

The Effects of a Central Clearinghouse on Job placement, Wages, and Hiring Practices: Gastroenterology Fellows as a Case Study

Muriel Niederle and Alvin E. Roth¹

May 15, 2007

I. INTRODUCTION

Almost all the entry level positions in the market for new doctors in the United States are mediated by a clearinghouse called the National Resident Matching Program (NRMP). Many other more advanced medical positions use similar clearinghouses, as do medical labor markets in Canada and Great Britain, and a number of other labor markets (e.g. for many non-medical health care workers in the U.S., for some new lawyers in Canada, etc. for a list see e.g. Table 1.. These clearinghouses work as follows: Applicants and employers interview each other in a decentralized way, before submitting rank order lists that represent their preferences, which are then used to centrally determine a matching that specifies which applicant will work for which employer. The algorithms used are deferred acceptance algorithms (Gale and Shapley 1962, see Roth 2007). In simple markets, in an employer-proposing deferred acceptance algorithm, using the rank order lists submitted by applicants and employers, every employer first makes an offer to its most preferred applicants, up to the number of positions it wishes to fill. Applicants collect all offers, keep the one they like the most if that offer is acceptable (i.e. was ranked by the applicant), and reject all other offers. Employers who had offers rejected make offers to their next choice candidate(s). These once more collect all offers, keep the one they like the most, in case it is acceptable, and so on, until either all firms have their offers held by applicants, or they ran out of offers (that is, reached the end of their rank order list). Once the algorithm is over, every applicant is matched to the firm whose offer they hold, i.e. receives a contract from that firm. The outcome of such a matching is stable, that is, there exists no applicant-employer pair, not matched to each other, who

¹ Muriel Niederle: Stanford University and NBER, www.stanford.edu/~niederle. Alvin E. Roth: Harvard University and NBER, www.economics.harvard.edu/~aroth/alroth.html.

prefer each other to their current match (given the submitted rank order lists).² Furthermore, in simple environments, it is a dominant strategy for employers to submit their true preferences (Roth, 1982).

These clearinghouses solve a set of market failures that often occur in entry level labor markets in which many people seek jobs that all begin at the same time. The source of many problems is that these markets suffer from *congestion*: since making offers and thinking about 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 to employers making short term (or exploding) offers, or trying 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.³ In a number of markets these problems have become extreme: markets have unraveled, with candidates being hired sometimes several years before employment starts (Roth and Xing 1994, Avery, Jolls, Posner, and Roth 2001, Niederle and Roth 2005 and Niederle Proctor and Roth 2006). This of course may entail other problems, as information about candidates, and even the candidates' preferences over different employers may not be as accurate as at the time employment actually starts.

Entry level medical markets, such as for residents and fellows, and specifically fellows in gastroenterology (a subspecialty of internal medicine) are prime examples of markets that experienced such problems, and also fixed them by adopting a centralized clearinghouse. The unraveling process was halted, and offers are made at a uniform time,

² This is easy to see. Suppose there were such an applicant A and employer E. Given that the employer prefers this applicant, A, to another applicant B to whom he is matched, then, by definition of the algorithm, the employer made an offer to A and A rejected the employer, even though the employer is acceptable, which means A had a better offer in hand (from some firm F), and so, at the end of the algorithm, A is matched either to F or to some firm he prefers even more. Hence if E prefers A to a worker to whom E is matched, A does not return the favor, so no blocking pair exists.

³ In the market for junior economists, such hesitation can be seen as many departments shy away from interviewing candidates who seem too accomplished, because they do not know how much the candidate is *really* interested, as opposed to simply very risk averse.

and closer to the time when employment actually starts. Furthermore, employers are not harmed by trying to hire long shots, and similarly candidates, in the algorithm, can safely await the best offer they receive without having to accept an offer while more preferred offers still might be forthcoming.

In this paper 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 wages.

The market for gastroenterology fellows provides us with a natural case study, 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, and then organized in a decentralized way. It re-established a match in 2006.

We find that, as the market moved from a centralized to a decentralized market, the national market broke up into a collection of several, 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 once more unraveled into a market in which, at any specific time, only a subset of hospitals were making offers, which means that the market broke down not only locally in space, but also in time (Niederle and Roth 2004 and Niederle, Proctor and Roth 2006). Candidates were once more subjected to very short term 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 made earlier from year to year. Finally, although a class action lawsuit (since dismissed) argued that a centralized match suppressed wages, we do not find that the wages of gastroenterology fellows, hired in a decentralized way, are any different from other internal medicine subspecialties 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 a match may affect or reduce wages.

Finally, we consider the obstacles to initiating a centralized match that will delay the start of the market until some uniform time. Many employers may fear that their main competitors may not refrain from hiring candidates early. We employed some insights from decentralized markets (such as graduate school admissions) to help the Gastroenterology professional organizations devise policies that helped to restart the

match for gastroenterology fellows, in June of 2006 (Niederle and Roth 2006 and Niederle, Proctor and Roth 2006).

II. 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 years as a gastroenterology 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 subspecialties of Internal Medicine, of which gastroenterology is but one.

While the number of GI fellowship positions each hospital can offer has been regulated for a long time, the market for fellows was decentralized before 1986. In the 1970's and '80's, hospitals announced positions, received applications, and interviewed candidates 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—a “match”—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 starts, and so two years into the IM residency. The MSMP uses the same algorithm to match applicants to programs as the NRMP (National Residency matching program) that matches medical students to residencies (Roth and Peranson 1999). The match for GI fellows operated well, with most non-military programs participating, and over 90% of participating positions being filled. However in the late 1990s, participation of GI fellows and programs rapidly declined,

after 1996 it ceased to have high rates of participation, 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 pressure, in which offers were made mostly all at once through the centralized match, adapts to the loss of the clearinghouse. Because the lack of the clearinghouse is recent (and because gastroenterology programs were interested in understanding how the new market worked), we were able to survey market participants and observe how the market changed and adapted to the loss of the clearinghouse, and how the decentralized market functioned in comparison. We'll also describe the process by which a new clearinghouse was organized and put into operation in 2006.

III. THE EFFECTS OF A CENTRALIZED MATCH

We first study how the market for gastroenterology fellows reorganized after the match broke down. We describe when interviews were conducted and offers made, what kind of offers internal medicine residents received, and how thick the market was, that is, how many programs were actively making and having outstanding offers at any given time.

We then address whether the decentralized organization of the market, compared to a centralized clearinghouse, influenced the outcome of the market apart from the timing and organization. We will investigate who gets matched to whom, under the different market organizations and whether wages are affected. This latter point received some prominence due to an antitrust lawsuit against the match that was dismissed following the passage of new legislation.

III.A. 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 IV, but first we describe this new decentralized market.

Immediately, we are 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 FREIDA online (<http://www.ama-assn.org/ama/pub/category/2997.html>). Many programs announce the time at which they plan to interview (which is certainly useful in a market which isn't regulated anymore).⁴ Second, together with our colleague Dr. Deborah Proctor, and with the sponsorship of the AGA we administered a survey on hiring procedures of gastroenterology programs, in January 2005 (see Niederle, Proctor and Roth 2006). A link to an online questionnaire was sent to the 154 GI fellowship programs that are accredited by the Accreditation Council for Graduate Medical Education and eligible to participate in a match. We obtained (partial) data from 64 US based programs, a response rate slightly higher than 40%, 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 (by 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 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).⁵ Not only were GI fellows interviewing earlier than subspecialties that still used a match, but they were also interviewing earlier from year to year, and this even many years after the match collapsed in the late nineties.

The 51 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

⁴ 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...NR 2004: GASTRO, p.661.

⁵ Figure 1 shows the cumulative distribution of programs that started interviewing at any given two-week period. Programs that start their interviews for example from Dec. 23 to January 6 are coded as starting in January, and those that interview from Jan. 7 to Jan. 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 in the same week.

interviewing before August planned to interview significantly earlier for 2007 positions ($p < .01$ using a Wilcoxon matched-pairs signed ran test). Of these 51 programs, the programs that planned to interview earlier for 2007 positions are the programs that started interviewing later for 2006 positions.⁶ 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 size of the program (which is a decent proxy for “desirability”, with larger programs being more prestigious).

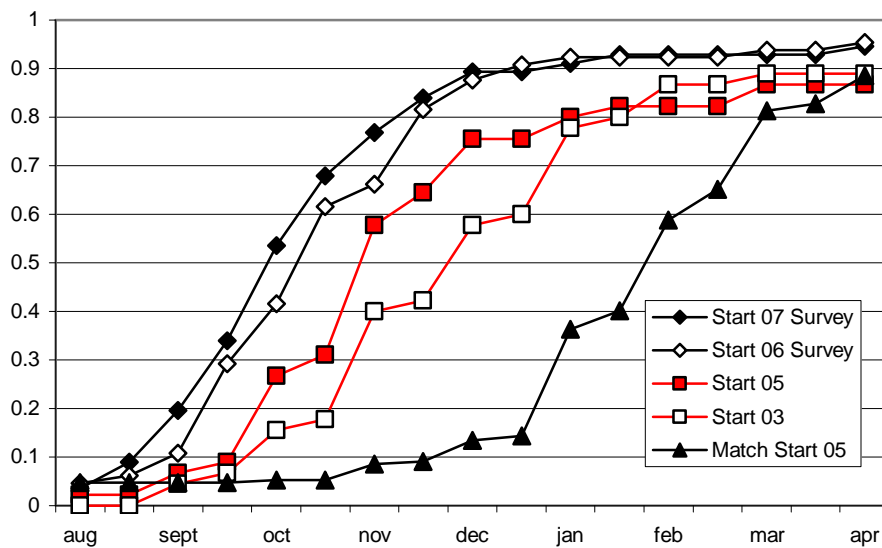


Figure I

Cumulative distribution of GI and Match programs that started interviewing by the time of any given 2-week period. Match Start 05: interview dates of internal medicine subspecialties that participate 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 (and 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).

⁶ 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.

In the survey, we not only asked about timing of interviews, but also about the timing and kinds of offers that are extended. For each of the 44 fellowship programs for which we have those data, figure 2 shows when the first offer was made, and the last offer expired, where (to be 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 at which the program was actively on the market.

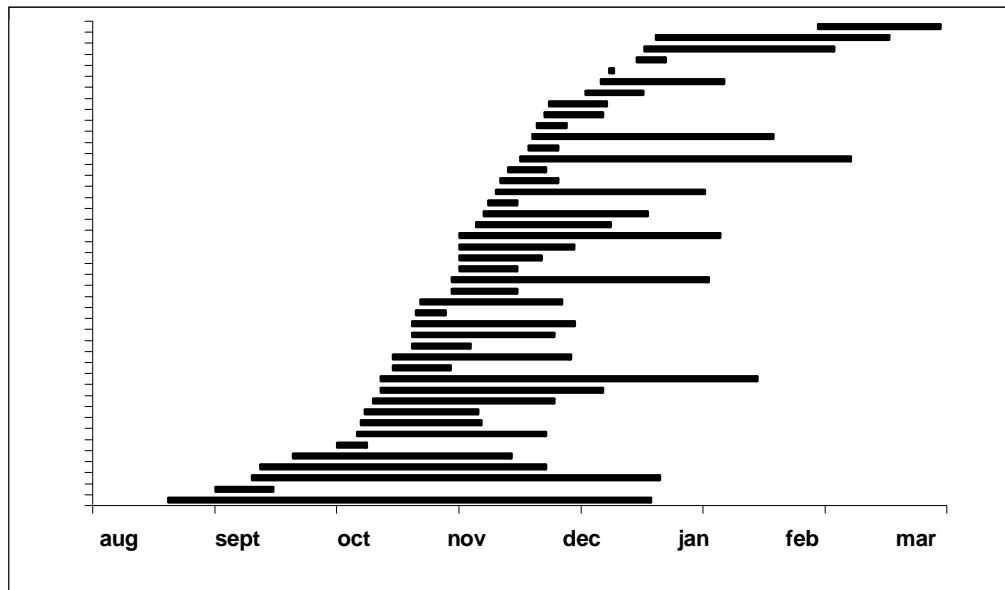


Figure II

Dates of open offers by 44 fellowship programs. Each program is represented by a horizontal line, indicating the dates during which it had outstanding offers.

The graph shows that by November 15, 11 (27%) programs had already finished making offers, 12 (25%) had not yet started, and 21 (48%) were in the midst. Another way to interpret this figure is to ask how many programs have outstanding offers at any point in time. At no point are there even 60% of programs that 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 results 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). 43% of the respondents (28 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% of programs (i.e. 21) considered how likely it was that an applicant would accept their offer when deciding whether to extend an offer. Programs not only strategically decide when and to whom to make an offer, but also on the deadline of offers. More than half the programs (60%) made at least one offer that required a reply in one week or less, and 95% required a reply to some offer in two weeks or less. And in fact, 21% of programs indicated that the longest time a candidate took to respond to an offer was one hour, 60% report one week, and 90% two weeks. Thus the market moved fast. It is not a market in which program directors can interview all the candidates they might like to before making offers, nor one in which they can safely extend offers to risky candidates, because meanwhile more attainable candidates may take other offers.

III.B. DOES A CENTRALIZED MATCH CHANGE THE FINAL OUTCOME OF THE MARKET?

With the collapse of the match, the market for GI fellows once more operated earlier and earlier, with offers requiring prompt answers, and it appears that markets are “thin” at any given point in time. While this does not necessarily imply that the loss of a match affects the market outcome (namely who matches to whom under what terms), prior to our empirical investigation we identified three potential sources of difference between the outcome of the decentralized market and of the centralized match.

First, the centralized match yields a stable outcome, that is there does not exist a program and resident pair that 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 they prefer their 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 at any point in time. Indeed,

results by Niederle and Yariv 2007, suggest that decentralized markets in which firms prefer to make short term offers, do not yield stable outcomes.

A second reason the decentralized market may yield a different matching, is that the decentralized market not only experiences short term offers, but also unravels. Offers in the decentralized market are made about 6 months to a year earlier than those in the centralized match. Instead of hiring internal medicine residents in the later second half 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 experience unraveling 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 internal medicine residents are from the same hospital, and have had a rotation in the GI unit, this unit will have more information on this applicant than others, 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 experienced more candidates renegeing 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), and because they may receive more attractive offers than the one they accepted initially. Hiring fellows within a network may help reduce the enforcement problem, and reduce the likelihood that a fellow reneges on their acceptance. Once more, the most extreme form may be to hire one's very own internal medicine residents.

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 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, and location of each residency and medical school. We have a total of 9180 fellows of the 15,187 entries that completed a residency and a subsequent GI fellowship in the US after

1977. They do their residency in 433 different hospital codes and come from 680 residencies.

Figure 3 shows the mobility of those fellows before, during, and after the collapse of 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). Note that the figure shows each fellow when they ended their fellowship, since fellowships were required to be 2 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 that could have gone through a match, while those ending in 2001 were those that had no functioning match anymore.

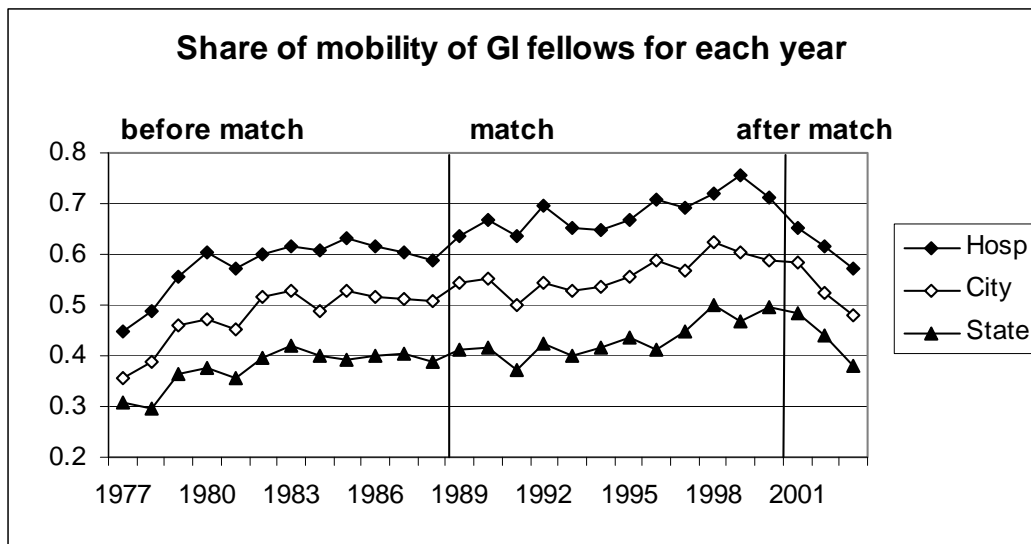


Figure 3: The vertical lines indicate the beginning and the end of the use of the centralized match, measured in year of Fellowship *completion*.

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 6 years when the Match was well established. Table 1 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.

Table I: Differences across Mobility

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

Notes: Prematch: 1980 – 88; match: 1989 – 2000; match 1: 1989 – 1994; match 2: 1995 – 2000; and Postmatch: 2001 – 2003; *p*- values.

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 hospitals (at the hospital, city, and state level). The effects of the Match are larger and more significant for large programs than for small ones.⁷

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 evidence (Kagel and Roth 2000, and 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 foreigners). 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 that choose to become gastroenterologists.

⁷ We also controlled for various other possible impacts, such as the fact that because of the consolidation of hospitals, many 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 3 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). The proportion of GI fellows who finished their GI fellowship 3 years after their previous residency was always at least 70%. The results do not change qualitatively.

III.C. DOES A CLEARINGHOUSE AFFECT AND LOWER SALARIES?

Another aspect of the matching or 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 over a dozen law firms filed a class action law suit, on behalf of three former residents, seeking to represent the class of all residents and fellows, arguing that the NRMP violated antitrust laws and was a conspiracy to depress wages. The lawsuit was against a class of defendants, including the NRMP (which also operates the 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).

One way to investigate whether a match affects wages of medical fellows is to examine comparable medical subspecialties, only some of which use a match. Niederle and Roth (2003a) and (2004) compare wages 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 2002-2003 and 2003-2004 respectively.

Table II shows the average wages of fellows for each internal medicine subspecialty.⁸

Specialty	Match	No. of programs	Mean wage	St.dev	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

⁸ We use the data from the Graduate Medical Education Library 2003-2004. We use all internal medicine subspecialties that require 3 years of prior residency, and all non-military programs that record a positive wage and are not in Puerto Rico.

Table II: For each Specialty the number of programs reporting a positive wage, the mean wage, the standard deviation, then minimum and the maximum wage. 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.

Using the 1148 wage data for 2003, a simple regression of the wage on a constant, 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.⁹

To account for possible effects of hospital size (since match specialties tend to be larger), we want to determine whether, within hospitals, wages for specialties that use the match are different than wages for specialties that do not. In the next regression we therefore include a dummy variable for each hospital when regressing the wage 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 (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 wages of fellows whose specialty uses a match are higher than those that do those that do not use a match, but the differences are not economically relevant, they are on the order of 1% of the salary.¹⁰¹¹

The lawsuit spurred a number of theoretical papers on its validity, most notable Bulow and Levin (2006) who provide support for the lawsuit in a simple theoretical model. They compare a market with impersonal wages (that is a market in which wages are attached to *positions* rather than depending on which applicant is hired for the position) to a market with perfectly competitive wages at which each worker is paid his marginal product. They find that a market with impersonal wages leads to lower average

⁹ The wages for 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.

¹⁰ However, within hospitals, GI fellows earn somewhat less than both the average fellow who is in a specialty that has a match, and the average fellow who is in a specialty without a match. While the results are statistically significant, they are not economically significant, they are very small (less than \$1000), no more than 2% of the wage. Using Graduate Medical Education Library 2002-2003, the wage difference for gastroenterology fellows is only 268.64 and the difference is not significant

¹¹ Similar results are obtained for the previous year, using Graduate Medical Education Library 2002-2003.

wages and a more compressed wage schedule. Subsequent theoretical papers have shown that these conclusions about wage compression do not necessarily follow if the model is expanded to include the possibility of firms hiring more than one worker (Kojima, forthcoming), or when the model incorporates the actual procedures by which the medical match is conducted (Niederle, forthcoming).

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 do not face the whole market, but only a smaller set of programs that make offers at that time. And indeed, some fellows lamenting the loss of the match do so for that reason.¹²

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, pro-competitive, 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.

IV. CHANGING THE MARKET ORGANIZATION

The organization of the market for GI fellows raises two kinds of questions for markets that use a centralized match. The first is why this match broke down (and failures are so rare), and how can we get the market for GI fellows reorganize through a clearinghouse.

IV.A. 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 than those that

¹² Gastroenterology fellows Bauer, Fackler, Kongara, Matteoni, Shen and Vaezi commented in 1999 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.”

do not. Of particular interest in this regard are the markets used in various regions in the British National Health Service. In the 1960's, these markets suffered from the same problems as the American market for medical interns in the late 40's (successfully solved by the centralized match, the NRMP). A Royal Commission recommended that each region use a centralized clearinghouse, and the various regions in Britain each invented their own algorithm, of which only some were stable.¹³ Clearinghouses that produced stable matches succeeded, while others mostly did not. However, considering all markets that use centralized clearinghouses, this correlation isn't perfect, some matches with algorithms that don't provide stable matches survive, and some stable match algorithms fail. Furthermore, there are in general more differences between markets than simply the algorithms they use.

Kagel and Roth (2000) provided clean evidence in the experimental laboratory, in which in two small, but otherwise identical set of markets, the market that use a stable algorithm adopt this algorithm successfully, and continue to use it. The sets of markets that use an algorithm that does not produce stable outcomes do not adopt this algorithm successfully, and the markets continue to experience offers and acceptances outside of the centralized clearinghouse.

Having a stable algorithm seems hence to be crucial for a centralized clearinghouse to perform well, and continue to be in use, and, as Table 1 shows, most of these have been successfully in operation for several 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 1993-1994, when, in the midst 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

¹³ An example of an unstable algorithm, are algorithms that use the exact place in which firms and workers rank each other. For example, one can first match all firms and workers that list each other first. Then one can match all (1-2) pairs, where workers list the firm first, and the firm lists the worker second, followed by (2-1) pairs. At each step, one removes matched firms and workers, and the order or removal is given by the product of the worker-firm ranking, where in case of the same products one gives priority to workers. One can see that this can create very problematic outcomes, Take 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 that firm F first, and the firm F lists him 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 highly, in which case Worker A and Firm F would block the outcome, in that they rather be together than with their current matches.

main conclusions were that the US health care system and gastroenterologists would benefit from a reduction in gastroenterology Fellowship programs. The Gastroenterology Leadership Council endorsed a goal of 25% to 50% reduction in the number of GI fellows over 5 years. Furthermore, an additional year of training was mandated: starting in the summer of 1996, three years of training were required to be board eligible, instead of two.

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

However, this announced (and hence expected) reduction in supply triggered an *even larger reduction* in the number of residents who applied for GI fellowship positions. This seems to have been the start of the demise of the match. In 1996, for the first time, and despite the reduction in the number of positions offered, there were fewer applicants for GI fellowship positions than there were positions offered in the match. This resulted in a record low fill rate: only 74.8% of the positions in the match were filled through the match in that year.

The next year, 1997, saw a sharp decline in the percentage of positions in the match. In particular, table 3 (from Niederle and Roth, 2003b) describes how withdrawal of positions from the match (as programs and applicants reached agreements outside of the match) preceded the formal demise of that match. Withdrawals went from about 5% in 1996 to 16% in 1997, to 44% in 1998, to 60% 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.¹⁴

¹⁴ 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.”

Table 3: Participation in the Gastroenterology Match

Yr	Positions advertised	Percent With-drawn	Positions in Match	Percent Matched	Number of Programs	Number of Applicants	Applicants per position in Match
'92	--	--	377	96.6	160	658	1.75
'93	374	-6.7	399	94	173	642	1.6
'94	--	--	369	93	169	591	1.6
'95	351	4	337	88.7	171	433	1.3
'96	313	4.8	298	74.8	164	277	0.9
'97	254	16.1	213	85	128	240	1.1
'98	178	44.3	99	77.8	60	148	1.5
'99	35	60	14	--	11	--	--

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 (Posts Withdrawn), which leaves the final number of positions in the match (Posts 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.

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 3, 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, and Infectious Disease successfully operates a match in which there are persistently fewer applicants than positions.¹⁵

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 subjecting them to controlled changes in supply and demand. McKinney,

¹⁵ 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 vary 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 (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 of anywhere near the magnitude caused by unanticipated shocks.

IV.B. 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 many of the participants do want to have the match back. With the breakdown of the Match, the market once more experiences unraveling and congestion: not enough offers can be processed in the available time. (By the time an offer is rejected, other candidates may no longer be available, and so employers have incentives to start making offers earlier, and to leave them open for less time, which makes the market unravel.) Clearinghouses solve both problems: they bring participants to the market at the same time, and they overcome congestion. The market conditions of GI fellows have stabilized, so, all seems favorable for a successful restart.

To address 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 60 responses, 50 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 confirm that this is a lively concern, with some expressing concern about specific programs they regard as competitors.

Program directors who wish to participate in the match worry that if their competitors make early offers, then applicants may lose confidence that the match will work and accept those early offers, because that has been the practice in the decentralized market. That is, in the first year of a match, applicants may not yet feel that it is safe to reject an early offer to wait for the match. Program directors who worry about their competitors may 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).

Empirically, most markets that experience unraveling are markets in which employers make short term offers, with a binding deadline, and in which the acceptance of an offer is binding (Niederle and Roth 2006, for a description of the market for law graduates see e.g. Avery, Jolls, Posner and Roth, 2001, and for college admissions see Avery, Fairbanks and Zeckhauser 2003).

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 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 attractive. A program that might be inclined to insist on an against-the-rules early response is discouraged from doing so in 2 ways. First, the chance of actually enrolling a student who is pressured in this way is diminished, because the student is not prevented from 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 have made binding agreements.

Niederle and Roth (2006) explore environments in which either eliminating the possibility of making exploding offers, or making early acceptances non-binding, helps prevents markets from operating inefficiently early.

Because, in general, it is very hard to enforce the time at which programs make offers and how long offers are left open, this policy helps the applicants themselves to 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 was adopted by all four major Gastroenterology professional organizations, the American Gastroenterological Association (AGA), the American College of Gastroenterology (ACG), the American Society for Gastrointestinal Endoscopy (ASGE) and the American Association for the Study of Liver Diseases (AASLD), regarding offers made before the (new) match. It states, in part

The general spirit of this resolution is that each applicant should have an opportunity to consider all programs before making a decision and be able to

participate in the Match. ... It therefore seeks to create rules that give both programs and applicants the confidence that applicants and positions will remain available to be filled through the Match and not withdrawn in advance of it. This resolution addresses the issue that some applicants may be persuaded or coerced to make commitments prior to, or outside of, the Match. ... Any applicant may participate in the matching process ... by ... resigning the accepted position if he/she wishes to submit a rank order list of programs ... The spirit of this resolution is to make it unprofitable for program directors to press applicants to accept early offers, and to give applicants an opportunity to consider all offers ...

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

V. CONCLUSIONS AND OTHER MARKETS

How to bring in research fellows (Niederle...☺...)

Many decentralized markets experience the problems we've see for the GI market.

See also college admission:

Talk about econ job market? Thinking of signaling, decentralized markets that do not want to centralize..?

REFERENCES

1. Avery, Christopher, Andrew Fairbanks and Richard Zeckhauser, *The Early Admissions Game: Joining the Elite*, Harvard University Press, Cambridge, MA 2003.
2. Avery, C., Jolls, C., Posner, R. A., and Roth, A. E. (2001), "The Market for Federal Judicial Law Clerks," *University of Chicago Law Review*, 68:793-902.
3. Bauer, William T., William Fackler, Kavita Kongara, Christie Matteoni, Bo Shen and Michael Vaezi, *Comment to It's Time to Bring the Best and Brightest Back to Gastroenterology*, *Gastroenterology* 116, 4, 1999, 1014.
4. Bulow, Jeremy and Jonathan Levin. 2006. "Matching and Price Competition." *American Economic Review*, 96(3), 652 - 668.
5. Coles, Peter and Muriel Niederle, "Signaling in Matching Markets", preliminary working paper May 2006.

6. Fréchette, Guillaume, Alvin E. Roth, and M. Utku Ünver, "Unraveling Yields Inefficient Matchings: Evidence from Post-Season College Football Bowls," March, 2004.
7. Gale, David, and Lloyd S. Shapley. 1962. "College Admissions and the Stability of Marriage." *American Mathematical Monthly*, 69, 9-15.
8. Gerson, Lauren, 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, Spring 1999, Volume 5, Number 1, <http://www.gastro.org/trainee/trainee6.html>
9. Kagel, J.H., Roth, A.E., 2000. The dynamics of reorganization in matching markets: a laboratory experiment motivated by a natural experiment. *Quarterly Journal of Economics* 115 (1), 201-235.
10. McKinney, C. Nicholas, Muriel Niederle, and Alvin E. Roth. 2005. "The collapse of a medical labor clearinghouse (and why such failures are rare)." *American Economic Review*, 95(3), 878-889.
11. Niederle, Muriel, "Competitive Wages in a Match with Ordered Contracts", December 2006. <http://www.stanford.edu/~niederle/Niederle.OrderedContracts.pdf>
12. Niederle, Muriel, Deborah D. Proctor and Alvin E. Roth. 2006. "What will be needed for the new GI fellowship match to succeed?" *Gastroenterology*, 130, 218-224.
13. Niederle, Muriel, and Alvin E. Roth. 2003a. "Relationship Between Wages and Presence of a Match in Medical Fellowships." *JAMA, Journal of the American Medical Association*, 290(9), 1153-1154.
14. Niederle, Muriel, and Alvin E. Roth. 2003b. "Unraveling reduces mobility in a labor market: Gastroenterology with and without a centralized match." *Journal of Political Economy*, 111(6), 1342 -- 1352.
15. Niederle, Muriel, and Alvin E. Roth. 2004. "The Gastroenterology Fellowship Match: How it failed, and why it could succeed once again." *Gastroenterology*, 127, 658-666.
16. Niederle, Muriel, and Alvin E. Roth. 2005. "The Gastroenterology Fellowship Market: Should there be a Match?" *American Economic Review Papers & Proceedings*, 95(2), 372-375.
17. Niederle, Muriel, and Alvin E. Roth. 2006. "Making Markets Thick: How Norms Governing Exploding Offers Affect Market Performance." <http://www.stanford.edu/~niederle/Thickmarkets.pdf>.
18. Niederle, Muriel and Leeat Yariv, "Matching through Decentralized Markets", working paper, 2007.
19. Roth, Alvin E. 1984a. "The evolution of the labor market for medical interns and residents: A case study in game theory." *Journal of Political Economy*, 92, 991-1016.
20. Roth, Alvin E. 2002. "The Economist as Engineer: Game Theory, Experimental Economics and Computation as Tools of Design Economics." *Econometrica*, 70(4), 1341-1378.
21. Roth, Alvin E. 2003. "The Origins, History, and Design of the Resident Match." *JAMA, Journal of the American Medical Association*, 289(7), 909-912.
22. Roth, Alvin E. 2007 " Deferred Acceptance Algorithms: History, Theory, Practice, and Open Questions," *International Journal of Game Theory*, Special Issue in Honor of David Gale's 85th birthday, forthcoming.

23. Roth, Alvin E. and Marilda Sotomayor. 1990. Two-Sided Matching: A Study in Game-Theoretic Modeling and Analysis. Econometric Society Monograph Series, Cambridge University Press.
24. Roth, Alvin E. and Elliot Peranson. 1999 "The Redesign of the Matching Market for American Physicians: Some Engineering Aspects of Economic Design." *American Economic Review*, 89(4), 748 - 779.
25. Roth, A.E. and U.G. Rothblum "Truncation Strategies in Matching Markets--In Search of Advice for Participants," *Econometrica*, 67, January 1999, 21-43.
26. Roth, A.E. and X. Xing "Jumping the Gun: Imperfections and Institutions Related to the Timing of Market Transactions," *American Economic Review*, 84, September, 1994, 992-1044.

Table 1 (adapted from Roth 1991, 2007): Labor markets that use a stable centralized clearinghouse (and date of first use of a centralized clearinghouse of some sort):

- 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 U.S. 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, Canada (1993)
- Medical Residencies in the United States (NRMP) (1952)
- Medical Residencies in Canada (CaRMS) (before 1970)
- Specialty Matching Services (SMS/NRMP):
 - Abdominal Transplant Surgery (2005)
 - Child & Adolescent Psychiatry (1995)
 - Colon & 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 & Reconstructive Surgery (2001)
 - Ophthalmic Plastic & Reconstructive Surgery (1991)
 - Pediatric Cardiology (1999)
 - Pediatric Critical Care Medicine (2000)
 - Pediatric Emergency Medicine (1994)
 - Pediatric Hematology/Oncology (2001)
 - 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)

- British (medical) house officer positions
 - Edinburgh (1969)
 - Cardiff (197x)
- Reform Rabbis (since 1998)