers are told to remain quietly at their workstations so as not to signal to the other participants that they have been removed from the market.

quality of workers and firms. The information condition affected whether workers know about the number and quality of workers.

1. Full Information: Workers are fully informed about the number and types of workers in each market. So, when there is a shock that changes the number of workers, the workers know about the shock as soon as the firms do.

2. Partial Information: Workers are not informed about the number and types of workers in each market. So, when there is a shock that changes the number of workers, only the firms can see the shock at the start of the market. Workers only find out about other workers when early matches are made.

For each of the shock treatments: 3Firms – 4Workers/2Workers Partial Information and 3Firms – 4Workers/2Workers Full Information we ran 4 sessions.

Experimental Results:

As in Kagel and Roth (2000) the data are best explained by examining the High type participants, since Low types almost universally participate in the centralized match once it becomes available[14]. To filter out the High-Low or Low-High matches that occur from the imbalance of supply and demand, in each market we will look at the High types on the short side of the market.

Figure 1 graphs the percentage of High-to-High matches that are made late (i.e. in period 0), first in the first fifteen decentralized markets, and then, after market 15, in the centralized markets. Once the market is centralized, period 0 matches are those that are done through the centralized clearinghouse, as opposed to being made earlier by decentralized offers and acceptances. For those sessions that experienced shocks in the balance of supply and demand following market 30, the figure shows how participation in the centralized clearinghouse reacted to the shock, in both the short term (markets 31-35),

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[14] Figures for the Low type participants are found in the appendix, as are screen shots of the experimental conditions.

and over the longer term (markets 31-45) under the new post-shock conditions of worker shortage.

The effects of a centralized Match under constant market conditions

For all 5 treatments, the decentralized market exhibits substantial early contracting. Furthermore, Markets 6-10 experience the same amount of late contracting as markets 11-15.

For all 5 treatments, the introduction of the centralized match increases the percentage of matches that are made efficiently late: markets 16-20 are significantly different from markets 11-15 in all treatments.[15]

Furthermore, the effectiveness of the centralized match increases as the participants gain experience with it: there is significantly more late matching in markets 26-30 than in markets 16 to 20.[16] In fact, the success of the centralized match is virtually the same across conditions.[17]

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[15] Mann-Whitney two sample test comparing Markets 16-20 to 11-15 yield .00 or .01 in all 5 treatments.
[16] Mann-Whitney two sample test comparing Markets 16-20 to 26-30 yield .00-.02 in all 5 treatments except Short 1 worker where it is .52
[17] Comparing the percentage of late matches in markets 26-30 across all conditions using the Mann-Whitney two sample test p-values we get

	3 Firms 3 Workers	3 Firms 2 Workers	2 Firms 3 Workers	Shock-Full Information	Shock-Partial Information
3 Firms 3 Workers	--				
3 Firms 2 Workers	.14	--			
2 Firms 3 Workers	.06	.66	--		
Shock-Full Information	.75	.24	.12	--	
Shock-Partial Information	.54	.38	.20	.77	--
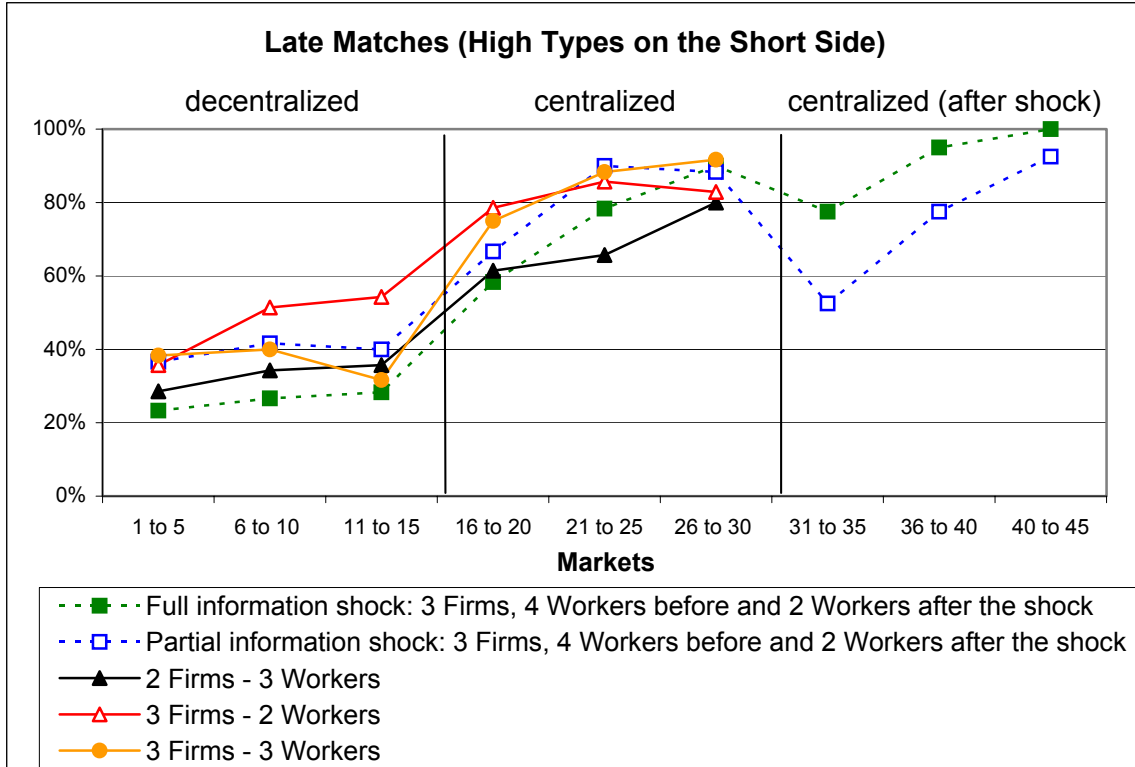
Figure 1: Percentage of Matches that are made in period 0.

Both when there was a shortage of firms and when there was a shortage of workers, a centralized market was effective in steadily reducing the percentage of early matches. There is no suggestion in these data that centralized matches work well only when supply and demand are balanced, or only when firms are not on the short side of the market. In each of the experimental sessions with no shocks (or before the shock), the centralized match, once introduced, achieved a steady rate of participation, suggesting that it is robust to varying conditions of supply and demand. Our results replicate those of Kagel and Roth 2000 in the current environment.

The effect of the shock

We are now in a position to consider the effect of the shock that changes the market from one in which workers are in excess supply to one in which they are in short

supply, starting in market 31.[18] We have already seen that the centralized mechanism is widely adopted when it is available, in both information conditions. And its adoption improves efficiency in both information conditions, resulting in significantly higher total payoffs to firms and workers.[19] Prior to the shock there are no important differences between the two information treatments. Mann-Whitney two sample tests yield a p-value of 0.77 when comparing the timing of markets 26-30 across treatments.

Figure 2 shows the two shock treatments in more detail. The first panel shows the initial fifteen decentralized markets, the second panel shows the first fifteen centralized markets (markets 16-30), and the third panel shows the centralized markets following the shock (markets 31-45). In each set of five markets participants matched in one of the three periods –2, -1, and 0, or remained unmatched, thus the bars will total 100%. The solid bars represent matches involving High Firms and High Workers. Matches between High types and Low types are represented by striped bars: these are very rare, since we are looking at the High types on the short side of the market.

Following the shock that removes two High type workers, unraveling reoccurs in markets 31-35 in both information conditions, but only marginally in the Full Information condition, and significantly more in the Partial Information condition. Mann-Whitney two sample tests yield p-values of 0.09 (full information) and 0.00 (partial information) when comparing the timing of markets 25-30 to markets 31-35.

The impact of the shock is significantly greater in the partial information treatment. Comparing markets 31-35 across treatments, the p-value is 0.020, confirming that lack of information leads to significantly more unraveling. Participation in the centralized match falls by 12.5% under full information, and 35.8% under partial information when compared to markets 26-30. Under partial information there is no detectable difference between the distribution of matches in markets 11-15 and markets 31-35 (Mann-Whitney two sample tests yields a p-value = 0.353); i.e. the unraveling after

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[18] The Appendix in addition reports two sessions in which we examined a small shock that removed one worker, so that the market changed from balanced supply and demand to one with a shortage of workers.
[19] The earnings/subject in the Full information condition are 78.00 for markets 11-15 and 100.59 for markets 16-20 (Wilcoxon matched-pairs test yields a p-value =0.0001), the Partial Information condition yields earnings/subject of 78.95 in markets 11-15 and 100.09 in markets 16-20 (p-value =0.0009).

the shock in the partial information condition is comparable in magnitude to the unraveling experienced in the decentralized markets. In contrast, under full information there is nowhere near as much unraveling after the shock as there was in the decentralized markets: Comparing markets 11-15 and 31-35 in the full information condition, the Mann-Whitney two sample tests yield a p-value = 0.000, so there is significantly less unraveling after the shock than in the decentralized market.

By the final 5 markets, markets 41-45, over 90% of the participants are again matching late. That is, the effect of the shock, minor in the full information condition and much larger in the partial information condition, is transient in both conditions. (The effect of workers not having information about the number of other workers diminishes as they gain experience of markets with no subsequent shocks in the number of workers.)

To summarize, in the full information condition the impact of the shock was minor, while in the partial information condition, matches after the shock were as early as in the decentralized markets. That is, in the immediate aftermath of the shock in the partial information condition, the centralized match ceased to operate effectively. But, even in the partial information condition, participation in the match recovered as applicants gained experience with being on the short side of the market.

Figure 2: Market Timing
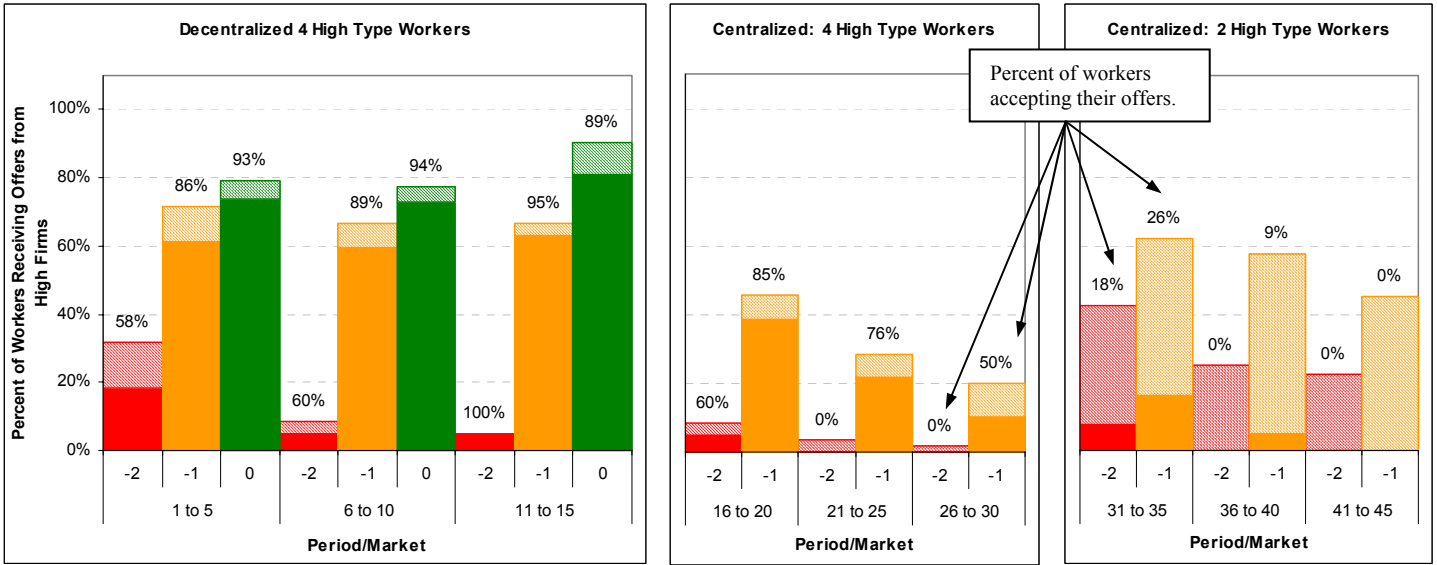**Full Information**
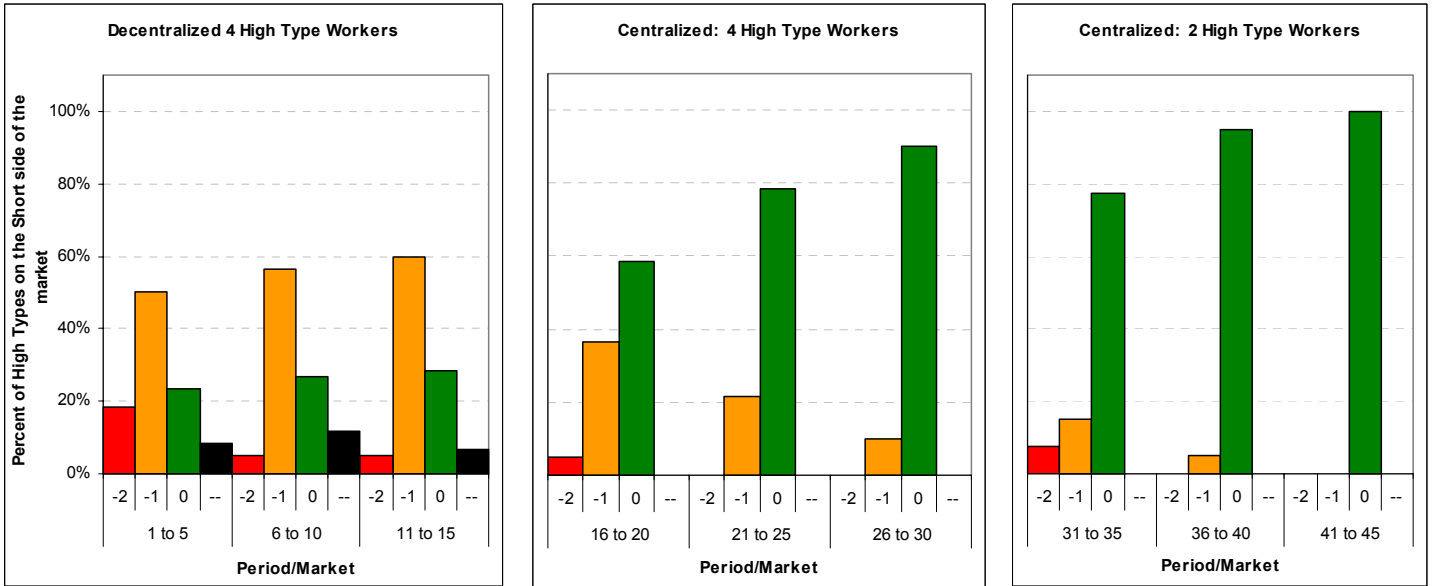
Partial Information
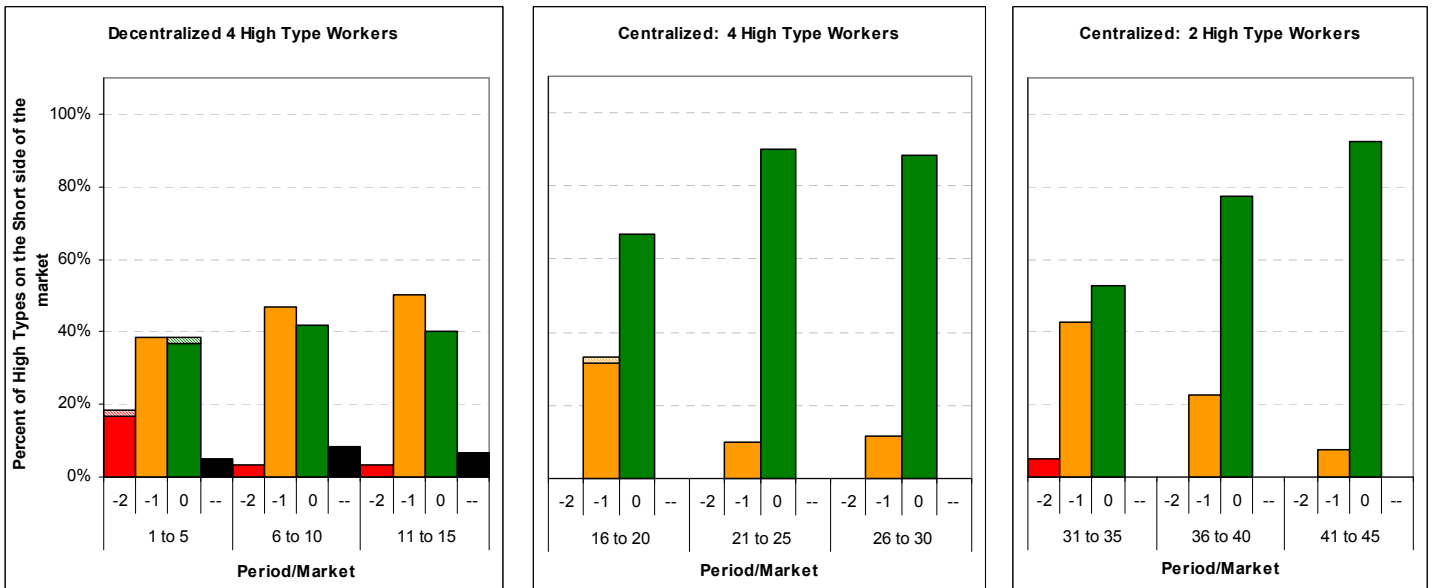
The figures plot the matches for the participants who drive the market, the High types on the short side. In the first 30 markets the colored solid bars represent the percent of the High firms matching with High workers in each period (note one High worker cannot match to a High Firm). After market 30, the solid bars represent the percent of High workers matching with High firms, now there can be only two High-High matches and one High firm will be left out. The striped portion of the bars represent the few High-Low matches. The black bars represent the unmatched High types on the short side of the market.

To understand the effect of the shock, and why it affects the partial information condition so much more than the full information condition, we look at the pattern of early offers by firms to workers, and workers' acceptance or rejection of these offers following the shock. We will see that, after the shock, when there is a shortage of High type workers, firms increase the number of early offers they make. But the workers accept these offers much less frequently in the full information condition, in which they know they are now on the short side of the market, than in the partial information condition.

Figure 3 shows the normalized percentage of High type workers who receive an offer from a High type firm, and the solid part of the bar shows the proportion that accept those offers. The percentages are once again normalized by the number of High type participants on the short side of the market, and also by the number of High type participants remaining on the market. Thus, in markets 1-30, a bar of total height 100% in period −2 would imply that each of the three High firms made offers to a different High type worker. A bar of total height 100% in period −1 or 0 implies that all remaining High type workers minus one (as High type workers are on the long side of the market) receive an offer from a High firm. (The numerical percentage on top of the bar, and the height of the solid part of the bar, indicate the percentage of these offers that were accepted.) After the shock, in markets 31-45, a total height of 100% in period -2 implies that both of the High type workers received at least one offer from a High firm. In period −1 or 0, a total height of 100% implies that each remaining High type worker received an offer from a High firm.

Figure 3: Offers, Acceptances, and Rejections
Full information
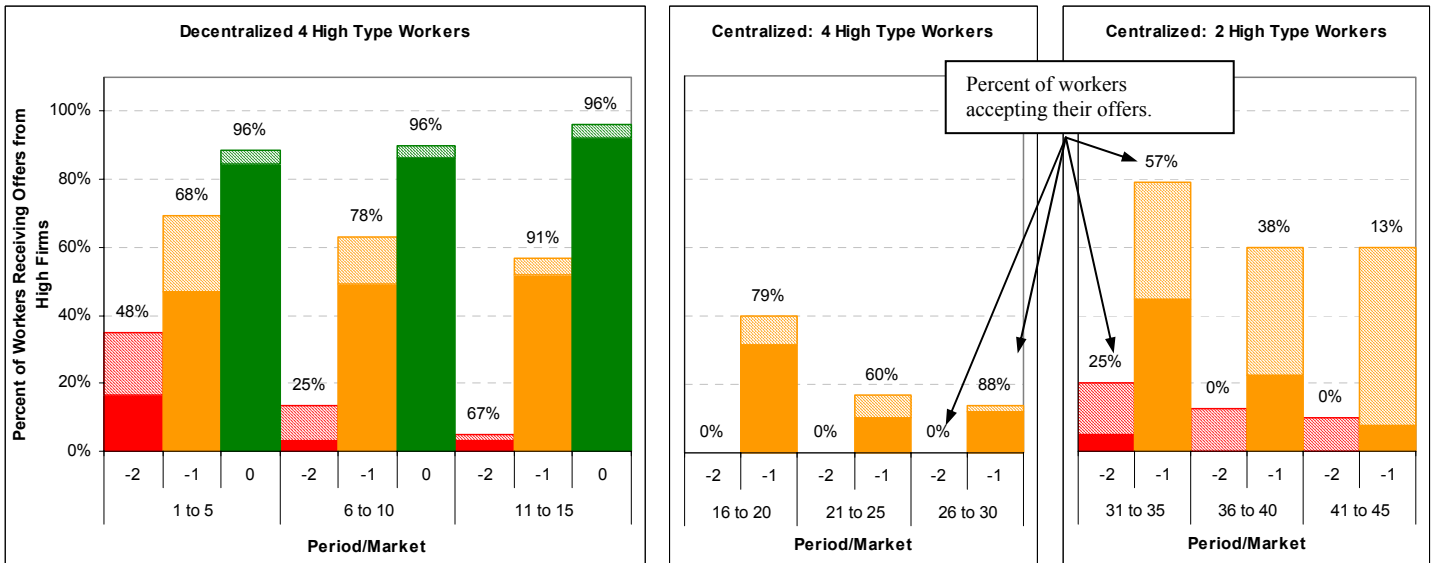
The percent on the vertical axis is normalized by the number of High type participants on the short side of the market, that are still available. Thus, in markets 1-30, a bar of total height 100% would imply that each of the remaining High type firms made offers to a different High type worker. After the shock, in markets 31-45, a total height of 100% implies that each of the remaining High type workers received at least one offer from a High firm. The numerical percentage on top of the bar, and the height of the solid part of the bar, indicates the percentage of these three offers that were accepted.

Behavior in the decentralized markets is not surprising. In both treatments the firms are aware that they are in short supply, but in order to avoid congestion in period 0 a number of early offers are made and most are accepted. In markets 16-30, the

centralized match solves the congestion problem and removes the incentives for the firms to make early offers. The number of offers falls significantly.

The notable differences arise after the shock. Firms are now on the long side of the market and have incentives to make early offers to secure a High type applicant. In the Partial information treatments, the workers are unaware of this. Under partial information, 57% of the workers accept offers made in period -1 in markets 31-35, compared to 26% under full information (the difference is significant, the proportion ratio test yields a p-value = 0.0015 or if periods –2 and –1 are pooled, p-value = .0144). Unraveling is also more persistent under partial information as it takes time for the workers to learn that they are now on the short side.

Overall, our experimental results show that a shock to the number of applicants, like the one that the gastroenterology market experienced in 1996, can affect participation rates in the match. The experiments show that this is particularly so when workers do not realize that they are, unexpectedly, on the short side of the market. The results thus tend to support our third hypothesis, that the match failed because there was a shock that reduced the demand for positions below the supply, and because firms knew this and applicants did not. (Recall how the low *demand* for positions in 1996 was an unexpected shock.)

4. Conclusions

This paper exploits a rare event—the failure of the stable matching mechanism used to organize the market for gastroenterologists—to explore how such clearinghouses fail, and why failures are rare.

Our results suggest that the shock the market experienced in 1996, namely a shock that reversed the earlier demand and supply imbalance and made applicants the short side of the market, could indeed have set off the unraveling of the market which followed. But our results also suggest why such failures are rare: in the laboratory, such a shock is insufficient to cause a large or sustained failure of the match unless it catches the applicants unaware. Expected shocks, or steady imbalances in supply and demand, do not seem to cause declines in match participation of anywhere near the magnitude

caused by an unexpected shortage of workers that workers are unaware of. It is this combination of events that creates the conditions that both cause firms to make early offers, and cause workers to accept them.

Thus the results of the experiment suggest that the collapse of the gastroenterology match was related to the peculiar situation in which gastroenterology found itself in the late 1990's. After having completed a manpower analysis that suggested there were too many gastroenterologists, and after reducing the number of gastroenterology positions, the market nevertheless suffered such a shortfall in applicants that applicants were in shorter supply than positions. Not only did this give fellowship programs an incentive to try to fill their positions early, it made applicants (who knew of the reduction in positions, but not of the shortage of well qualified applicants) eager to accept offers whenever they received them.

In the laboratory, we can see that when matchings become early, they become inefficient, in that they don't maximize the sum of participants' welfare.[20] In the field data, it is impossible to directly assess the extent of a market's efficiency, since we have no data to measure the productivity of gastroenterologists, or the incidence of gastroenterological disease. However in a companion paper, Niederle and Roth (2002), we collect data on the scope of the gastroenterology market from before, during, and after the period in which the clearinghouse operated. Those data allow us to see that the match, while it operated, had a big effect on the market outcome.

Niederle and Roth found that when gastroenterology fellowship positions were offered through a centralized clearinghouse, the market became significantly more national than it was before the match, or since its demise. The mobility of GI fellows, as measured by whether their GI fellowship is in the same hospital, city or state as their former residency, significantly increased with the use of a centralized match.

To summarize, the proximate cause of the collapse of the gastroenterology match seems to have been the shock to the market from the administrative decision to reduce the number and increase the lengths of GI fellowships required for board certification, and

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[20] In the experiments reported here, this is because of the fines that participants pay when they match early, but in other experiments such as those of Haruvy, Roth, and Unver, 2001, and Niederle, Gneezy, and Roth, 2002, inefficiency of early matchings results even when the only cost of early matching is that information needed for efficient matches is not yet available.

the resulting unexpected sharp drop in the number of applicants, resulting in a shortage of applicants. Since that time, the number of positions has again stabilized, raising the question of whether this market might be able to successfully employ a match again. The results of our experiments suggest that a centralized match, if reintroduced, would once again be successful. And reintroducing a centralized match would increase the scope of the market and the mobility of gastroenterologists, as well as allowing matches to be made after more information has become available.

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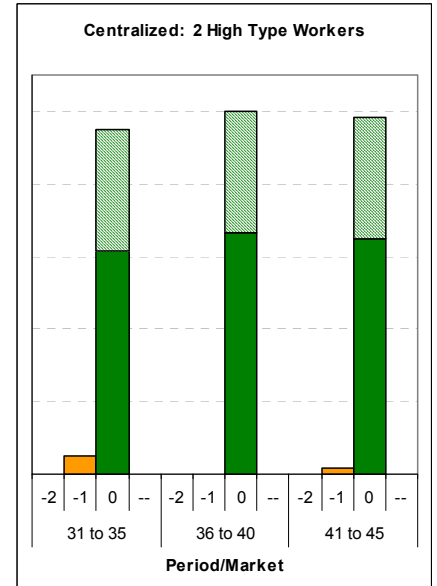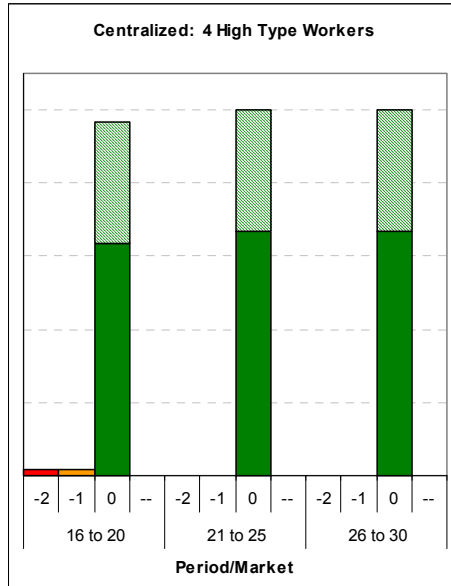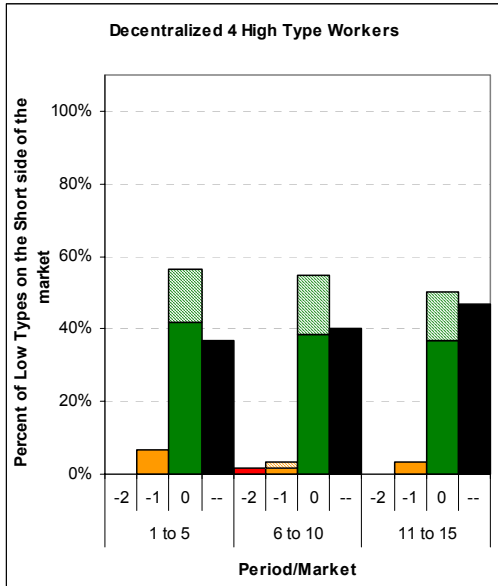
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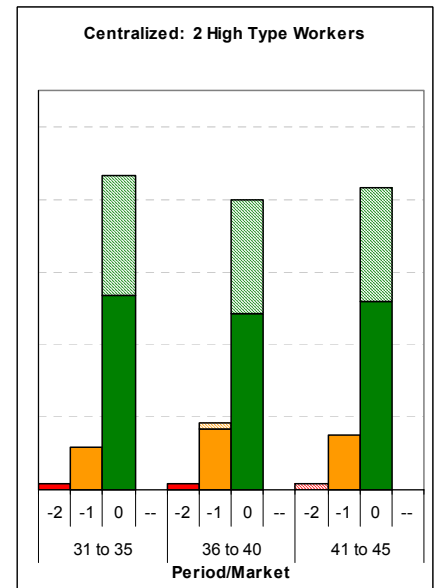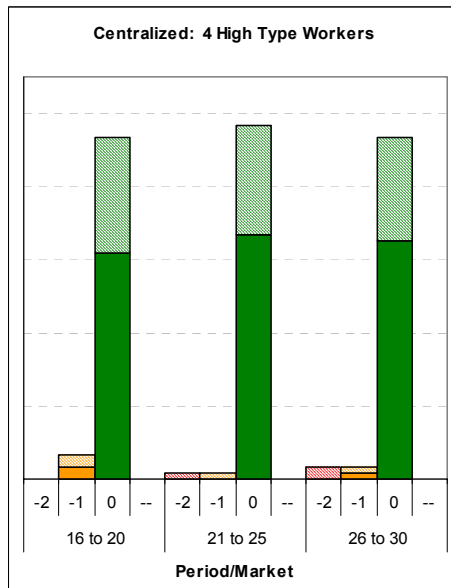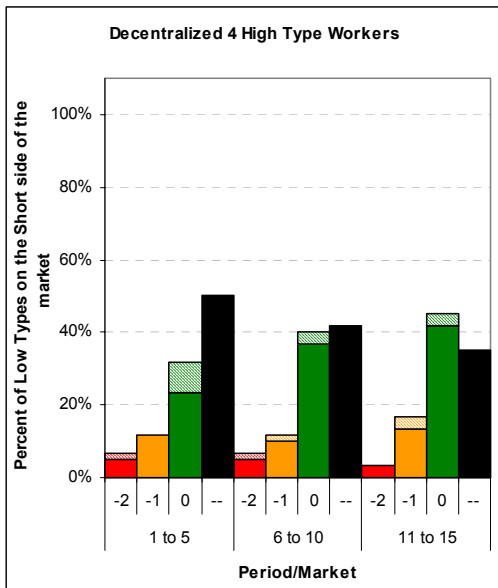
Appendix

I. Low Type Matches

Full Information

Partial Information

The percents are based on the short side of the market. In the first 30 markets the colored solid bars represent the percent of the Low firms matching with Low workers in each period. The striped portion of the bars represent the Low High matches. After market 30, the solid bars represent the percent of Low workers matching with Low firms (now one Low firm will likely remain unmatched). The black bars represent the unmatched Low types on the short side of the market.

II. Data—Percentages of Early and Late Matches of High Productivity Firms and Workers

Table a: Balanced Supply and Demand[21]

	Period	3 High Firms-3 High Workers Full Information #1		3 High Firms-3 High Workers Full Information #2	
		Timing		Timing	
	Period	Early	Late	Early	Late
Decentralized Markets	1 to 5	56.7%	40.0%	43.3%	38.3%
	6 to 10	40.0%	46.7%	51.7%	40.0%
Centralized Markets	11 to 15	6.7%	93.3%	63.3%	31.7%
	16 to 20	3.3%	96.7%	25.0%	75.0%
	21 to 25	**0.0%**	**100.0%**	11.7%	88.3%
	26 to 30	--	--	**8.3%**	**91.7%**

Table b: Unbalanced Supply and Demand[22]

	Period	2 High Firms-3 High Workers Full Information		3 High Firms-2 High Workers Full Information	
		Timing		Timing	
	Period	Early	Late	Early	Late
Decentr. Markets	1 to 5	68.6%	28.6%	60.0%	35.7%
	6 to 10	57.1%	34.3%	40.0%	51.4%
	11 to 15	61.4%	35.7%	40.0%	54.3%
Centralized Markets	16 to 20	38.6%	61.4%	21.4%	78.6%
	21 to 25	34.3%	65.7%	12.9%	85.7%
	26 to 30	**20.0%**	**80.0%**	**17.1%**	**82.9%**
	31 to 35	6.7%	93.3%	0.0%	100.0%
	36 to 40	10.0%	90.0%	0.0%	100.0%
	40 to 45	3.3%	96.7%	0.0%	100.0%

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[21] All sessions have 3 Low type firms and 3 Low type workers plus the High types listed in the table. The percentages are the total number of possible High-High matches. The change from Decentralized to Centralized markets is denoted with the dashed line.   The "Early" matches are matches from Periods –2 and –1. Late matches are the period 0 matches. There are 2 sessions in the *Full information #2* treatment and 4 sessions in the *Full information #2* treatment. We added five more decentralized markets in order to give the decentralized markets more time to stabilize.

[22] There are seven sessions of each of the unbalanced treatments, but only three of the sessions ran for the last 15 markets, 31-45.

Table c: Shock Treatments[23]:

	Period	"Small Shock" 3 Firms-3Workers to 3Firms-2Workers Full Information		"Large Shock" 3 Firms-4Workers to 3Firms-2Workers Full Information		"Large Shock" 3 Firms-4Workers to 3Firms-2Workers Partial Information	
		Timing		Timing		Timing	
		Early	Late	Early	Late	Early	Late
Decentralized Markets	1 to 5	23.3%	16.7%	68.3%	23.3%	55.0%	36.7%
	6 to 10	43.3%	36.7%	61.7%	26.7%	50.0%	41.7%
	11 to 15	46.7%	43.3%	65.0%	28.3%	53.3%	40.0%
Centralized Markets	16 to 20	16.7%	83.3%	41.7%	58.3%	31.7%	66.7%
	21 to 25	0.0%	100.0%	21.7%	78.3%	10.0%	90.0%
	26 to 30	**3.3%**	**93.3%**	**10.0%**	**90.0%**	**11.7%**	**88.3%**
	31 to 35	**0.0%**	**100.0%**	**22.5%**	**77.5%**	**47.5%**	**52.5%**
	36 to 40	0.0%	100.0%	5.0%	95.0%	22.5%	77.5%
	40 to 45	0.0%	100.0%	0.0%	100.0%	7.5%	92.5%

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[23] There are 2 sessions in the *3 Firms-3Workers to3Firms-2 Workers* treatment and 4 sessions in the remaining two treatments. The shock is denoted by the bold line.

III. Data—Percentages of Early and Late Matches of Low Productivity Firms and Workers

Table a: Balanced Supply and Demand[24]

		High Firms-High Workers			
		3F-3W Full Information		3F-3W Full Information	
		Timing		Timing	
	Period	Early	Late	Early	Late
Decentralized Markets	1 to 5	20.0%	56.7%	20.8%	43.3%
Decentralized Markets	6 to 10	6.7%	70.0%	23.3%	47.5%
Centralized Markets	11 to 15	0.0%	100.0%	20.0%	41.7%
Centralized Markets	16 to 20	3.3%	96.7%	3.3%	96.7%
Centralized Markets	21 to 25	0.0%	100.0%	0.0%	100.0%
Centralized Markets	26 to 30	--	--	1.7%	98.3%

Table b: Unbalanced Supply and Demand[25]

		High Firms-High Workers			
		2F-3W Full Information		3F-2W Full Information	
		Timing		Timing	
	Period	Early	Late	Early	Late
Decentr. Markets	1 to 5	14.3%	53.3%	33.3%	34.3%
Decentr. Markets	6 to 10	18.1%	48.6%	30.5%	42.9%
Decentr. Markets	11 to 15	16.2%	52.4%	25.7%	50.5%
Centralized Markets	16 to 20	3.8%	96.2%	8.6%	91.4%
Centralized Markets	21 to 25	1.0%	99.0%	1.9%	98.1%
Centralized Markets	26 to 30	0.0%	100.0%	0.0%	100.0%
Centralized Markets	31 to 35	0.0%	100.0%	0.0%	100.0%
Centralized Markets	36 to 40	0.0%	100.0%	0.0%	100.0%
Centralized Markets	40 to 45	2.2%	97.8%	0.0%	100.0%

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[24] The percentages are the total number of possible matches in volving a low type on the short side of the market. The change from Decentralized to Centralized markets is denoted with the dashed line.   The "Early" matches are matches from Periods –2 and –1. Late matches are the period 0 matches. There are 2 sessions in the *Full information #2* treatment and 4 sessions in the *Full information #2* treatment. We added five more decentralized markets in order to give the decentralized markets more time to stabilize.

[25] There are seven sessions of each of the unbalanced treatments, but only three of the sessions ran for the last 15 markets, 31-45.

Table c: Shock Treatments[26]

	Period	High Firms-High Workers(Pre/Post-shock)					
		3F-3W/3F-2W Full Information		3F-4W/3F-2W Full Information		3F-4W/3F-2W Partial Information	
		Timing		Timing		Timing	
		Early	Late	Early	Late	Early	Late
Decentralized Markets	1 to 5	10.0%	55.0%	6.7%	56.7%	18.3%	31.7%
	6 to 10	30.0%	36.7%	5.0%	55.0%	18.3%	40.0%
	11 to 15	30.0%	40.0%	3.3%	50.0%	20.0%	45.0%
Markets	16 to 20	16.7%	83.3%	3.3%	96.7%	6.7%	93.3%
	21 to 25	0.0%	100.0%	0.0%	100.0%	3.3%	96.7%
	26 to 30	**1.7%**	**98.3%**	**0.0%**	**100.0%**	**6.7%**	**93.3%**
Centralized	31 to 35	**5.0%**	**95.0%**	**5.0%**	**95.0%**	**13.3%**	**86.7%**
	36 to 40	0.0%	100.0%	0.0%	100.0%	20.0%	80.0%
	40 to 45	0.0%	100.0%	1.7%	98.3%	16.7%	83.3%

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[26] There are 2 sessions in the *3 Firms-3Workers to3Firms-2 Workers* treatment and 4 sessions in the remaining two treatments. The shock is denoted by the bold line.

IV. Instructions-Decentralized Markets[27]

Please don't touch the computer until you are told to do so. You will not need your keyboard in this experiment so it has been conveniently placed aside.

This experiment involves matching between firms and workers. It will consist of a number of matching Markets. At the beginning of Market 1 you will be assigned the role of either Firm or Worker and you will remain in that role throughout the duration of this experiment.

A firm and a worker become "matched" if the firm makes an offer to the worker and the worker accepts it. You will have the opportunity to make and accept offers in a number of matching markets. How much money you will earn will depend on whether you end a matching market matched or unmatched, and, if you are matched, on whom you are matched to.

How much money you will earn also depends on when you become matched. There will be three periods in each matching market, numbered -2, -1, and 0. Period -2 comes first, followed by Period -1, followed by Period 0. The reason for these numbers is that if you match in Period -2, you will earn 20 points less than if you had made the same match in Period 0, and if you match in Period -1, you will earn 10 points less. That is, there is a charge for matching early.

There are 26 people in this room. At the beginning of the experiment you will be assigned to a group of 13. Each group contains up to 6 firms and up to 7 workers. Some participants will sit out some markets.

We have set up an example in order to explain the computer screens. In order to keep things simple, this example only has 3 Firms and 3 Workers. As each matching market begins, you will see a screen like one of the two below. These screens are for a firm and a worker that in market 1 have the IDs Firm F1 and Worker W6.

Firm F1 Screen

Worker W6 Screen

Market 1 Period -2 **You are Type: H** In this market you are Worker W6 Participants on your side of the market:	**Value to you of matches to the other side of the market in Period 0**	**Matches** | Period | Firm | Worker |

Value to you of matches to the other side of the market in Period 0

Firms	Type	Value
F1	H	158
F2	H	141
F3	L	50

There is a 20 point penalty for a Period 2 match.

You are a Worker
   Please wait for the firms to move

Your log for Market 1

In the upper left box of the screen you see the current market you are in (Market 1) and period are always displayed in this corner. The color will change as the periods change. These screens are from Period –2. Period –2 is always Red, Period –1 is Yellow, and Period 0 is green.

Below The market and period numbers is your level of productivity. Types are either **High (H)** or Low (L). **High** type firms and workers are always listed in bold. In this example Firm F1 and Workers W6 are both **High** productivity. You will be assigned one of the two types at the beginning of Market 1 and will remain that type throughout the duration of the experiment. As we will explain in a moment, it is more valuable to be matched to a **High** than a Low.

Below your type is your ID. Firms ID's begin with the Letter "F" and workers with the letter "W". ID numbers are shuffled at the beginning of each new market.

If you are a Firm, directly below your ID number is a list of the other participants on your side of the market. You see will your ID and type (**High** or Low) as well as the ID's and type's (**High** or Low) for the other firms in your group. If you are a worker you will **NOT** see the other workers on your side of the market. There are always up to 6 firms and up to 7 workers. Remember, some participants will sit out in some markets, and the ID's are shuffled in each market; so a firm and a worker may have different ID numbers in different periods, even though they will remain of the same type.

The table in the middle of the upper part of the screen lists the participants on the other side of the market. Firm 1 sees 3 workers (as does every firm). For each worker ID, there is the type of the worker (**High** or Low). And the Value Firm 1 receives when matching to that specific worker. In this example the value of W6 to Firm F1 is 159, the value of W4 is 147. and the value of W5 is 59. The workers are ordered by value (the Highest value worker is listed first). You can see in the screen shot from Worker W6, a similar table for all the firms.

The value of a match depends on the type of the participant with whom you match. Regardless or whether you are a firm or a worker, your value for a **High** Type is 150 ± up to 10 points, and your value for a Low Type is 50 ± up to 10 points where the exact realization for each participant in each market is given in the table we just described.

So everyone prefers to be matched to a **High** than to a Low, but you can't tell which is anyone else's first or second choice among the Highs or among the Lows. So the fact that F1's most desirable worker is W6, doesn't mean that other firms do not prefer worker W4, who is also of **High** Type. Nor does it mean that W6 will have Firm F1 as his most desirable firm, although Worker W6 does prefers Firm F1 in this example.

Lets go through a few examples in order to explain the rest of the screen. Firms must make offers by choosing a worker form the drop-down menu in the bottom left corner of the screen. The menu will always list all of the unmatched workers as well as "Nobody". To make an offer simply choose a worker from the list and click "OK." In the actual experiment you will notice that the worker in which you are about to make an offer will flash on the middle table. The color of the flash will correspond to the current period. If you do not want to make any offers, choose "Nobody" from the list and click OK.

Lets assume Firm F1 makes an offer to Worker W6. The Period 0 value of Worker W6 to Firm F1 is 159 points, but since this is Period –2, there will be a 20 point penalty if the offer is accepted, hence the payoffs for this market would be 139 points if the offer is accepted. His screen would look like the following:

The log in the lower right corner keeps track of all your offers and responses.

In order to keep this example simple lets assume no other offers are made in Period –2. After the other 2 firms chose "Nobody" from the menu the workers' screen will change. Most of the workers in this example would get a message that they received no offers, but Worker W6 will get to respond to Firm F1's offer:
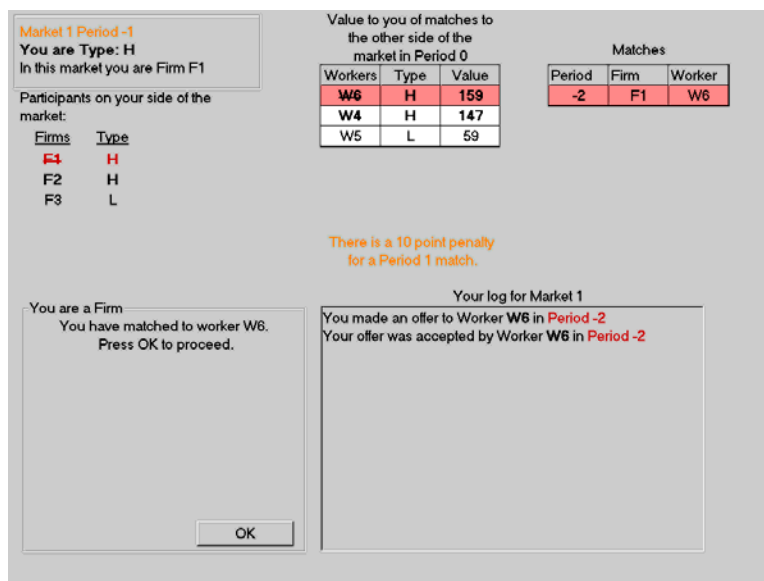
Market 1 Period -2
You are Type: H
In this market you are Worker W6

Participants on your side of the market:

Value to you of matches to the other side of the market in Period 0

Firms	Type	Value
F1	H	158
F2	H	141
F3	L	50

Matches

Period	Firm	Worker

There is a 20 point penalty for a Period 2 match.

Your log for Market 1

You are a Worker
Firm F1 made you an offer
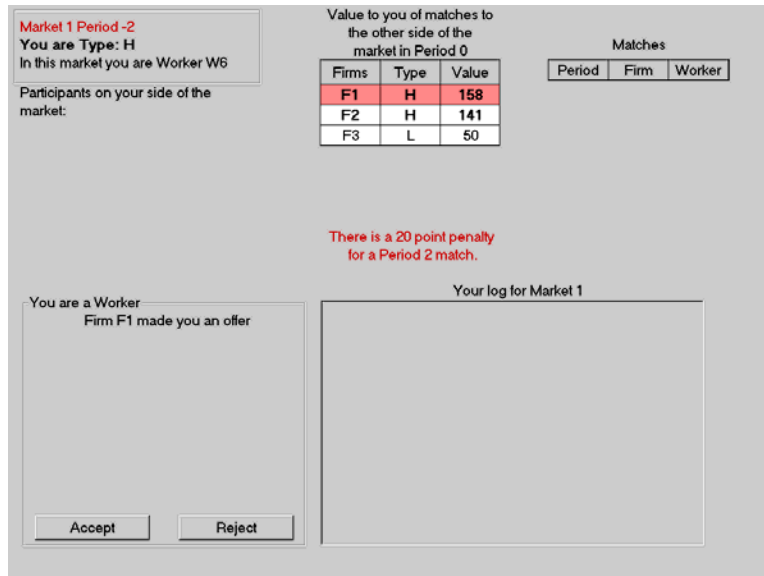
[Accept]   [Reject]

Firm F1's line will flash red in the middle table. Worker W6 does not know if this is his only offer, but he must click "Accept" or "Reject" this offer before he sees anything else.

Lets assume for this example that Worker W6 accepts this offer. After all workers respond to all offers, Period –1 will begin. Since Firm F1's offer was accepted his log was updated and he can no longer make offers. See below:

Market 1 Period -1
You are Type: H
In this market you are Firm F1

Participants on your side of the market:

Firms	Type
F1	H
F2	H
F3	L

Value to you of matches to the other side of the market in Period 0

Workers	Type	Value
W6	H	159
W4	H	147
W5	L	59

Matches

Period	Firm	Worker
-2	F1	W6

There is a 10 point penalty for a Period 1 match.

Your log for Market 1

You made an offer to Worker W6 in Period -2
Your offer was accepted by Worker W6 in Period -2

You are a Firm
You have matched to worker W6.
Press OK to proceed.

[OK]

The remaining 4 participants in this example will proceed just like they did in Period –2 with a few minor changes:

- All matched participants (Firm F1 and Worker W6) will be crossed out on everyone's screens. They will also remain red to indicate that the match occurred in Period –2.

- Firms will not see matched workers in their drop-down offer boxes and thus will not be allowed to make offers to matched workers.

- The "Matches" table will expand to show all Period –2 matches (F1 to W6). Only now to Workers W4 and W5 know that Worker W6 was on the market.

- The Penalty reminder is also updated to remind you the Period –1 penalty is 10 points.

Let's assume now that both Firm F2 and Firm F3 make offers to Worker W4 in Period –1. When a Worker receives multiple offers, they are displayed on the screen one at a time in random order. In this case the computer randomly chose Firm F3 to display first. So Worker W4 only knows that he has received an offer from Firm F3. Worker W4 may or may not have received other offers, he has no way to tell, before he has accepted or rejected the offer of Firm F3. Worker W4's screen is presented below:

Suppose Worker W4 rejects the offer, then he will see the offer of Firm F2, and the screen will look like the one below.

Once again Worker W4 must choose to accept or reject with out knowing if he has received any more offers or if he will receive any offers in Period 0. Lets assume he accepts.

After all the workers respond to all the offers, Period 0 begins.

- All matched participants (in this example F1 and W6 and F2 and W4) will be crossed out on everyone's screens.
- Firms will not see matched workers in their drop-down offer boxes.
- The "Matches" table shows all Period –2 matches (F1 to W6) and all Period -1 matches (F2 to W4). Only now to Workers W5 and W6 know that Worker W4 was on the market.
- The penalty reminder is also updated to remind you that there is no penalty to match in Period 0.

Firm F3's Period 0 screen is displayed below. Note that there are now 4 participants matched and thus crossed out.
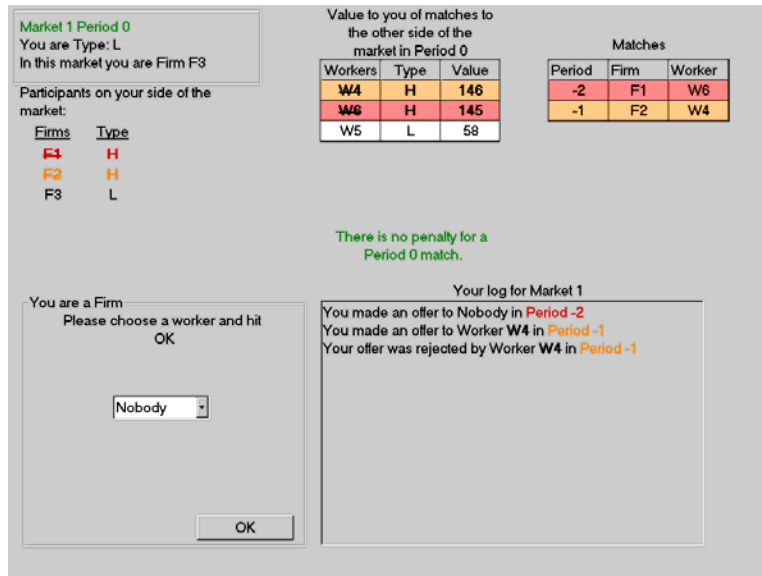
After Period 0 is over, a History screen will be displayed. When the experiment begins we will pause after Market 1 and I will explain the History screen.

Lets now discuss the earnings in the above example. Remember, regardless of your type you earn $150 \pm$ up to 10 points for matching with a **High** type, and $50 \pm$ up to 10 points for matching to a Low Type. If you do not match by the end of Period 0, you earn 0 points. At the end of the experiment, you will be paid $0.008 for each point.

In this specific example:

- Worker W6 earns 138 points. 158 points for matching to a **High** Type minus 20 points for going early.
- Firm F1 earns 139 points. 159 points for matching to a **High** Type minus 20 points for going early.
- Worker W3 earns 137 points. 147 points for matching to a **High** Type minus 10 points for going early.
- Firm F2's screen is never shown so we do not know his exact earnings; but we do know he earns 150 ± 10 points for matching with a **High** type minus the 10 points for going early. So his earnings will be between 130-150 points.

We will begin with 15 markets. Time permitting; we will conduct additional markets after the first 15 under a modified set of matching rules. In addition, all firms and workers will receive a $10 show-up fee.

In some sessions of this study, certain types of firm and/or workers will receive an additional participation fee[28].

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[28] In the 8 sessions with no shock and shortages of firms or workers, the low type subjects on the long side of the market received an addition $4 in order to keep their earnings above the minimum required by the HBS Human Subjects Board. All subjects in every session were told: "In some sessions of this study, certain types of firms and/or workers will receive an additional participation fee." This footnote was is not part of the actual instructions read by the subjects.

Summary:

At the beginning of the Experiment, you will be assigned to be either a Firm or a Worker and you will be either of **High** or Low type. Each group contains up to 6 firms and up to 7 workers. Some participants will sit out some markets. You will remain in that group for the duration of the experiment.

In each market:
- Each Participant receives a new ID number (so you will not be able to identify firms and workers across markets).
- Some participants may sit out in some markets.
- Each Participant receives different new values for each possible match, where a match to a **High** type is a random number of 150 ± up to 10, and a match to a Low type is a random number of 50 ± up to 10.
- Each market consists of 3 periods, Period –2, Period –1 and Period 0.
- Firms: In each period, each firm has to choose to make an offer to one worker or to "Nobody" and click the OK button.
- Workers: Workers who receive multiple offers will see them one at a time, in random order. If you see that you have received an offer, you must accept or reject it before you can see if you have any more offers. You can only accept one offer. Once you accept an offer, your "Accept" button will be disabled as you view any remaining offers.
- If a worker accepts an offer of a firm, the worker receives the number of points that corresponds to the value of the firm he is matched to, and the firm receives the number of points that correspond to the value of the worker he is matched to.
- If the match was made (i.e. the offer made and accepted) in Period –2, the worker and the firm both pay a penalty of 20 points, if the match was made in Period –1, the worker and the firm each pay a penalty of 10 points, if the match was made in Period 0, there is no Penalty.
- You will be paid $0.008 for each point at the end of the experiment. You will be paid in private and in cash.

Are there any questions?

V. Instructions: Centralized Markets

You have just completed the first part of this experiment. For the second part, there will be a new way of making matches in period 0, via a centralized matching mechanism. Firms and workers will submit a rank order list of their possible matches, and the centralized matching mechanism (which is a computer program) will determine the final matching, based on the submitted rank order lists.

This centralized matching mechanism is designed to produce the best match possible, taking everyone's preferences into account. For example, if there is a matching which matches everyone to his or her first choice, this will be the outcome of the matching mechanism. Even if this is not possible, if your first choice also ranks you first, you can be sure of being matched to your first choice. And the Higher you rank some firm (if you are a worker) or some worker (if you are a firm), the greater your chance of being matched to that firm or worker.

Periods –2 and –1 will remain the same as they were in the first 15 markets. At the beginning of period 0 all unmatched participants will see a new table on their screen. The table will list all the unmatched participants on the other side of the market. The records are sorted according to your potential earnings with matches yielding the Highest payoffs at the top of the list. This will be your rank order list. We assume you prefer more money to less money, thus you will not be able (or need) to modify your list. You simply have to click OK to submit your list to the centralized matching program. If you matched in an earlier period, you will not see a list and will simply hit OK to continue.

Once everyone has submitted his or her rank order list, the centralized clearinghouse performs the match, and the record screen is displayed as before. All participants that are listed as matching in period 0 went through the centralized match.

Remember, in the 30 matching markets we are about to begin, you will first have the opportunity to match, if you wish, in Period -2, and then in Period -1, just as in the first part of the experiment. As before, there is a cost to going early (20 points for Period –2 and 10 points for Period –1). But now, if you wait until Period 0 to be matched, you will have an opportunity to be matched by submitting a rank order list to a centralized matching mechanism, as we have just demonstrated. And, as before, there is no cost to matches that are made in Period 0.

ARE THERE ANY QUESTIONS?

VI. Outcome screen[29]