Can Relational Contracts Survive Stochastic Interruptions? Experimental Evidence

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Abstract

This paper tests the robustness of the "two-tiered labor market" in which efficient bilateral contracts emerge between firms and workers (Brown, Falk and Fehr, 2004). Our experiment introduces stochastic interruptions in firm's ability to offer contracts. Involuntarily laid off workers are eager to be reemployed; they are unselective about job offers and do not shirk. Firm's preference for these "temp workers" induces all workers to compete harder to enter relational contracts. Wages in low-tier markets rise dramatically, suggesting that the stigma of unemployment is removed. The results show that interruptions may shorten relational contracts without harming market efficiency.

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Typical employment contracts specify the duration and terms of employment only loosely, leaving many details implicit (Williamson 1975; Chevalier and Ellison 1997,1999; Baker et.al., 2002).[1] Since a third party cannot enforce implicit contracts, in theory they may be inefficient due to moral hazard. However, experimental evidence has pointed to two forces which often lead to very high rates of efficiency even in incomplete contracts: reciprocity, and the possibility of private contract renewal conditional on good performance.

Early experiments showed that paying high wages elicits reciprocal high worker effort thereby reducing losses from moral hazard, even when identities are anonymous and no individual reputations can form (e.g., Fehr, Kirchsteiger and Reidl, 1993). Furthermore, the introduction of private contracting with public identification allows firms to respond to workers' effort through a series of spot-market labor contracts that are offered specifically to an identified worker. This creates a high-tier market populated by firms and workers who maintain informal long-term relationships (i.e., relational contracts). In this market, high-wages contracts are reciprocated with high effort and the gains from trade are shared equally (Brown, Falk and Fehr, 2004, henceforth BFF1). The high tier market often coexists with a low tier market of "McJobs" in which firms make public (indiscriminate) low wage offers and workers deliver low effort. Brown, Falk and Fehr (2011) found the same result under excess *demand* for labor (rather than excess supply). Note that many naturally occurring labor markets also exhibit these two tiers, in which well-paid permanent workers coexist with poorly paid peripheral workers (Amuendo-Dorantes (2000) on Spain, Herrera and Shady (2005) on Peru).

[1] Most US firms utilize 'employment at will' clauses, which state that either the employer or the employee can terminate an employment contract of indefinite duration at any time, for any reason.

This paper adds stochastic interruptions to the two-tiered labor market experiment.[2] Interruptions occur in practice, because a manager's ability to guarantee renewal of contracts is often limited by a multitude of external circumstances unrelated to a worker's performance, such as spanning business cycle effects, layoffs from seasonality and liquidity shocks, and changes in upper management's priorities.[3] When managers do not have complete control over hiring decisions, relational contracts live under the threat of future interruptions. A laboratory experiment is well suited to studying the impact of these types of temporal shocks on relationships because so many complicating factors can be controlled. These complicating factors in naturally-occurring labor markets include informal or enforceable promises to rehire workers, uncertainty about the length of interruption (due to business cycle or bankruptcy effects), effects of unionization, details of formal unemployment insurance or social insurance for laid-off workers, and so forth. Our experiment extends the Brown, Falk and Fehr (2004) (henceforth BFF1) gift exchange paradigm by introducing, in every period, a small probability that a firm experiences a publicly observable stochastic shock, which prevents three periods of hiring.

Intuitively, these interruptions increase the likelihood that even after investing high effort in the current period, a worker may find himself unemployed in the next period. In this situation, workers may be more likely to behave as if the

[2] Two other experimental papers also feature stochastic outcomes in a relational contract setup. Fehr and Zehnder (2009) find that reputation formation is crucial for a functioning credit relationship when stochastic outcomes impact borrowers' ability to pay back loans. Renner and Tyran (2004) find that consumers are willing to bare part of the cost of one-time shocks to firms' production costs if there is public information about the shock. Neither paper tests the impact of direct shocks on the trading partner's ability to contract.

[3] In developing countries (for example, see Duflo and Banerjee (2000) on India) weak legal enforcement and limited capital markets often subject firms to exaggerated shocks, which in turn affect their contractors. Workers in the hospitality, entertainment, service, and hi-tech industries, to name a few, also regularly experience job instability due to external factors. Interruptions also happen in personal relationships; see Angrist and Johnson (2000) on the effect of deployment on divorce rates and Vormbrock (1993) on job related marital separation.

current period of employment is the last, and shirk. Firms, in anticipation of workers' shirking, may lower wages, resulting in lower market efficiency. But stochastic interruptions can also improve the market. Azariadis (1975) and Cardoso and Portela (2009) argue that firms will provide workers with unemployment insurance in the event of stochastic shocks. This may induce the gift exchange effect and increase workers' effort if workers feel a sense of positive reciprocity toward firms that pay generous wages.[4] In addition, if there is an interruption, an anxious worker may attempt to insure against losing the current employer for good by putting in extra effort in the current period, thus building up goodwill to insure rehiring when the firm recovers.

Perturbations in contract renewals may also create exogenous turnovers of matches, which can reduce efficiency. In experimental designs involving relational (private) contracts and some degree of prosociality, there are always equilibria in which high wage-effort exchange is supported, but there are also equilibria in which wages and effort are low. Many experiments in other domains with multiple equilibria have shown that exogenous random re-matching of agents in groups can undermine efficiency.[5] Therefore, it would be useful to know whether stochastic interruptions in labor markets will produce the same kind of reduction in efficiency, especially since experimental research on gift exchange in public spot-markets has already shown some degree of variation as a result of descriptive and institutional factors (e.g., Hannan, Kagel and Moser, 2002; Rigdon, 2002; Camerer and Weber, in press).

[4] The gift exchange effect has been observed in many experiments. Some experiments have shown boundary conditions under which wages and efforts are not very much higher than the minimum (e.g., Rigdon, 2002). Note, however, that in all cases (including the latter) when efforts are regressed against prepaid wages there is a strong, significant correlation.

[5] See Camerer, 2003 Chapter 7 on coordination games (coordination game (Van Huyck et al. 1990, 1991, Anderson et al. 2001); and partner-stranger differences in prisoner's dilemma and public goods experiments including linear public good game (Andreoni 1988, Croson, 1996, Palfrey and Prisbey, 1997).

Our experimental data reveals an environment where the presence of relationship shocks delays market segmentation. However, labor markets maintain high efficiency and even improve the low-tier (public) market. Without stochastic interruptions, firms make low-wage effort offers in the public market, as if those workers are likely to shirk and will not deserve repeated relational contracts. With stochastic interruptions, firms make wage offers in the public market that are similar to entry-level private offers. It appears that interruptions remove the stigma of unemployment[6], which changes the public market from a place for dead-end jobs for shirkers into a "temp market" for entry-level job tryouts.[7]

With interruptions, the temp public-offer market flourishes because temp workers are eager to accept any offers and tend not to shirk. They appear to be insecure about reconnecting with incumbent firms who hired them earlier, and are eager to establish goodwill toward new connections. As a result, firms seek out these temp workers and the public market sheds its stigma to become a place where firms and workers try out potential new partnerships under entry-level contract terms.

The rest of the paper proceeds as follows. In Section I we discuss the experimental design. Section II presents our behavioral predictions. We present and explain our findings on maintained market efficiency and improvement of the low-tier market in Section III. Section IV concludes.

[6] A similar effect occurs in volunteering, in which stochastic interruptions provide an excuse for volunteers to quit without shame (Linardi and McConnell, 2011).

[7] We use the phrase "temp market" because the market for medium-skill office workers often features hiring to temporarily replace workers on leave, or during a temporary surge in business. These workers are often offered permanent jobs, which suggest that there is an element of auditioning during the temporary employment.

I. Experimental Design

We implemented the following two conditions to test the robustness of relational contracts to exogenous stochastic interruptions. Our baseline treatment, a labor market without interruptions (LM0), is a replication of BFF1's incomplete contract condition with reputation formation. This is a finitely repeated game where firms and workers are assigned a fixed ID that will persist for the entire game. Firms make contract offers, specifying wages (w) and desired effort level (ẽ). A firm can offer the same contracts to all workers at once using a publicly posted offer, observable to everyone in the market (including firms). A firm can also address its offer to a specific worker using private contracts sent to the worker's ID.

A firm can make as many offers as it desires, but can only contract with one worker in each period. Workers cannot make offers, instead they can only choose from a listing of all public offers and the private offers addressed to them. A worker can only accept one contract per period.[8] After accepting a contract, the worker chooses the effort level he wants to deliver (e). The cost of effort is displayed in Table 1 below. Since third party enforcement is absent, the worker does not have to abide by the effort level requested by the firm.

Table 1: Cost of effort

Effort (e)	1	2	3	4	5	6	7	8	9	10
Cost (c(e))	0	1	2	4	6	8	10	12	15	18

[8] When a worker accepts a firm's contract, both worker and firm leaves the market: all the firm's unaccepted offers disappears from workers screen and a check appears in front of the worker's ID, indicating that the worker is no longer available.

Let w stands for wages offered by the firm and e be the effort level delivered by the worker. The firm's payoff is

π_F = 10e-w if worker accepts the contract and deliver effort e
0 otherwise

The worker's payoff is

π_W = w-c(e) if worker accepts a contract and deliver effort e
5 otherwise.

The payoff for the trading firm and worker are displayed to both contracting parties before a new round begins.

Our LM0 experiment consists of 9 firms and 10 workers, who traded for 30 periods.[9] We utilize a large number of firms, workers, and periods in order to implement the Labor Market with Interruptions (LMI) treatment. In the LMI treatment, there is commonly known probability (δ) of a firm-specific shock, which prevents contracting for several periods. As explained in the introduction, this treatment modeled idiosyncratic firm-specific shocks that exogenously interrupt relationships and provide other firms with an opportunity to contract with temporarily "laid-off" workers. A firm that is experiencing this interruption cannot make any offers, and therefore cannot hire any workers. However, this firm is able to observe the market and is therefore aware of other firms' public offers and of all workers' employment status. To eliminate the firm's misrepresentation of its ability to hire, the identities of the firms who are

[9] BFF1 had 7 firms and 10 workers who traded for 15 periods. Figure 1 in the Appendix shows the similarity between the wage and effort in BFF1 and ours (9 firms and 10 workers)—numerically, BFF1 wage and effort level falls right between our two subject pools.

experiencing a shock in the current round are public knowledge to all firms and workers.

Table 2: Experimental treatment

	Location	Periods	Firm	Worker	Pr(interruption)
Pilot 1	Caltech	15	7	10	0
Pilot 2	Caltech	15	10	15	0
Total Pilot sessions:	**2**		**17**	**25**	
LM0 C1 & C2	Caltech	30	9	10	0
LM0 U1 & U2	UCLA	30	9	10	0
Total LM0 sessions:	**4**		**36**	**40**	
LMI C1	Caltech	30	9	10	0.05
LMI C2	Caltech	30	8	9	0.05
LMI C3	Caltech	30	9	10	0.1
LMI U1 & U2	UCLA	30	9	10	0.1
Total LMI sessions:	**5**		**44**	**49**	**0.08**
Total	**11**		**97**	**114**	

Table 1 lists treatments and subject pools for all sessions. A key design feature is the frequency and duration of the stochastic interruptions. Interruption duration changes both the value of expected future wages and profits, and also provides a window of opportunity for non-incumbent firms to respond to the sudden availability of laid-off workers.[10] We implemented a three-period interruption; this duration is short enough to have a minimal effect on payoffs, but long enough that a laid-off worker and his new firm may develop a new relationship.

The choice to extend separation length to three periods makes high frequency interruptions impractical to implement. More importantly, the aforementioned

[10] Ruhm (1987) finds that interruption duration is more important as source of permanent separation than increased interruption probabilities. Van Ours (2004) finds that the unemployed tend to become locked-in to what was supposed to be a temporary job, thereby reducing the likelihood of returning to their regular jobs.

treatment will have a similar effect to random rematching, which, as the literature shows, adversely affects efficiency (e.g Van Huyck et al, 1990). On the other hand, previous gift exchange experiments show that design changes, which have no theoretical impact, such as switching subject pools (Healy, 2007) or adding a table showing payoffs from wage-effort pairs to the instructions (Charness et al, 2002), can reduce efficiency. We therefore choose to study infrequent interruptions ($\delta \leq .10$ per period) that theoretically should have negligible effects.

Because the interruption "knocks out" firms for several periods, the average demand for labor in the LMI market is lower than that in LM0. Demand for labor can be measured by the ratio of firms to workers (a low ratio indicates less demand by firms). The ratio of firms to workers in LMI across all periods (after accounting for the interruptions) is 0.76, while the ratio of firms to workers in LM0 is 0.90. In order to check that our results are not driven by a lower demand for labor, we ran pilot treatments that replicate the original BFF1 setup in which stochastic interruptions are not present and the average ratio of firm to workers is less than or equal to that of the LMI (0.68).

The computerized experiment was programmed and conducted with the z-Tree software, based on the BFF1 original software. Figure A.1 in the Appendix provides a graphical timeline of the experiment using screenshots. Before the game started, subjects were given a quiz to ensure their understanding of the game and the payoffs to firm and seller. Each session lasted approximately 100 minutes and subjects earned, on average, $35. In order to establish the robustness of our results, we conducted subject pool experience and characteristics sessions at both the California Institute of Technology (Caltech), where subjects have substantial laboratory experience, and at University of California in Los Angeles (UCLA), which is representative of a more typical large-university student population.

II. **Behavioral Prediction**

Our theoretical model extends Brown Falk and Fehr (2008) model to show one effect of interruptions on relational contract.[11] The equilibrium discussed here is one of many equilibria of this repeated game. Continuing with their framework, the interruptions in LMI will function solely as a discount factor for future payoffs, thus reducing the difference in future expected payoffs between shirkers and non-shirkers. The effect will be felt particularly near the end, when the difference in payoffs is smaller. When the probability of interruptions is large, we would expect LMI sessions to unravel earlier, resulting in lower market efficiency than in LM0 sessions.

However, in theory, the infrequent interruption probabilities of interest should result in only a slight reduction of future expected payoffs. The reduction is low enough that shirking is not the best strategy for workers in LMI sessions (except in the final period). Given that there will be no shirking in equilibrium, the strategy in LM0 of offering fair wages and rewarding non-shirkers with contract renewal should also result in the high efficiency equilibrium in LMI.

As before let [w, ẽ] denote the wage and desired effort level in a contract offered by a firm. A fair worker has a bad conscience if he fails to fulfill a contract that offers an equal (or better) split of surplus. Let ŵ(ẽ) denote a fair wage offer.

[11] An argument can also be made that stochastic interruptions can improve contracting. Firms, in anticipation of lower continuation probabilities, pay higher, above-market wages. These higher wages create a larger differential between employed and unemployed workers, thus reducing the incidence of shirking among selfish workers. Fair workers respond to the higher wages through the gift exchange effect, thus producing higher equilibrium effort. In short, this repeated gift exchange setup has a multitude of possible equilibria, as is normally the case in repeated games (Fudenberg and Maskin, 1986). Therefore, the effect of stochastic interruptions on relational contracting is an empirical question.

$$\hat{w}(\tilde{e}) = [10\tilde{e} + c(\tilde{e})]/2 \qquad (1)$$

The marginal disutility b of not fulfilling a fair contract is assumed to be high enough, such that a fair worker will always provide the requested effort if he accepts a fair contract.

Definition 1 The utility of a fair worker who accepted a contract of $[w, \tilde{e}]$ is $w - c(e)$ if $w < \hat{w}(\tilde{e})$ and $w - c(e) - b\max(\tilde{e}, e)$ if $w \geq \hat{w}(\tilde{e})$.

A single period of the game proceeds as follows:

Proposition 1 Consider a game of $T = 1$ period with two firms and $n > 2$ workers where a proportion p of workers are fair, as defined above (with $0<p< 1$). If $p < .55$, there exists no PBE where firms offer more than (5, 1) and workers perform $e > 1$. If $.55 \leq p < .6$, a PBE exists where fair workers perform $e = 2$ and selfish workers perform $e = 1$. If $.6 \leq p < .65$, a PBE exists where fair workers perform $3 \leq e \leq 8$ and selfish workers perform $e = 1$. If $p \leq .65$, a PBE exists where fair workers perform $e > 8$ and selfish workers perform $e = 1$.
Proof: See Appendix.

We next consider a multi period model, adding the subscript t in all variables to denote the period. Since all offers will be fair in equilibrium and fair workers will always deliver the effort requested in a fair offer, we need only consider the shirking behavior of selfish workers. We assume that when faced with identical offers from an incumbent firm and a new firm, a worker prefers the incumbent firm. Additionally, when facing identical expectations about a worker's type (i.e., whether the worker is fair or not), a firm prefers their previously hired worker to an unknown worker. The proposition below solves the equilibrium effort level for

p = .55, the minimum proportion of fair types needed, such that firms will offer more than the reservation wages. This provides the lower bound of the achievable effort level in this setup.

Proposition 2 Consider a game of T > 1 periods with two firms and n > 2 workers where p = .55 are fair as in Definition 1. Let there be a probability δ of a k period interruption in the firms' ability to hire. The following strategies and beliefs constitute a perfect Bayesian equilibrium in which both worker types display/exhibit maximum effort in all non-final periods t < T.

• At t = 1 all firms make public offers with the identical payoff splitting contract [59, 10].

• The firm offers to his previous worker profit maximizing contracts depending on (δ, k) if the worker performed the demanded effort in all previous periods. If a firm is prevented from hiring in period t, the contract will be offered in period t + k when the firm is again able to hire. The table below provides the optimal wage/effort schedule for the experimental parameter.

Table 3: Wage effort schedule

(δ, k)	t < T − 3	T − 2	T − 1	T
LM0: (0, 3)	[59, 10]	[59, 10]	[28,5]	[11, 2]
LMI: (0.1, 3)	[59, 10]	[53, 9]	[22,4]	[11, 2]

If a worker shirks in one period, the firm does not rehire the worker, and instead privately offers a contract in the next period to a worker that has never been employed by any firm. If all workers have shirked, the firm makes public offers of [5, 1] in all future periods.

• In period 1, two workers accept the two public offers and perform the desired effort $\tilde{e}_t$ regardless of whether they are selfish or fair. At period T a selfish worker

performs $e_T = 1$ while a fair worker performs $\tilde{e}_T$. Pairing happens at the first period and persists throughout all periods; n−2 workers remain unemployed for all t. When a worker's incumbent firm is temporarily unable to hire, the worker is temporarily unemployed.

• Out of equilibrium beliefs: a firm believes that if a worker ever shirks he is certainly selfish.

Proof: See Appendix.

The model's predictions are:

1. There will be no significant difference in market efficiency between LM0 and LMI, though LMI might unravel slightly earlier.

2. There will be no change in contracting dynamics. In both LM0 and LMI, the labor market will separate early into a high-tier private market, featuring high wages and effort level and a low-tier public market with low wages and effort level.

3. Workers do not have employment opportunities when incumbent firms are under shock and thus experience temporary unemployment.

III. Results: Market Efficiency and Contracting Dynamics

A. Summary Statistics

The first column of Table 4 presents session averages for the baseline LM0 treatment. Measuring efficiency by comparing the total surplus generated[12] against the maximum possible total surplus, we find that the LM0 sessions, as

[12] Total surplus is defined by the sum of firm and worker profit. The efficiency of a contract is measured as: (10*Effort – cost of Effort) / (10*maximum effort – cost of maximum effort), where maximum effort is 10. However, because cost increases monotonically in effort level, effort in itself is often a sufficient proxy for efficiency.

whole, achieve a high level of efficiency (0.78) with the expected last period drop (0.55). To calculate the length of relational contracts, we first follow all firms and workers pairs within a session and count the number of repeated private contracts that occur between them by the last periods. The final relationship length indicated that, on average, contracts in LM0 take place between partners that will remain together for 17.4 periods. This implies an average proportional relationship length of 58% (17/30). By summing up worker total surplus for the entire 30 periods, we find that surpluses were shared roughly equally, with worker's receiving 48% of the total generated surplus in LMI session.

Figure A.2 in the Appendix illustrates the basic patterns of contracting in LM0 for both our UCLA and Caltech subject pools. Relational contracts emerged in a remarkably consistent fashion across our UCLA and Caltech subject pools and replicate that of BFF1 quite closely, with Caltech's market efficiency higher than that of UCLA and BFF1's market efficiency falling roughly between the two.

In the LMI treatment, the shock to a firm's ability to hire is a low probability event ($\delta <= 0.10$) that causes a three period interruption. Firms in LMI sessions experience an average of 1.8 downturns, and were able to contract for 24.47 periods (as compared to 30 periods in LM0). Throughout the 5 LMI sessions, there were a total of 79 firm-periods of interruptions. We will analyze these interruptions separately in Section 3.2.

The LMI column in Table 4 presents the summary statistics with the idle interruption periods excluded in computing averages. Figure 1 conveys the main results by comparing LM0 and LMI through the time series of wage offers (a), delivered efforts (b), and final relationship length (c).

Result 1: *Stochastic interruptions neither harm market efficiency nor induce earlier unraveling.*

The LMI column in Table 2 shows that the high efficiency in LM0 is preserved in LMI (77%). This is not surprising given the subgame perfect equilibrium (assuming a sufficient number of workers with fairness concerns), which predicts no harm from this type of interruptions. This robustness is suprising given the experimental literature on the sensitivity of gift exchange equilibria to framing and parameter values. There is no evidence of earlier unraveling: efficiency in the last period of LMI is 61%, compared to 55% in LM0.[13]

Result 2: *There are changes in contracting dynamics. Stochastic interruptions delay formation of relational contracts and the associated market segmentation. The public market improves through higher wage offers and higher delivered effort; the private market suffers from shorter relationships but is able to maintain high wage and effort levels.*

Looking first at private offers, we see that average relationship lengths are shorter in absolute terms in LMI (12.62) compared to LM0 (17.40; $p<.01$ using conservative session-level averages in a rank-sum test). However, this simple comparison does not control for interruptions. After normalizing the number of repeated private contracts between firm-worker pairs by the number of periods in which the firm is actually able to hire workers, we learn that relationship length has indeed decreased slightly from 58% in LM0 to 50% in LMI. [14]

[13] At the last period in both treatments, roughly 40% of workers reveal themselves as fair types by delivering the requested level of effort.

[14] If firms and workers reconnected after an interruption LMI as frequently as they continue in relationships in LM0, these corrected relationship lengths would be identical in the two treatments.

Plotting this interruption-adjusted final length in Figure 1.c, we see that relationship formation in LM0 stochastically dominates LMI, suggesting a delay in the formation of relational contracts, particularly in the first 10 periods.

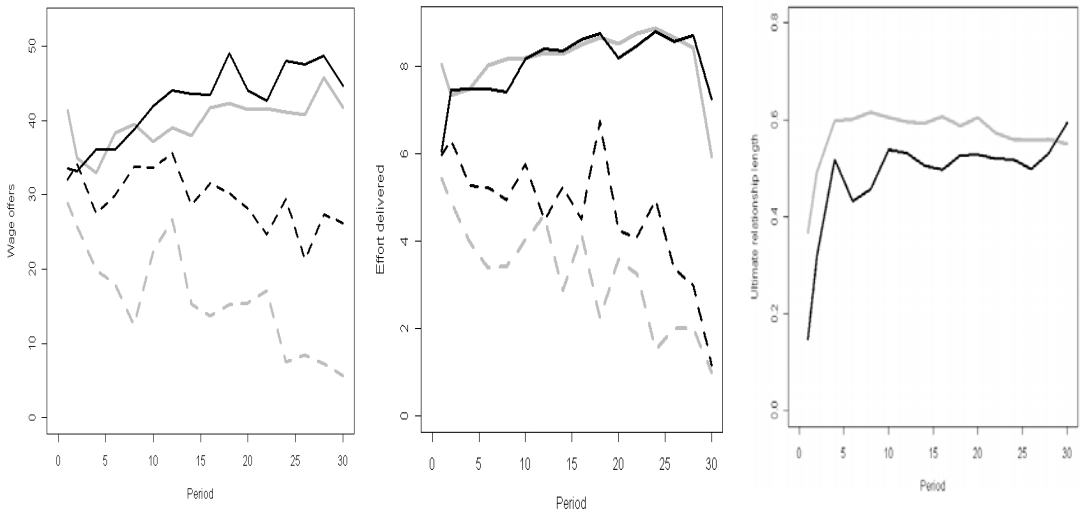
Table 4: Summary statistics: session averages

		LM0	LMI	p-value of difference
Market efficiency	All periods	0.77	0.78	0.548
	Last period	0.55	0.62	0.794
Private	Wage offered	39.17	41.16	0.278
	Effort delivered	8.28	8.23	0.635
	Final relationship length	17.40	12.62	0.008***
	Interruption adjusted final length	0.58	0.50	0.095*
Public	Wage offered	20.44	30.72	0.032**
	Effort delivered	4.29	5.29	0.095*
	% public contracts	0.19	0.22	0.635
Number of sessions		4	5	
Total offers		1781	1666	
Total contracts (accepted offers)		1050	1055	

*One-sided Wilcoxon test: *** 1%, ** 5%, * 10%*

A comparison of the private and public markets in LM0 and LMI confirms that the dynamics of contracting are different in the two treatments. The time series in Figure 1(a) and (b) shows a typical dynamic pattern in which a two-tiered labor market gradually emerges featuring higher wage-effort pairs in private contracts and lower wage-effort pairs in public contracts. The public offer market in LMI (dashed black) is substantially more competitive than the market in LM0 (dashed gray). The average wage offer in LMI is 30.72, 50% higher than the average offer in LM0 (20.44, $p<0.05$ with rank sum test of session-level averages). The increase can also be seen, to a lesser extent, for delivered effort (4.29 to 5.29, $p<0.10$).

Figure 1: Wage offers from firms (a), delivered effort from workers (b), and length of relationship (c) as a function of time.



LM0 (gray), LMI (black). Dashed line illustrates session averages for public offers, solid lines for private offers. See Fig A.3 in Appendix for standard errors.

In addition, there is a striking difference between LM0 and LMI in the time it takes for the market to segment. The separation between the solid gray line (LM0 private) and dashed gray line (LM0 public) starts from the earliest periods and continues to widen as time progresses. In contrast, the solid black line (LMI private) and the dashed black line (LMI public) are closer together than in LMO sessions. The large gap between private and public which emerges rapidly in the first half of the LM0 sessions only emerges in the second half (periods 15-30) in LMI sessions. There is, however, no change in volume of public offers relative to private offers. In LM0, public offers make up 36% of all contracts in the first 10 periods and decrease to 11% in the last 10 periods. The pattern is very similar in LMI, starting from 41% in the first 10 periods and decreasing to 13% by the last 10 periods.

In Table A.1 in Appendix, we utilize the pilot sessions (where on average the ratio of firm to worker is 0.68) to check whether the more competitive public offer market in LMI is driven by lower demand for labor (0.76 in LMI compared

to 0.90 in LM0). The first model utilizes a dummy variable for the LMI session while the second model controls for the variation in the probability of interruption across sessions. In both regressions, the coefficient for Pilot:Public offer is negative and not statistically significant, which suggests that stochastic interruptions (as opposed to lower demand for labor) are the primary contributor to the competitiveness of the public offer market in LMI.

The proceeding sections explore the dynamics behind these changes. Note that since we are interested in how firms and workers make decision at each period, we will no longer be using final relationship length. Instead, the variable of interest will be current relationship length, which is the number of previous private contracts between firm-worker pairs in the current period.

B. Interruptions

Out of the 79 instances of interruptions, there are 70 instances in which interruptions occurred after period 2 and before period 26, thus providing an opportunity to observe the activity of laid-off workers during interruptions and during firm-worker reconnections.

Result 3: *There is a demand for temporarily laid off workers. A temp market emerges where contract terms (wages and effort) are lower, however, workers deliver the same level of effort-for-wage as they do with their incumbent firms. Post-interruption reconnection between laid-off workers and incumbent firms are determined by pre-interruption tenure length and surplus sharing.*

Table 5 compares several characteristics of contracts accepted by workers before and during the layoffs. Out of the 70*3=210 periods of layoffs, workers are employed for 109 periods. While it is true that workers are less likely to work

under private contracts (67%) than in their pre-interruption periods (80%), there does appear to be demand for laid-off workers. Table A.2 in the Appendix shows that laid-off workers are more likely to receive private offers than workers whose contracts are not renewed for other reasons. Laid-off workers contract with former employers: the average temp market contract occurs between partners with 3.09 previous private contracts. Taken together, these empirical features demonstrate that when relationships are interrupted by exogenous factors, a worker's reputation as a trustworthy contracting partner becomes a less relationship-specific asset (cf. Williamson, 1985). Worker reputations can have value for firms beyond the current incumbent firm.

Table 5: Comparison of contracts: the temporary market

	Before	**During**	**p-value of difference**
Wage offered	43.72	36.09	0.06*
Surplus offered	0.38	0.28	0.03**
Realized surplus	0.71	0.75	0.59
Relationship length	6.40	3.09	0.03*
% private contracts	0.80	0.67	0.06**
Number of contracts	70	109	
Number of sessions	5		

*Session averages for contracts accepted by workers before hiring interruptions and during the three periods that follows. The stars indicate the significance of a paired one-sided Wilcoxon test: *** 1%, ** 5%, * 10%*

How do contract terms of this temp-worker spot-market compare to pre-interruption terms? Wages are indeed lower and represent stingier shares of the total surplus generated by the requested effort (28% during interruption compared to 38% before interruption, p=0.03 with matched rank-sum test of session

averages).[15] However, workers do not shirk any more than they do in the pre-interruption contract. This effort stability is revealed by the roughly similar levels of surplus sharing (75%) in the temp market and in the pre-interruption contract (71%) (See Section III C).

Table 6: Characteristics of pre-interruption contracts by reconnection status

Pre-interruption statistics	Post-interruption reconnection status					
	No attempt by firm		Rejected by worker		Reconnected	
	Mean	S.E	Mean	S.E	Mean	S.E
Wage offered	33.92	3.58	37	6.35	47.97	2.74
Surplus offered	0.34	0.03	0.31	0.04	0.43	0.03
Realized worker surplus	0.87	0.23	0.38	0.07	0.51	0.03
Relationship length	2.8	0.54	4.5	1.18	7.89	1.02
	N=30		N=6		N=36	

N sums to 72 instead of 70, because two of the reconnections were public offers that were accepted by incumbent workers instead of reconnection attempted by the firm.

Table 6 breaks down the 70 pre-interruption contracts by the reconnection outcomes in the post-interruption periods. There are 40 attempts to reconnect with previous workers.[16] Six of these reconnection attempts are rebuffed by workers, and 2 previous workers initiate reconnection by accepting returning firms' public offers. Worker's pre-interruption tenure length is positively correlated with firms' reconnection attempts, suggesting support for the specific human capital model of Mincer & Jovanovic (1981) and empirical evidence of the decline in separation rates as a function of job tenure (Ruhm 1987).

[15] Surplus offered = (Wage offered - cost of requested effort)/ (Requested effort * 10 - cost of requested effort). Realized surplus = (Wage offered - cost of delivered effort)/ (Delivered effort * 10 - cost of delivered effort).

[16] The 30 other firms made private offers to new workers (14) or made public offers (16).

Interestingly, the amount of pre-interruption surplus sharing between worker and firm determines whether that same pair reconnects after the interruption. The average pre-interruption surplus sharing of successful reconnections is 0.51—almost exactly a 50-50 split (with a low standard error around that average). If the worker share has been *less* than .50%, then when firms attempt to reconnect, workers will typically refuse them. If the worker has claimed *more* than 50% of the pre-interruption surplus, firms make no attempt to reconnect.[17] Overall, the reconnection rate is 54%.

Together, Sections III A and B suggest that the robustness of market efficiency in LMI is not due to the mechanism described in Section II. In our simple model, stochastic interruptions affect firms and workers only through lower continuation probability, which discounts the value of future periods. Shirking is still never a best response until the last period with the low probability of interruptions; laid-off workers are therefore irrelevant to hiring firms; the changes in the market will only be observed as the end of the session approaches. This is inconsistent with the experimental data in which firms demand laid-off workers and delayed market segmentation is observed from the earliest periods. The next section will look more closely at the effect of interruptions on firms and workers behavior in order to unpack the reason behind the high efficiency of the LMI sessions. An explanation of variable names used in regressions for the remainder of the paper is provided in Table 7.

Table 7: Variable definitions for regression models

Variable names	Definition
Wage offered	Wage specified in firm's offer
Requested effort	Effort level specified in firm's offer
Effort delivered	Effort chosen by worker after accepting contract
Renewal attempt	Dummy variable (DV): 1 if current offer is private and firm-worker pair contracted in the previous period
Not renewed (Appendix)	DV: 1 if incumbent firm did not make any offer in this period to this worker
Public offer	DV: 1 if current offer is a public offer (is not addressed to a specific worker)
Relationship length	The number of private contracts that the firm-worker pair has engaged in **thus far.**
LMI specific variables	
Laid off worker	DV: 1 if worker's incumbent firm (from immediate past period) is in a downturn
Firm experienced first shock	DV: 1 if firm experienced its first hiring interruption in the previous period
Firm recovered from shock	DV: 1 if firm experienced hiring interruption in the previous period
LMI	DV: 1 if experimental session features stochastic interruptions
Interruption probability (Appendix)	Probability of interruptions (percent)
Other controls	
Period	Period at which the decision is made
Last period	DV: 1 if current period is period 30
# of active firms	Number of firms unaffected by stochastic interruption in the current period
UCLA	DV: 1 if subjects were UCLA students
Pilot (Appendix)	DV: 1 if pilot session (average firm-worker ratio 0.67, no stochastic shocks)

C. **Workers search more for job security in LMI**

In this subsection we investigate how stochastic interruptions affect workers' decisions regarding employment offers.

Result 4: *Workers in LMI appear less secure about continued employment. a) During layoffs, workers accept offers more readily and do not shirk. b) In general, LMI workers try harder to maintain relational contracts than LM0 worker (through high effort): renewal offers are readily accepted and bonus effort is provided in return. a) and b) result in an attractive temp market and higher overall market efficiency despite shorter relationships.*

Table 8 provides two regressions that support findings a) and b). Table 7 provides definitions for each variable name. The column on the left describes a logistic regression on the probability that an offer is accepted. The right column is an OLS regression on the determinants of effort delivered. Alternative specifications are included in Appendix Table A.3 and A.4.

The first set of variables confirms the findings from previous relational contracting experiments. Workers across the two treatments are more likely to accept offers with generous surplus sharing or sent by incumbent firms. Effort-delivered is higher for higher wages, and corresponds more closely to the firms' requested effort, supporting the gift exchange effect. Controlling for wages, public offers are more likely to be accepted since they are sent to all workers, delivered effort is, however, lower. Turning to the control variables in the bottom rows, we see the well-documented last period drop in effort, a reminder of subjects' rationality. The number of active firms (which changes period by period in LMI) has little influence on workers' effort level, but forces workers to be less

selective with available offers. The UCLA subjects were more likely to accept any offer and to deliver lower overall effort. [18]

We now turn to the effect of stochastic interruptions. The coefficient for *Laid off worker* provides information about the supply-side of the temp market discussed in Section III b. The positive and significant coefficient for the logistic regression shows that temporarily unemployed workers are especially eager to secure a contract. The coefficient on the OLS effort regression is negative but not significant, which indicates that workers deliver the same level of effort-for-wage to the firms in the temp market as they do with their incumbent firms.[19] This suggests that workers are uncertain about being rehired by the incumbent firms after the interruption period is over.

In general, workers in LMI appear more anxious about job security than workers in LM0. The coefficient of the *LMI* dummy is positive and significant for effort, indicating that workers in LMI work harder for the same wages as workers in LM0. Recalling Table 6, workers may believe that firms offering generous surplus-sharing are more likely to attempt post-interruption reconnections. This may explain the significant and negative coefficient on *LMI:Requested Effort*, which suggests that workers respond negatively to stingier offers. Most importantly, the coefficients for *LMI:Renewal attempt* are significant and positive in both of the regressions, suggesting that as important as contract renewals are for workers in LM0, workers in LMI seek out and reward these renewals to an even greater extent.

As a whole, Table 8 suggests that workers vie harder for guarantees of future employment when relationships can be interrupted by exogenous factors. Workers

[18] As seen in Appendix Figure 1, the UCLA sessions are qualitatively similar, but less efficient than the Caltech sessions.
[19] See realized surplus before and during interruption in Table 5.

in LMI invest in their reputation with more than one firm. They avoid offers that are unlikely to result in contract renewals and put forth more effort to secure those that will. As we see in the next section, while firms also respond to interruptions by searching harder for a good contracting partner, their search has a negative effect on relational contracts.

Table 8 Worker's Behavior

	Pr (Accept offer) Logistic regression			**Effort delivered** OLS		
	Coeff	Std. Err	pval	Coeff	Std. Err	p val
Intercept	-1.79	0.90	0.05	1.63	0.58	0.00
Wage offered	0.07	0.01	0.00	0.09	0.02	0.00
Requested effort	-0.11	0.05	0.02	0.35	0.09	0.00
Renewal attempt	1.01	0.18	0.00	0.41	0.16	0.01
Public offer	2.71	0.20	0.00	-0.81	0.16	0.00
Relationship length	0.09	0.02	0.00	0.03	0.02	0.06
Period	0.03	0.01	0.00	-0.02	0.01	0.09
Laid off worker	0.96	0.22	0.00	-0.26	0.21	0.22
Firm recovered from shock	-0.16	0.24	0.50	-0.01	0.19	0.97
LMI	0.66	0.68	0.33	0.95	0.40	0.02
LMI:Requested effort	-0.12	0.08	0.14	-0.14	0.05	0.00
LMI:Renewal attempt	0.48	0.22	0.03	0.34	0.20	0.09
# of active firms	-0.13	0.07	0.04	-0.07	0.05	0.17
UCLA	-0.84	0.22	0.00	-2.11	0.37	0.00
Last period	0.63	0.28	0.02	-0.54	0.14	0.00
Likelihood Ratio	1555.33					
R2	0.49			0.77		
Observations	3447			2105		
Number of workers	89			89		

Robust standard error clustered on worker level.

D. **Firms are less willing to commit to workers in LMI**

Result 5: a) *Firms in LMI prefer to hire laid-off workers than to renew contracts with average performing current workers. b) The public market in LMI sheds the stigma it carries in LM0: while public wages in LM0 are significantly discounted from entry-level private wages in LM0, the two are identical in LMI.*

Table 9 provides support for Result 5. The first set of columns describes a logistic regression on the probability that a contract is renewed. The second set of columns is an OLS regression on the determinants of wage offers. The independent variables are described in Table 7. Alternative specifications are included in Appendix Table A.5 and A.6.

It is well established in the gift-exchange and relational contract literature, that firms offer wages that correspond to their requested effort level and renew contracts when workers deliver high effort. Wage offers and the probability of contract renewal increase with the number of repeated private contracts between the firm and the intended worker (*Relationship length*) and in firm's previous contracting experience (*Effort delivered*). Public offers in LM0 carry a certain stigma: a public offer wage is 8.06 points lower than an entry-level (zero relationship length) private offer wage of similar requested effort. Controlling for delivered effort and offered wages, public offers are much less likely to be renewed than private offers.

How do stochastic interruptions change firms' behavior? We first investigate if firms act differently when they return to the market after three periods of inactivity. The positive and significant coefficient on the dummy variable *Firm experienced first shock* indicates that firms pay workers a bonus

wage of 4.20 after experiencing their first interruption.[20] We interpret this as evidence that firms learn to pay a kind of "unemployment insurance" to workers only after those firms actually experience a shock (even though they know shock likelihood from the start, and also see other firms' shocks). Firms' propensity to renew contracts remains unchanged.

Turning our attention to firms that are not directly experiencing interruptions, we look at the coefficient for *Laid off worker* for clues on firms' behavior in the temp market. The positive and significant coefficient for the logistic regression shows that firms are especially eager to continue their contract with temp workers when those workers' previous employers are unable to hire. The coefficient on the OLS wage regression is negative—the significance appears to depend on the specification of the model (see Appendix). Since offers to the temp market make up only 9% of all offers in LMI, this coefficient is likely to be weak. We interpret this as mixed evidence that firms are offering temp workers a lower surplus share, weakly suggesting that firms view the temp market as a place to find workers that are willing to perform at a high level with less pay.

Although the temp labor pool is small in size (because interruptions are not that common), it has a large impact on the overall market. Firms become more selective about renewing contracts with current employees: the coefficient for *LMI* is significant and negative while the coefficient on *LMI:Effort* is positive and significant. This suggests that firms believe they can easily replace average performers. Firms in LM0 may believe that switching workers after the first few periods is costly since the remaining pool of unemployed workers is made up of shirkers. In LMI, this stigma is tempered by the exogenous reasons for unemployment. Firms' better perception of unemployed workers is reflected in

[20] We ran the models in Appendix Table A.5 and A.6 using the dummy variable *Firm recovered from shock* from Table 8 (which is 1 on all instances where firms return from stochastic shock) and found no effect. Subsequent experiences of stochastic interruptions do not appear to have an effect on wages or renewal probabilities.

the public market wages: the coefficient for the *LMI:Public* interaction is positive and significant (8.42) and completely erases the public market discount seen in LM0.

Table 9 Firm Behavior

	Pr(immediate renewal) Logistic regression			**Wage offered** OLS		
	Coeff	Std. Err	pval	Coeff	Std. Err	pval
Intercept	-0.36	0.87	0.68	-7.19	4.57	0.12
Wage offered	-0.06	0.01	0.00			
Requested effort				3.50	0.36	0.00
Effort delivered	0.46	0.08	0.00	1.68	0.32	0.00
Renewal attempt	1.13	0.25	0.00	2.98	1.08	0.01
Public offer	-1.47	0.30	0.00	-8.06	1.62	0.00
Relationship length	0.20	0.03	0.00	0.56	0.10	0.00
Period	-0.07	0.01	0.00	-0.17	0.09	0.06
Laid off worker	0.77	0.28	0.01	-1.52	1.11	0.17
Firm experienced first shock	0.19	0.36	0.60	4.20	1.51	0.01
LMI	-1.34	0.68	0.05	-2.04	2.82	0.47
LMI: Effort delivered	0.17	0.08	0.04	0.25	0.33	0.45
LMI: Public offer	0.06	0.43	0.89	8.42	2.43	0.00
# of active firms	-0.01	0.09	0.88	0.46	0.49	0.35
UCLA	0.19	0.27	0.47	-0.83	1.17	0.48
Last period				-1.74	1.26	0.17
Likelihood Ratio	1139.55					
R2	0.59			0.76		
Observations	2028			3147		
Number of firms	80			80		

"Effort delivered" in the OLS regression refers to effort chosen by worker in last period's contract. In the logistic regression, this variable refers to effort chosen in the current period. Robust standard error clustered at firm level.

IV. Conclusion

In this paper we provide the first experimental investigation on the robustness of relational contracting to temporal shocks that create involuntary separations. Previous experiments have found that when implicit contracts are enforced through relational contracts, a two-tiered market reliably emerges, with a high wage-effort tier of repeated contracting (the private market), and a low wage-effort tier of spot market contracting (the public market). It is not known whether the emergence of relational contracting is robust to interruption. We therefore study an experimental labor market in which there is a probability of temporary interruptions in contract renewals due to circumstances unrelated to the worker's performance (such as exogenous demand shocks).

Previous gift exchange experiments have shown that minor design changes with no theoretical impact can affect efficiency. We therefore chose frequencies and durations of interruptions that theoretically should have no effect on market efficiency or relationship lengths. Our experimental results are seemingly counterintuitive: relationships are shorter, but market efficiency remains high. We also find delayed and significantly less-pronounced market segmentation; the difference between private offer wages and public offer wages in LMI is only half of the difference in LM0. This is due to strikingly more competitive wage offers in the LMI public market.

Looking deeper into LMI we find that interruptions create a new supply of workers: "temp workers" who are involuntarily laid-off by the interruptions. Eager to be reemployed, these workers are unselective about job offers and do not shirk. Firms prefer these temp workers to average performing employees and seek them out through both private and public offers. The formation of relational contracts is delayed since firms are less likely to renew contracts. Surprisingly,

this does not reduce market efficiency since workers put forth greater effort for contracts that may lead to secure long-term relationships.

Our findings contribute to the existing literature, which shows the remarkable resilience of relational contracts. Brown, Falk, and Fehr (2010) find that high wage-effort equilibrium is maintained even when relational contracts are subjected to stress in the form of excess demand for workers (in which case shirking will not be penalized by unemployment). Interestingly, the dynamics that maintain high equilibrium in our paper are the opposite of the dynamics in their paper. In Brown Falk and Fehr (2010), workers terminate current relationships for better ones, and are induced by firms to provide high effort through high wages. In contrast, firms in our market terminate current relationships to find better ones, and are induced by workers to provide contract renewals through high effort. It appears that when market conditions induce one party to move away from bilateral contracting, the other party will adjust the terms of contracting such that bilateral contracting again becomes the preferred outcome for both parties.

While we believe that our study provides interesting insights, we feel that this is only a first step in studying temporary job separation in labor markets with implicit contracting. Our experimental design of stochastic interruptions in the repeated gift exchange framework can easily be extended to investigate features such as business cycles (through correlated shocks), firm bankruptcy possibilities (through uncertainty in the length of interruptions), and worker-side shocks such as medical or family leave.

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Can Relational Contracts Survive Stochastic Interruptions? Experimental Evidence

Sera Linardi and Colin Camerer

For Online Appendix

- Proofs for Proposition 1 and 2
- Figures A1 to A3.a-c
- Tables A.1 to A.6

Proposition 1

Proof. Selfish workers will always provide $e = 1$ in the one period game. Eq. 1 defines fair wages as $\hat{w}(\tilde{e}) = 5\tilde{e} + c(\tilde{e})/2$. Fair worker will shirk if a contract is unfair, hence firms are restricted to making fair offers. Given the proportion of fair worker p, firm's expected payoff for making a fair offer requesting $\tilde{e}$ is

$$\pi_F(\tilde{e}) = p(10\tilde{e} - \hat{w}(\tilde{e})) + (1-p)(10 - \hat{w}(\tilde{e}))$$

Substituting and simplifying we have

$$\pi_F(\tilde{e}) = 10p\tilde{e} - 5\tilde{e} - c(\tilde{e})/2 + 10 - 10p$$

Since there is an excess supply of labor and workers are ex-ante identical, there is competition among workers for firms and no competition between firms for workers.[1] This allows firms to maximize their profit. Taking a derivative of $\pi(\tilde{e})$ over $\tilde{e}$ and setting it to zero, we get $\partial\pi(\tilde{e})/\partial\tilde{e} = 10p - 5 - c'(\tilde{e})/2 = 0$. We find that firm's profit is maximized when $c'(\tilde{e}) = 20p - 10$. Substitung $c'(\tilde{e}) = 1$ for $\tilde{e} = 2$, $c'(\tilde{e}) = 2$ for $3 \leq \tilde{e} < 8$, $c'(\tilde{e}) = 3$ for $\tilde{e} \geq 8$, we can solve for minimal share of fair worker p such that it is optimal for firms to request effort level $\tilde{e}$, arriving at the PBE in the proposition. □

Proposition 2

Proof. **Step 1 (behavior of fair workers):** All fair workers will always perform the desired effort since in equilibrium all wages will be fair. Since all firms make identical offer and there are no offers for a worker whose incumbent firm is temporarily unable to hire, a fair worker will always accept incumbent firm's offer.
Step 2 (behavior of selfish workers): A worker that does not shirk at period t will receive a private offer from his incumbent firm at period $t+1$ with probability $1-\delta$ and at period $t+k+1$ with probability δ. Without an offer from his incumbent firm a worker will only receive a wage of 5 since firms make non-minimum offers only to incumbent workers or workers that have never been employed by any firms. The expected payoff of not shirking at period $t < T-1$ is therefore:

$$V_t^{\delta,k} = (1-\delta)(\hat{w}(\tilde{e}_{t+1}) - c(\tilde{e}_{t+1}) + V_{t+1}^{\delta,k}) + \delta(5max\,[T-t,k] + V_{t+k+1}^{\delta,k})$$

The expected payoff of not shirking at period $t = T-1$ is $(1-\delta)\hat{w}(\tilde{e}_{t+1}) + 5\delta$ since the selfish worker will shirk at the last period.
The expected payoff of shirking at period t is:

$$U_t^{\delta,k} = 5(T-t)$$

The incentive compatibility constraint faced by the selfish type is $V_t^{\delta,k} - U_t^{\delta,k} \geq c(\tilde{e}_t)$ (Eq.2).
Given a final period contract of $[11, 2]$, it is a unique best strategy of the selfish worker to accept

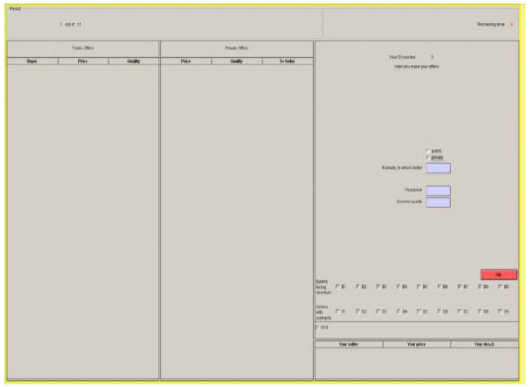
[1] Suppose Firm A and B makes an offer to the same person, who rejects A for B. Firm B and the worker are then matched, and Firm A can make another offer to the remaining $n > 1$ workers with no competition.

the contract and then deliver $e = 1$. The IC constraints is always fullfilled in any period $t < T$ given the wage effort schedule in Table 3. Selfish type will therefore always accept incumbent firm's offers and adhere to the terms in all non-final periods.

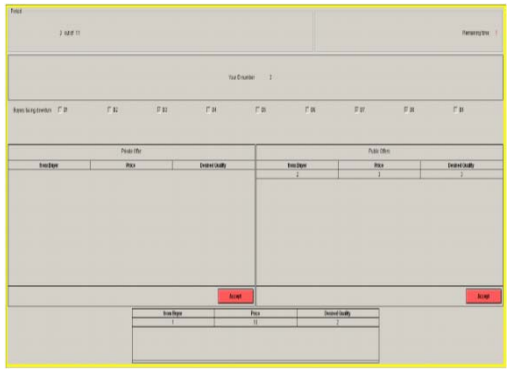
Step 3 (firm behavior): In equilibrium there is no shirking in any non-final periods; therefore firm has the same expected utility from contracting with any worker. Since there is no competition for workers, firms maximize profits at all periods. By Proposition 1, firms maximize last period payoff by requesting effort level of 2 and offering 11 when $p = .55$. The period T contract of $[11, 2]$ leads to a marginal utility of not shirking of 11-5=6 in LM0 where $\delta = 0$ and 0.9(11)+0.1(5)-5=5.4 in LMI where $\delta = 0.9$ and $k = 3$. The maximum effort that satisfy the incentive compatibility constraints are $e^{T-1} = 5$ in LM0 and $e^{T-1} = 4$ in LMI. Using the same reasoning we arrive at $e^{T-2} = 10$ for LM0 and $e^{T-2} = 9$ for LMI, which both leads to $V^{\delta}_{T-3} - U^{\delta}_{T-3} \geq = 18 = c(10)$. Since $V^{\delta}_{t} - U^{\delta}_{t}$ is the sum of future expected payoffs, $V^{\delta}_{t} - U^{\delta}_{t} \geq V^{\delta}_{t-1} - U^{\delta}_{t-1}$ and therefore $e_t = 10$ is the equilibrium effort level for all $t \leq T - 3$. Firm-worker matches will therefore happen at $t = 1$ through public offers of $[59, 10]$; a firm that experiences hiring shock at period $t = 1$ will make a private offer of $[59, 10]$ at period $t = 4$ to a worker that has never been employed. Since firms prefer renewing contracting with incumbent workers when facing identical expectation of workers all following offers are private renewals to previous trading partner, leaving $n - 2$ workers remain unemployed for all t.

□

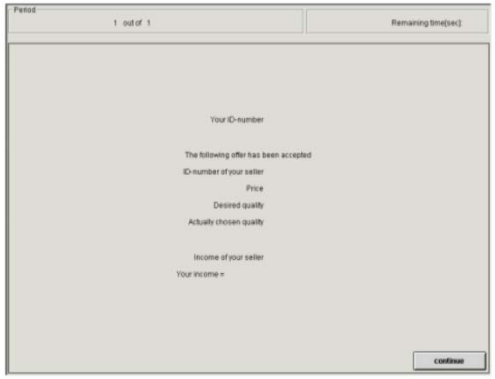
Figure A.1 Timeline of experiment



Firm see which firms are under downturn.
Firms see which workers are in the market and public offers posted by other firms.
Firms make “public” offers (seen by all workers and firms)
or “private” offers to specific worker ID.
An offer specifies wage and desired effort.



Workers see which firms are under downturn.
Workers see only private offers sent to him and all available public offer.
Worker chooses an offer.
The first worker to choose a public offer gets it.
If a firm send private offer to multiple workers, the first worker to choose that firm is hired.
Worker chooses an effort level.



After worker chooses an effort level,
the original terms (worker & firm ID, price, desired quality) and the actual outcome of the contract is displayed
Firms earn: 10e(t)-w(t)
Workers earn: w(t) - c(e(t))

Figure A.2 Patterns of relational contracting in BFF1 (gray) replicated at Caltech (dark blue) and UCLA (light red).

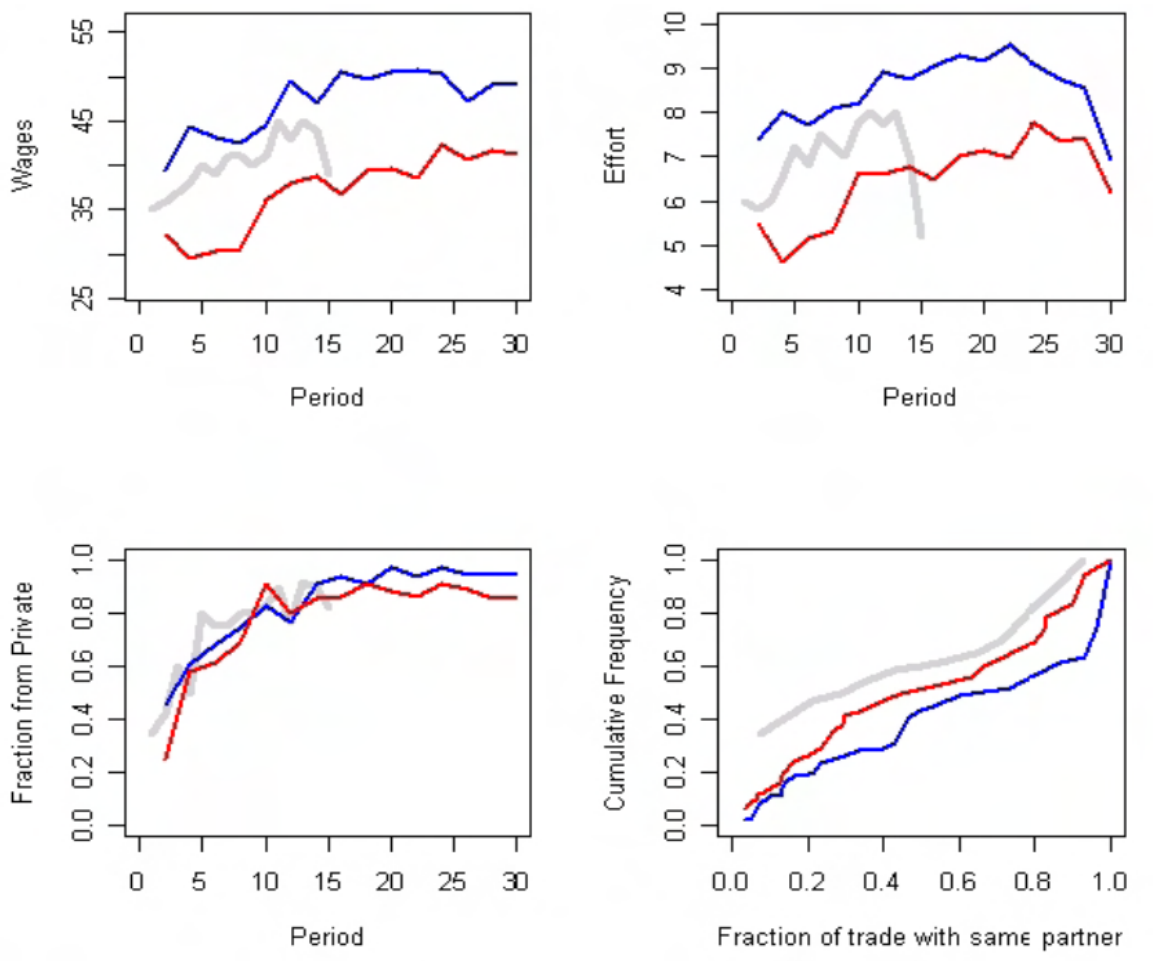


Figure A3.a-c: Wage offers from firms, delivered effort from workers, and length of relationship as a function of time.
LM0 (gray), LMI (black). Dashed line illustrate session average for public offers in period t, solid lines for corresponding private offers.

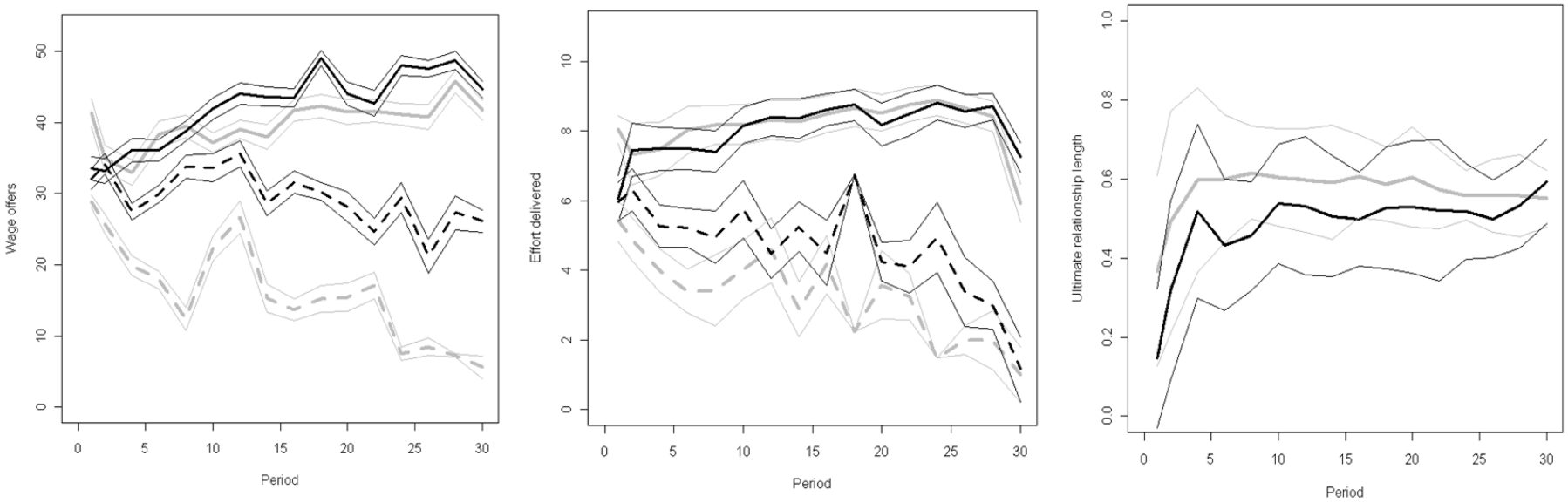


Table A.1: Firm behavior: OLS on offered wages.
Public offers in pilot (demand :supply ratio 0.68) are priced similarly to public offers in LM0 (0.90) but public offers in LMI (0.76 with Pr(interruption)<=0.1) are much higher.

	Model 1			Model 2		
	Coeff	Std. Err	p value	Coeff	Std. Err	p value
Intercept (LM0)	-4.89	3.07	0.11	-4.95	3.22	0.12
Public offer	-14.15	2.85	0.00	-14.21	2.69	0.00
Pilot	-1.19	3.94	0.76	-1.18	3.94	0.77
Pilot: Public offer	-0.67	3.53	0.85	-0.61	3.39	0.86
LMI	-0.64	2.15	0.77			
LMI: Public offer	9.98	3.65	0.01			
Interruption probability				-0.04	0.23	0.86
Interruption probability: Public offer				1.30	0.36	0.00
Requested effort	5.52	0.29	0.00	5.52	0.29	0.00
UCLA	-2.85	2.13	0.18	-3.16	2.12	0.14
Adjusted R2	0.63			0.64		
Observations	3787			3787		
Number of firms	97			97		

Robust standard errors clustered at the individual (firm) level.

Table A.2: Logistic regression on probability of receiving private offers.
Laid off workers are more likely to receive private offers than workers whose contracts are not renewed for other reasons.

	Pr (Worker receives private offer this period)					
	All			Contract not renewed		
	Coeff	Std. Err	p value	Coeff	Std. Err	p value
Intercept	1.00	0.07	0.00	0.40	0.13	0.00
Not renewed	-0.59	0.04	0.00			
LMI	0.00	0.00	0.67	-0.14	0.05	0.00
LMI: Not renewed	-0.13	0.05	0.00			
Laid off worker	0.12	0.05	0.01	0.12	0.05	0.01
Period	0.00	0.00	0.89	0.00	0.01	0.89
UCLA	-0.01	0.02	0.66	-0.02	0.04	0.66
Adjusted R2	0.47			0.02		
Observations	2670			1513		
Number of workers	89			89		

Robust standard errors clustered at the individual (worker) level.

Table A.3: Worker behavior: Logistic regression on probability of accepting an offer

	Model 1			Model 2			Model 3			Model 4		
	Coeff	Std. Err	p value	Coeff	Std. Err	p value	Coeff	Std. Err	p value	Coeff	Std. Err	p value
Intercept	-2.60	0.24	0.00	-1.97	0.81	0.02	-2.36	0.76	0.00	-1.79	0.90	0.05
Wage offered	0.07	0.00	0.00	0.07	0.01	0.00	0.07	0.01	0.00	0.07	0.01	0.00
Requested effort	-0.17	0.03	0.00	-0.17	0.04	0.00	-0.12	0.04	0.01	-0.11	0.05	0.02
Renewal attempt	1.17	0.12	0.00	1.26	0.13	0.00	1.01	0.17	0.00	1.01	0.18	0.00
Public offer	2.49	0.14	0.00	2.59	0.19	0.00	2.57	0.20	0.00	2.71	0.20	0.00
Relationship length	0.10	0.02	0.00	0.10	0.02	0.00	0.10	0.02	0.00	0.09	0.02	0.00
Period	0.02	0.01	0.00	0.02	0.01	0.01	0.03	0.01	0.00	0.03	0.01	0.00
Laid off worker	0.95	0.22	0.00	1.12	0.24	0.00	1.07	0.20	0.00	0.96	0.22	0.00
Firm recovered from shock	-0.24	0.26	0.36	0.02	0.29	0.96	-0.04	0.27	0.89	-0.16	0.24	0.50
LMI							1.09	0.70	0.12	0.66	0.68	0.33
LMI:Requested effort							-0.15	0.08	0.05	-0.12	0.08	0.14
LMI:Renewal attempt							0.51	0.22	0.02	0.48	0.22	0.03
# of active firms										-0.13	0.07	0.04
UCLA										-0.84	0.22	0.00
Last period										0.63	0.28	0.02
Session fixed effect	YES			NO			NO			NO		
Clustering at individual level	NO			YES			YES			YES		
Likelihood Ratio	1594.63			1484.65			1502.96			1555.33		
Pseudo R2	0.50			0.47			0.48			0.49		
Observations	3447			3447			3447			3447		
Number of workers	89			89			89			89		

Table A.4: Worker behavior: OLS regression on determinants of effort

	Model 1			Model 2			Model 3			Model 4		
	Coeff	Std. Err	p value	Coeff	Std. Err	p value	Coeff	Std. Err	p value	Coeff	Std. Err	p value
Intercept				1.02	0.27	0.00	0.57	0.34	0.10	1.63	0.58	0.00
Wage offered				0.09	0.02	0.00	0.09	0.02	0.00	0.09	0.02	0.00
Requested effort				0.31	0.09	0.00	0.38	0.09	0.00	0.35	0.09	0.00
Renewal attempt				0.58	0.15	0.00	0.37	0.19	0.05	0.41	0.16	0.01
Public offer				-0.87	0.18	0.00	-0.86	0.18	0.00	-0.81	0.16	0.00
Relationship length				0.02	0.01	0.11	0.02	0.02	0.12	0.03	0.02	0.06
Period				-0.03	0.01	0.00	-0.03	0.01	0.00	-0.02	0.01	0.09
Laid off worker				-0.16	0.22	0.47	-0.17	0.21	0.42	-0.26	0.21	0.22
Firm recovered from shock				0.01	0.22	0.96	-0.03	0.21	0.89	-0.01	0.19	0.97
LMI							0.90	0.39	0.02	0.95	0.40	0.02
LMI:Requested effort							-0.12	0.05	0.01	-0.14	0.05	0.00
LMI:Renewal attempt							0.41	0.22	0.06	0.34	0.20	0.09
# of active firms										-0.07	0.05	0.17
UCLA										-2.11	0.37	0.00
Last period										-0.54	0.14	0.00
Session fixed effect		YES			NO			NO			NO	
Clustering at individual level		NO			YES			YES			YES	
Adjusted R2		0.58			0.75			0.75			0.77	
Observations		3447			2105			2105			2105	
Number of workers		89			89			89			89	

Table A.5: Firm behavior: Logistic regression on probability of attempting to renew a contract

	Model 1			Model 2			Model 3			Model 4		
	Coeff	Std. Err	p value	Coeff	Std. Err	p value	Coeff	Std. Err	p value	Coeff	Std. Err	p value
Intercept	-1.47	0.35	0.00	-0.84	0.38	0.03	-0.27	0.35	0.45	-0.36	0.87	0.68
Wage offered	-0.06	0.01	0.00	-0.06	0.01	0.00	-0.06	0.01	0.00	-0.06	0.01	0.00
Effort delivered	0.55	0.05	0.00	0.50	0.07	0.00	0.44	0.08	0.00	0.46	0.08	0.00
Public offer	-1.38	0.19	0.00	-1.43	0.26	0.00	-1.50	0.30	0.00	-1.47	0.30	0.00
Current contract is a renewal	1.08	0.17	0.00	1.17	0.26	0.00	1.15	0.24	0.00	1.13	0.25	0.00
Relationship length	0.21	0.02	0.00	0.20	0.03	0.00	0.20	0.03	0.00	0.20	0.03	0.00
Period	-0.07	0.01	0.00	-0.07	0.01	0.00	-0.07	0.01	0.00	-0.07	0.01	0.00
Laid off worker	0.72	0.27	0.01	0.60	0.29	0.04	0.77	0.27	0.00	0.77	0.28	0.01
Firm experienced first shock	0.33	0.21	0.13	0.13	0.25	0.59	0.23	0.32	0.48	0.19	0.36	0.60
LMI							-1.32	0.70	0.06	-1.34	0.68	0.05
LMI:Effort delivered							0.16	0.08	0.05	0.17	0.08	0.04
LMI:Public offer							0.08	0.42	0.85	0.06	0.43	0.89
# of active firms										-0.01	0.09	0.88
UCLA										0.19	0.27	0.47
Session fixed effect	YES			NO			NO			NO		
Clustering at individual level	NO			YES			YES			YES		
Likelihood Ratio	1156.67			1127.41			1137.96			1139.55		
Pseudo R2	0.60			0.59			0.59			0.59		
Observations	2028			2028			2028			2028		
Number of firms	80			80			80			80		

Table A.6: Firm behavior: OLS regression on determinants of wage offers

	Model 1			Model 2			Model 3			Model 4		
	Coeff	Std. Err	p value	Coeff	Std. Err	p value	Coeff	Std. Err	p value	Coeff	Std. Err	p value
Intercept	-6.04	0.92	0.00	-6.11	2.42	0.01	-5.08	2.13	0.02	-7.19	4.57	0.12
Requested effort	3.41	0.10	0.00	3.51	0.35	0.00	3.58	0.35	0.00	3.50	0.36	0.00
Effort delivered	1.86	0.09	0.00	1.95	0.30	0.00	1.77	0.33	0.00	1.68	0.32	0.00
Public offer	-3.85	0.53	0.00	-3.81	1.48	0.01	-7.97	1.54	0.00	-8.06	1.62	0.00
Renewal attempt	2.73	0.49	0.00	2.73	1.07	0.01	2.76	1.08	0.01	2.98	1.08	0.01
Relationship length	0.56	0.04	0.00	0.55	0.10	0.00	0.55	0.10	0.00	0.56	0.10	0.00
Period	-0.17	0.03	0.00	-0.18	0.09	0.06	-0.18	0.09	0.05	-0.17	0.09	0.06
Laid off worker	-1.65	0.83	0.05	-1.44	1.43	0.31	-1.85	1.18	0.12	-1.52	1.11	0.17
Firm experienced first shock	3.74	0.59	0.00	3.84	1.34	0.00	3.69	1.53	0.02	4.20	1.51	0.01
LMI							-2.67	3.06	0.38	-2.04	2.82	0.47
LMI:Effort delivered							0.29	0.35	0.41	0.25	0.33	0.45
LMI:Public offer							8.31	2.33	0.00	8.42	2.43	0.00
# of active firms										0.46	0.49	0.35
UCLA										-0.83	1.17	0.48
Last period										-1.74	1.26	0.17
Session fixed effect	YES			NO			NO			NO		
Clustering at individual level	NO			YES			YES			YES		
Adjusted R2	0.76			0.76			0.76			0.76		
Observations	3147			3147			3147			3147		
Number of firms	80			80			80			80		