

Unraveling The Effects of a Match

Market Design Class 2012

What are the effects of a Match

- Medical Residencies, before introducing the Match, suffered from unraveling problems.
 - Hiring decisions start to be made earlier and earlier, and employment agreements are made often quite far before actual employment starts.
- Markets that experience unraveling can often be “fixed” by introducing centralized clearinghouses. This will in general be successful when the clearinghouse uses a stable mechanism.
- What are the effects of a match?
- Difficulties:
 - Difficult to get data from decentralized markets
 - Problem of studying the effect of a match: Need a control: What would have happened had we not had a match...

Market	Successful (still in use)
National Resident Matching Program (NRMP) (over 40 specialty markets and submarkets for first year postgraduate positions, and 15 for second year positions)	yes (new design in '98)
Regional medical markets in Britain (Edinburgh '69 and Cardiff)	Yes
Specialty Matching Services (SMS) (over 30 subspecialty markets and submarkets for advanced medical residencies and fellowships)	yes (except Gastroenterology since 2000)
Canadian Lawyers: articling positions (Ontario since '86, BC since '87, Alberta since '93)	yes (except British Columbia since 1996 and Ontario since 2002)
Dental Residencies (5 specialties)	yes (except for periodontists since 1997 and prosthodontists since 2000)
Osteopaths (> '94)	Yes
Pharmacists	Yes
Reform rabbis (first used in '97-98)	Yes
Clinical psychologists (first used in '99)	Yes

Gastroenterologists

- The failure of a stable match is a rare event.
- Why did the Gastroenterology fellowship match fail?
- Why are failures such a rare event?
- What are the effects of a match: Looking at gastroenterology and other markets.

History of the Gastroenterology fellowship market

Gastroenterology (2-3 years): subspecialty of Internal
Medicine (3 years).

Before 1986: Decentralized Process.

- Residents apply for fellowship positions, receive interviews, and offers from hospitals.
- However, they experienced market failure in terms of unraveling (early, dispersed, exploding offers).
- Interim attempts to solve the problem: “Setting guidelines for interviewing candidates and negotiating positions was tried, and it was unsuccessful. Some applicants and programs received calls asking them for decisions three months before the deadline. Since it was only a recommended policy, directors say, it was terribly abused, which is why the training directors developed the match. Many felt that there was a chaotic atmosphere.”

Common kind of failure for entry-level labor markets (Roth
& Xing '94)

1986-~1996: The Match (MSMP)

Applicants (and hospitals) submit rank order lists over hospitals (and applicants).

The MSMP uses a version of a hospital proposing Gale Shapley algorithm which yields stable outcomes.

Empirically: Matches that yield stable matches have failed very rarely.

The Collapse of the GI Match

Gastroenterology, in '93-94 (the midst of a health care reform): Manpower analysis. Meyer et al 1996: JAMA:

- US healthcare system, and gastroenterologists, would benefit from a reduction in GI fellows.
- 25-50% reduction of GI fellows (over the next 5 years) endorsed as goal by GI leadership council.
- Starting with summer 1996: 3 years of GI fellowship required for board certification eligibility

The demise of the Match

Year	Percent withdrawn	Posts in Match	Percent Matched	Applicants per Position
'92	--	377	96.6	1.75
'93	- 6.7	399	94	1.6
'94	--	369	93	1.6
'95	4	337	88.7	1.3
'96	4.8	298	74.8	0.9
'97	16.1	213	85	1.1
'98	44.3	99	77.8	1.5
'99	60	14	--	--

Within 4 years the Match collapsed.

Since 1997, they are effectively not using the match, and since 2000 were not anymore offered the possibility of a match.

Why did the Match break down? And why are such failures so rare?

Some Hypotheses

- A centralized Match only works when there are more applicants than positions.
 - There may not be enough “high quality” applicants to fill high quality positions.
 - Shortages may be believed to exist on both sides of the market...
- The match failed because of the shock that reduced the demand of positions below the supply.

These two: Favored explanations of Gastro's

- The match failed because, when this shock occurred, fellowship programs were aware of it, but applicants were not.
 - Programs could update their priors when they saw how many applications they received.

How to sort among these hypotheses?

- Each of them is consistent with the historical data.
- And, since stable match failures are rare, there isn't a good possibility of a cross-market comparison.
- But in the laboratory, we can shock a market in different ways, and try to make a stable matching mechanism fail.

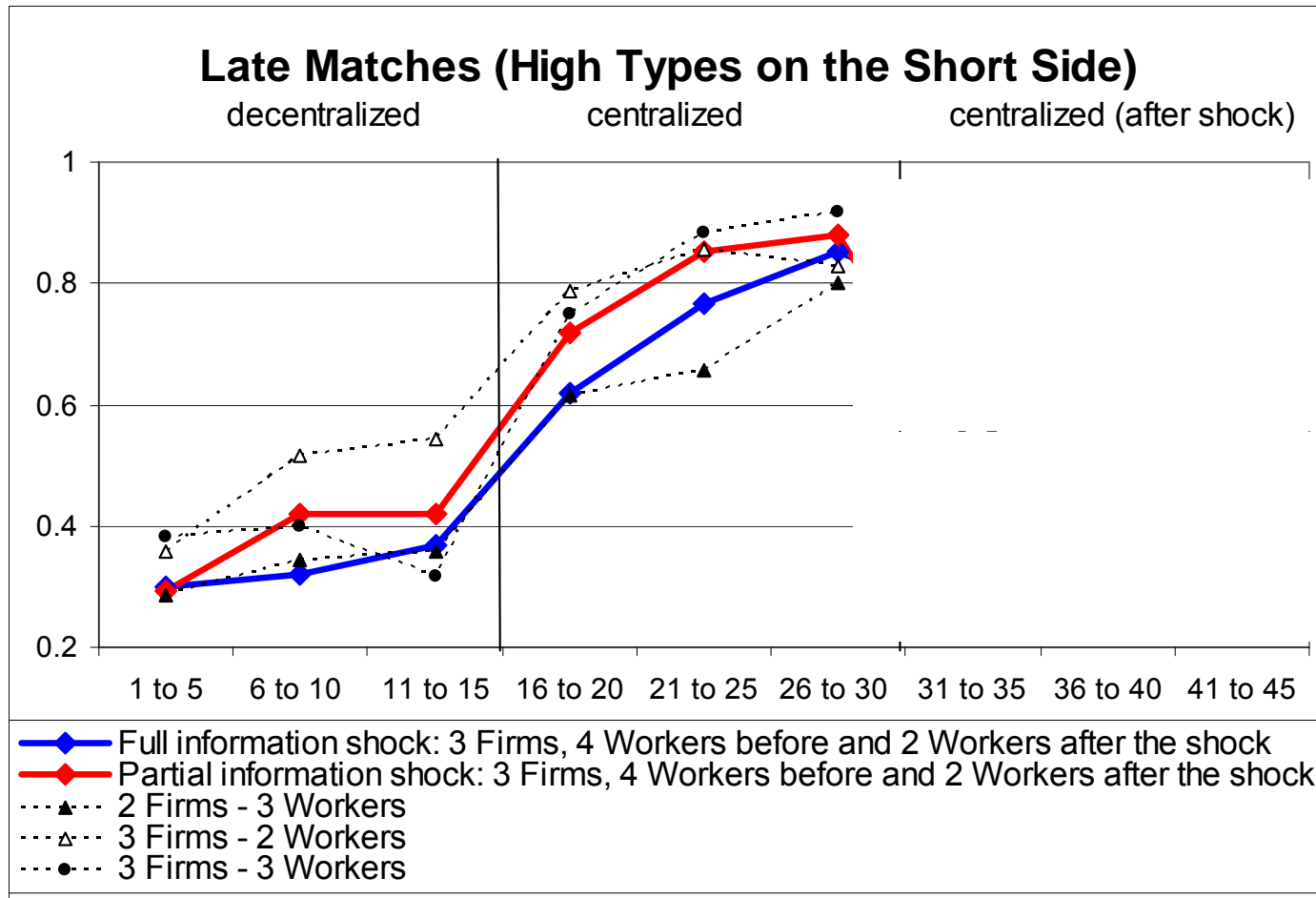
A simple experimental environment

- 2 types of firms and workers; "High" and "low" productivity
- Matching to a High type is worth 150 points + private value: in $[-10,10]$.
- To a low type is worth 50 (+ private value)
- There are three periods in which to match: **-2, -1, 0.**
- Your payoff is the value of your match, minus 20 points if made in period -2, minus 10 points if made in period -1
- *Decentralized match technology*: firms may make one offer at any period if they are not already matched. Workers may accept at most one offer. Each participant learns only of his own offers and responses until the end of period 0. (no period 0 eq.)
- After experiencing ten decentralized games, a centralized matching technology was introduced for period 0 (periods -2 and -1 were organized as before).
- *Centralized matching technology*: participants who are still unmatched at period 0 submit rank order preference lists, and are matched by a centralized (stable) matching algorithm.

Experimental conditions

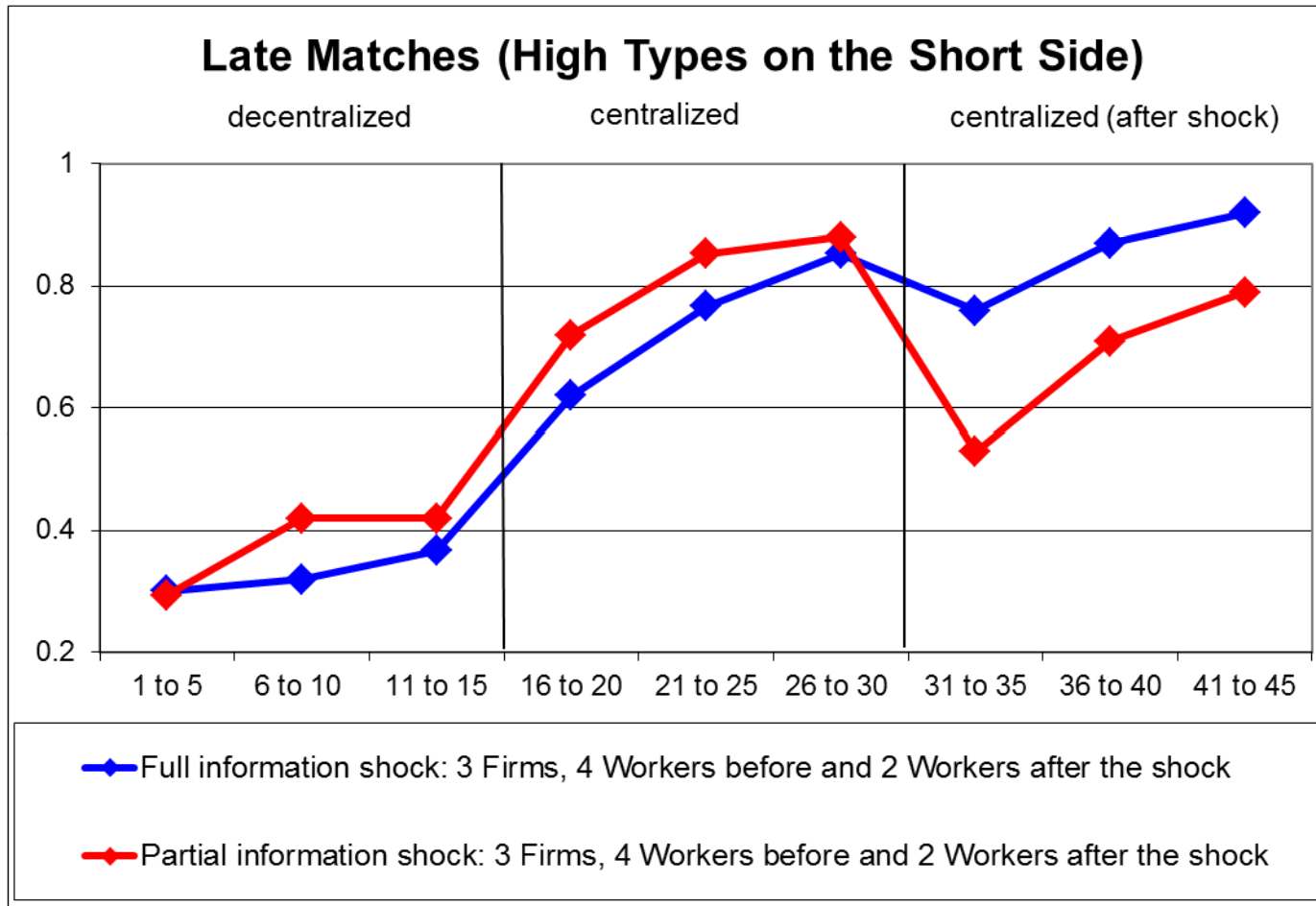
- Decentralized and Centralized matching (within subject)
- Different supply and demand (between subjects variable)
- Shocks that change the long side of the market (within subject variable)
 - 3 H firms, 4H workers → 2 H workers
- Different information conditions (symmetric or asymmetric between firms and workers) (between subject variable)

Experimental Results



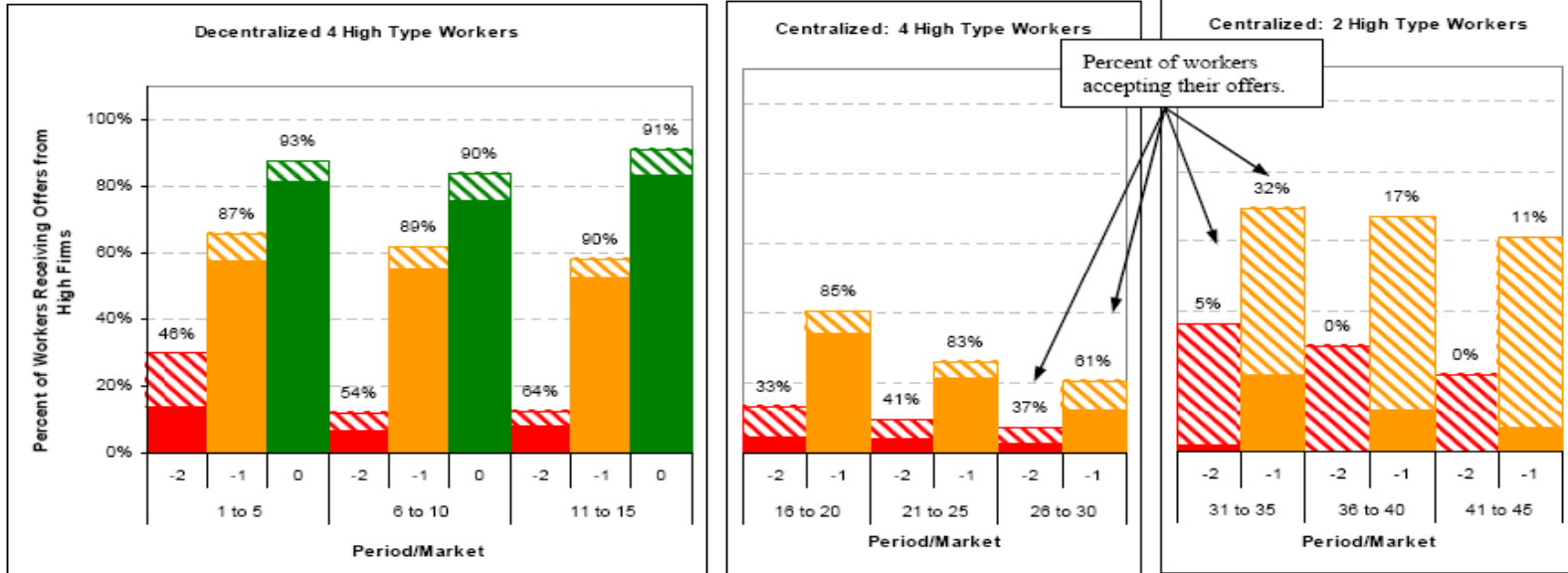
- Simple demand/supply imbalances have no effect.
- Gradual adoption of the Match (see also Kagel and Roth, 2000)

Experimental Results

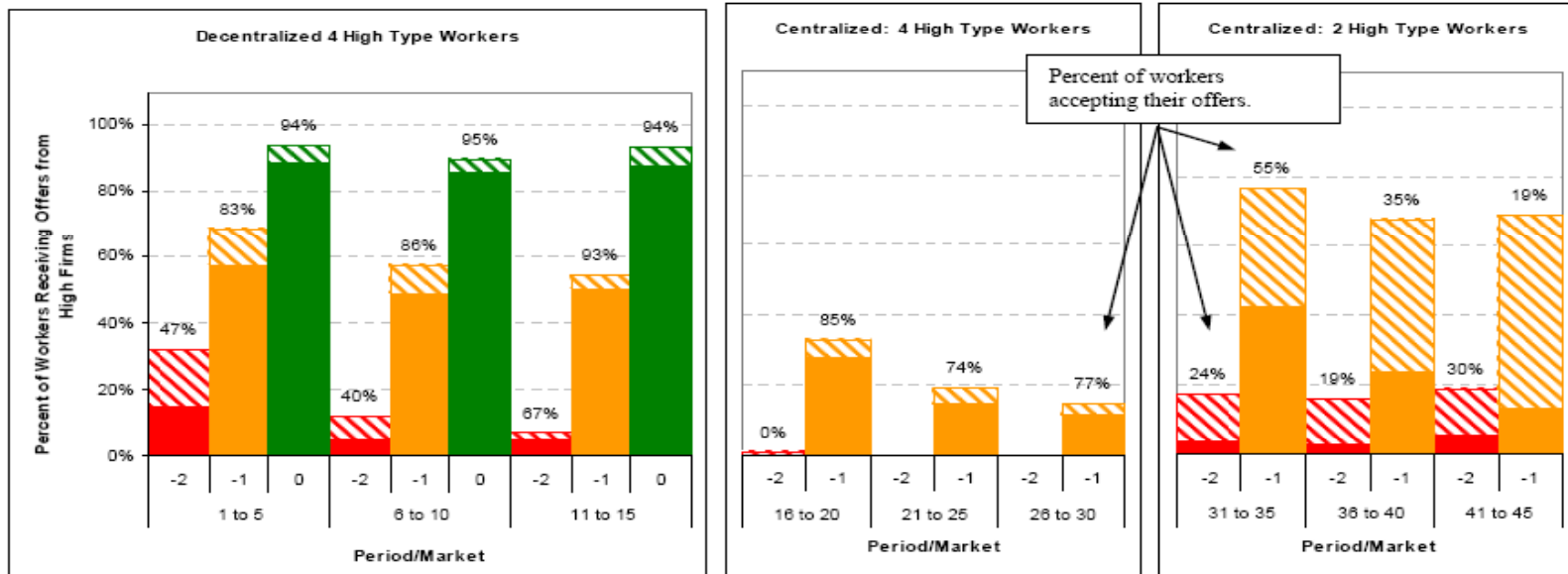


- Shocks disturb the match, especially when applicants are not aware of them.
- Gradual adoption of the match...

Full Information



Partial Information



After the shock firms start making more early offers to workers.

Workers:

- Before the shock: high type workers eagerly accept early (-1) high offers.
- After the shock: firms are in excess supply, workers have no big incentive to accept early offers.

Workers only know this when they are informed of the shock, and indeed in that case accept early offers with much lower propensity.

The ability of applicants to reject early offers seems important to prevent unraveling.

No other specialty experienced such shocks:

Cardiovascular: from 1990 to 1998 the ratio of applicants to positions offered varied from a high of 1.6 to a low of 1.3.

Pulmonary disease those ratios varied from a high of 1.5 to a low of 1.1,

For Infectious disease (from 1994 to 1998) those ratios vary from a low of .68 to a high of .92.

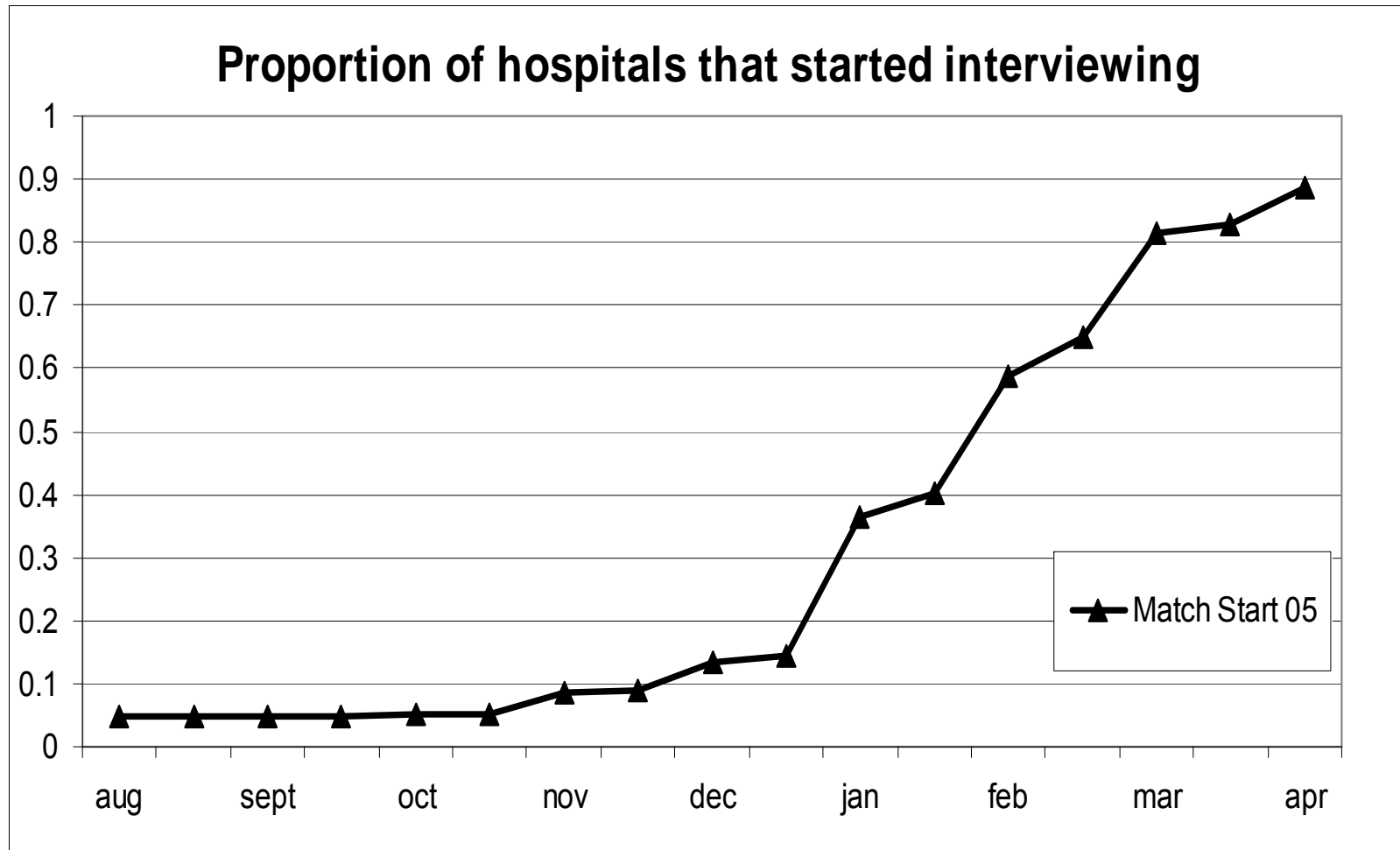
Gastroenterology: Unique Case Study

What can we learn for other markets?

Does having a centralized system affect the final outcome of the market:

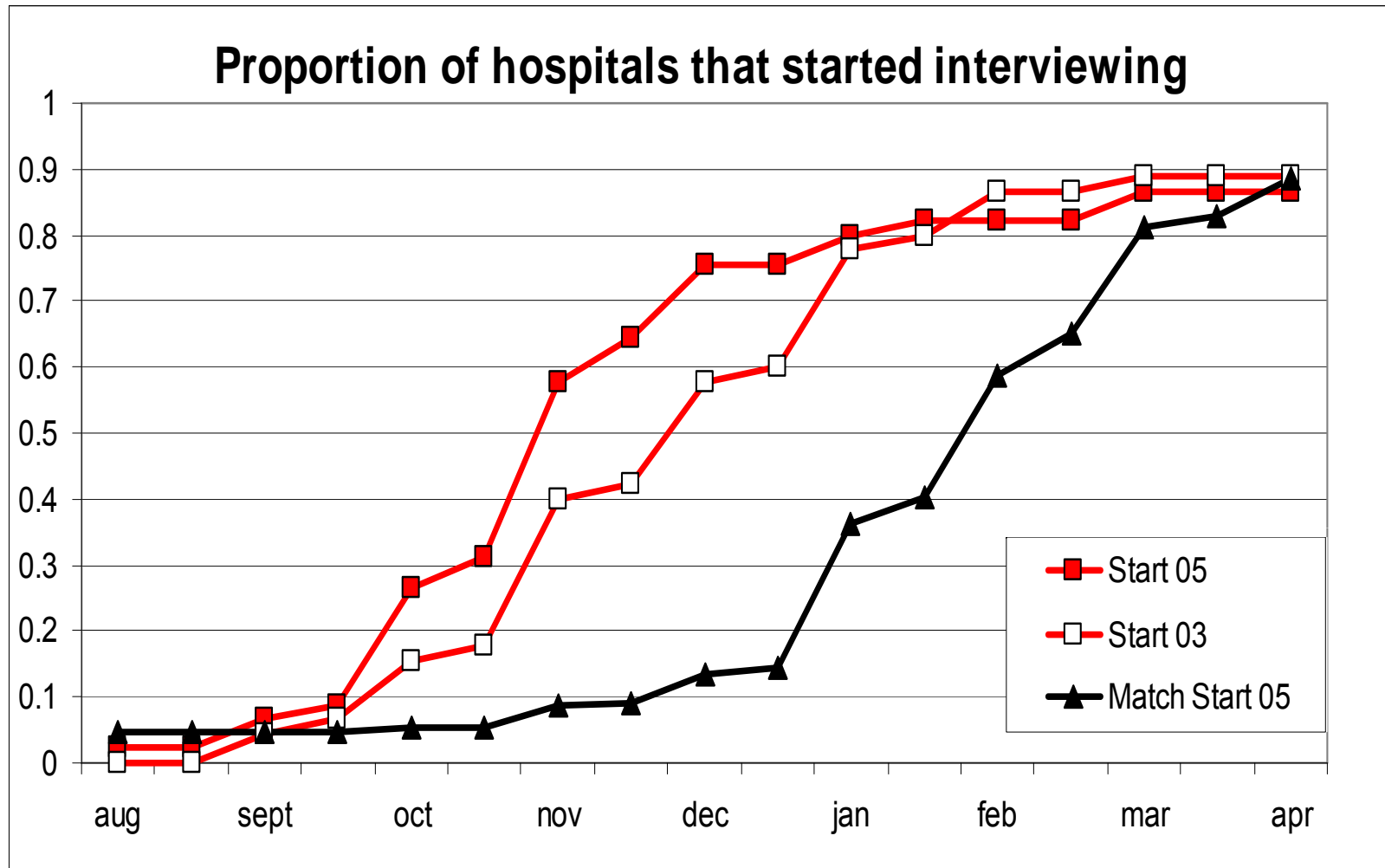
- Timing:
 - When are offers made
 - What kind of offers are made
- Who matches with whom
 - What is the importance of “Networks”
- Wages
 - Class Action Lawsuit: A match reduces wages by reducing competition... (next class)

Timing of Interviews: Unraveling



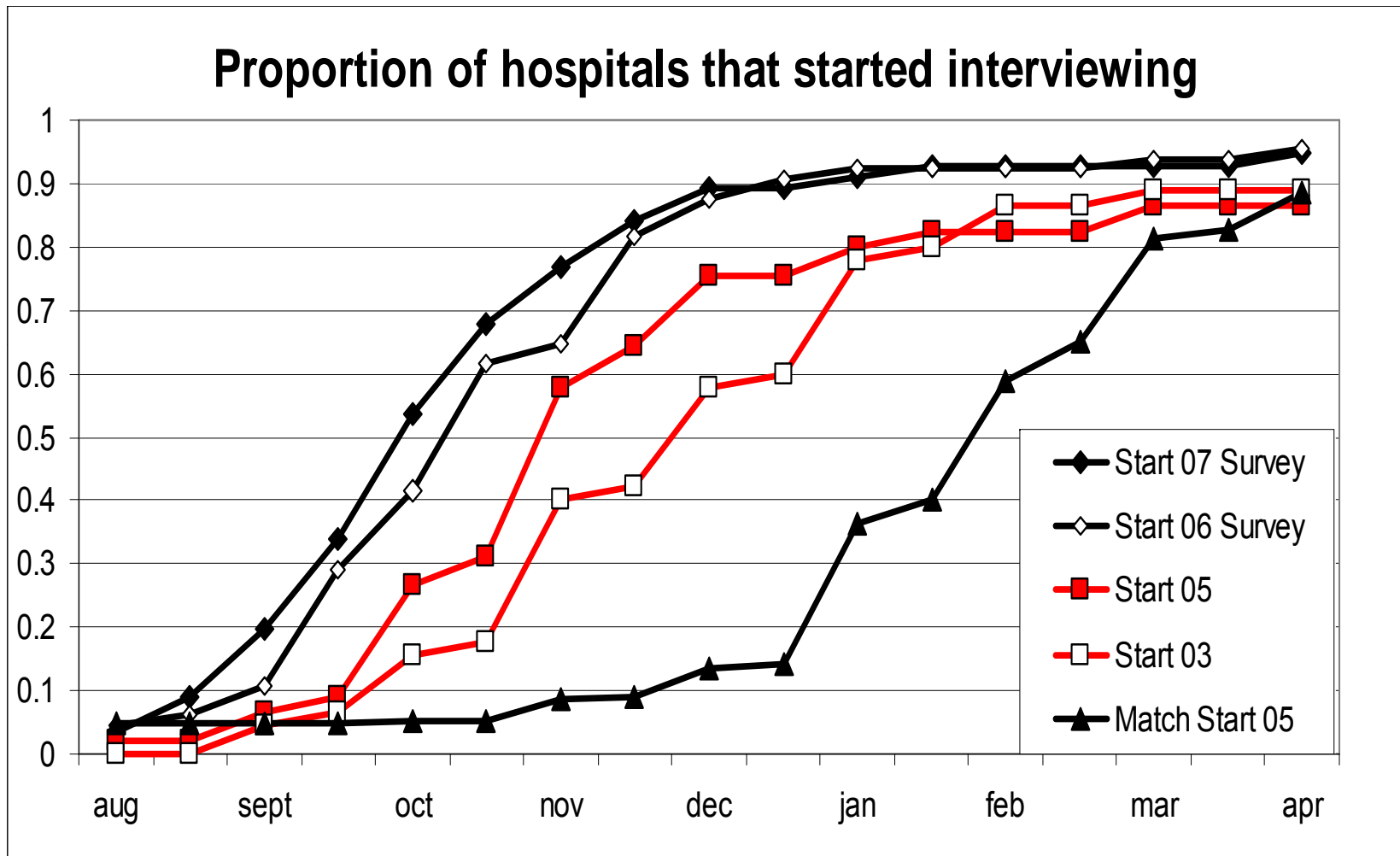
Interviews for positions starting in 05 for specialties in Match.

Timing of Interviews: Unraveling



Interviews are happening earlier and earlier

Timing of Interviews: Unraveling



Interviews are happening earlier and earlier

Timing of Offers

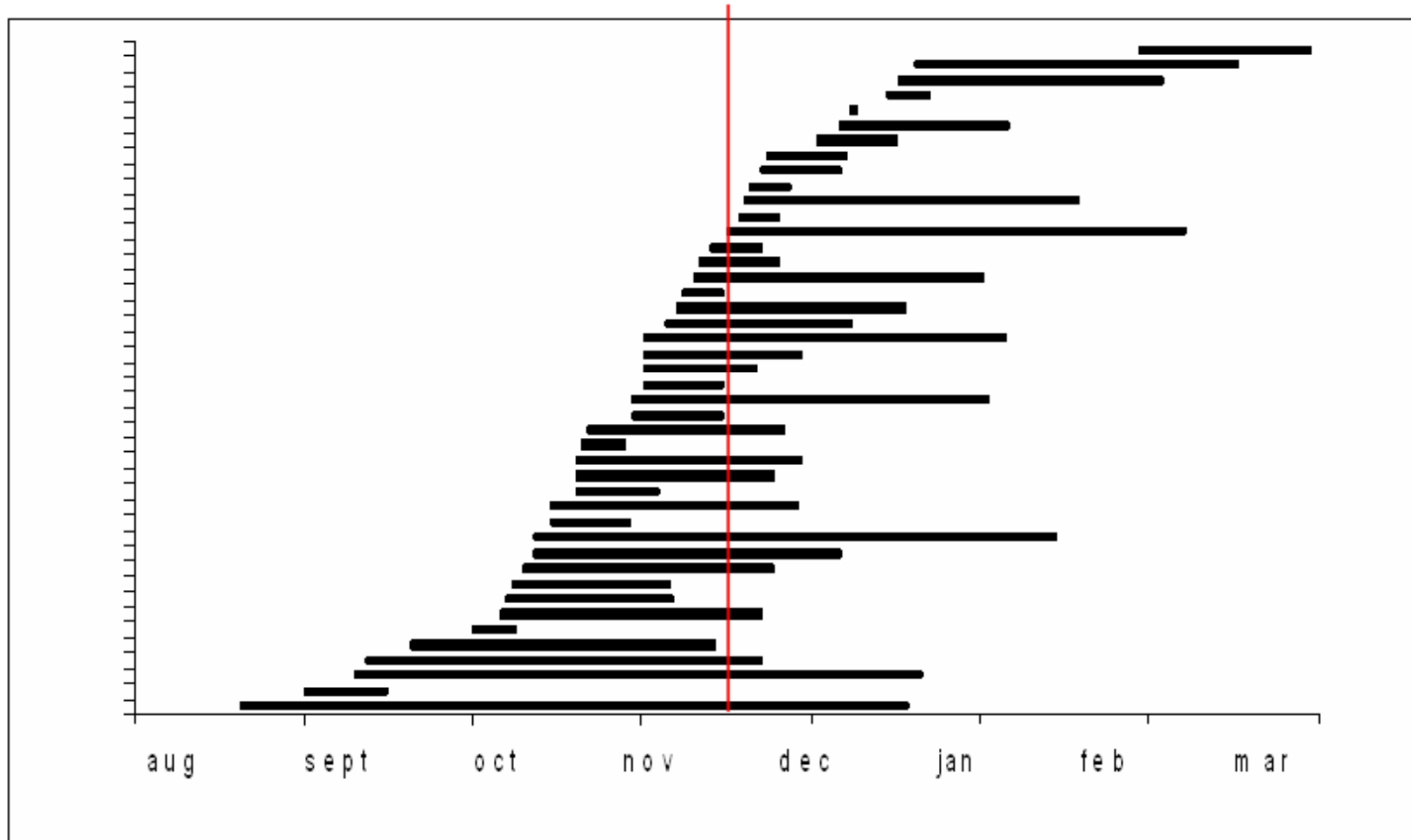
For each of 44 programs:

Use date of first and last offer, and assume that last offer is the longest open offer: Overestimate length of time they are on the market.

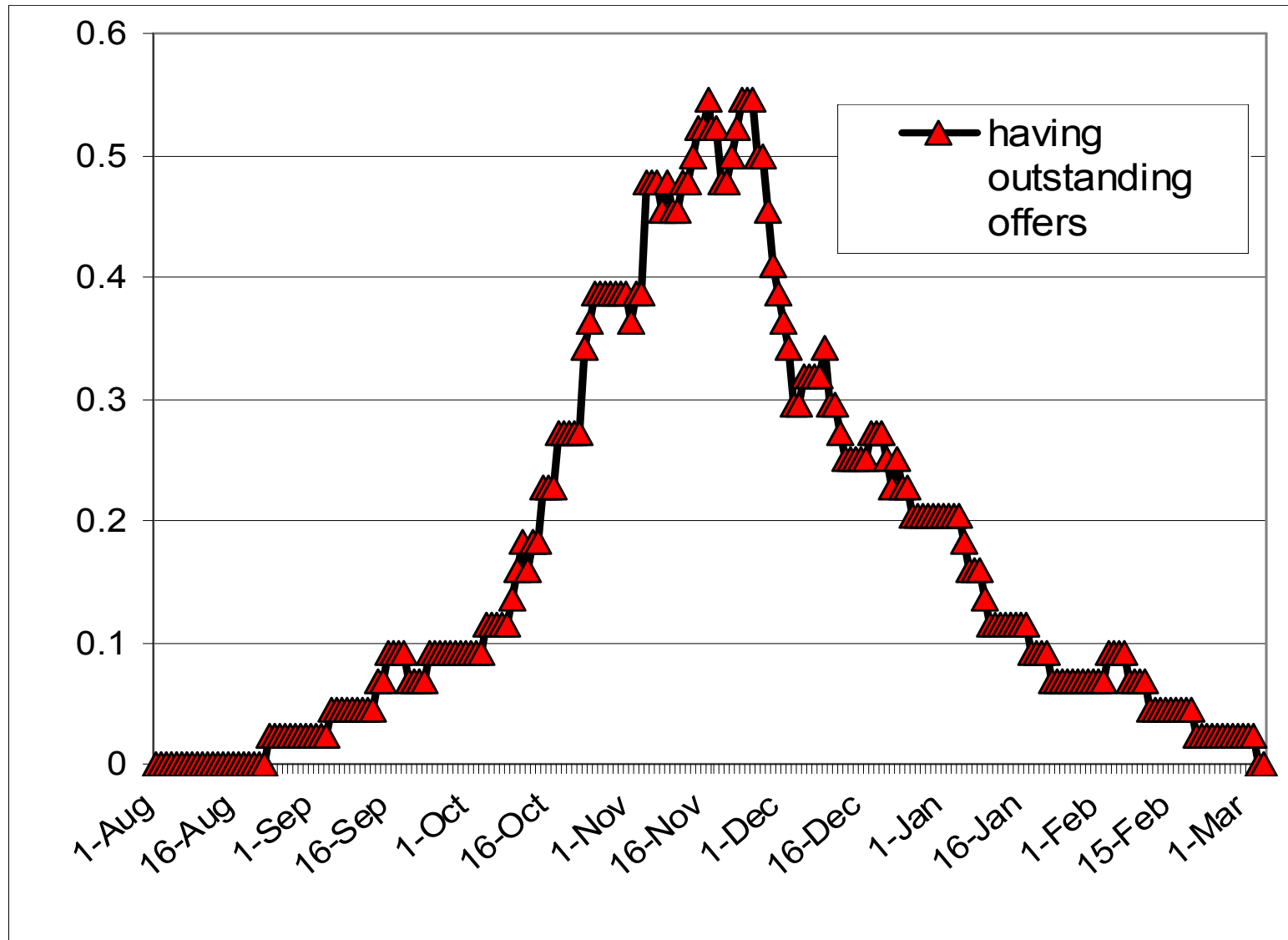
Each program is represented by one line.

Dates during which fellowship programs were making offers. Each program is represented by one of the horizontal lines, indicating the (maximal) dates during which it could have had outstanding offers (2005 survey data, n=44).

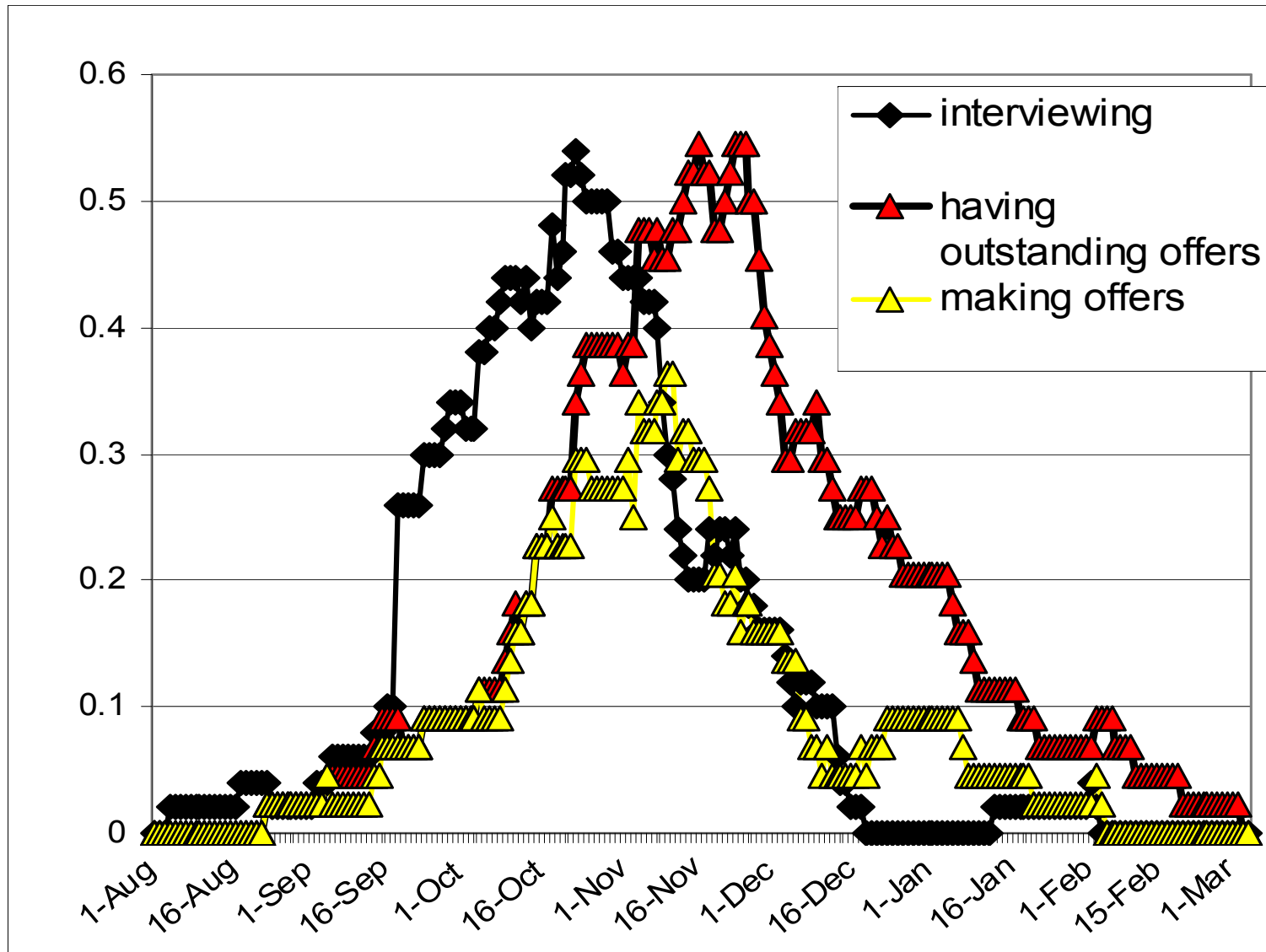
(As of November 15, 11 (27%) programs had already finished making offers, 12 (25%) had not yet started, and 21 (48%) were in the midst.)



Market is very dispersed in time...



Market is very dispersed in time...



Questionnaire

87% of programs had applicants cancel interviews.
Almost 40% experienced 5 or more of such cancellations.

46% make offers before they finish interviewing (and 6% had all slots filled by the time of their last interview).

56% of programs give deadlines of a week, and 93% of 2 weeks or less.

31% take the chance of acceptance into account when making a offer

45% speed up offers for applicants who have a short term offer in hand.

21%: longest time it took to accept an offer: one hour

- Are there other effects of a breakdown of a match in terms of who matches to whom?

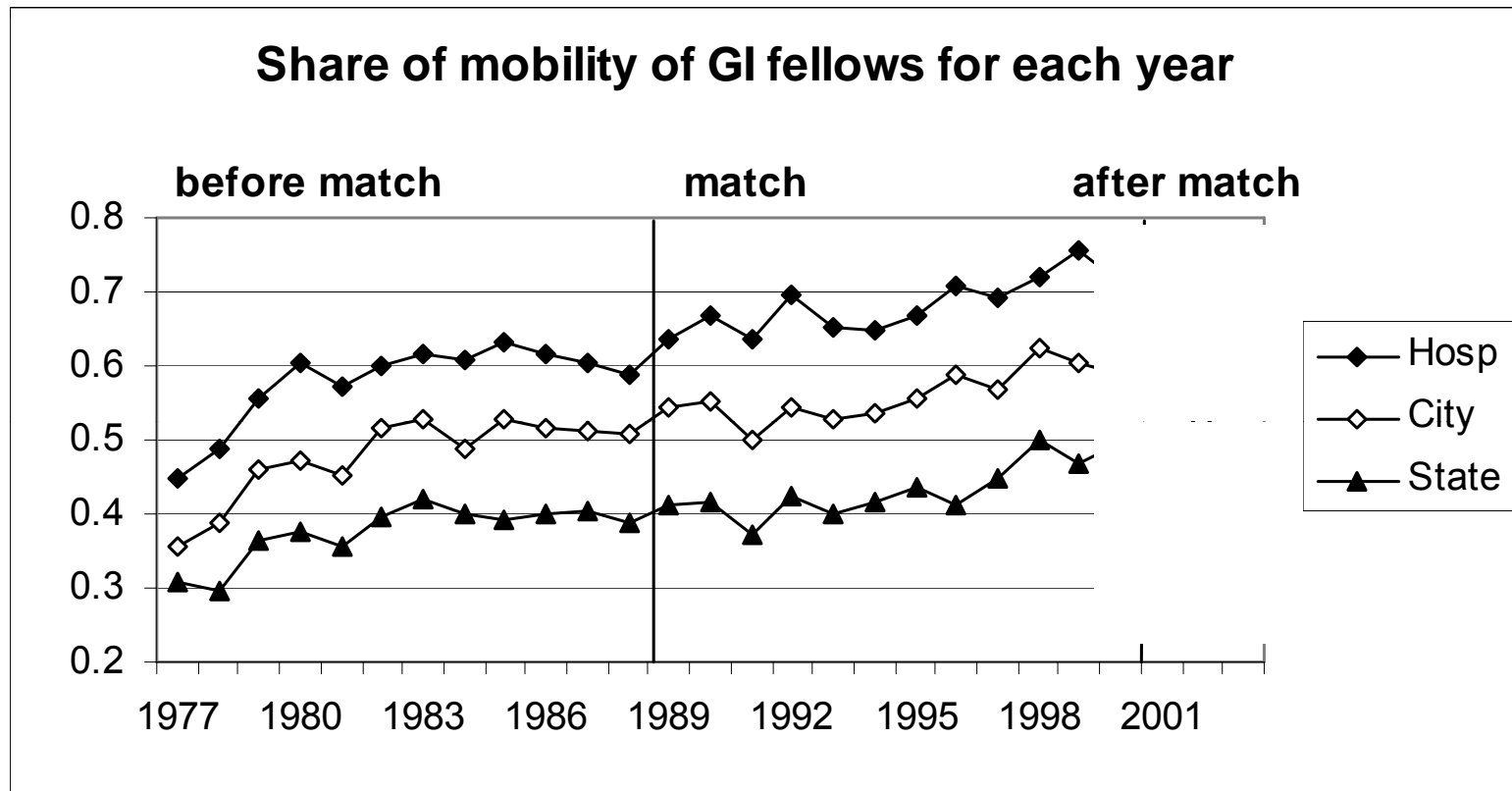
Niederle, Muriel and Alvin E. Roth, "Unraveling reduces mobility in a labor market: Gastroenterology with and without a centralized match," *Journal of Political Economy*, 111, 6, December 2003, 1342-1352.

Casual evidence: When markets unravel, participants seem to rely more on their personal networks, because they are:

- Sources of otherwise scarce information
- Can facilitate transactions when they must be completed quickly
- Can enhance the credibility of commitments made years in advance.
- We can track mobility of GI fellows during the match and compare it with mobility before and after the demise of the match.

First direct evidence that the use of a centralized clearinghouse leads to different matchings, and that unraveling may reduce the *scope* of the market.

Effects of a Match: Mobility

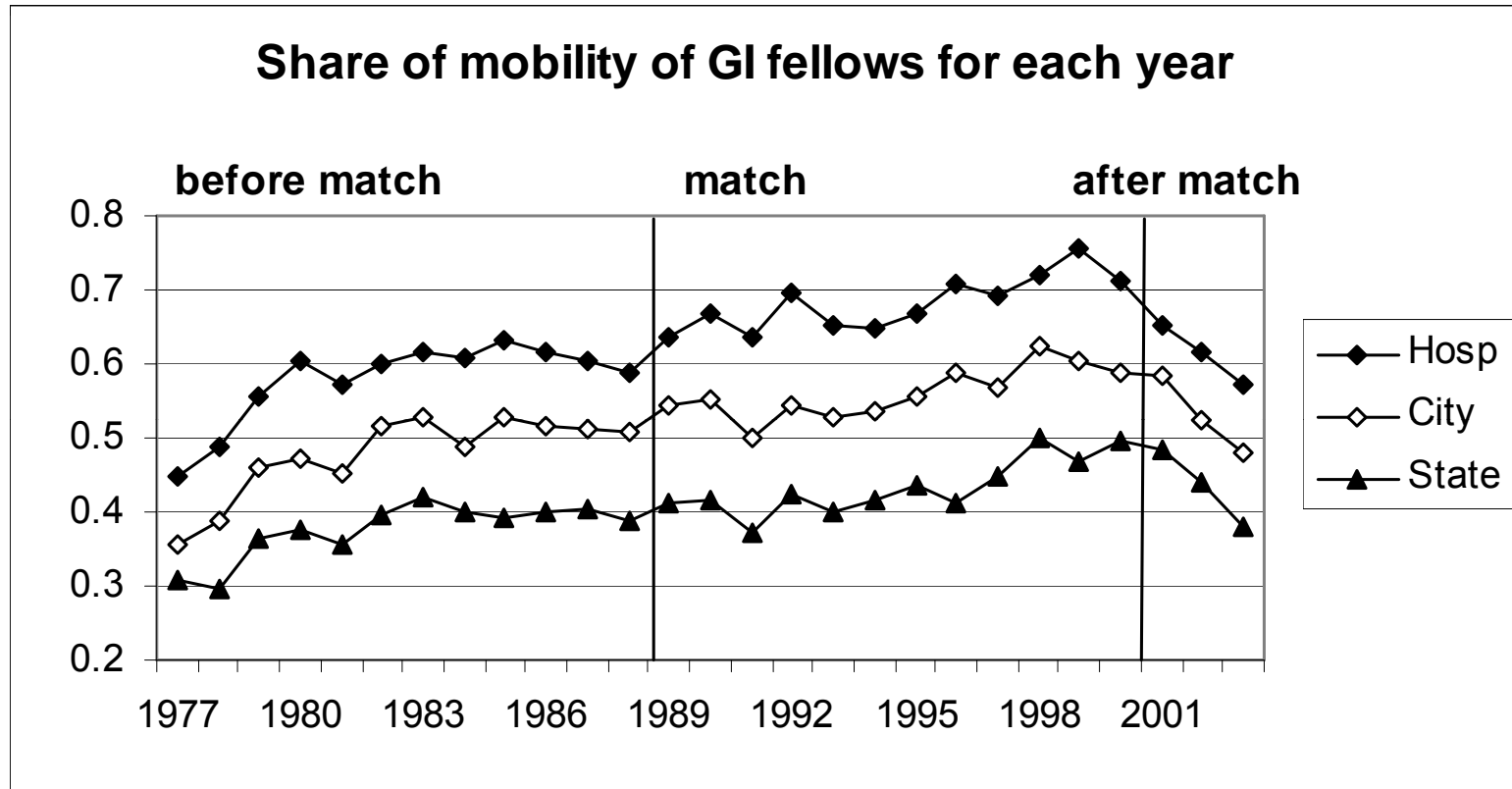


With a Match, fellows are more mobile.

This effect is more pronounced for large hospitals.

(Data: 9180 of 15,187 gastroenterologists who completed residency and fellowship in US after 1977.)

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- What about Efficiency?
- In labor markets, efficiency is hard to measure, there are however other markets in which we can see the affect of a loss of information:
- College football bowls are a three sided market (two teams and a bowl), but they make the evolution of information clear.
- For many years the NCAA attempted to organize this as a stage 2 market, with a date before which agreements should not be made between bowls and teams.
- After the 1990 season, the NCAA gave up (and the market subsequently moved to a more centralized system of matching teams to bowls).
- But the costs of matching early in that market are easy to see, since matching early sacrifices important information, and makes mismatches more likely. (This is a market in which the tv contracts have clauses relating payments to match quality, with special interest in a game between the teams ranked numbers 1 and 2 at the end of the regular season.)

1990 College Football Bowl Games: Ratings

Bowl	Match	Ratings (Writers' Poll)										
		Post-Game	12/04	11/27	11/2	11/13	11/06	10/30	10/23	10/16	10/09	10/02
Rose	Washington (Pacific-10)	5	8	9	9	10	2	7	7	13	17	17
	Iowa (Big Ten)	18	17	18	13	13	6	13	15	22	25	-
Orange	Notre Dame (Independent)	6	5	7	7	1	1	2	3	6	8	1
	Colorado (Big Eight)	1	1	1	1	2	4	9	10	14	14	12
Sugar	Virginia (Atlantic Coast)	23	-	-	17	8	11	1	1	1	2	4
	Tennessee (Southeastern)	8	10	12	14	14	9	11	11	3	5	6
Cotton	Miami (Independent)	3	4	3	2	3	5	8	8	2	3	9
	Texas (Southwest)	12	3	5	6	7	14	14	13	19	-	-
Fiesta	Louisville (Independent)	14	18	17	20	20	22	25	-	-	-	-
	Alabama (Southeastern)	-	25	-	-	-	-	-	-	-	-	-
Citrus	Nebraska (Big Eight)	24	19	19	10	11	13	3	4	4	7	8
	Ga.Tech (Atlantic Coast)	2	2	2	3	4	7	16	16	11	18	23
Gator	Michigan (Big Ten)	7	12	13	15	16	19	20	20	10	1	3
	Mississippi (Southeastern)	21	15	15	21	15	16	17	17	18	24	-
Hall of Fame	Clemson (Atlantic Coast)	9	14	14	16	16	18	18	19	22	15	16
	Illinois (Big Ten)	25	16	16	22	22	17	5	5	8	11	13
Holiday	Texas A & M (Southwest)	15	-	-	-	-	-	-	-	25	20	19
	B.Y.U. (Western)	22	13	4	4	5	8	10	9	12	13	11

Probability of top 2 teams ending the season as top 2 in AP Poll

	1 Week Prior	2 Weeks Prior	3 Weeks Prior	4 Weeks Prior
Probability	.690	.586	.310	.345
Standard Error	.086	.091	.086	.088
Number of Obs.	29	29	29	29

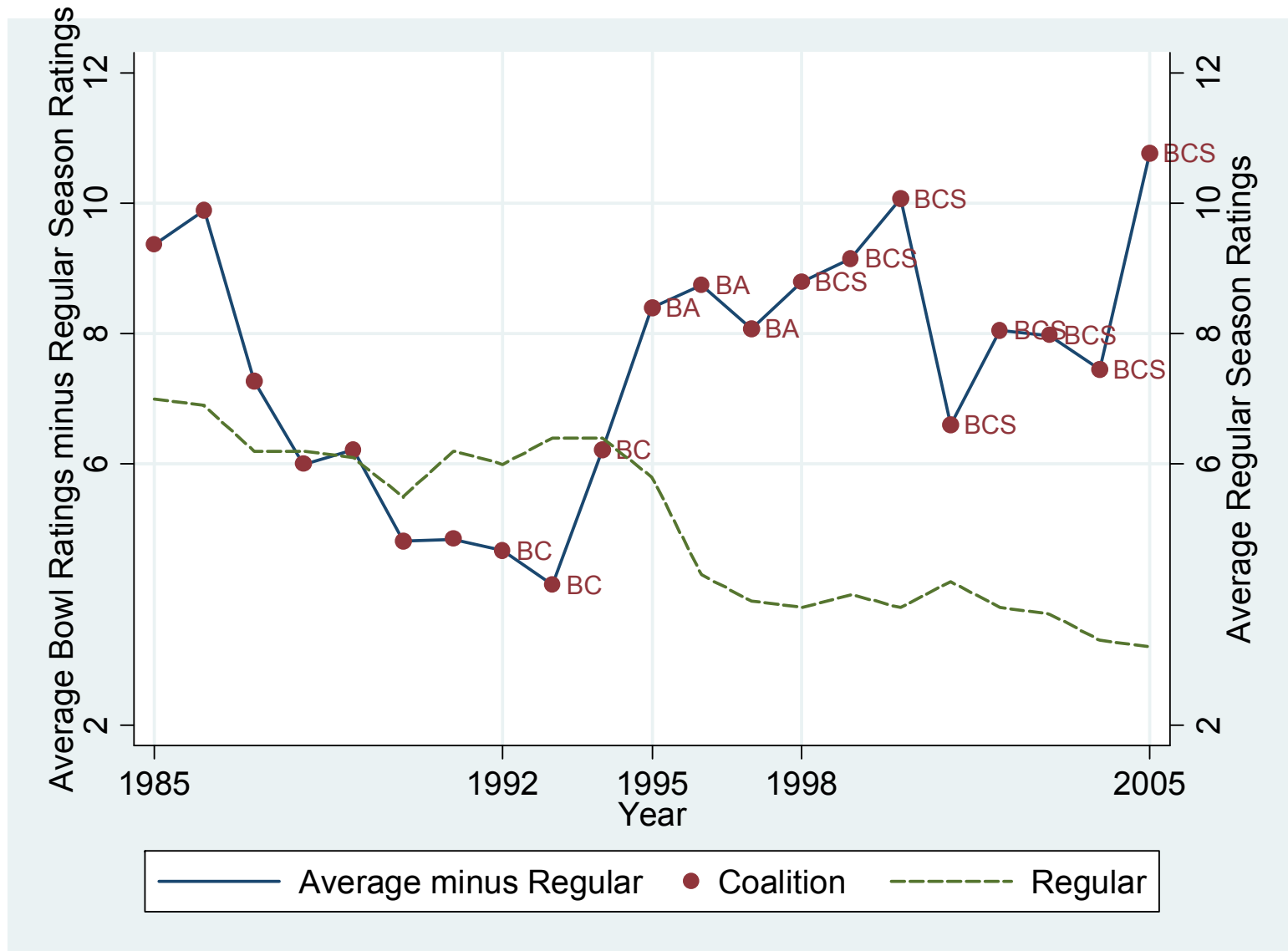
Summary of College Bowl arrangements after the NCAA abandoned its attempt to control the market after 1991

		Rose Bowl	Fiesta Bowl	Orange Bowl	Sugar Bowl	Cotton Bowl
Starting Year		1902	1971	1935	1934	1937
Matchups prior to Bowl Coalition Era (- 1992)	First Team	Since 1947 - Champion of Big Ten Conference	Until 1978 – Champion of Western Conference Starting 1978 – At Large Team	Champion of Big Eight (Twelve) Conference	Champion of Southeastern Conference	Champion of Southwest Conference
	Second Team	Since 1947 - Champion of Pacific Ten (Coast or Eight previously) Conference	At Large Team	At Large Team	At Large Team	At Large Team
Matchups in Bowl Coalition Era (1992-1994)	BC Bowl?	No	Yes	Yes	Yes	Yes
	First Team	Champion of Big Ten Conference	At Large Team possibly to create 1 – 2 matchup	Champion of Big Eight (Twelve) Conference	Champion of Southeastern Conference	Champion of Southwest Conference
	Second Team	Champion of Pacific Ten Conference	At Large Team possibly to create 1 – 2	At Large Team possibly to create 1 – 2	At Large Team possibly to create 1 – 2	At Large Team possibly to create 1 – 2

Matchups in Bowl Alliance Era (1995-1997)	BA Bowl?	No	Yes	Yes	Yes	No
	First Team	Champion of Big Ten Conference	2 At Large Teams, ACC, Big East, Big – Twelve, Southeastern conference champions possibly to create 1-2 matchup in one of these bowl games			First Team from Big – Twelve Conference not going to BA Bowls
	Second Team	Champion of Pacific Ten Conference				A team from Pacific Ten or Western Conferences out of BA Bowls
Matchups in Bowl Championship Series Era (1998-)	BCS Bowl?	Yes	Yes	Yes	Yes	No
	First Team	<i>ACC, Big East, Big – Twelve, Big Ten, Pacific Ten, Southeastern conference champions, up to 2 highly ranked other conference or at large teams (with Notre Dame having priority) always to create always 1-2 matchup in BCS rankings in one of these bowl games</i>				First team from Big – Twelve Conference out of BCS Bowls
	Second Team					A comparable team from Southeastern Conference

During this time the membership of the various conferences also changed, and a number of independents joined conferences.

...and increased the efficiency of the market:
 Average Normalized Nielsen Ratings in BCS Bowls



What is the effect of a Match (and of unraveling) on wages?

Motivation:

- In 2002, 16 law firms filed a class action law suit, representing 3 former residents, arguing that the NRMP violated antitrust laws and was a conspiracy to depress resident's wages. They sought to represent the class of all current and former residents, against a class of defendants including the NRMP, many other medical organizations, and all hospitals that employ residents.
- “Defendants and others have illegally contracted, combined and conspired among themselves to displace competition in the recruitment, hiring, employment and compensation of resident physicians, and to impose a scheme of restraints which have the purpose and effect of fixing, artificially depressing, standardizing and stabilizing resident physician compensation and other terms of employment.”

What do fellows think of this situation:

- For example, GI Fellows Bauer, Fackler, Kongara, Matteoni, Shen and Vaezi, 1999, comment in a letter on the effects of the demise of the match.
- *“Of recent concern is the deterioration of the match process for candidates applying for fellowship positions over the past two years. Our junior colleagues are concerned that they may not be able to wait safely to interview with the institution of their choice while a position is offered elsewhere early in the decision process. The absence of the match benefits the programs a great deal more than their applicants.”*

We'll defer this to the next class.

Should GI restart the Match? And How?

As GI lost the match, the market reverted to unraveling: Hires are almost a year earlier than they were with the MSMP

The market also became more localized:

Trade Journals: several calls for a return to the match

Some design issues for restarting a match

- Match may not be a Pareto improvement (Ehrinpreis AJG 2004)
 - We are most likely to choose from among our own residents [..]. Indeed, some GI programs no longer solicit applications from other programs' residents. Program directors at these institutions know that they are still disappointing some of their own very good residents, and try hard to promote their virtues to other programs. However, programs hesitate to recruit fellows from a pool of residents rejected by the GI program at the residents' own institutions.
- If many programs hire early, it is difficult to wait for a (not yet established) match, despite the advantages of late hiring at a uniform time.

Transition to a later market

- In May 2005, 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) decided to reintroduce a GI fellowship match, starting in 2006, for positions beginning in July 2007.
- How to manage the transition?
 - Rates of participation
 - Concern among programs about whether their chief competitors will participate.
 - Change of dates to June 2006 (from as early as July 2005)
 - How to reassure programs that other programs will wait for Match? (Without a congested transition like 1945-50)⁴⁰

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

Which markets are unraveled?

- It appears that markets in which transactions are made at early, uncoordinated times are markets in which there are both
 - Exploding offers
 - Binding commitments
- Many markets have institutions that directly address when offers can be made and accepted, and what it means for an offer to be accepted.

Organizations concerned with the timing of when offers are made,
accepted, rejected

- **Council of Graduate Schools (CGS): graduate admissions,**
- National Association for College Admission Counseling (NCAC): undergraduate admissions, (early action, early decision...)
- National Resident Matching Program (NRMP): entry level medical residencies, (also Canadian Resident Matching Service – CaRMS – and various regional matches in Britain)
- **Specialty Matching Services (SMS): advanced medical residencies and fellowships,**
- Association of Psychology Postdoctoral and Internship Centers (APPIC): clinical psychology positions,
- National Association for Law Placement (NALP) for positions in law firms,
- **Judicial Conference of the United States and various ad hoc committees of judges for federal judicial clerkships,**
- Provincial Law Societies in Canada.
- National Association of Colleges and Employers (NACE) for US college undergraduates,
- **NCAA: formerly for postseason college football bowls, now regulated by the Bowl Championship series (BCS),**
- NCAA for recruitment of college athletes, and various drafts...
- National Panhellenic Conference for sorority matching
- The Japan Federation of Employers' Associations (Nikkeiren) for Japanese university graduates



**Council of
Graduate Schools**

**Resolution Regarding Graduate
Scholars, Fellows,
Trainees, and Assistants**

“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.

The discussion about the culture is explicit: \

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

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

Early exploding offers are discouraged

- Directly
- indirectly: They are made less enforceable.

Hypothesis

Markets in which transactions are made at early, uncoordinated times are markets in which there are both

- Exploding offers
- Binding commitments

But, markets in the list differ in many dimensions: Size, Wages, Rules, Norms...

The need for experiments

- Note that a simple experimental environment will be quite different from the markets in the table, and from the gastroenterology market.
- The laboratory environment, because it is so simple, is different from each of these markets in more transparent ways than they are different from one another.
 - while it is always somewhat risky to draw inferences about the effect of a rule change in one market from the effects in a different market, the inferences may be clearer when one of the markets is simple.
- And in the experiment, the rules are an exogenous experimental variable, so that their influence can be readily observed.

An experiment allows us to view different offer regimes in a controlled environment

- 5 firms, 6 applicants, 9 periods.
- In each period, a firm may make an offer to at most one applicant. Firms make offers, applicants decide upon the offers they receive.
- *Firms and applicants are assigned “qualities.”*
- *If firm of quality x hires an applicant of quality y , both firm and applicant will receive a payoff of xy points each.*
- *Firms’ qualities are simply their assigned participant number, 1,2,3,4,5.*
- *Uncertainty about applicants’ quality is only resolved over time:*
- *In periods 1, 4 and 7, each applicant receives a “signal,” an integer between 1 and 10, each equally likely.*
- *In period 7, the relative ranking of the sum of the 3 signals determines the applicants’ quality. The applicant with the highest sum of 3 signals has a quality of 6... Ties are broken randomly.*
- Firms see all signals, applicants see only their own signals (as they become available over time) and their ranking in period 7.

(Note that in this experiment the cost of early matching is bad matches due to uncertainty about quality.)

Experimental treatments: 3 “market cultures”

Exploding offers: Firms can make exploding offers and acceptances are binding.

Reneges: Firms can make exploding offers, but applicants can renege on their acceptance, for a small fee (1 point).

Open offers: Firms can only make open offers.

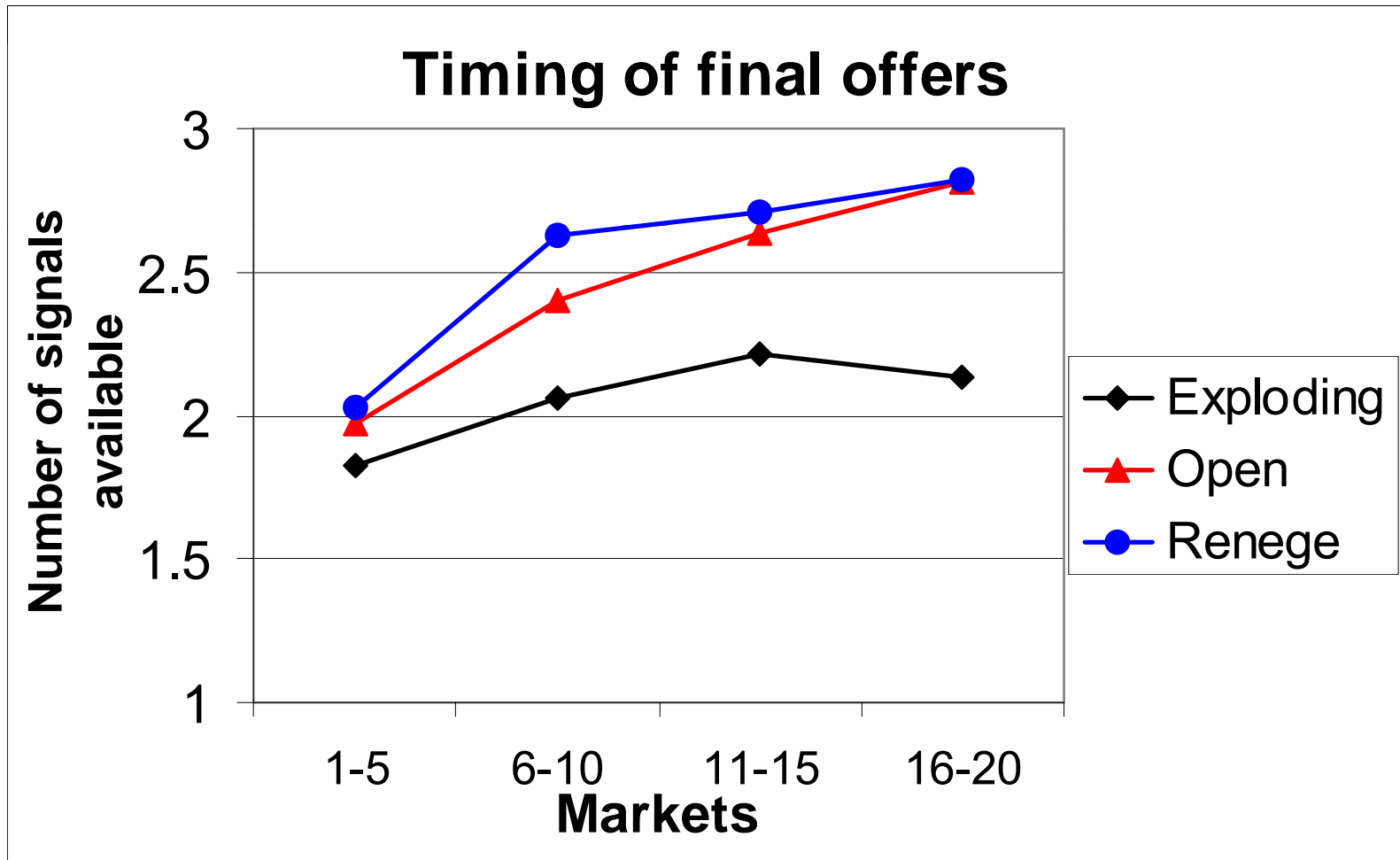
(Many equilibria:

One in which all matches are agreed upon inefficiently early.

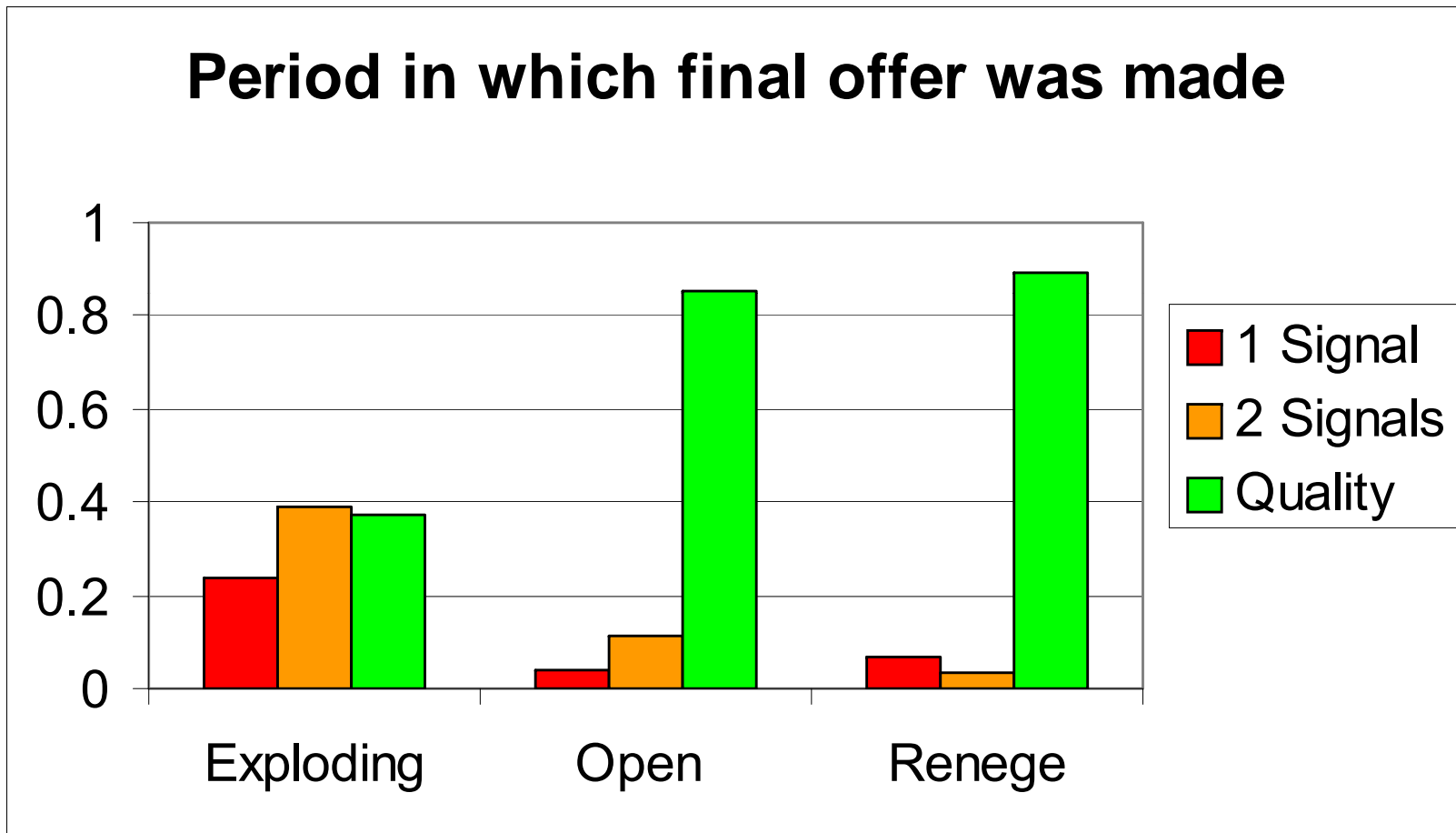
All environments have a perfect equilibrium with efficient late matching.

But the late matching equilibrium is more fragile when offers are exploding and acceptances are binding.)

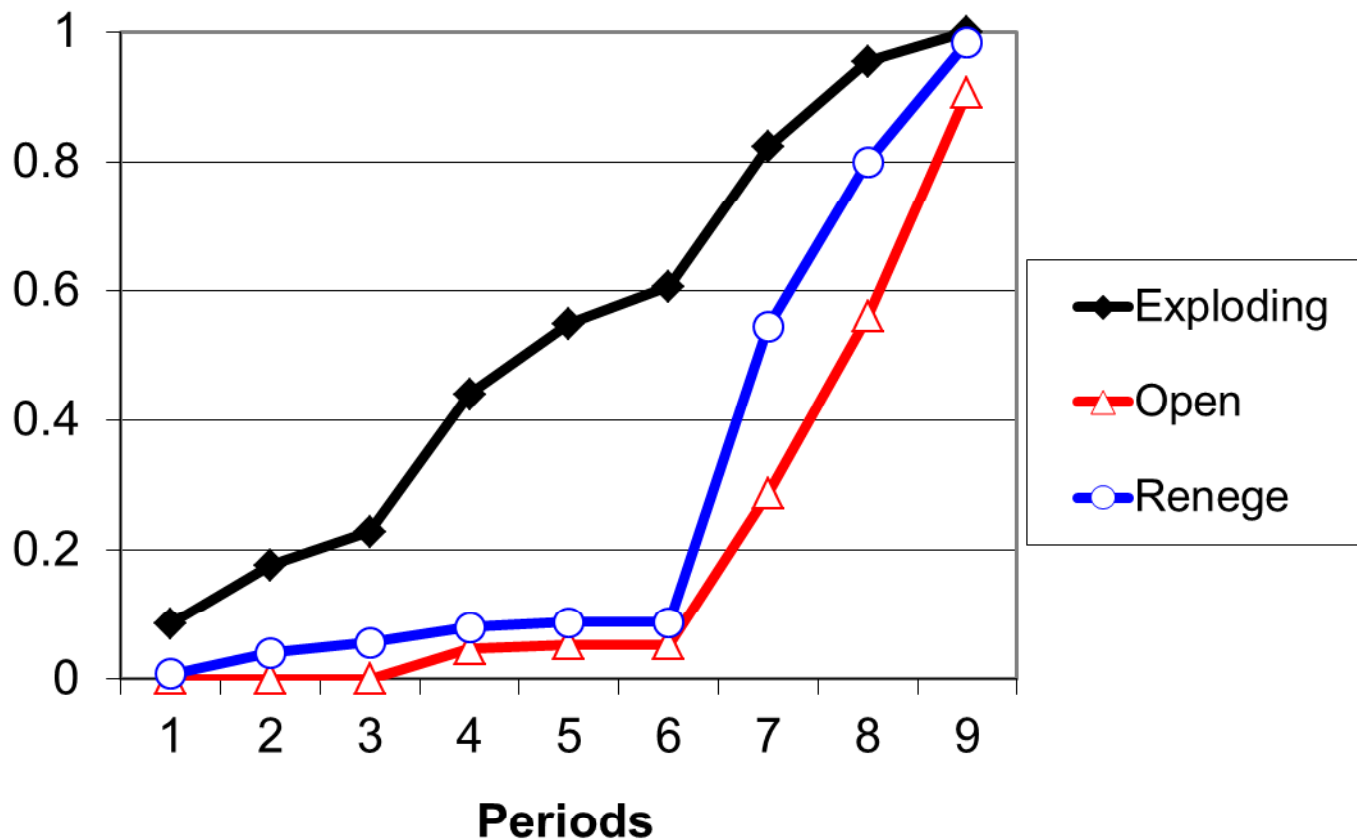
Timing of final offers (offers that were accepted and not renege upon for the renege treatment) in terms of the number of signals that were observed.



In last five periods...

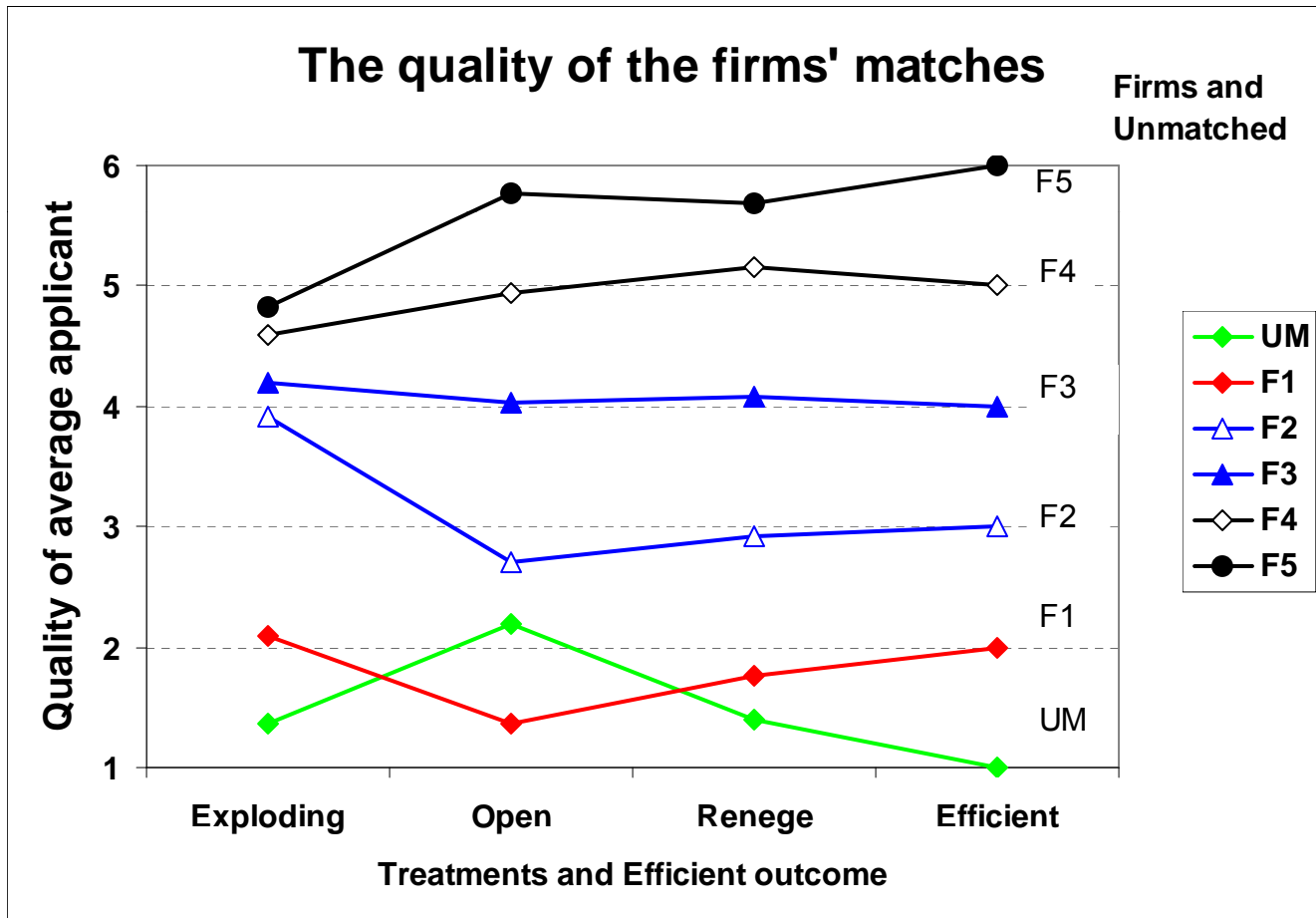


Unraveled Markets are more dispersed



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

Not everyone loses... (so it can be hard to get consensus on reversing unraveling:)





Resolution Regarding Gastroenterology Fellowship Applicants, Including all Research and Clinical Fellowship Applicants and Positions

This resolution concerns the conditions surrounding gastroenterology fellowship offers to applicants, acceptance by applicants of such offers, and participation by applicants and programs in the gastroenterology fellowship Match. 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. ... The intention of this resolution is to ensure uniformity so that everyone participates fairly and to establish the principle that all positions should be filled through the Match or after Match Day. 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. Early offers and acceptances, and offers outside of the Match, are violations of the rules and of this resolution and are not condoned. Any applicant may participate in the matching process by registering for the Match to interview and consider match-participating programs; however, an applicant who accepts a position prior to, or outside of, the Match must comply with the National Resident Matching Program/Specialty Matching Services (NRMP/SMS) Match Participation Agreement by either resigning the accepted position if he/she wishes to submit a rank order list of programs or by withdrawing from the Match prior to the rank order list certification deadline, which is the first week in June. In addition, no program may withdraw a position from the Match after the quota change deadline to offer that position outside the matching process. ... 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 as well as to provide uniform and widely acceptable rules that protect both applicants and fellowship programs.

Table 2. Important Dates for the 2011 Match for Positions Starting July 2012^{15,16}

Date	Event
July 1, 2010	ERAS Post Office (MyERAS web site) opens to fellowship applicants.
November 15, 2010	Applicants may electronically apply through ERAS to programs of their choice.
December 1, 2010	Programs can access ERAS Post Office to download applications submitted to them.
January 5, 2011	GI Fellowship Match (NRMP/SMS) opens for on-line registration by programs and applicants.
January–May 2011	Programs interview applicants.
April 6, 2011	The Match Rank Order List (ROL) option opens for programs and applicants.
May 18, 2011	The Match Quota Change Deadline—the date on which programs MUST submit the final number of positions offered in each track to be matched.
May 31, 2011	ERAS Post Office closes.
June 1, 2011	The Match Rank Order List (ROL) certifications are due from programs and applicants.
June 15, 2011—Match Day	Match results for programs and applicants are posted to the NRMP website at 12 noon Eastern time.
July 1, 2012	Fellowship training begins.

“In addition to this resolution, and to promote and build trust and confidence in the process, the NRMP/SMS implemented a 2-week time gap between the position quota and the ROL submission deadlines. In other words, all programs must submit their position quota for each track to the NRMP/SMS 2 weeks before the ROL deadline. This creates a risk for any program that considers offering [...] positions outside of the Match. The program would have to withdraw a corresponding number of positions before the quota deadline, but there would exist a 2-week window in which [...]the “accepted” applicants could decide to withdraw their “acceptance” and go on to submit an ROL for the Match (which is completely permissible by both NRMP/SMS rules as well as per the resolution). This would leave the program with unfilled positions.”

Deborah D. Proctor, Arthur J. Decross, Charles E. Willis, Tamara N. Jones, et al, “The Match: Five years later”, *Gastroenterology* Vol. 140, 1, Pages 15-18 55

The gastroenterology match for 2007 fellows was held June 21, 2006, and succeeded in attracting 147 of the 151 eligible fellowship programs, 13 of which withdrew before the match.

The final participation rate: 89%

98% of the positions offered in the match were filled through the match.

Early movers couldn't impose a big negative externality on those who waited for the match, since pre-match exploding offers would not necessarily remove candidates from the market. This made it easier for everyone to wait for the match.

The second year of the centralized match was successfully run in June 2007, and the third in 2008.

Table 1. GI Fellowship Match Participation^a

Start Date	Tracks ^a	Programs	Positions Offered	Total Applicants	Matched Applicants
2007	134	112	283	585	276
2008	150	123	325	622	313
2009	153	126	339	608	328
2010	153	127	361	627	345
2011	157	130	383	642	362

^aThe NRMP lists this column as certified programs, counting all of the participating tracks in gastroenterology, as many as 4 for any single program. Excluding military programs, there are approximately 155 GI fellowship programs that are eligible to participate in the NRMP/SMS giving GI programs an 84% participation rate for positions starting in July 2011.

But, challenges remain...

“not all programs are eager or willing to participate in the Match process. This reticence is often attributed to 1 of 2 challenges”

1. competition for candidates at a regional level and
2. competition for candidates in research tracks.

Example of regional challenge: the 3 programs in the New Orleans area understandably faced unique challenges in sustaining trainee recruitment after the devastation of Hurricane Katrina. Some of the New Orleans program directors felt they needed to recruit outside of the match to secure applicants who might otherwise have been discouraged from ranking these programs owing to the loss of regional resources.

Ad 2: The competition for these increasingly scarce, well-qualified, research-track applicants has become fierce, and the authors are aware of several examples during the last application cycle of candidates interested in research being offered fellowship positions outside the Match.

It is an awareness of this potential for exploitation by a minority of programs that creates unrest among the majority, and seems to fuel the gossip each season, which is undermining to the confidence in the Match.

Orthopedic surgery has the same problem

- But aspiring surgeons may not be able to turn down early offers after accepting them, even if the orthopedic organizations were to adopt a policy like the gastroenterologists'.
- However, while the (15) orthopedic professional organizations also cannot directly prevent employers from making early offers, unlike the gastroenterologists, they feel they can effectively punish employers who make early offers, by not allowing them to present papers at professional meetings.
- So it looks like the orthopedic organizations are going to try to adopt a clearinghouse by instituting a series of penalties for employers who don't participate according to the rules.
- Harner, Christopher D., Anil S. Ranawat, Muriel Niederle, Alvin E. Roth, Peter J. Stern, Shepard R. Hurwitz, William Levine, G. Paul DeRosa, Serena S. Hu, "Current State of Fellowship Hiring: Is a universal match necessary? Is it possible?," *Journal of Bone and Joint Surgery*, 90, 2008,1375-1384.

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Orthopaedic Foot and Ankle Fellowship Match

The **Orthopaedic Foot & Ankle Fellowship Program** is sponsored by the **American Orthopaedic Foot & Ankle Society (AOFAS)**. Registration and the match is administered by the San Francisco Matching Program (SF Match), and the application for fellowship programs and distribution of application materials to the programs are administered by the AOFAS. The Orthopaedic Foot & Ankle Fellowship Program is designed to be a transparent, unbiased process in which applicants are matched to foot and ankle fellowship programs on a competitive basis.

Sponsorship

The **American Orthopaedic Foot & Ankle Society (AOFAS)** sponsors the matching process and is responsible for enforcement of applicable rules. The Matching office does not sponsor or approve any of the participating programs. The function of the Matching Program is strictly limited to processing of the match. Listing or not listing of any program in the directory does not imply any form of approval, disapproval or endorsement.

Pediatric Orthopaedic Surgery Fellowship Match

The Pediatric Orthopaedic Surgery Fellowship Match (POSM) was established in 2009. Its goal is to coordinate fellowship appointments, thus relieving the pressure of uncoordinated appointments and forced early choices. The participating programs will not make any appointments until the match has been completed.

Sponsorship

The **Pediatric Orthopaedic Society of North America (POSNA)** sponsors the match process and provides a forum for the discussion of match-related issues. The Matchin

Orthopaedic Trauma Fellowship Match

The Fellowship Match for **Orthopaedic Trauma (OTA Match)** was established in 2008. Its goal is to coordinate fellowship appointments, thus relieving the pressure of uncoordinated appointments and forced early choices. The participating programs will not make any appointments until the match has been completed.

OTA Fellowships at a Glance

<http://www.ota.org/fellowshipprogram/searchataglance.aspx>

Sponsorship

The **Orthopaedic Trauma Association (OTA)** sponsors the matching process and is

Orthopaedic Sports Medicine Fellowship Match

The Orthopaedic Sports Medicine Fellowship Match (OSMFM) was established in 2008. Its goal is to coordinate fellowship appointments, thus relieving the pressure of uncoordinated appointments and forced early choices. The Match has 93 programs representing 219 fellowship positions participating. The participating programs will not make any appointments until the match has been completed.

Sponsorship

The **American Orthopaedic Society for Sports Medicine (AOSSM)** and **Arthroscopy Association of North America (AANA)** sponsor the matching process and provides a forum for the discussion of match-related issues. The Matching office does not in any way sponsor or approve any of the participating programs. The function of the Matching

Federal judges hiring law clerks have a similar problem

- This market has also unraveled.
- Like orthopedic surgeons, law students can't change their minds no matter how early the offer (law students are not in a position to break promises to federal judges).
- Like the gastroenterology organizations, the judicial conferences have no way to prevent judges from hiring early, or from making exploding offers, or punishing those who do.
- Judges, while debating using a centralized clearinghouse, won't move there: One problem is that they will have to first become willing to do some "community enforcement" of norms against early exploding offers before a clearinghouse will work for them.
- Instead: They opt for a "decentralized" solution: Trying to enforce timing of transactions.

Law Clerks

Avery, Christopher, Christine Jolls, Richard A. Posner, and Alvin E. Roth, "The Market for Federal Judicial Law Clerks", *University of Chicago Law Review*, 68, 3, Summer, 2001, 793-902.

- The market for clerkships starting in 2003 cleared in the September 2001, i.e. at the very beginning of the first semester of the second year of law school; nearly two years before the start of employment.

This introduces several potential causes of inefficiency.

- because the market clears so early, it clears before information becomes available (e.g. students' second and third year grades, law review articles, etc.) that can help produce efficient matches of particular clerks and judges.
- because competition among judges to hire earlier than their competitors makes the market fast, chaotic, and thin, many students and judges have little opportunity to consider a wide range of options, but rather have to transact quickly, before options can be developed.

The proximate cause of that study:

Memo from the Administrative Office of the United States Courts, to All United States Judges, October 7, 1998.

“At its September 15, 1998 session, the Judicial Conference of the United States rescinded its September 1993 policy recommending to all judicial officers that March 1 of the year before a clerkship begins be the benchmark starting date for law clerk interviews. This action was taken because the policy on law clerk interviews has not been universally followed...”

Over the next few years

- interviews led very quickly to offers
- offers produced very quick responses
- responses were generally acceptances; and
- many scheduled interviews were canceled as a result.

Thus, students and judges tended to pair off quickly with those with whom they have early interviews. As a result,

- many students limited the judges to whom they apply to avoid being paired off early with a less preferred judge
- We also witnessed complex but binding verbal contracts.
- Offers became earlier from year to year (moving back from February to September of the second year).

Avery, Christopher, Christine Jolls, Richard A. Posner, and Alvin E. Roth,
“The New Market for Federal Judicial Law Clerks”, *University of Chicago
Law Review*, 74, Spring 2007, 447-486

**Proximate Cause for the Study
UNITED STATES COURTS OF APPEALS**

March 11, 2002

Dear Dean:

We are pleased to report that the federal appellate judges have voted overwhelmingly in favor of a new Plan for Law Clerk Hiring. The Plan includes: **(1) a moratorium on law clerk hiring during the Fall of 2002, (2) an arrangement ensuring that the hiring of law clerks will not be done earlier than the Fall of the third year of law school, and (3) an agreement that the focus of law clerk hiring will be on third year law students and law graduates.**

The precise terms of the new Plan are set forth in the attached "Summary," and the history leading to the Plan's adoption appears in the appended "Background" statement. More than two-hundred federal appellate judges considered the Plan. Ninety-two percent (92%) of the judges either supported the Plan or indicated that they would not oppose it. Thus, the "substantial consensus" requirement that was needed to put the Plan into operation was easily satisfied. 66

Judges' memo, cont.

“There are numerous advantages to a law clerk hiring system that focuses on third year students and law graduates. Law clerk candidates will be able to present more information with their applications and be judged more fairly. Thus, for example, applicants who are in their third year of law school will be able to offer

- a transcript showing performance during four semesters of school in a good variety of courses;
- information on law journal selection, journal publications, and election to a journal editorial board;
- writing samples from seminar courses;
- information regarding experience gained in clinical courses and public interest endeavors;
- references from law professors for whom the student has worked as a research assistant or a teaching assistant;
- recommendations associated with judicial internships;
- significant recommendations from Summer employers;
- information on moot court competitions; and
- information on selection or election to positions in student government.

Initial FAQ (accompanying judges' memo)

Q Does the Plan endorse Summer interviewing?

A No. Many judges would have opposed the Plan had it endorsed Summer interviewing. There was a concern that Summer interviews would be very inconvenient for many people. The reasons are manifold: many judges are away on vacation during the Summer; law clerk applicants are otherwise occupied with Summer jobs, vacations, foreign travel, and bar examinations (for recent graduates); law professors often are away on vacation and thus unavailable to furnish references; and law schools do not release grades on any uniform schedule, so official student transcripts from some law schools are not available until near September. **However, the Plan does not forbid a law student who, say, is from Virginia and working in Tulsa during the Summer from talking with a judge who is otherwise available to chat.** This has happened under existing hiring arrangements and the judges saw no reason to prohibit it under the new Plan. The main point, however, is that the formal hiring process will take place in the Fall when applications will be submitted and materials and references from the law schools will be sent to the judges.

Initial FAQ, cont.

Q How is "Fall" determined under the Plan?

A **There is no fixed definition of Fall, nor is there any fixed starting date for the hiring season.** Under existing arrangements, some judges do their hiring in September, some in October, and others do it even later. The Plan does not change this.

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

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

Subsequent refinements of rules

- From year to year, changes have been made to
 - Put precise start dates for applications (after Labor Day—already specified by start of market in 2003)
 - Specify later precise dates for
 - Scheduling interviews
 - Conducting interviews and making offers
 - No rules regarding exploding offers

2004 modifications

The critical dates under the Revised Law Clerk Hiring Plan are as follows:

- **After Labor Day:** Third year law students and law school graduates may submit law clerk applications and letters of reference may be submitted on their behalf.
- **From the Day After Labor Day Through the Second Sunday After Labor Day** (September 7 - 19 in 2004): Reading period.
- **Beginning on the first Monday after Labor Day** (September 13 in 2004): Judges may schedule interviews to be held after the reading period.
- **Beginning on the Second Monday After Labor Day** (September 20 in 2004): Judges may conduct interviews and extend offers.

Subsequent modification of dates in 2005.

2009

FEDERAL JUDGES LAW CLERK HIRING PLAN

Critical Dates Under the Law Clerk Hiring Plan for 2009

Event	Fall 2009
First date when applications may be received:	Tuesday, September 8, 2009 (OSCAR release: 10:00 a.m. (EDT))
First date and time when judges may contact applicants to schedule interviews:	10:00 a.m. (EDT), Friday, September 11, 2009
First date and time when interviews may be held and offers made:	8:00 a.m. (EDT) Thursday, September 17, 2009

Data

They have repeated the surveying of both federal appellate judges and applicants that they did in their prior study.

- Federal appellate judges surveyed in fall of 2004 and fall of 2005.
- Third year law students at the four law schools that provide the greatest number of clerks surveyed in fall of 2004, fall of 2005, and fall of 2006.
- About a 50% response rate from both federal appellate judges and students. On the key measure of judge reports of adherence versus nonadherence to the start dates, if anything selection bias should lead us to underestimate the level of nonadherence.

Adherence to start dates (2004 judge survey; gray areas = nonadherence)

	Number and (in parentheses) cumulative percentage of responding judges				
	Before September 7	September 7–12	September 13–19	September 20–26	After September 26/Not yet
Date of first interview	11 (9%)	6 (15%)	22 (33%)	66 (91%)	11 (100%)
Date of first offer	5 (4%)	9 (12%)	11 (21%)	67 (78%)	26 (100%)

Judges' perceptions: 2004

Number and (in parentheses) cumulative percentage of responding judges					
	Overall				Within Circuit
	Relatively few judges adhered	To responding judge's knowledge, many judges adhered but a substantial number did not	To responding judge's knowledge, almost all judges adhered	To responding judge's knowledge, all judges adhered	At least one judge in Circuit did not adhere
Start date for scheduling interviews	3 (3%)	34 (36%)	41 (75%)	26 (100%)	36 (69%)
Start date for conducting interviews and making offers	5 (5%)	43 (46%)	40 (85%)	16 (100%)	36 (73%)

Judges' perceptions: 2005

Number and (in parentheses) cumulative percentage of responding judges					
	Overall				Within Circuit
	Relatively few judges adhered	To responding judge's knowledge, many judges adhered but a substantial number did not	To responding judge's knowledge, almost all judges adhered	To responding judge's knowledge, all judges adhered	At least one judge in Circuit did not adhere
Start date for scheduling interviews	5 (6%)	40 (52%)	27 (84%)	14 (100%)	35 (87%)
Start date for conducting interviews and making offers	4 (5%)	44 (58%)	23 (86%)	12 (100%)	34 (81%)

Student reports: 2004

(gray areas = nonadherence)

	Number and (in parentheses) cumulative percentage of responding students				
	Before September 7	September 7–12	September 13–19	September 20–26	After September 26/Not yet
Date of first scheduling of interview	8 (5%)	39 (31%)	94 (92%)	8 (97%)	5 (100%)
Date of first interview	9 (6%)	7 (11%)	18 (23%)	101 (91%)	13 (100%)
Date of first offer	4 (3%)	3 (5%)	8 (12%)	84 (77%)	29 (100%)

Student reports: 2005

(gray areas = nonadherence)

	Number and (in parentheses) cumulative percentage of responding students				
	Before September 6	September 6–14	September 15–21	September 22–28	After September 28/Not Yet
Date of first scheduling of interview	12 (9%)	35 (35%)	80 (95%)	1 (96%)	5 (100%)
Date of first interview	8 (6%)	10 (13%)	24 (31%)	83 (93%)	9 (100%)
Date of first offer	3 (3%)	7 (9%)	5 (13%)	89 (89%)	13 (100%)

Student reports: 2006

(gray areas = nonadherence)

	Number and (in parentheses) cumulative percentage of responding students				
	Before Sept. 5	Sept. 5-13	Sept. 14-20	Sept. 21-27	After Sept. 27/Not Yet
Date of first scheduling of interview	13 (11%)	31 (38%)	68 (97%)	3 (99%)	1 (100%)
Date of first interview	13 (11%)	6 (16%)	18 (32%)	77 (97%)	3 (100%)
Date of first offer	10 (9%)	3 (12%)	10 (22%)	69 (87%)	14 (100%)

Exploding offers remain a problem: Some representative quotes

- “I received the offer via voicemail while I was in flight to my second interview. The judge actually left three messages.
First, to make the offer.
Second, to tell me that I should respond soon.
Third, to rescind the offer.
It was a 35 minute flight.”
- “I had 10 minutes to accept.”
- “I asked for an hour to consider the offer. The judge agreed; however thirty minutes later [the judge] called back and informed me that [the judge] wanted to rescind my offer.”

Exploding and short-fuse offers: **judges'** reported deadlines

	1998-1999 and 1999-2000 markets	2004-2005 and 2005-2006 markets
Within one day	23%	34%
Within two days	36%	42%
Within a week	67%	76%
Number of responding judges	193	163

Fast market clearing: student responses

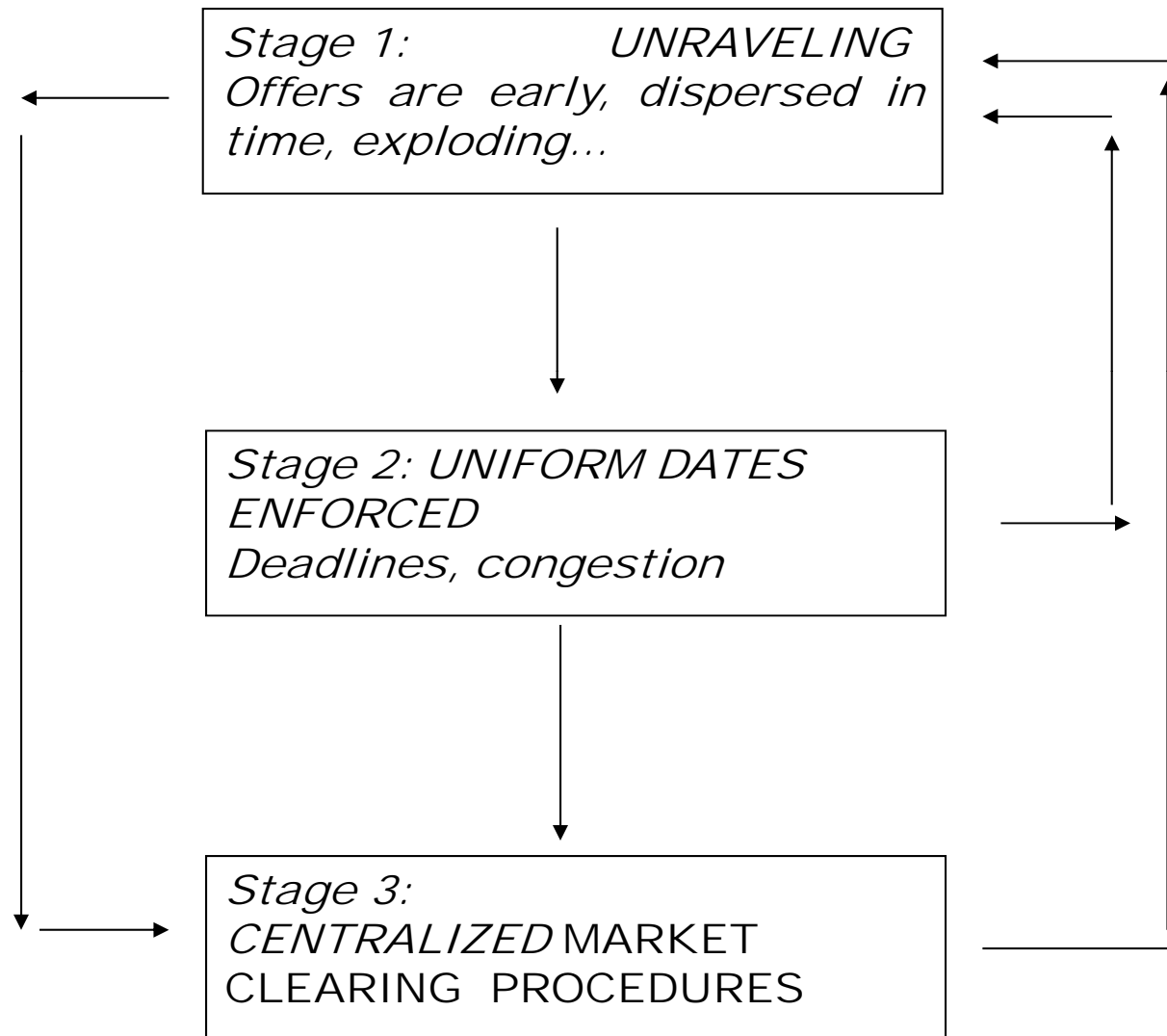
	Fall of 2004	Fall of 2005	Fall of 2006
First offer received on start date for interviewing and making offers	38	51	45
First offer received after start date for interviewing and making offers	59	52	38
Of first offers received on start date for interviewing and making offers, percentage accepted on start date	42%	63%	62%

So, for a nontrivial proportion of students, the market ends after the first interview (and some offers come even before the start date). Similarly for judges, the market is not thick.

Recap

- The market has now successfully held the late date (fall of third year of law school) for several years in a row (2003-).
 - This yields an advantage due to better information
 - This certainly helps the many non-complying judges who make the earliest offers, and apparently also helps many of the complying judges.
- But congested interviewing, exploding offers are still a problem
 - This means that for many participants, the market still isn't in fact thick.
- What are the prospects for the future?

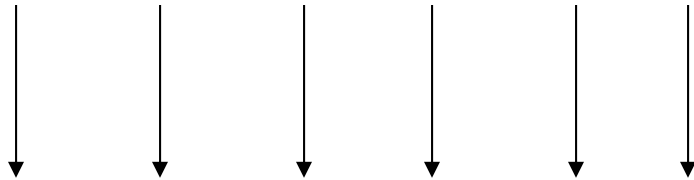
Stages and transitions observed in various other markets with timing problems



Uniform start dates in the law clerk market

Stage 1: UNRAVELING

1983, 1986, 1989, 1990, 1993, 2002



Stage 2: UNIFORM
DATES ENFORCED

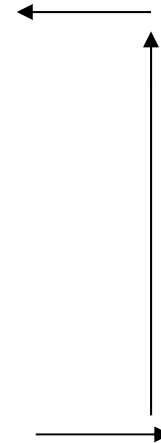
1983: Sept 15 of 3rd year, abandoned in '84

1986: April 1 of 2nd year

1989: March 1, not adopted

1990: May 1, 12:00 Noon

1993: March 1 (not formally abandoned until 1998)



Thoughts on the future evolution of the clerk market

- It has cycled between stage 1 and stage 2 multiple times
- Comparison to other markets,
 - Stage 2 markets
 - Psych—25 years in stage 2.
 - Japanese universities
- The current arrangement has formally held together longer than the previous longest (1993-97) stage 2 arrangement. But there's lots of 'non-compliance'.
- Discussions are underway about market design...

Which markets are unraveled?

Supply and demand.

- Li and Rosen, Li and Suen, ...insurance
- Halaburda
- Niederle, Roth and Unver
 - In some markets unraveling is attributed to an imbalance of supply and demand
 - But to get unraveling you need two things:
 - Firms have to be willing to make early offers
 - Workers have to be willing to accept them
 - This is most likely to occur when both firms and workers can plausibly think of themselves as being on the long side of the market...a common state of mind in the markets we study...

Simple supply and demand hypothesis

- ***Excess supply or demand (in the relevant part of the market) increases competition, which causes inefficiently early transactions.***
 - Menard (book review, 2003), on college admissions:
"There are many reasons that college admission has become so complex, but the main one is demand..(In 1932 Yale admitted 72% of applicants, now 13%)".
 - Avery, Fairbanks, and Zeckhauser (book, 2003, p32) quote a 1990 U.S. News and World Report story.
"Many colleges, experiencing a drop in freshman applications as the population of 18-year-olds declines, are heavily promoting early-acceptance plans in recruiting visits to high schools and in campus tours in hopes of corralling top students sooner."
 - Roth (JPE 1984) about the market for new physicians around 1900,
"The number of positions offered for interns was, from the beginning, greater than the number of graduating medical students applying for such positions, and there was considerable competition among hospitals for interns. One form in which this competition manifested itself was that hospitals attempted to set the date at which they would finalize binding agreements with interns a little earlier than their principal competitors."

Comparable supply and demand hypothesis

- Early transactions require both that firms should want to make early offers, and workers should want to accept them.
- So too much imbalance in supply and demand should *not* be associated with unraveling.

In many markets, both sides feel they are on the long side...

College admissions	Fewer positions at “elite” colleges than students eager to enroll.	Many positions available at unselective colleges
Federal court clerkships	Many more law grads than judges	Fewer Law Review editors than Federal appellate judges
American medical residents	Many more first year positions than graduates of American med schools	Many more interested foreign medical graduates than American positions
Medical subspecialties	More board-certified applicants than positions	Fewer “top” and research oriented applicants than positions
Postseason College Football Bowls (before BCS)	More teams than bowls	Fewer “top” teams than “top” bowls

Law Clerks (Wald, 1990)

- "But why the fervent competition for a handful of young men and women when our law schools spawn hundreds of fine young lawyers every year? Very simply, many judges are not looking just for qualified clerks; they yearn for neophytes who can write like Learned Hand, hold their own in a discussion with great scholars, possess a preternatural maturity in judgment and instinct, are ferrets in research, will consistently outperform their peers in other chambers and who all the while will maintain a respectful, stoic, and cheerful demeanor.... Thus, in any year, out of the 400 clerk applications a judge may receive, a few dozen will become the focus of the competition; these few will be aggressively courted by judges from coast to coast. Early identification of these "precious few" is sought and received from old-time friends in the law schools -- usually before the interview season even begins."

Supply and demand model

- n_F firms, n_F^h of high quality
 - **Firm quality is common knowledge from time 1**
- n_A applicants, of which n_A^h will **eventually** become high quality
 - Only the proportion n_A^h/n_A is known until the first period of the **late** hiring stage, when the high quality individuals are realized
- Rules: there are multiple *early* and *late* periods: each unmatched firm may make an offer to at most one worker in each period, acceptances are binding.

Rules

- At the beginning of each period, each available firm can extend an offer to an applicant of its choice.
- After the firms make offers, the applicants observe all the offers made by the firms and each applicant can accept one of the offers she got in the period or reject them all.
- Acceptances are binding; once an applicant accepts an offer, firms cannot make her further offers.
- Each offer is valid only in the period it is extended (it is an exploding offer; although workers can consider multiple offers if made in the same period...)
- After the period is over, all decisions made in the period become public information.

Payoffs

- Remaining unmatched earns zero. Let $EU(i,j)$ be the expected payoff of a quality i agent from being matched with a quality j agent. $EU(i,j)$ is increasing in both arguments and supermodular so that

$$EU(h,h)-EU(h,\ell)>EU(\ell,h)-EU(\ell,\ell)\geq 0$$

- At the beginning of the late stage, a tie-breaking lottery e is drawn to rank high quality agents among each other and low quality applicants among each other from the best to the worst. The lottery results become public information.
- The payoff of an agent a with quality i being matched with a partner b of quality j is given by
$$u_a(b)=EU(i,j)+e_b$$
- where e_b is the lottery draw of the agent b . $E[e]=0$ and support of e is small enough so that being matched with a high quality partner is always better than being matched with a low quality partner

Efficiency and inefficiency due to unraveling

- We'll see big (and visible) inefficiencies in which high quality agents are unnecessarily matched with low quality, i.e. in which the matching isn't as assortative as it could be.
- ***Qualitywise Efficiency*** = Sum of the Expected Payoffs are maximized (without taking tie-breaker into account)
 - Supermodularity A matching is qualitywise efficient if and only if it is qualitywise assortative i.e. high type applicants are matched with high firms as long as it is possible and remaining agents are matched with low quality partners as long as it is possible.

Many Nash equilibria

- But we'll be able to say something about subgame perfect equilibria.

Supply and demand conditions

- Case 1. EXCESS SUPPLY: $n_A^h \geq n_F$: Every firm can be matched with a high quality applicant, some high quality applicants remain unmatched.
- Case 2. COMPARABLE DEMAND & SUPPLY: $n_A > n_F > n_A^h$: Excess applicants, but shortage of high quality applicants. *Comparable supply and demand*
- Case 3. EXCESS DEMAND I: $n_F \geq n_A > n_F^h$
Excess firms, but shortage of high quality firms
- Case 4. EXCESS DEMAND II: $n_F^h \geq n_A$ Every applicant can be matched with a high quality firm, some high quality firms remain unmatched₉₇

Subgame perfect equilibria: lemmas

- **Late stage:** Any subgame perfect equilibrium produces assortative matching among the firms and applicants *still unmatched at the beginning of the late hiring stage*.
- **From the beginning:** In the cases of *excess supply or demand*, $n_A^h \geq n_F$ (Case 1), and $n_F \geq n_A > n_F^h$ (Case 3) the unique subgame perfect equilibrium outcome is late, assortative matching.

What causes late and assortative matching when supply and demand are unbalanced?

- Excess supply (case 1): $n_A^h \geq n_F$
 - Applicants would accept early offers but firms prefer to wait and guarantee a high quality applicant.
- Excess demand (case 3): $n_F \geq n_A > n_F^h$
 - Applicants won't accept low quality early offers, since they can always get a low quality offer late.
 - Applicants would accept high quality early offers
 - At equilibrium, high quality firms prefer to wait⁹

Unraveling that doesn't harm efficiency

- Lemma: In the case of $n_F^h \geq n_A$ (Case 4, excess demand), the outcome of any subgame perfect equilibrium is qualitywise efficient.
 - That is, high quality firms may make early offers that are accepted, but this doesn't harm (qualitywise) efficiency, since not all high quality firms can be matched anyway. (i.e. if all applicants are matched, the outcome is qualitywise efficient.)

Necessary conditions for *inefficient* unraveling at SPE

- Theorem: A qualitywise inefficient early matching is an outcome of a subgame perfect equilibrium only if the market is one of *comparable* demand and supply (Case 2):
$$n_A > n_F > n_A^h .$$
- Inefficiency results at equilibria in which high quality firms wait for the late stages (when they can always hire someone), but low quality firms make early offers which are accepted (since some applicants will be left unmatched).
 - But these necessary conditions aren't sufficient.

Sufficient conditions for full unraveling

In the case of comparable demand and supply

$n_A > n_F > n_A^h$ (Case 2), if

$$0 > n_F^h u_{hh} + (n_F - n_F^h - n_A^h) u_{hl} - (n_A - n_A^h) u_{ll}$$

and $n_F^h \geq n_A^h$,

then ***all low quality firms hire in the early hiring stage at any subgame perfect equilibrium***, leading to a qualitywise inefficient matching with positive probability.

- **So we can choose experimental parameters in which the SPE predicts unraveling.**

Conduct of the experiment

- Every cohort played 20 consecutive games. Each game consists of 4 periods of early hiring and 4 periods of late hiring. (uncongested)
- Experiments were run at HBS and Pitt: 7 cohorts of 6 applicant treatments, 4 cohorts of 12 applicant treatments.
- Subjects kept their identity as applicant, low firm, or high firm. Random ID numbers are generated for applicants in each game.
- $EU(h,h)=36$ points, $EU(h,\ell)=EU(\ell,h)=26$ points, and $EU(\ell,\ell)=20$ points
- Payment: Summation of earnings in each game: Exchange rate: \$1=20 points, + Showup fee of \$10

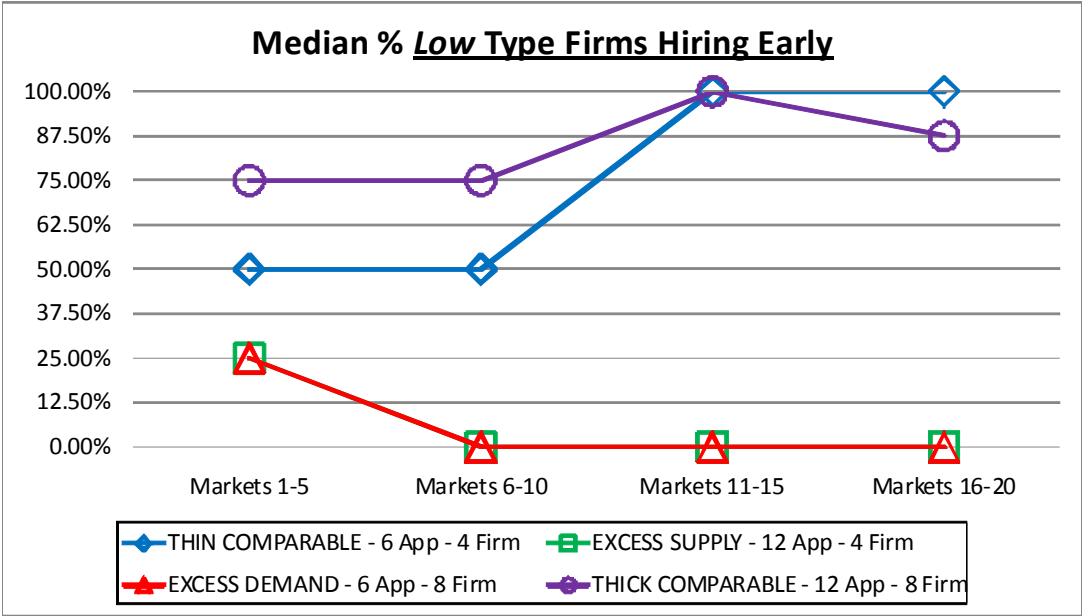
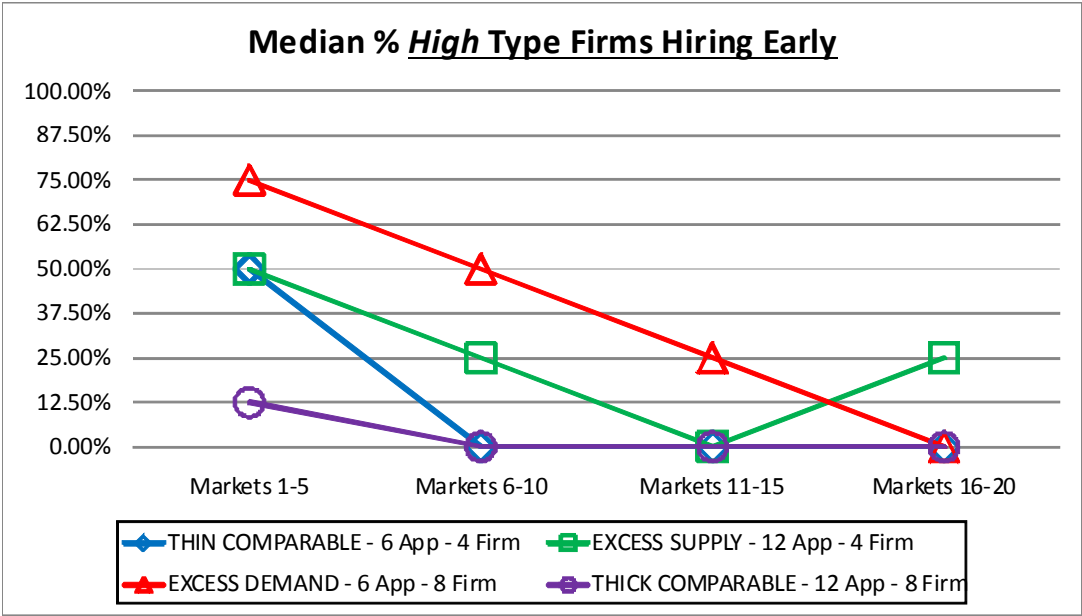
Experimental design: 4 firms with 1 or 2 position(s) each and 6 or 12 applicants. Half of the positions are high quality and one third of the applicants are high quality.

<i>Treatments</i>	<i>6 Applicants 2 High Quality Applicants</i>	<i>12 Applicants 4 High Quality Applicants</i>
<i>4 Firm Positions 2 High Quality Positions</i>	<i>Baseline – Thin comparable supply/demand market treatment (Case 2)</i>	<i>Treatment with excess supply (Case 1)</i>
<i>8 Firm Positions (with firm quota 2) 4 High Quality Positions</i>	<i>Treatment with excess demand (Case 3)</i>	<i>Thick comparable supply/demand market treatment (Case 2)</i>

Prediction (Theorem) A qualitywise **inefficient early matching** is an outcome of a subgame perfect equilibrium only if the market is one of comparable demand and supply (case 2). (Inefficiency results when low quality firms make early offers that are accepted.)

(SPE) Predictions

SPE	$n_A \leq 6$ $n_A^h \leq 2$	$n_A \leq 12$ $n_A^h \leq 4$
$n_F \leq 4$ $n_F^h \leq 2$	THIN COMPARABLE Low quality firms hire early qualitywise-inefficient outcome	EXCESS SUPPLY Late and assortative matching efficient outcome
$n_F \leq 8$ $n_F^h \leq 4$	EXCESS DEMAND Late and assortative matching efficient outcome	THICK COMPARABLE Low quality firms hire early qualitywise-inefficient outcome



What have we learned so far?

- Unraveled markets (with early, dispersed, exploding offers) produce different outcomes in predictable ways.
 - Less thick, unsafe, suffer from congestion, inefficient
 - Loss of mobility in the gastro market
- Unraveling involves both
 - Market design: e.g. how exploding offers are treated
 - Supply and demand: both firms and workers have to be willing
- Centralized markets can solve these problems
- Centralized matches are preceded by (potential) decentralized markets.
 - Even well-designed (stable) matches can unravel
 - Moving from an early to a late equilibrium can be hard

Experiments have multiple roles to play

- They allow us to investigate questions that the field data cannot answer
 - E.g. why did the GI match fail in '96?
- They allow us to investigate hypotheses suggested by the field data
 - E.g. does the ability to renege on early acceptances reduce exploding offers and unraveling?
 - What conditions of supply and demand promote unraveling?
- They play a role in the considerable amounts of discovery, demonstration, and persuasion that are necessary to coordinate market participants to move from one equilibrium to a better one.

Conclusions:

- Markets don't always spring up like weeds, some of them are hothouse orchids that need care and attention.
- We need to understand how markets work in enough detail so we can fix them when they're broken.