Volume Title: Studies of Labor Market Intermediation

Volume Author/Editor: David H. Autor, editor

Volume Publisher: University of Chicago Press

Volume ISBN: 978-0-226-03288-7; 0-226-03288-4

Volume URL: http://www.nber.org/books/auto07-1

Conference Date: May 17-18, 2007

Publication Date: November 2009

Chapter Title: The Effects of a Centralized Clearinghouse on Job Placement, Wages, and Hiring Practices

Chapter Author: Muriel Niederle, Alvin E. Roth

Chapter URL: http://www.nber.org/chapters/c3583

Chapter pages in book: (235 - 271)

7

The Effects of a Centralized Clearinghouse on Job Placement, Wages, and Hiring Practices

Muriel Niederle and Alvin E. Roth

7.1 Introduction

The market for almost all entry level positions (called residencies) for new doctors in the United States is mediated by a clearinghouse called the National Resident Matching Program (NRMP). Many other more advanced medical positions (called fellowships, which are the entry level positions for medical subspecialties) use similar clearinghouses, as do medical labor markets in Canada and Great Britain, and a number of other markets (e.g., for many nonmedical health care workers in the United States, for some new lawyers in Canada, and so on; see table 7.2).

These clearinghouses work as follows: applicants and employers make their own arrangements to interview each other, before submitting rank order lists representing their preferences, which are then used by the clearinghouse to centrally determine a matching that specifies which applicant will work for which employer. The algorithms used are generalized deferred acceptance algorithms (Gale and Shapley 1962; Roth 2002, 2008a), which we will describe in section 7.2.

These clearinghouses correct a set of market failures that often occur in entry level labor markets in which many people seek jobs that all begin at the

Muriel Niederle is an associate professor of economics at Stanford University and a research associate of the National Bureau of Economic Research. Alvin E. Roth is the George Gund Professor of Economics and Business Administration at Harvard University and in the Harvard Business School, and a research associate of the National Bureau of Economic Research.

Part of this work was supported by the National Science Foundation and the Sloan Foundation. We owe a special debt to Dr. Cody Webb, who first alerted us to the ongoing market failure in the labor market for gastroenterologists, and to our coauthor Dr. Deborah D. Proctor, who took the lead in reorganizing the gastroenterology match.

same time. One source of many problems is that these markets suffer from *congestion:* since making offers and considering them takes time, there may not be sufficient time for all offers that employers might like to make to, in fact, be made in a timely way. By the time a candidate has rejected an offer, the next-choice candidate may already have accepted an offer elsewhere. This often leads employers to make short-duration offers (or even exploding offers, which have to be accepted or rejected virtually immediately), and/or to try to make offers just a little bit earlier than their main competitors. It also means that employers may hesitate to make offers to their most preferred candidates if those offers have only a small chance of being accepted. That is, when choosing which offers to make, congestion forces firms to think not only about how much they like each candidate, but how much each candidate likes them, which can lead to coordination failures. Congestion makes it un*safe* for employers to make offers according to their preferences only.[1]

Once it becomes understood that positions in a market may reliably be filled through exploding offers, employers can use them strategically. By making an exploding offer, an employer can impose an ultimatum on a candidate, and make the candidate's effective market potentially very thin, limiting it, in the most extreme case, to this one employer. The use of exploding offers by some employers drives competitors to make offers with short deadlines themselves, even earlier, so as to not lose out on promising candidates. This prevents the market from being *thick* (see Niederle and Roth 2009).

To summarize, the problems many entry-level labor markets face are problems of (a) *thickness,* (b) *congestion,* and (c) *safety.*[2] (See table 7.1.)

In a number of markets these problems have become extreme: markets have unraveled, with candidates sometimes being hired several years before employment starts (see e.g., Avery et al. 2007 on lawyers; Niederle and Roth 2005; Niederle, Proctor, and Roth 2006 on gastroenterologists; and Roth and Xing 1994 on the labor market for Japanese university graduates, among many others). This, of course, may entail problems other than the lack of thickness. Information about candidates, and even the candidates' preferences over different employers, may not be as accurate long before employment as they will be nearer the time employment actually starts. As a result, many markets have institutions and organizations that aim to regulate the time and way in which offers are made and accepted; see table 7.1.

Entry-level medical markets, such as for residents and fellows, are prime examples of markets that experienced such problems, and also include many

1. In the market for junior economists, such hesitation can be seen as many departments shy away from interviewing candidates who have applied to them if the candidate seems too accomplished, because they do not know how much the candidate is *really* interested, as opposed to simply risk averse and applying widely.

2. See also Roth (2008), which expands on these themes in connection with a different set of markets.

Table 7.1 **Some institutions to regulate offers, acceptances, and rejections**

Market	Institution	Description
Graduate school admissions	Council of Graduate Schools (CGS)	Exploding offers discouraged, and acceptances before April 15 nonbinding (see text)
Undergraduate college admissions	National Association for College Admission Counseling (NACAC)	Binding early decision, nonbinding 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 to 2005 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.naceweb.org/about/principl.html	Guidelines for good conduct that discourage reneging 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

examples of markets that fixed problems of timing by adopting centralized clearinghouses. In these markets, most applicants become available for work at a specific time; for example, residents take up work on graduating from medical school, and fellows upon completing their residency. In addition, these are markets in which the employers tend to share some forms of professional organization. Both of these things may facilitate the organization of a clearinghouse, to fix problems that may be common also to other markets.

In this chapter we discuss the effects of such a clearinghouse not only on hiring practices (namely the timing of the market, and the kinds of offers that are made), but also employment opportunities, job placement, and potential impact on salaries. A clearinghouse may affect more than just a market's timing. By making offers through a computerized algorithm, congestion problems can be solved, as algorithms operate very fast. Furthermore, as we will describe when we explain *deferred acceptance algorithms,* when applied to markets of this size, they make it safe for both employers and applicants to reveal their true preferences, no one is harmed by listing a first choice that they are unlikely to get. A deferred acceptance algorithm also allows consideration of any offer, no matter when it is made. Similarly, deferred acceptance algorithms allow applicants to safely wait for better offers, even if they receive an acceptable offer early on. Therefore if there is sufficient participation in the centralized clearinghouse, the market is thick, as employers and applicants are all available at the same time and the whole market can be considered at once.

The market for gastroenterology fellows provides a natural case study of the effects of a centralized clearinghouse, as this market was organized through a centralized fellowship match, the Medical Specialties Matching Program (MSMP, organized by the NRMP) from 1986 to the mid-nineties. The arrangement fell apart, and for the next decade the market operated in a decentralized way. It reestablished a match in 2006.

These events give us a unique opportunity to discern the effects of such a centralized clearinghouse. We find that, as the market moved from a centralized to a decentralized market, the national market broke up into a collection of more local markets (Niederle and Roth 2003b). Fellowship programs, particularly smaller ones, were more likely to hire their own residents than under a centralized match. Furthermore, the market without a centralized match again unraveled into a market in which, at any specific time, only a subset of hospitals were making offers, which means the market fragmented not only geographically, in space, but also in time (Niederle and Roth 2004; Niederle, Proctor, and Roth 2006). Candidates were once more subjected to very short duration offers, and the market, even after several years of operating without a centralized match, had still not settled down, in that interviews and offers were still made earlier from one year to the next. Finally, although a class action lawsuit (since dismissed) argued that a centralized match sup-

pressed salaries, we did not find that the salaries of gastroenterology fellows, hired in a decentralized way, are any different from other internal medicine subspecialties, either those that use a match, or those that have not used a match for decades (Niederle and Roth 2003a). That is, we did not find any evidence that the match affected salaries.

Finally, we consider the obstacles to initiating a centralized match, especially in a market that had seen the breakdown of an earlier attempt. In the gastroenterology market, many employers who were themselves willing to delay hiring in order to participate in a match feared that their main competitors would not refrain from hiring candidates early, before a match. We employed some insights from decentralized markets (such as graduate school admissions), and from laboratory experiments, to help the gastroenterology professional organizations devise policies that helped to restart the match for gastroenterology fellows, in June of 2006 (Niederle and Roth 2009; Niederle, Proctor, and Roth 2006, 2008).

In the last section of the chapter we argue that medical labor markets are not special, many markets suffer from similar problems, namely problems establishing and maintaining (a) *thickness,* (b) *congestion,* and (e) *safety.* This can already be intuited from table 7.1, and we will present some examples in more detail. We also discuss decentralized alternatives to a centralized clearinghouse that some markets have adopted, such as the market for junior economists since 2006.

7.2 Deferred Acceptance Algorithms

In simple markets, in an *applicant-proposing deferred acceptance algorithm,* employers and applicants each submit rank order lists of potential matches; that is, each applicant lists which employer is his or her first choice, second choice, and so on, and each employer similarly ranks applicants. The algorithm uses these lists to conduct the following operations on behalf of applicants and employers. First, every applicant applies to his or her most preferred employer. Each employer collects all applications, and keeps those it has ranked highest—up to the number of positions it wishes to fill—and rejects all other applications. Applicants who had applications rejected apply to their next choice employer. Employers once more collect all applications (including applications kept from the last period), keep the ones they ranked the highest among the applications received so far, and so on, until no rejections are issued (because all applicants are either being held by an employer, or have run out of applications they wish to make; that is, reached the end of their rank order list). At this point the algorithm stops and every applicant is matched to the employer holding his or her application, and receives a contract from that employer. The outcome of such a matching is *stable;* that is, there exists no applicant-employer pair, not matched to each other,

who prefer each other to their current match (given the submitted rank order lists).[3]

Furthermore, in simple environments it is a dominant strategy for applicants to submit their true preferences (Roth 1982, 1985). This is due in part to the fact that any employer remains available until the algorithm stops. That is, applicants incur no disadvantage from applying to employers in the order of their preferences, including applications to very desirable employers who are not likely to accept them. The centralized clearinghouse also makes the market safer for employers; they do not have to accept an applicant before they know that they cannot receive a better one (hence the term "deferred acceptance").

A centralized market solves the congestion problem by using an algorithm that produces a stable outcome, makes the market safe, and in turn, thick. Any employer can consider any applicant they interviewed, and vice versa.

The NRMP developed an algorithm in the early 1950s that is equivalent to a hospital proposing deferred acceptance algorithm (Roth 1984), and in 1998 adopted a redesigned algorithm, which among other things switched from an employer-proposing version of the deferred acceptance algorithm to one more like the applicant-proposing deferred acceptance algorithm described previously.[4] The more general Roth Peranson algorithm (Roth and Peranson 1999), now used by the NRMP and other stable centralized clearinghouses (see table 7.2), also allows for the possibility for couples to go through the match together, and for reversions or ordered contracts (in which employers can specify an increased demand for some positions in case other positions are not filled; see also Niederle 2007). In general, the stable outcome of a firm- and a worker-proposing deferred acceptance algorithm can be different. However, the same set of firms and positions are filled.[5] And, using rank order lists submitted to the medical residency match, Roth and Peranson (1999) show empirically that, given the submitted preferences, the outcomes were the same for all but about one in a thousand applicants (of which there are approximately 20,000/year). When the market is sufficiently large (Roth and Peranson 1999; Immorlica and Mahdian 2005; Kojima and

3. This is easy to see. Suppose applicant A prefers some employer E to his or her current match F. Then applicant A must already have applied to E before he or she applied to F, and been rejected, at a point in the algorithm at which E was holding a full set of applications that it preferred to A. Hence if A prefers E to F, E does not return the favor, so no blocking pair exists (Gale and Shapley 1962).

4. In general, the outcome of the applicant-proposing algorithm is the stable match that every applicant prefers over any other stable match (Gale and Shapley 1962; see Roth and Sotomayor 1990 for a survey of the related theory.)

5. Consider the case of two firms and two workers, where firm 1 prefers worker 1 over worker 2, while firm 2 prefers worker 2 over worker 1. Workers have just the opposite preferences, with each worker preferring the firm with the opposite index. Firm 1 will be matched to worker 1 (and firm 2 to worker 2) if we use the agents preferences and a firm-proposing algorithm, while the opposite matching is achieved with an applicant-proposing algorithm.

Table 7.2 **Stable two-sided centralized clearinghouses that have been studied (and verified to use an algorithm that produces a stable outcome)**

Matches now using the Roth Peranson algorithm

Organized by the NRMP

Medical Residencies in the United States (NRMP) (1952)
Abdominal Transplant Surgery (2005)
Child and Adolescent Psychiatry (1995)
Colon and Rectal Surgery (1984)
Combined Musculoskeletal Matching Program (CMMP)
- Hand Surgery (1990)

Medical Specialties Matching Program (MSMP)
- Cardiovascular Disease (1986)
- Gastroenterology (1986–1999; rejoined in 2006)
- Hematology (2006)
- Hematology/Oncology (2006)
- Infectious Disease (1986–1990; rejoined in 1994)
- Oncology (2006)
- Pulmonary and Critical Medicine (1986)
- Rheumatology (2005)

Minimally Invasive and Gastrointestinal Surgery (2003)
Obstetrics/Gynecology
- Reproductive Endocrinology (1991)
- Gynecologic Oncology (1993)
- Maternal-Fetal Medicine (1994)
- Female Pelvic Medicine and Reconstructive Surgery (2001)

Ophthalmic Plastic and Reconstructive Surgery (1991)
Pediatric Cardiology (1999)
Pediatric Critical Care Medicine (2000)
Pediatric Emergency Medicine (1994)
Pediatric Rheumatology (2004)
Pediatric Surgery (1992)
Primary care sports medicine (1994)
Radiology
- Interventional Radiology (2002)
- Neuroradiology (2001)
- Pediatric Radiology (2003)

Surgical Critical Care (2004)
Thoracic Surgery (1988)
Vascular Surgery (1988)

Organized or supported by NMS (National Matching Services)

Postdoctoral Dental Residencies in the United States
- Oral and Maxillofacial Surgery (1985)
- General Practice Residency (1986)
- Advanced Education in General Dentistry (1986)
- Pediatric Dentistry (1989)
- Orthodontics (1996)

Psychology Internships in the United States and Canada (1999)
Neuropsychology Residencies in the United States and Canada (2001)
Osteopathic Internships in the United States (before 1995)
Pharmacy Practice Residencies in the United States (1994)
Articling Positions with Law Firms in Alberta, CA (1993)
Medical Residencies in Canada (CaRMS) (before 1970)

Matches using other generalized stable algorithms

British (medical) house officer positions
- Edinburgh (1969)
- Cardiff (197x)

Reform rabbis (1998)
New York City high schools (2003)
Boston public schools (2006)

Note: Year of first use in parentheses.

Pathak forthcoming), it is almost a dominant strategy for all participants, both employers and applicants, to submit their true preferences.

7.3 The History of the Market for Gastroenterology Fellows

Gastroenterologists typically begin work in their subspecialty three years after graduating from medical school, after having completed a residency in internal medicine (IM). Three additional years as a gastroenterology (GI)[6] fellow qualifies them for gastroenterology board certification (before 1996, only two years of fellowship were required). Internal medicine residents who consider becoming gastroenterologists have many other possible career choices, including practicing as an internist or pursuing other internal medicine subspecialties, of which gastroenterology is but one.

While the number of GI fellowship positions each hospital can offer has been regulated by the gastroenterology organizations for a long time, prior to 1986 the market for fellows was decentralized. In the 1970s and 1980s, hospitals announced positions, received applications, interviewed candidates, and made offers at their own pace. The market experienced problems very similar to those experienced by the market of medical interns several decades earlier (Roth 1984, 2003), including the gradual unraveling of appointment dates. Offers for positions came to be made years before employment as a GI fellow would start. In an attempt to halt unraveling, guidelines for the time at which offers could be made were proposed, unsuccessfully. Eventually a centralized labor market clearinghouse was adopted, of the kind used for matching medical students to internal medicine and other residencies.

In 1986, the MSMP (Medical Specialties Matching Program) initiated a centralized match for gastroenterology and other internal medicine subspecialties, conducted one year before employment would start, and so two years into the IM residency. The MSMP uses the same algorithm to match applicants to programs such as the NRMP (National Residency Matching Program), which matches medical students to residencies (and since 1998 this is the Roth and Peranson [1999] algorithm). The match for GI fellows operated well, with most nonmilitary programs participating, and over 90 percent of participating positions being filled. However, after 1996, participation of GI fellows and programs rapidly declined, and the match was formally abandoned in 2000.

The collapse of the centralized market allows us to study how a labor market that operated in an organized way, in which interviews were conducted without time pressure, in which offers were made mostly all at once through the centralized match, adapted to the loss of the clearinghouse. Because the lack of the clearinghouse is recent (and because gastroenterology programs

6. The abbreviation "GI" stems from the older name for the specialty, *gastro*intestinal disease.

were interested in understanding how the new market worked), we were able to survey market participants and observe how the market changed, and how the decentralized market functioned in comparison to when the clearinghouse was in operation. We will also describe the process by which a new clearinghouse was organized and put into operation in 2006.

7.4 The Effects of a Centralized Match

We first study how the market for gastroenterology fellows operated after the match broke down. We describe when interviews were conducted and offers made, what kind of offers applicants received, and the thickness of the market—that is, how many programs were actively hiring at any given time.

We then address whether the decentralized organization of the market produced different outcomes than the centralized clearinghouse, apart from the timing and organization. We will investigate who got matched to whom under the different market organizations and whether salaries were affected. This latter point received some prominence due to an antitrust lawsuit against the match that was dismissed following the passage of new legislation.

7.4.1 The Decentralized Market for GI Fellows: What Kind of Offers When?

In the late nineties, the market moved from a centralized clearinghouse to a decentralized market: programs started to match to applicants outside of the match, more specifically, *before* the match. We will provide an overview of the reasons for the collapse of the match in section 7.4, but first we describe this new decentralized market.

From the outset, we were faced with a common problem when studying and describing decentralized markets. By their very nature, there are not a lot of data collected on the way the market works. We use two sources of data: the first is Fellowship and Residency Electronic Interactive Database (FREIDA) online (http://www.ama-assn.org/ama/pub/category/2997.html), on which many programs announce the time at which they plan to interview.[7] Second, together with our colleague Dr. Deborah Proctor, and with the sponsorship of the American Gastroenterology Association (AGA), we administered a survey on hiring procedures of gastroenterol-

7. We accessed FREIDA in 2003 to retrieve data concerning fellowship positions in internal medicine subspecialties starting in 2005, and in the spring of 2002 for GI fellowship positions starting in 2003. We used data from programs whose end date of the interviews occurred after the deadline of the application period. The number of data points we have for the start date of the interview period (end date in parentheses) for positions starting in 2005 is forty-five (forty-four) of the 155 GI programs, of the match specialties we have eighty-three of the 174 cardiovascular disease programs, sixty-four of the 139 infectious disease programs, ten of the thirty pulmonary disease programs, and fifty-two of the 122 pulmonary disease and critical care programs.

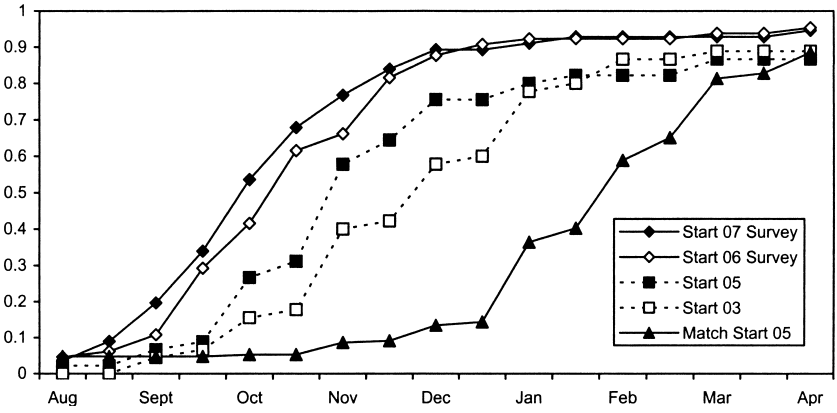

Fig. 7.1 Cumulative distribution of GI and Match programs that started interviewing by the time of any given two-week period

Source: Match Start 05: interview dates of internal medicine subspecialties that participated in the MSMP for positions starting in 2005. Start 03 and Start 05: Start dates of interviews for GI fellowship positions starting in 2003 and 2005, respectively, from FREIDA (Niederle and Roth 2004). Start 06 Survey: The replies from the survey of GI program directors to the question of when they started interviewing for 2006 positions. Start 07 Survey: the answers to the question of when GI program directors expected to start interviewing for 2007 positions (without a centralized match; see Niederle, Proctor, and Roth 2006).

ogy programs, in January 2005 (see Niederle, Proctor, and Roth 2006). A link to an online questionnaire was sent to the 154 GI fellowship programs accredited by the Accreditation Council for Graduate Medical Education and eligible to participate in a match. We obtained (partial) data from sixty-four U.S.-based programs, a response rate slightly higher than 40 percent, with larger and more prestigious programs somewhat overrepresented. The survey focused on the mechanics of how fellows were hired.

We asked when program directors conducted their first and last interview for positions beginning in the summer of 2006. We also asked when they expected to start interviewing for positions beginning in 2007 (at the time of the survey no decision had yet been made to reintroduce the GI fellowship match).

Using data from FREIDA and the survey on interview schedules, figure 7.1 shows the timing of interviews for GI fellowship positions, compared to the time of interviews of other internal medicine subspecialties that maintained participation in the match (Niederle, Proctor, and Roth 2006). We show the cumulative distribution of programs that started interviewing at any given two-week period.[8] Not only were GI programs interviewing earlier

8. Programs that started their interviews, for example, from December 23 to January 6 are coded as starting in January, and those that interviewed from January 7 to January 22 as mid-January. This way, programs that start interviewing on the last day of a month, or the first day in the next month—both prominent start times—are coded as starting at the same time.

than subspecialties that still used a match, but they were also interviewing earlier from year to year, even many years after the match collapsed in the late nineties.

The fifty-one programs that in the survey provided both a start date for interviews for 2006 positions and an anticipated start date for 2007 positions and did not start interviewing before August planned to interview significantly earlier for 2007 positions ($p < .01$, using a Wilcoxon matched-pairs signed rank test). Of these fifty-one programs, the programs that planned to interview earlier for 2007 positions are the programs that started interviewing later for 2006 positions.[9] This is consistent with the view that programs that interview later find that many of the applicants they would have liked to interview have already accepted positions. Furthermore, regression analysis shows that the timing of interviews is not correlated with the size of the program (which is a decent proxy for "desirability," with larger programs being more prestigious).

In the survey, Niederle, Proctor, and Roth (2006) not only asked about timing of interviews, but also about the timing and kinds of offers that were extended. For each of the forty-four fellowship programs that answered the questions in the survey, figure 7.2, panel A shows when the first offer was made, and the last offer expired, where (to be very conservative) we assumed that the last offer made was also the one with the longest deadline. Thus the figure shows, for each responding program, a line that begins on the day when the first offer was made and ends when the last offer made would have expired if it was the offer with the longest duration. This provides an upper bound for the time during which the program was actively on the market. Figure 7.2, panel B provides the proportion of programs that are actively on the market at any given time.

Figure 7.2, panel A shows that by November 15, eleven programs (27 percent) had already finished making offers, twelve (25 percent) had not yet started, and twenty-one (48 percent) were in the middle. Figure 7.2, panel B presents the same data another way by showing how many programs had outstanding offers at any point in time. At no point did even 60 percent of programs have outstanding offers. So offers were dispersed in time, with programs that made offers early, often requiring answers before many other programs had begun to make offers.

The hiring process resulted in quite intricate scheduling of interviews and offers. Most programs (53/61) had interviews cancelled, and about half (29/64) made offers before they finished interviewing (of these, almost half reported that they did so because of pressure from the market). Forty-three

9. A regression on the amount of time the program wants to move its interviews ahead (i.e., predicted interview begin next year minus interview begin this year), as a function of when the program started to interview, yields a coefficient of –0.17 (s.e. 0.07, $p = .02$). The relationship holds even when we control for the number of positions the program is trying to fill or the length of the interview period.

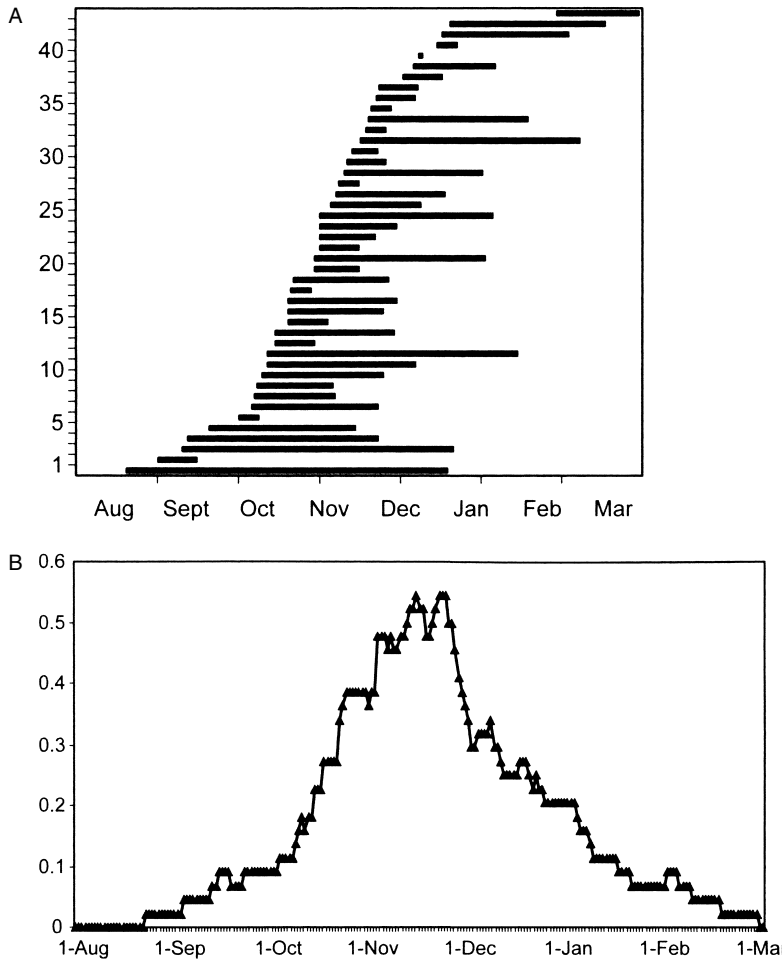

Fig. 7.2 Dates of offers by forty-four fellowship programs: *A*, Each program is represented by a horizontal line, indicating the dates during which it had outstanding offers; *B*, The proportion of programs that have an outstanding offer on any given day

percent of the respondents (twenty-eight programs) reported that they speeded up offers because the candidate had another offer, and many other programs reported that in such cases they provided feedback to the candidate about their chance of receiving an offer. Furthermore, 33 percent of programs (i.e., twenty-one) considered how likely it was that an applicant would accept their offer when deciding whether to extend an offer. Programs not only decided strategically when and to whom to make an offer, but also on the deadline of offers. More than half the programs (60 percent made

at least one offer that required a reply in one week or less, and 95 percent required a reply to some offer in two weeks or less. And in fact, 21 percent of programs indicated that the longest time a candidate took to respond to an offer was one hour, 60 percent report one week at most, and 90 percent two weeks at most. Thus, the market moved fast. It was not a market in which program directors could interview all the candidates they might wish to before making offers, nor one in which they could safely extend offers to risky candidates, because meanwhile more attainable candidates might take other offers.

That is, the decentralized GI fellowship market made it unsafe to act straightforwardly according to preferences over candidates or employers only. It was a congested, thin market, even though there were (and are) many GI programs and potential GI fellows. As such, the GI market was less competitive than when there was a match, in that competition for each fellow was reduced to a thin slice of employers, and direct competition among fellows for programs was reduced as fellows were hired quickly and could only be considered by very few programs.

7.4.2 Does a Centralized Match Change the Final Outcome of the Market?

There were several reasons to think that the thin, early decentralized market that followed the loss of the match might produce different outcomes than the centralized match.

First, the centralized match yields a stable outcome—that is, there does not exist a program and resident that mutually prefer each other to their match outcome. (That is, every program could make an offer to any fellow it prefers to its current fellow, only to learn that this new fellow would turn them down, as he or she prefers the current match.) It seems unlikely that the decentralized market as operated by GI programs and fellows can achieve stability, when programs make exploding offers, strategically decide on the candidates to whom to make an offer, and markets are thin. Indeed, theoretical results by Niederle and Yariv (2009) suggest that, in general, a decentralized market like the market for GI fellows will not result in a stable outcome.

A second reason the decentralized market may yield a different matching is that offers in the decentralized market were made about six months to a year earlier than those in the centralized match. Instead of hiring internal medicine residents near the end of their second year, they came to be hired at the beginning of their second year. This means there was less information about residents available when programs decided to whom to make offers.

Finally, there is anecdotal evidence that markets that unravel rely more on informal networks. This can have several reasons: the first is that because candidates are hired earlier, interviews may be less informative, which means program directors have to rely more on recommendation letters and other

sources of information. Clearly, if an internal medicine resident is from the same hospital, and has had a rotation in the GI unit, this unit will have more information on this applicant than on more distant applicants (and more information than other GI programs), and this difference increases as the information on outsiders becomes more noisy. Another reason why markets that unravel may rely more on networks is that the unraveled GI market had more candidates reneging on their acceptance, as internal medicine residents faced offers even earlier than before (and it may be harder to plan two years instead of one year in advance). Hiring fellows within a network may help reduce the enforcement problem and reduce the likelihood that a candidate reneges on his or her acceptance.

To address whether the market for GI fellows yields a different outcome when it used a centralized match than before or after, we purchased data from the AMA that includes the career path of every living U.S. physician who has completed or is currently completing a GI fellowship, is a board-certified gastroenterologist, or claims gastroenterology as a specialty (see Niederle and Roth 2003b). The data consist of the year in which each physician graduated from medical school and finished each residency, the location of each residency, and the medical school attended. Of the 15,187 entries we have a total of 9,180 fellows who completed a residency and a subsequent GI fellowship in the United States after 1977. They do their fellowship in 433 different hospital codes and come from 680 residencies.

Figure 7.3 shows the mobility of those fellows before, during, and after the fellowship match (i.e., whether they move to a different program, a different city, or a different state between their residency and the fellowship). We view 1997 as the first year in which the market was no longer effectively organized via the match. That is, gastroenterology fellows who got hired in

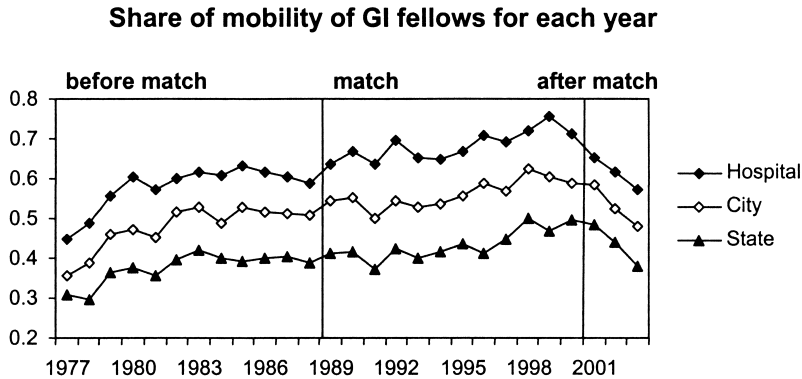

Fig. 7.3 Share of mobility of GI fellows for each year

Note: The vertical lines indicate the beginning and the end of the use of the centralized match, measured in year of fellowship *completion.*

Table 7.3 Differences across mobility

	Prematch—Match	Match 1—Prematch	Match 2—Match 1	Postmatch—Match 2	Postmatch—Match	Postmatch—Prematch
Hospital	.079	.052	.053	–.096	–.069	.009
	(.00)	(.00)	(.02)	(.02)	(.04)	(.52)
City	.059	.032	.054	–.058	–.031	.028
	(.00)	(.02)	(.00)	(.07)	(.19)	(.41)
State	.041	.014	.053	–.026	0	.041
	(.00)	(.099)	(.03)	(.44)	(.89)	(.23)

Notes: Prematch: 1980–88; match: 1989–2000; match 1: 1989–1994; match 2: 1995–2000; and Postmatch: 2001–2003; Differences in mobility, with *p*-values in parentheses.

1997, started employment in 1998, and finished in 2001 will have obtained their job after the match had started to break down. Note that the figure shows each fellow by the date when he or she ended the fellowship. Since fellowships were required to be two years before 1996, but three years since then—and the match operates a year before employment starts—gastroenterologists ending their fellowship in 1989 were the first ones who could have gone through a match, while those ending in 2001 were those who had no functioning match anymore.

Before the match, and after the collapse of the match, fellows were much more likely to perform their GI fellowship at the same hospital at which they performed their internal medicine residency. There is a statistically significant increase in mobility with the introduction of the match, and for the hospital and the city level there is a significant decrease in mobility since the demise of the match compared with the six years when the match was well established. Table 7.3 provides the differences across mobility with *p*-values, where we use a two-sided Mann-Whitney *U* test, with the proportion of mobility in each year as our data points.

Furthermore, we divided our sample into large and small GI fellowship programs. We found that larger programs hired a smaller proportion of local fellows than small programs (at the hospital, city, and state level). The effects of the match are larger and more significant for large programs than for small ones.[10]

Note that the increase in mobility is gradual, as measured over the first and second six-year periods of the match. This conforms to experimental

10. We also controlled for various other possible impacts, such as the fact that because of the consolidation of hospitals, some hospitals may have changed their name, introducing a spurious mobility at the hospital level. To control for this source of bias we eliminated for each hospital the first three years of observation (and hence eliminated fellows who may have finished their internal medicine residency in the same hospital when it had a different name). Note that the proportion of GI fellows who finished their GI fellowship by three years after their previous residency was always at least 70 percent. The qualitative results do not change.

evidence (Kagel and Roth 2000; McKinney, Niederle, and Roth 2005) in which the centralized match only gradually becomes fully used by participants.

An alternative explanation for the increase in mobility during the use of the centralized match is not that the match affects the process, but rather changes the self-selection of interns who aim for a GI fellowship. Specifically, it could be that physicians who are more mobile choose to do a GI fellowship whenever the market operates through a centralized match. To account for that, we can compute for each GI fellow a measure of "mobility" that corresponds to a change in city or state between finishing medical school and the residency they completed just before entering their GI fellowship (this reduces the sample to 6,789 physicians, as we discard all foreign medical graduates). While physicians become less mobile as their career advances, we do not find any evidence that the mobility of GI fellows during the match is driven by an increase in mobile physicians who choose to become gastroenterologists.

Therefore, the decentralized GI fellowship market was not only congested and thin, it also produced different outcomes than when it was organized through a match. With the loss of the centralized clearinghouse, the market broke down into more localized markets (the market became not only thin in time, but also in space).

7.4.3 Did the Clearinghouse Affect Salaries?

Another aspect of the matching of fellows to GI programs is not only who works where, but also under what conditions—specifically, at which salary. This question drew a lot of attention after, in May 2002, sixteen law firms filed a class action lawsuit on behalf of three former residents, seeking to represent the class of all residents and fellows, arguing that the National Resident Matching Program (NRMP) violated antitrust laws and was a conspiracy to depress salaries. The lawsuit was against a class of defendants, including the NRMP (which also operates the Medical Specialties Matching Program [MSMP]), other medical organizations, and the class of all hospitals that employ residents. (*Jung et al. v. Ass'n of Am. Med. C., et al.,* Class Action Complaint, No. 02-CV-00873, D.D.C. May 5, 2002).[11]

One way to investigate whether a match affects salaries of medical fellows is to examine comparable medical subspecialties, only some of which use a match (see table 7.4). Niederle and Roth (2003a) and (2004) compare

11. Another aspect that received considerable attention is the number of hours residents and fellows have to work each week, prompting demand for legislation to limit the hours per week to eighty. There are two reasons we did not focus on hours worked. First, the limitation to eighty hours is in general not binding for fellows, and more importantly, hours come in very different flavors and are not readily comparable across fellowship programs: some hours are spent on research, patient care, and educational activities, and may have considerable positive value, while others spent on clerical activities may be a cost.

Table 7.4 Salaries in Internal Medicine Subspecialties

Specialty	Match	No. of programs	Mean salary	Standard deviation	Min	Max
PUD	MSMP	26	45,418	5,859	37,185	58,536
CCM	No	31	43,460	3,376	36,966	50,422
IMG	No	90	43,266	4,989	28,200	58,536
HEM	No	17	42,952	4,739	36,000	51,853
ON	No	24	42,650	4,922	28,200	51,853
HO	No	110	42,526	4,415	32,000	58,328
NEP	No	118	42,426	4,357	30,733	58,328
ID	MSMP	124	42,352	4,863	30,000	58,328
CD	MSMP	153	42,288	4,246	26,749	54,450
PCC	MSMP	111	41,973	4,268	26,916	53,463
GE	No	142	41,800	4,638	26,000	58,328
END	No	103	41,656	4,000	33,700	53,463
ISM	No	2	41,390	1,259	40,500	42,280
RHU	No	97	41,182	4,743	28,824	58,328

Notes: For each specialty the number of programs reporting a positive salary, the mean salary, the standard deviation, the minimum and the maximum salary. The specialties are: PUD: pulmonary disease, CCM: critical care medicine; IMG: geriatric medicine; HEM: hematology; ON: oncology; HO: hematology and oncology; NEP: nephrology; ID: infectious disease; CD: cardiovascular disease; PCC: pulmonary disease and critical care medicine; GE: gastroenterology; END: endocrinology; ISM: internal sports medicine; RHU: rheumatology. We use the data from the Graduate Medical Education Library 2003–2004. We use all internal medicine subspecialties that require three years of prior residency, and all nonmilitary programs that record a positive wage and are not in Puerto Rico.

salaries of nonmilitary U.S. fellowship programs in all internal medicine subspecialties that require three years of prior residency. The data are from the Graduate Medical Education Library 2002 to 2003 and 2003 to 2004, respectively.

Using the 1148 salary data for 2003, a simple regression of the salary on a match dummy yields a constant of $42,210.76 (s.e. 168.04, $p = 0.00$) and a coefficient on the match dummy of $208.33 (s.e. 279.82, $p = 0.46$). That is, specialties that use a match do not have significantly lower salaries.[12]

To account for possible effects of hospital size (since match specialties tend to be larger), we want to determine whether, within hospitals, salaries for specialties that use the match are different than for specialties that do not. In the next regression we therefore include a dummy variable for each hospital when regressing the salary on a match dummy (there are 201 different hospitals, of which 165 have both match specialties and specialties that do not use the match). The regression yields a constant of $42,650

12. The salaries of GI fellows, while somewhat on the low side, are not significantly different (at any conventional level of significance: lowest is 0.16) from either the specialties that participate in a match, or the specialties that do not.

(s.e. 2372.30, $p = 0.00$), and a coefficient on the match dummy of \$343.86 (s.e. 152.60 and $p = 0.024$). That is, within hospitals, the salaries of fellows whose specialty uses a match are higher than those that do not use a match, but the differences are not economically relevant; they are on the order of 1 percent of the salary.[13]

That is, while salaries may not be very high, empirically it does not appear that using a match affects the salary level in any way.

The lawsuit spurred a number of theoretical papers. Bulow and Levin (2006) provide some support for the lawsuit in a simple theoretical model. They compare a market with impersonal pay (that is, a market in which pay is attached to *positions* rather than depending on which applicant is hired for the position) to a market with perfectly competitive salaries at which each worker is paid his or her marginal product. They find that in their model, a market with impersonal salaries leads to lower average salaries and a more compressed pay schedule.[14]

Subsequent theoretical work has shown that these conclusions about pay compression do not necessarily follow if the model is expanded to include the possibility of firms hiring more than one worker (Kojima 2007).

There are centralized algorithms that allow for pay to be flexible, and whose outcomes can yield a competitive equilibrium (Kelso and Crawford 1982). The preferences firms and workers submit to a centralized match in such an algorithm consist of a ranking of each other for any possible pay. For example, a worker would indicate that his or her first choice is to work for a certain firm at a certain salary, his or her second choice may be to work for the same firm at a lower salary, and his or her third choice could be to work for another firm at the higher initial salary, and so on. While the centralized clearinghouse does not use exactly this algorithm, it uses the Roth and Peranson (1999) algorithm, which allows firms to list alternative positions at different salaries, and to express preferences for some workers in only some positions. This algorithm, in the environment studied by Bulow and Levin (2006), can yield competitive outcomes (Niederle 2007). A centralized clearinghouse using the Roth and Peranson (1999) algorithm therefore, does not reduce price competition per se.

How would a *decentralized* market yield competitive wages? In general, the assumption is that if a wage is below the competitive level, either the worker or some other firm becomes aware of an arbitrage opportunity, which would

13. However, within hospitals, GI fellows earn somewhat less than both the average fellow in a specialty that has a match, and the average fellow in a specialty without a match. While the results are statistically significant, they are not economically significant—they are very small (less than \$1,000), no more than 2 percent of the salary. Using Graduate Medical Education Library 2002 to 2003, the salary difference for gastroenterology fellows is only 268.64 and the difference is not significant. Otherwise, the results are similar when we use data from the Graduate Medical Education Library 2002 to 2003 (see Niederle and Roth 2004).

14. Bulow and Levin note that the empirical evidence in Niederle and Roth (2003a) does not bear this out in the actual market data.

eventually lead to a competitive outcome. This was implicitly the motivation for the lawsuit: the notion was that without a match, residents would receive many offers, and bargain until they receive their competitive outcome. We already showed that in the market for internal medicine residents seeking GI fellowships, the decentralized market is far from one in which residents can safely wait for multiple offers. Instead, the market is characterized by exploding offers made at very dispersed times that do not allow residents to seek out multiple offers simultaneously.

We studied empirically whether the limited offers that can be obtained simultaneously lead to bargaining (Niederle, Proctor, and Roth 2006). We asked gastroenterology program directors in the survey whether they offered different terms to different fellows, and whether wages were adjustable. Out of sixty-three program directors, all but four, (i.e., 94 percent) offered the same salary to all their fellows. Furthermore, all but four (although not all the same four programs) offered the same hours on call. While eighteen of the sixty-three programs (29 percent) offered different fellows different amounts of time for research, all but three of these programs formally differentiated the kinds of fellows doing different jobs (i.e., they had at least two kinds of fellows). That is, not many program directors offered different contracts to different fellows they hired in the same year (and remember that we oversampled the larger programs, which have more than one fellowship per year). All program directors responded that offers were not adjusted in response to outside offers and terms were not negotiable.

In general, markets with impersonal pay may be more common than standard models would suggest.[15] Thus, while different programs offer different salaries and terms, and while program directors respond in many other ways to the contingencies that arise in the course of the hiring process (such as adapting the timing and length of their offers), it does not appear that they adjust the terms of their offers to the situations of individual candidates. Rather, as the market for GI fellows abandoned the match it seems to have become less competitive, in the sense that at each point in time, residents did not face the whole market, but only the smaller set of programs that made offers at that time. And indeed, some fellows lamenting the loss of the match did so for that reason.[16]

A centralized match halted unraveling and solved congestion, allowing for a thick GI fellowship market, in which programs and fellows could safely

15. Wages seem to be also rather inflexible when it comes to junior hiring of professors. Assistant professors who start in the same department and the same year often receive almost the same salary, and some departments make that a policy.

16. Gastroenterology fellows Bauer et al. (1999) commented on the effects of the loss 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."

make and consider their offers. This led to a more national market with increased mobility of GI fellows. Furthermore, there is no theoretical or empirical evidence that a clearinghouse using the Roth and Peranson (1999) algorithm adversely affects the terms of the contracts.

Reflecting these considerations, President George W. Bush signed into law, as an addendum to the Pension Funding Equity Act of 2004, legislation that included a Congressional finding that "Antitrust lawsuits challenging the matching process, regardless of their merit or lack thereof, have the potential to undermine this highly efficient, procompetitive, and longstanding process. . . ." The legislation goes on to "confirm that the antitrust laws do not prohibit sponsoring, conducting, or participating in a graduate medical education residency matching program, or agreeing to do so. . . ." Following this legislation, the antitrust suit was dismissed.

7.5 Changing the Market Organization

The market for GI fellows raises two kinds of questions about the organization of a market. The first is why this match broke down (and why failures of centralized clearinghouses that produce stable matchings are so rare). The second is how can an unraveled, decentralized market be reorganized through a clearinghouse.

7.5.1 Why Did the GI Match Fail, and Why Are These Failures So Rare?

The market for GI fellows is among many markets that introduced a centralized match to overcome problems of unraveling and congestion. Empirically, markets that use a centralized algorithm that produces a stable outcome are more successful in remaining in use than those that do not. Of particular interest in this regard are the centralized clearinghouses used in various regions in the British National Health Service (NHS). In the 1960s, these markets suffered from the same problems as the American market for medical interns in the 1940s (successfully solved by the centralized match, the NRMP). A Royal Commission recommended that each region of the NHS use a centralized clearinghouse, and the various regions in Britain each invented their own algorithm, of which only some were stable.[17] Clearinghouses that produced

17. An example of unstable algorithms, are "priority algorithms" that use the exact place in which firms and workers rank each other. For example, Roth (1990, 1991) observed clearinghouses in Newcastle and Birmingham that first matched all firms (medical practices) and workers that listed each other first. After all such "1-1" pairs, 1-2 pairs were matched; that is, pairs in which the workers list the firm first, and the firm lists the worker second, followed by 2-1 pairs, and so forth. At each step, matched firms and workers are removed and the order of removal is given by the product of the worker-firm ranking, where in case of the same products priority is given to workers. This can create unstable outcomes. Consider a firm F and a worker A that both list each other 4th, which gives them priority 16. Now assume some other worker B lists firm F first, and the firm F lists him or her 15th. Nonetheless, this gives them priority 15, and hence firm F will be matched to worker B over worker A, who may receive some other lower-ranked firm that lists him or her highly, in which case worker A and firm F would be a blocking pair, in that they would rather be together than with their current matches.

stable matches succeeded, while others mostly did not (Roth 1991). However, considering all markets that use centralized clearinghouses, this correlation is not perfect—some matches with algorithms that do not provide stable matches survive, and some stable match algorithms fail. Furthermore, there are more differences between markets than simply the algorithms they use. Thus, controlled experiments can help clarify what is going on.

Kagel and Roth (2000) report an experiment that compares two small unraveled markets in the laboratory. In one, the stable matching mechanism observed in Edinburgh was introduced, while in the other the unstable mechanism used in Newcastle was used. In these otherwise identical sets of markets, the markets that used a stable algorithm adopted the clearinghouse successfully, and continued to use it. The markets that used the Newcastle mechanism that does not produce stable outcomes did not adopt the clearinghouse successfully, and the markets continued to experience offers and acceptances before the operation of the centralized clearinghouse.

Having a stable algorithm thus seems to be an important factor for a centralized clearinghouse to perform well, and continue to be used, and, as table 7.2 shows, most of these have been successfully in operation for years. The market for GI fellows is unusual, in that it used a centralized clearinghouse with a stable algorithm, and then, in the late nineties, started to unravel.

These events seem to have been set in motion in 1993 to 1994, when, in the middle of general discussions of health care reform, gastroenterology subjected itself to a manpower analysis. The resulting study was published in 1996 (Meyer et al. 1996). Its main conclusions were that the U.S. 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 percent reduction in the number of GI fellows over five years. Furthermore, an additional year of training was mandated: starting in the summer of 1996, three years of training were required to be eligible for board certification as a gastroenterologist, instead of two.

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

However, the announced (and hence expected) reduction in supply was accompanied by 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. This resulted in a record low fill rate: only 74.8 percent of the positions in the match were filled through the match that year.

The next year, 1997, saw a sharp decline in the percentage of positions in the match. In particular, table 7.5 (Niederle and Roth 2003b) describes how withdrawal of positions from the match (as programs and applicants

Table 7.5 Participation in the gastroenterology match

Yr.	Positions advertised	Percent withdrawn	Positions in match	Percent matched	Number of programs	Number of applicants	Applicants per position in match
1992	—	—	377	96.6	160	658	1.75
1993	374	–6.7	399	94	173	642	1.6
1994	—	—	369	93	169	591	1.6
1995	351	4	337	88.7	171	433	1.3
1996	313	4.8	298	74.8	164	277	0.9
1997	254	16.1	213	85	128	240	1.1
1998	178	44.3	99	77.8	60	148	1.5
1999	35	60	14	—	11	—	—

Notes: For each year, Positions advertised is the number of positions whose availability in the match was announced in late March. Until late May, the programs may add or withdraw positions (Percent withdrawn), which leaves the final number of positions in the match (Positions in match). Percent matched is the percentage of positions in the match that are filled by the match. Number of applicants is the total number of applicants who listed at least one GI program in their rank order list.

reached agreements outside of the match) preceded the formal demise of that match. Withdrawals went from about 5 percent in 1996 to 16 percent in 1997, to 44 percent in 1998, to 60 percent in 1999, in each case followed by a sharp reduction the following year in the number of positions even advertised in the match, and after 1999 the match was formally abandoned, having already become moribund, as almost all positions were filled outside of the match.[18]

If a simple shift in supply or demand were enough to cause a match to collapse once it had become successfully established, many other markets, including other internal medicine subspecialties, would also have failed matches, since these shifts turn out not to be so rare. What was unusual about the change that the gastroenterology match experienced in 1996 was that it temporarily *reversed* the traditional excess supply of applicants (in table 7.5, the ratio of applicants to positions in the match dropped below 1 in 1996). None of the other internal medicine subspecialty matches (cardiovascular disease, pulmonary disease, and infectious disease) experienced such a shift. Infectious disease successfully operates a match in which there are persistently fewer applicants than positions.[19]

18. Dr. David Brenner, quoted in Gerson (1999), described that demise in part as follows: "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."

19. From 1990 to 1998 the ratio of applicants to positions offered in the cardiovascular match varied from a high of 1.6 to a low of 1.3. For pulmonary disease those ratios varied from a high of 1.5 to a low of 1.1, and for infectious disease (from 1994 to 1998) those ratios varied from a low of .68 to a high of .92. Thus, unlike in the gastroenterology market, the short side of these markets did not change, although in infectious diseases the *applicants* were in short supply, and in the other matches the *positions* were in short supply (Niederle and Roth 2004).

There are limits to the confidence with which one can draw conclusions simply by studying the circumstances in which rare events (like the collapse of a stable match) occur. So, one way to gather more evidence is to create small artificial markets in the laboratory and subject them to controlled changes in supply and demand. McKinney, Niederle, and Roth (2005) find in the laboratory that *anticipated* shifts in supply in demand, visible to both sides of the market, do not cause declines in match participation anywhere near the magnitude caused by unanticipated shocks, particularly when these are more visible to one side of the market than to the other. In particular, they consider shifts in demand for positions that are either visible to both firms and workers, or only to firms (as when an unexpected change in demand becomes visible to firms when they receive few applications, but not to workers). They find that demand reductions of both kinds cause firms to try to make more early hires, but that when workers know that they are on the short side of the market they are more likely to decline such offers than when they are unaware of the shift in demand. It is the combination of firms making early offers outside of the match, and workers not feeling safe to reject them and wait for the match that causes the market to unravel in the experiment. That is, the experiment shows that this combination of events can by itself be sufficient to cause the breakdown of a match. The results are thus suggestive that the same combination of events in the late 1990s caused the breakdown of the GI match.

On the basis of these results, McKinney, Niederle, and Roth (2005) conjecture that the breakdown in the GI market in 1996 was due to the unusual shock that caused an unanticipated reversal in the short side of the market, with many fewer high-quality residents wishing to start a GI fellowship. This increased incentives for programs to try to capture those GI fellows early. And because the shock was unusual, and not predicted, remaining residents may not have felt safe to reject early offers. The evidence supported the conjecture that now that market conditions had stabilized, a match could once more be successful.

7.5.2 Beyond Centralized Matching: Why Do Some Markets Work Well, while Others Do Not? How to Restart the GI Match?

The market for GI fellows seems to have broken down due to an unusual event, and then once more experienced unraveling and congestion. Clearinghouses solve both problems: they bring participants to the market at the same time and they overcome congestion. This helps to make it safe for participants to act according to their preferences over other participants, without additional constraints on behavior imposed by inferior market organization. The supply and demand for GI fellowships had stabilized in the interim, and many participants on both sides of the market wanted to have a match once again, so all seemed favorable for a successful restart.

To assess the demand by fellowship programs for a restart of the match,

the questionnaire we administered to GI program directors in January 2005 (Niederle, Proctor, and Roth 2006) also asked "Do you think a match would be better than the current system if most programs would adhere to it?" Of the sixty responses, fifty said yes, and many of those who said no indicated that "most" would not be enough for them to have confidence in the match.

Following the announcement of the new GI match, communications from program directors confirmed that this was a lively concern, with some expressing concern about specific programs they regard as competitors.[20]

Program directors who wished to participate in the match worried that if their competitors made early offers, then applicants would lose confidence that the match would work and consequently would accept those early offers, because that had been the practice in the decentralized market. That is, in the first year of a match, applicants might not yet feel that it is safe to reject an early offer to wait for the match. Program directors who worried about their competitors might thus be more inclined to make early offers themselves. Recall that, before the reintroduction of the match, many program directors sped up offers because they felt pressured by applicants who were disappearing from the market in response to the early offers of other programs.

This raises the more general question as to why some markets unravel and experience congestion problems in the first place (and hence are good candidates for introducing a centralized match), and what are good policies to make markets operate at a later time.

Empirically, most markets that have been observed unraveling are markets in which employers make short-duration offers, and in which the acceptance of an offer is binding (see Niederle and Roth [2009]; for a description of the market for law graduates seeking employment as appellate court clerks see Avery et al. [2001, 2007], and for college admissions see Avery, Fairbanks, and Zeckhauser [2003]).[21]

On the other hand, there are markets that do not unravel, such as the market for graduate school admission. In this market, a policy (adopted by the large majority of universities) states that offers of admission and financial support to graduate students should remain open until April 15.

> Students are under no obligation to respond to offers of financial support prior to April 15; earlier deadlines for acceptance of such offers violate

20. In June 2005, our colleague Debbie Proctor, the gastroenterologist who took the lead in reorganizing the match, sent us an e-mail 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?"

21. Since 2003, the market for law clerks has succeeded in moving hiring new graduates nearer (by a year) to the date of graduation (and the beginning of employment). But exploding offers with binding agreements have kept the market very thin (Avery et al. 2007; Haruvy, Roth, and Ünver 2006).

> 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. Similarly, an offer by an institution after April 15 is conditional on presentation by the student of the written release from any previously accepted offer. It is further agreed by the institutions and organizations subscribing to the above Resolution that a copy of this Resolution should accompany every scholarship, fellowship, traineeship, and assistantship offer.

This, of course, makes early exploding offers much less profitable. A program that might be inclined to insist on an against-the-rules early response is discouraged from doing so in two ways. First, the chance of actually enrolling a student who is pressured in this way is diminished, because the student is not prevented from later receiving and accepting a more preferred offer. Second, a program that has pressured a student to accept an early offer cannot offer that position to another student until after the early acceptance has been declined, at which point most of the students in the market may have made binding agreements.

Niederle and Roth (2009) study in the laboratory the impact of the rules that govern the types of offers that can be made (with or without a very short deadline) and the commitment of applicants upon accepting an offer. Firms decide when and to whom to make offers, while information about the quality of applicants is only revealed over time. In these small environments, designed so they are not prone to congestion, either eliminating the possibility of making exploding offers or making early acceptances nonbinding helps prevent markets from operating inefficiently early.

In practice, it is very hard to enforce the time at which programs make offers and how long offers are left open. The policy of making acceptances nonbinding instead helps the applicants themselves deal with such early and short offers. Because applicants can accept these offers without compromising their availability for subsequent offers from programs they prefer, no program need feel pressured to make an early offer itself just because another program is doing so.

We proposed a similar policy, adapted to the situation of the upcoming GI match (Niederle, Proctor, and Roth 2006). Ideally, such a policy would remove any temptation for fellowship programs to extend early offers and ask for a response before the match, by allowing applicants who had accepted early offers nevertheless to participate in the match. Under such a policy, an applicant who had accepted a prematch offer would be able to enter the match, listing only programs he or she preferred to the early offer. The match result would be binding, and if the applicant were

successfully matched, he or she would then be freed from his or her prematch commitment and able to fulfill his or her commitment to the match. Under such a policy, programs would have little incentive to ask for prematch agreements, because doing so would give them no advantage in "capturing" candidates who would have preferred to consider all the options available in the match and await the match outcome. Note that programs would not lose in any way the ability to attract candidates who genuinely regarded them as their first choice, because any program and applicant who list each other first in the match are guaranteed to be matched to one another.

A modified version of this policy 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. While it does not allow applicants who have accepted early offers to participate in the match before declining those offers, it does allow them to decline early offers and then participate in the 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.[22]

The gastroenterology match for 2007 fellows was held June 21, 2006, and succeeded in attracting 121 of the 154 eligible fellowship programs (79 percent). Ninety-eight percent of the positions offered in the match were filled through the match. Niederle, Proctor, and Roth (2008) show that in the second year of the new centralized match the interview dates were successfully pushed back and are now comparable to those of other internal medicine specialties that have used a centralized match for many years. Furthermore, there is considerable enthusiasm for the new match.

22. http://www.gastro.org/user-assets/Documents/04_Education_Training/Match/Match_Resolution_Nov_5_05_final.pdf.

7.5.3 Other Effects of the GI Match

There is an additional unexpected advantage of the match. It changed not only the timing but also the nature of interviews between candidates and fellowship programs (Niederle, Proctor, and Roth 2008). Interviews conducted prior to the match were more informative than those that had been conducted as part of the decentralized hiring process, and not only because they are now conducted later in applicants' careers, and hence with more information. The early impression is that the fact that interviews no longer lead immediately to offers changes the interaction: candidates are more relaxed, less anxious to please, and the discussion is more focused on the fellowship and the candidate, that is, on the transfer of information relevant to evaluating the quality of the match between that candidate and that position.

A further advantage of using a centralized match, briefly mentioned previously, is that a match also allows for programs to flexibly fill different kinds of positions. The GI fellowship match has been set up through the NRMP/SMS so that programs may offer four different tracks or categories through the match: (a) clinical, (b) clinical investigator research, (c) basic science research, and (d) research. Each track in every program is given a unique identifying code number by the NRMP/Specialty Matching Services (SMS). For each track, a program will submit a separate rank order list of applicants in preferred order. Furthermore, the program can specify that if it does not fill all of its available positions for one of its tracks, the position(s) can be *reverted* (i.e., reassigned) to one of the other tracks. In particular, by using the flexibility of the reversion algorithm, the match removes the pressure on programs to fill research positions early because, if a research position cannot be filled, it can automatically be converted into a clinical position.

Note that the move to a match does not appear to be a Pareto improvement: not all prospective GI fellows and GI program directors benefit from a match compared to a decentralized market. Recall that a decentralized market is a very local market, in which GI fellows were often internal medicine residents at the same hospital. In a more national market mediated by the match, therefore, some lower-prestige programs that were accustomed to recruiting talented local residents may find that these residents can now go to more prestigious programs elsewhere. Indeed, there are GI fellowship programs that were not pressing for gastroenterology to rejoin the match, and preferred the market to operate in a decentralized way, for this reason (Ehrinpreis 2004).[23]

23. This was seen very clearly in the experimental results of McKinney, Niederle, and Roth (2005). In the lab, unraveled markets were less efficient, and so there was less assortative matching. But this meant that some low-productivity employers were matched with some frequency to higher productivity workers than they could attract at a stable match, and such employers do less well under a stable matching mechanism operated at an efficient time (see also Niederle and Roth 2009).

7.6 Gastroenterology as a Case Study of Some General Phenomena

The market for gastroenterology fellows provides a case study for the effects of a centralized match and illustrates some challenges facing decentralized markets. As we have discussed, in periods in which it was decentralized, the market for gastroenterology fellows unraveled, but a centralized clearinghouse helped the market maintain thickness, avoided congestion, and with appropriate supporting rules about offers and acceptances, made it safe for applicants and employers to participate.

Which of the lessons learned from the GI market have relevance for other markets? And what makes markets prone to the problems faced by gastroenterologists—namely, lack of thickness, congestion, and lack of safety for market participants to act straightforwardly according to their preferences? While we were able to study the gastroenterology fellowship market in unusual detail, we observe many pieces of the pattern in other markets (cf. Roth and Xing 1994, 1997). Most recently we studied the market for orthopedic surgery fellows, which shows patterns very much like the market for GI fellows (Harner et al. 2008).

Another market recently studied in detail is the market for law clerkships. A prestigious and valuable career step for lawyers, after they finish the three years of law school, is to clerk for a senior federal judge. Over the past decades, the market moved from hiring students at the end of the third year to the beginning or middle of the second year of law school. The past two decades have been characterized by a multitude of reforms that try to regulate the timing and nature of the hiring process. These lasted, on average, three years, and share the fact that they all failed, apart from the most recent attempt, which is still ongoing (Avery et al. 2007).

While most of the market is now officially coordinated to make offers only after a specific point in time (most recently, this was Monday two weeks after Labor Day), the market is still thin. Most offers are exploding offers, which are often accepted instantly (even when they are not from the most preferred judge who offered an interview), resulting in a market that moves very fast. Because congestion has not been solved and exploding offers are still ubiquitous, a large proportion of applicants only receive one offer, and many judges do not make multiple rounds of offers. This is not a marketplace in which applicants can safely wait for more desirable offers, or judges can wait to make offers until they interview all candidates.

Hence, moving a market to an agreed-upon time window is not sufficient to solve problems of thickness, congestion, and safety. Indeed, the market appears to once more be experiencing some unraveling. Many judges have made offers shortly before the allowed time. Those who do so have access to a large applicant pool, and no information on applicants is lost by moving only a few days early.

Another well-studied market that experienced problems similar to those

in gastroenterology is the very small market of post-season college football games, called "bowls" (Roth and Xing 1994; Fréchette, Roth, and Ünver 2007). In the early 1990s, the determination of which teams would play each other in which bowls was often made when several games still remained to play in the regular fall season. Most bowls had long-term contracts with football conferences, at least for one of the two teams that would play in their post-season bowl game, and had to recruit the other team. The National Collegiate Athletic Association (NCAA) tried for years to prevent the unraveling of the dates at which bowls and teams finalized agreements about which teams would play in which bowls. However, it gave up in failure following the 1990 to 1991 football season, in which early matching—when there were still four games left to play in the regular season—(once again) led to poorly matched teams. (A team that looks like a champion with four games still left to play will not look as good at the end of the season if it has lost some of those games.) Starting in 1992, a series of reforms eventually led to a reorganization through the Bowl Championship Series (BCS), in which a consortium of four bowls (Rose, Fiesta, Orange, and Sugar) and six athletic conferences agreed to do the matching of teams to bowls only after the conclusion of all regular season games, and always allow for a matchup in one of the participating bowls between the two highest-ranked teams in the BCS rankings. Fréchette, Roth, and Ünver (2007) show that the missed championship matchups (i.e., the number one team playing against the number two team according to the Associated Press [AP] Sportswriters' end of regular season rankings) in the precoalition era were due not only to precommitments of conferences to bowls, but largely also due to in-season unraveling that led to the selection of teams while games were still to be played.[24] Matchups between top-ranked teams has significantly increased in the coalition era, which has led to more viewers as measured by Nielsen ratings of the televised games. To the extent that the number of viewers is a measure of the output of this industry, this means that the changes in market organization that led to later and improved matchings substantially increased output and efficiency.

7.6.1 Do Problems of Congestion, Thickness, and Safety Afflict Only Special Markets?

How special is the market for GI fellows? Given the variety of markets that have experienced at least some of the failures that afflicted the GI fellows market, we consider some features of the market that we know are *not* special.

24. Four weeks prior to the end of the season, the top two teams have only a 35 percent chance to remain the top two teams at the end of the season, while it is 69 percent one week prior to the end of the season (and 100 percent if the teams are picked after the conclusion of the regular season [Fréchette, Roth, and Ünver 2007]).

The Size of the Market

The GI fellows market has about 300 fellows a year. The market for post-season college football bowls is substantially smaller, while the market for medical residents is much larger, with over 20,000 positions a year. An even larger market that has experienced significant unraveling is the market for college admission. In the late nineties, many highly ranked universities filled 40 to 60 percent of their slots through "early admission" (Avery, Fairbanks, and Zeckhauser 2003). In early admission, as opposed to regular admission, students submit their applications around October or November, as opposed to January; that is, without information about their fall semester of their last year in high school. Most early admissions programs allow students to only apply early to one program, and some (called "binding early decision") require students to agree to attend if accepted early. In this respect, early college admissions is not only unraveled in time, but it also becomes a thin market in which at least some students can entertain no more than one offer of admission.

Entry-Level Labor Markets Only?

The market for college football bowls has suffered from problems of thickness, congestion, and safety.[25] So has the market for college admissions (although it shares some of the property of an entry level labor market).

Price-Regulated Markets Only?

The market for college football bowls is a market in which prices are not regulated but which also suffered from unraveling. Similarly, in the late 1980s, the market for new law associates at large law firms substantially unraveled as summer associate positions increasingly became the channel through which new lawyers were hired, in a market that also showed active yearly wage competition (see Roth and Xing 1994).

7.6.2 Discussion

It is worth spending a little time reflecting on why unraveled, congested markets fail to produce competitive, stable outcomes; that is, why standard arbitrage and recontracting arguments fail. Suppose there is an outcome that is not competitive—why would a firm and a worker who would both prefer to be matched to each other not act on this, and match to each other, as opposed to his or her current partner? There are (at least) two constraints commonly observed in naturally occurring markets. The worker may have

25. Li and Rosen (1998), Li and Suen (2000), and Suen (2000) show how unraveling can occur as a form of insurance in competitive markets. In their models, markets clear early but remain competitive. In the markets we study, the decentralized markets do not appear to be well modeled as perfectly competitive markets. See also Halaburda (2007), who models unraveling as a function of how correlated are the preferences of firms for workers.

agreed to some prior commitment and may not be free to change his or her mind. Alternatively, if firms have a limited number of positions, the firm may have already hired another worker, who it cannot fire at will, or easily, or without loss of reputation. Then why did the firm and the worker make these prior commitments in the first place? For firms and workers to realize their best possible outcomes, the market has to transmit sufficient information to allow firms and workers to determine their stable match partner without first engaging in binding commitments. Much of the benefit of a market has to do with bringing together many buyers and sellers at the same time, so that they can consider a wide range of possible transactions. This is, however, not what happens in unraveled markets that experience exploding offers: in such markets, participants are not able to gather information about multiple options and then act on that information to seek out their most preferred alternatives. Choices must be made from a very small set of alternatives and in a short period of time. Decisions are reached on the basis of very limited information.

While there are not many detailed models of congested decentralized markets, Niederle and Yariv (2009) show theoretically how exploding offers, even in markets in which no other frictions are present, in general do not allow participants to reach a stable outcome. The problem is that the transmission of information is reduced compared to markets in which offers are tendered without a binding deadline.[26]

This description of obstacles to a stable outcome suggests that markets that are especially prone to unraveling are markets in which frictions are important, such as high costs of making an offer, or a long time required to make an offer (or a high cost of waiting for some participants). It may also be that markets in which employers are not very flexible in the number of workers they can hire are especially vulnerable to the difficulties caused by congestion. Recall, for example, the college football bowls: in a market in which transactions are made early, there are costs to waiting too long to try to engage a team, as good teams may become committed to other bowls. Neither can a bowl simply add a third team to its game because it turns out that a good team was overlooked early in the market. That is, a bowl needs to field exactly two teams. Similarly, medical residency and fellowship programs have inelastic demand for residents and fellows because of the way that funding and sometimes accreditation of those programs are determined by their ratio of doctors to patients.

In contrast to markets in which the number of contract partners is strictly limited, in the market for graduate students most departments are somewhat flexible as to the number of students in their incoming class. This may be the main reason that they can successfully use the Council of Graduate Schools

26. See also Segal (2007) on the information needed to determine if an outcome is stable.

policy that promotes open offers to regulate the timing of their market (see section 7.5.2).

In the market for GI fellows, a similar policy was successful *in combination* with a centralized clearinghouse to solve the congestion problem. Since fellowship programs have quite inelastic demand for fellows, it is likely that, in the absence of a clearinghouse, a policy promoting open offers would have been insufficient. Before adopting a centralized match, the market for residents tried a policy of advocating open offers, but failed, because of the congestion that resulted when many offers all had deadlines at roughly the same time, so that employers whose offers were rejected found that most applicants had already accepted positions (Roth 1984, 2003).

In addition to markets in which the number of positions is very inflexible, many markets that experience unraveling are also markets in which there is important heterogeneity. Consider once more the market for college football bowls: there is a very important difference between the best team and the third best team, not to mention the seventeenth best. If all teams were the same, the problem of finding a good match of bowls and teams would be much more tractable. But because viewership is driven most by the chance to see the number one ranked team play the number two ranked team, bowls were willing to tolerate considerable risk to sign up early teams that might be number one or two when the season ended.

It appears therefore that markets in which there is not a high degree of flexibility in the number of positions, and in which heterogeneity is important, are markets that may be particularly susceptible to problems associated with thickness, congestion, and safety. Entry-level labor markets for elite professionals often seem to fit this profile, particularly when the simultaneous entry of many new workers (e.g., upon graduation from medical or law school) exacerbates potential congestion since many workers have to be matched at the same time.

Do Centralized Markets Increase Efficiency?

There are several levels of efficiency that can be considered. Simple Pareto efficiency is hard to violate: for example, in a market in which all sides agree on which are the good jobs and the good candidates, a matching that assigns the worst candidates to the best jobs is still Pareto efficient, as an assortative match would make low-quality candidates worse off. It is very hard to gather data on narrower notions of efficiency; for example, to measure if an unraveled market lowers the total welfare or productivity of gastroenterologists compared to a centralized match. It is, however, the case that the majority of fellows and program directors welcomed the new system.

This is why it was useful to study college football bowls, in which the coalition era led to an increase in viewership, a reasonable proxy for output. In laboratory experiments, too, total welfare (sum of earnings) is in general lower for unraveled markets, due to the costs imposed by unraveling (either

direct costs, or costs due to inefficient matchups, when hiring occurs before the final quality of applicants is known [Niederle and Roth 2009]).

Thus, although we often cannot measure efficiency loss due to unraveling, we have found inefficiency when we can measure it.

Why Do Only Some Markets Organize through a Centralized Clearinghouse?

Most markets that are organized through a centralized clearinghouse are markets that both (a) experienced very severe unraveling or congestion, in which the resulting inefficiencies were very widely felt, and (b) have a strong set of market organizations and institutions that were able to effectively coordinate market participants. This is certainly true for many medical labor markets that use a centralized match.[27]

While the sizable number of markets that use a centralized clearinghouse is still only a small proportion among all entry-level labor markets, many markets do experience problems of thickness, congestion, and safety. This means that employers, when making offers, not only have to assess how much they like each worker, but also how likely it is that the worker will accept an offer. This is because offers often have opportunity costs, because there are only a fixed number of positions, and the market moves ahead—that is, the pool of applicants for future offers becomes smaller over time, sometimes very rapidly. That is, there are costs to making offers that get rejected, since, in the meantime, other desirable candidates may have accepted commitments elsewhere.

Some markets that experience congestion and unraveling sometimes seek relief through other means than a centralized clearinghouse: they try to facilitate the process of transmitting information about how much candidates are interested in potential employers (see e.g., Roth and Xing 1997; Coles and Niederle 2007). In the economics junior market (for new PhDs), congestion is an issue when deciding which subset of about thirty applicants to interview at the ASSA meetings. Many departments face real constraints, as they have too many outstanding candidates they could interview, but need to make sure they also interview candidates that they would have a chance to hire later on. In this market it has been common that letters from advisors often would transmit specific interest for a place, or maybe even a country or continent. Last year, the AEA[28] instituted a centralized signaling facility,

27. The absence of a single strong professional society is presently making it somewhat difficult to change the market organization in the currently unraveled market for orthopedic surgery fellows. There are multiple orthopedic subspecialties that hire similar fellows. This is in contrast to the gastroenterologists, in which the American Gastroenterology Association had the largest number of members, and managed to coordinate with three other professional organizations on adopting a match, and appropriate policies to foster it.

28. Through its Ad Hoc Committee on the Job Market (Alvin E. Roth [chair], John Cawley, Philip Levine, Muriel Niederle, and John Siegfried). See http://www.aeaweb.org/joe/signal/signaling.pdf.

which applicants could use to credibly transmit signs of interest to employers, by allowing each job candidate to send a signal to at most two potential employers. This was used extensively; about 1,000 job candidates used the service in the year 2006 to 2007 (see Roth 2008b).

Market Failure and Market Design

Markets of all sorts need to provide thickness, deal with congestion, and make participation safe. Market failures often involve the failure to accomplish one or more of these things. How such failures can be fixed, however, often depends on the details of the particular market in question.

Consider again the problem of coordinating a market around a centralized clearinghouse, as opposed to having employers make early offers in a decentralized way. In the gastroenterology fellows market, the four relevant professional associations did not feel they could prevent program directors from making early exploding offers, but they did believe that they could effectively empower applicants to deal with such offers by allowing them to change their minds later. This was effective in moving the market from early exploding offers at dispersed times to wide participation in a clearinghouse.

Orthopedic surgery fellows face a very similarly unraveled market, with early offers at dispersed times (Harner et al. 2008). There is considerable doubt in that community, however, whether a policy allowing applicants to change their minds about accepted early offers would be as effective as it has been in gastroenterology. (Among other things, there is doubt that junior surgeons would feel able to break promises to senior surgeons, even if this was sanctioned by the professional societies.) However, unlike the case in the gastroenterology market, a number of the orthopedic surgery professional organizations feel that they could police the behavior of program directors and effectively prevent them from making early offers by imposing sanctions on offenders. Thus it is possible that the path to a labor clearinghouse in the orthopedic surgery market may be different from the one in gastroenterology. (This transition may also be complicated by the fact that there are fifteen professional organizations involved, rather than just four.)

The problems faced by federal judges who wish to reform the perennially chaotic market for clerks is made more difficult by the fact that they face a combination of the problems that confront gastroenterologists and orthopedic surgeons. Like the gastroenterologists, judges have no professional organization that is able to prevent early offers by judges. Like the orthopedic surgeons, judges may not be able to adopt any policies that would effectively allow law students to change their minds after having accepted an early offer. (In fact, in that market, not only do law students not feel free to change their minds about accepted offers, often they do not feel free to decline the first offer they receive; cf. Avery et al. [2001, 2007]; Haruvy, Roth, and Unver [2006].)

Sometimes, policies that might promote a centralized clearinghouse face

objections having nothing to do with feasibility. In the market for clinical neuropsychologists, a policy empowering applicants to change their minds after accepting an early offer seems feasible in principle. However, there are strong feelings on the part of some involved that such a policy would be repugnant. The current president of the relevant professional organization said in an e-mail "I have said it once, and I will say it again: Two wrongs do not make a right. To state it another way: The end does not justify the means. I will be strongly opposed to any attempt at [a] . . . policy that allows candidates to accept an offer outside of the match, participate in the match anyway, and then renege on their earlier 'acceptance.'" Constraints imposed by repugnance toward certain kinds of transactions may be as powerful as constraints imposed by the nature of the market, and have to be taken seriously by market designers (see Roth 2007).

While the underlying problems are similar in the four markets discussed previously, namely to ensure that offers and acceptances are made in a late, centralized market, the possible solutions and policies to achieve that depend on the details of the market, including constraints given by the structure of the market as well as its social norms.

7.7 Conclusions

The market for gastroenterology fellows provides a case study of market failure and of the ways in which centralized clearinghouses can sometimes fix them. It appears that labor markets and other heterogeneous markets can suffer from congestion, which can in turn lead to strategic behavior that can result in lack of thickness and add risk to straightforward participation in the market. Consequently these markets may not always function efficiently when left to their own devices, but may need market institutions to facilitate commerce. Professional organizations can sometimes play a useful intermediary role in establishing and maintaining such institutions. More research is needed to try to understand how labor markets work in detail, so that we can better understand when they work well, and can fix them when they are broken.

References

Avery, C., A. Fairbanks, and R. Zeckhauser. 2003. *The early admissions game: Joining the elite.* Cambridge, MA: Harvard University Press.

Avery, C., C. Jolls, R. A. Posner, and A. E. Roth. 2001. The market for federal judicial law clerks. *University of Chicago Law Review* 68:793–902.

———. 2007. The new market for federal judicial law clerks. *University of Chicago Law Review* 74 (Spring): 447–86.

Bauer, W. T., W. Fackler, K. Kongara, C. Matteoni, B. Shen, and M. Vaezi, 1999.

Comment to "It's Time to Bring the Best and Brightest Back to Gastroenterology." *Gastroenterology* 116 (4): 1014.
Bulow, J., and J. Levin. 2006. Matching and price competition. *American Economic Review* 96 (3): 652–68.
Coles, P., and M. Niederle. 2007. Signaling in matching markets. Preliminary Working Paper, May.
Ehrinpreis, M. N. 2004. Con: The gastroenterology fellowship match: R.I.P. *American Journal of Gastroenterology* 99:7.
Fréchette, G., A. E. Roth, and M. U. Ünver. 2007. Unraveling yields inefficient matchings: Evidence from post-season college football bowls. *Rand Journal of Economics* 38 (4): 967–82.
Gale, D., and L. S. Shapley. 1962. College admissions and the stability of marriage. *American Mathematical Monthly* 69 (1): 9–15.
Gerson, L. 1999. To match or not to match. In *Gastroenterology: An interview with David Brenner, MD, Chair of AGA's Manpower and Training Committee. AGA Trainee & Young GI News* 5 (1). Avaialble at: http://www.gastro.org/trainee/trainee6.html.
Halaburda, H. W. 2007. Unravelling in two-sided matching markets and similarity of preferences. Harvard Business School Working Paper no. 09-068. Cambridge, MA: Harvard University.
Harner, C. D., A. S. Ranawat, M. Niederle, A. E. Roth, G. P. DeRosa, P. J. Stern, S. R. Hurwitz, W. Levine, and D. Hu. 2008. Current state of fellowship employment: Is a match necessary? Is it possible? *Journal of Bone and Joint Surgery* 90:1375–84.
Haruvy, E., A. E. Roth, and M. U. Ünver. 2006. 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): 457–86.
Immorlica, N., and M. Mahdian. 2005. Marriage, honesty, and stability. *SODA 2005:* 53–62.
Kagel, J. H., and A. E. Roth. 2000. The dynamics of reorganization in matching markets: A laboratory experiment motivated by a natural experiment. *Quarterly Journal of Economics* 115 (1): 201–35.
Kelso, A. S., and V. P. Crawford. 1982. Job matching, coalition formation, and gross substitutes. *Econometrica* 50 (6): 1483–1504.
Kojima, F. 2007. Matching and price competition: Comment. *American Economic Review* 97 (3): 1027–31.
Kojima, F., and P. A. Pathak. Forthcoming. Incentives and stability in large two-sided matching markets. *American Economic Review.*
Li, H., and S. Rosen. 1998. Unraveling in matching markets. *American Economic Review* 88 (June): 371–87.
Li, H., and W. Suen. 2000. Risk sharing, sorting, and early contracting. *Journal of Political Economy* 108 (October): 1058–91.
McKinney, C. N., M. Niederle, and A. E. Roth. 2005. The collapse of a medical labor clearinghouse (and why such failures are rare). *American Economic Review* 95 (3): 878–89.
Meyer, G. S., I. Jacoby, H. Krakauer, D. W. Powell, J. Aurand, and P. McCardle. 1996. Gastroenterology workforce modeling. *Journal of the American Medical Association* 276 (September): 689–94.
Niederle, M. 2007. Competitive wages in a match with ordered contracts. *American Economic Review* 97 (5):1957–69. Available at: http://www.stanford.edu/~niederle/Niederle.OrderedContracts.pdf.
Niederle, M., D. D. Proctor, and A. E. Roth. 2006. What will be needed for the new GI fellowship match to succeed? *Gastroenterology* 130 (January): 218–24.
———. 2008. The gastroenterology fellowship match: The first two years. *Gastroenterology* 135 (2): 344–46.

Niederle, M., and A. E. Roth. 2003a. Relationship between wages and presence of a match in medical fellowships. *Journal of the American Medical Association* 290 (9): 1153–54.

———. 2003b. Unraveling reduces mobility in a labor market: Gastroenterology with and without a centralized match. *Journal of Political Economy* 111 (6): 1342–52.

———. 2004. The gastroenterology fellowship match: How it failed, and why it could succeed once again. *Gastroenterology* 127:658–66.

———. 2005. The gastroenterology fellowship market: Should there be a match? *American Economic Review Papers and Proceedings* 95 (2): 372–75.

———. 2009. Market Culture: How Rules Governing Exploding Offers Affect Market Performance. *American Economic Journal: Microeconomics* 1, 2 (August), forthcoming.

Niederle, M., and L. Yariv. 2009. Decentralized matching with aligned preferences. NBER working paper, 14840.

Roth, A. E. 1982. The economics of matching: Stability and incentives. *Mathematics of Operations Research* 7 (4): 617–28.

———. 1984. The evolution of the labor market for medical interns and residents: A case study in game theory. *Journal of Political Economy* 92 (6): 991–1016.

———. 1985. The college admissions problem is not equivalent to the marriage problem. *Journal of Economic Theory* 36 (2): 277–88.

———. 1990. New physicians: A natural experiment in market organization. *Science* 250 (4987): 1524–28.

———. 1991. 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* 81 (June): 415–40.

———. 2002. The economist as engineer: Game theory, experimental economics and computation as tools of design economics. *Econometrica* 70 (4): 1341–78.

———. 2003. The origins, history, and design of the resident match. *Journal of the American Medical Association* 289 (7): 909–12.

———. 2007. Repugnance as a constraint on markets. *Journal of Economic Perspectives* 21 (3): 37–58.

———. 2008a. Deferred acceptance algorithms: History, theory, practice, and open questions. *International Journal of Game Theory* (Special issue in honor of David Gale's eighty-fifth birthday) 36 (March): 537–69.

———. 2008b. What have we learned from market design? Hahn Lecture, *Economic Journal* 118 (March): 285–310.

Roth, A. E., and E. Peranson. 1999. The redesign of the matching market for American physicians: Some engineering aspects of economic design. *American Economic Review* 89 (4): 748–79.

Roth, A. E., and M. Sotomayor. 1990. *Two-sided matching: A study in game-theoretic modeling and analysis.* Cambridge, MA: Econometric Society Monograph Series, Cambridge University Press.

Roth, A. E., and X. Xing. 1994. Jumping the gun: Imperfections and institutions related to the timing of market transactions. *American Economic Review* 84 (September): 992–1044.

———. 1997. Turnaround Time and Bottlenecks in Market Clearing: Decentralized Matching in the Market for Clinical Psychologists. *Journal of Political Economy,* 105:284–329.

Segal, I. 2007. The communication requirements of social choice rules and supporting budget sets. *Journal of Economic Theory* 136 (1): 341–78.

Suen, W. 2000. A competitive theory of equilibrium and disequilibrium unravelling in two-sided matching. *Rand Journal of Economics* 31 (Spring): 101–20.