Robustness of Relational Contracts to Interruptions in Employer-worker Gift Exchange Experiments

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1 Introduction

Typical employment contracts specify the duration and terms of employment only loosely, leaving many details implicit (Williamson, Wachter, and Harris 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. That is, after contracts are agreed upon, each party could take actions which undermine efficiency but cannot be fully anticipated and contracted around. However, experimental evidence has pointed to two forces which often lead to 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. Reciprocation occurred even when identities were anonymous and no individual reputations could form (e.g., Fehr, Kirchsteiger and Reidl, 1993). Moreover, the introduction of private contracting with public identification allows employers 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 employers and workers who maintain informal long-term relationships—relational contracts—with no explicit guarantee of relationship continuation. In this market, high-wages contracts are reciprocated with high effort and the gains from trade are typically shared equally (Brown, Falk and Fehr, 2004, henceforth BFF). The high tier market often coexists with a low tier market of “McJobs” in which employers make public (indiscriminate) low wage offers and workers who accept those jobs deliver

¹Most US employers 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 clause renders the terms under which termination occurs vague and hence implicit.

low effort.² Note that many naturally occurring labor markets also exhibit these two tiers, in which well-paid permanent workers coexist with poorly paid peripheral temporary workers (see Amuendo-Dorantes (2000) on Spain; Herrera and Shady (2005) on Peru; and Lindbeck and Snower, 2001 on "insider-outsider" theory).

The upper tier of the labor markets that emerges endogeneously in these experiments relies on implicit relational contracts — which are, empirically, typically built out of a series of private worker-specific contract renewals. Given the replicability of the BFF results in various ways, an important question is how robust these markets are to lifelike institutional or behavioral features which could undermine relational contracting. We focus on exogenous disruption of the employers' ability to hire.

Interruptions in labor demand occur often in everyday labor markets, as workers in hospitality, entertainment, service and high-tech industries know only too well. A manager's intention to renew a contract with a good worker is limited by business cycle effects, layoffs from seasonality, liquidity shocks and foreign exchange, and changes in upper management's priorities. In developing countries, weak legal enforcement and limited capital markets often subject employers to exaggerated shocks, which in turn affect their contractors.³ Incidentally, interruptions also happen in personal relationships which also have properties of relational contracts, though such relationships are not our focus.⁴

Laboratory experiments provide a useful first step to investigate the impact of temporal labor demand shocks on relational contracts. Unlike in naturally-occurring labor markets, complicating factors (such as uncertainty about the length or probability of interruption, informal promises to rehire workers, or doubt about whether the downturn is real) can be controlled for in the lab. In addition, shocks that are truly and evidently exogenously can easily be created in the lab. In our experiment, an extension of the BFF exchange paradigm, there is a probability in every period that an employer experiences a publicly observable stochastic labor demand shock, which prevents hiring for three periods.⁵

Intuitively, exogenous interruptions increase the likelihood that a worker who invested high effort in the current period to maintain goodwill may find himself not working for the same employer in the next period. In this situation, workers may be more likely to behave as if a current period is their last

²See the review in Camerer and Weber (2008) for conditions under which wages and efforts are not as reciprocal (e.g., Rigdon 2002) or are sensitive to details of the environment and subject pool (Hannan, Kagel and Moser, 2002; Charness, Frechette and Kagel 2004, Healy, 2007). Falk, Huffman and MacLeod (2015) show effects of dismissal barriers and discretionary post-effort bonus pay to workers by employers in the BFF environment.

³For example, see Duflo and Banerjee (2000) on India.

⁴See Angrist and Johnson (2000) on the effect of deployment on divorce rates and Vormbrock (1993) on job-related marital separation.

⁵Two 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 bear part of the cost of one-time shocks to employers' 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.

contracted period with their current employer, and shirk. Employers may lower wages in anticipation of such defensive shirking, resulting in lower market efficiency.⁶ But stochastic interruptions can conceivably improve market efficiency. Azariadis (1975) and Cardoso and Portela (2009) argue that employers will provide workers with *de facto* unemployment insurance in the event of stochastic shocks (such as more generous wages), thus inducing positive reciprocity from the workers. In addition, an anxious worker may attempt to insure against burning her bridges with a current employer, in case of a downturn, by putting in extra effort in the current period so the current employer will be eager to rehire her when employer recovers and is able to hire again.

We develop a theory that follows previous literature in assuming the existence of some known proportions of fair (non-shirking) workers and selfish workers. We show that there is a perfect Bayesian equilibrium in which stochastic interruptions do introduce instability in relationships, but the high wage-effort equilibrium can persist in spite of downturns. The intuitive idea is that both employers and workers prefer to contract with their incumbent partner, but unmatched employers poach workers who are involuntarily unemployed because of a downturn. These workers do not bear a "stigma of unemployment" since downturns are publicly known, and new employers are sensitive to whether a downturn provides an alternative explanation for the incumbent employer's failure to renew a worker's contract.⁷

The main experimental result is that exogenous interruptions slow down and destabilizes relational contracts but the high efficiency of the labor markets is maintained by adaptation in both firms and workers strategies. Without stochastic interruptions, employers quickly become matched with workers and then rely on immediately renewing offers to these workers as long as they do not shirk. This leaves only the worse shirkers unmatched (such as those in the "McJob" public market). Immediate renewal is increasingly difficult as the frequency of stochastic interruption increases (going from 53% of contracts in markets with no interruption to only 9% of contracts when interruption probability is 50%), and both employers and workers must develop new strategies to remain productive in the market. As workers must bounce around several employers longer, employers must be even more discerning about who they hire. Loyalty is prized more than ever: workers who are involuntarily unemployed by downturn are the target of attempted "poaching" by unmatched firms, since they are likely to have been good workers to their incumbent firms, and returning firms give up on their incumbent workers that allow themselves to be poached. As a result, this selective – yet still somewhat random – rematching does not result in more shirking.

⁶In experimental designs involving relational contracts and prosociality, there are always high and low equilibria. Many experiments in other domains with multiple equilibria have shown that exogenous random re-matching of agents can undermine efficiency. See Camerer, 2003 Chapter 7 on coordination games (Van Huyck et al. 1990, 1991, Anderson et al. 2001); and partner-stranger differences in prisoner's dilemma and public goods experiments (Andreoni 1988, Croson, 1996, Palfrey and Prisbey, 1997).

⁷A similar effect occurs in volunteering, in which stochastic interruptions provide an excuse for volunteers to quit without shame (Linardi and McConnell, 2011).

Other recent experiments have explored robustness of gift-exchange efficiency. Bartling et al (2018) studied the BFF setting with worker effort that is only stochastically related to employer value.⁸ They find that with stochastic outcome, expectations matter. Sessions indeed arrive at self-fulfilled high- and low-trust expectations depending on whether they were previously shown previous sessions with a strong wage-effort relation (high trust) or sessions with weak wage-effort relation (low trust). This suggests that firms' ability to target (or disconnect) from workers that they have high (or low) expectation of was crucial in overcoming the difficulties introduced by the stochastic interruptions. Bernard, Fanning and Yuksel (2018) find that allowing free sorting / matching employers with fair-minded workers is indeed key. They observe lower efficiency in their gift-exchange experiment when they introduce fixed-partner and pay cut restrictions. Their results are consistent with a model of heterogeneous selfish and reciprocal workers, much like ours in the general outline and dynamics.

An interesting real life example of the same robustness of relational contracts to one side's ability to fulfill implicit commitments to the others is Macchiavello and Morjaria (2015)'s study of relational contracts for cut roses in Kenya. Local Kenyan growers contract with foreign buyers. In the time period of their data, ethnic violence which is localized and plausibly exogenous (to activity in the flower business) disrupts the regular supply chain of flowers. The violence imposes costs on different growers to fulfill implicit supply commitments. The authors show that relational contracts emerge, and that those growers with the newest and oldest buyer relationships do not ship roses during violence, but growers with mid-length relationships do ship roses to maintain relational stability. This again illustrates that underneath the robustness of relational contracts is the remarkable adaptability of the contracting partners, who given enough freedom, appear to reliably invent new strategies and norms that allow business to proceed even in the most difficult environments.

The rest of the paper proceeds as follows. In Section II we provide a theoretical model of the impact of stochastic interruptions on contracting, with testable implications that are later tested by data from the experiments. Section III describes the experimental design. Section IV discusses results. Section V is a short conclusion.

2 Theoretical Model

In this gift exchange game let $[w, \tilde{e}]$ denote the wage $w \in [0, 100]$ and desired effort level $\tilde{e} \in [1, 10]$ in a contract offered by an employer. A worker who accepts the contract then chooses an actual effort level $e \in [1, 10]$. This effort costs the worker $c(e)$.

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

⁸As a result, employers might make mistaken inferences about effort from what the effort earns them.

The monetary payoff of an employer is:

$$\pi(w, e) = \begin{cases} 10e - w & \text{if the offer is accepted} \\ 0 & \text{otherwise} \end{cases}$$

The monetary payoff to the worker is:

$$v(w, e) = \begin{cases} w - c(e) & \text{if the offer is accepted} \\ 5 & \text{otherwise} \end{cases}$$

Let $\hat{w}(\tilde{e}) = [10\tilde{e} + c(\tilde{e})]/2$ denote a fair wage offer — one that offers an equal (or better) split of surplus. For desired effort $\tilde{e}$, the corresponding schedule of fair wages is given below:

$\tilde{e}$	1	2	3	4	5	6	7	8	9	10
$\hat{w}(\tilde{e})$	5	10.5	16	22	28	34	40	46	52.5	59

Let there be two types of workers, selfish workers and fair workers. A worker is fair with probability $p \in (0, 1)$. Utility of a selfish worker is just his monetary payoff:

$$u(w, e) = v(w, e)$$

The utility of a fair worker offered a contract of $(w, \tilde{e})$ and delivering e is:⁹

$$u(w, e) = \begin{cases} v(w, e) & w < \hat{w}(\tilde{e}) \\ v(w, e) - b \max(\tilde{e} - e, 0) & w \geq \hat{w}(\tilde{e}) \end{cases}$$

where 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.

Proposition 1 Consider a game of 1 period with excess demand of labor: $F \geq 2$ employers and $W > F$ worker where p workers are fair. The following is a Perfect Bayesian Equilibrium: employers will offer $\hat{w}(\tilde{e})$ and fair workers will perform $e = \tilde{e}$ while selfish workers perform $e = 1$ for the following $p, \tilde{e}$ pairs.

$$\begin{array}{ll} p < 0.55 & \tilde{e} = 1 \\ 0.55 \leq p < 0.6 & \tilde{e} = 2 \\ 0.6 \leq p < 0.65 & 3 \leq \tilde{e} \leq 8 \\ p \geq 0.65 & 8 \leq \tilde{e} \leq 10 \end{array}$$

Proof. Since there are no future periods, $1 - p$ selfish workers would shirk no matter what wage is offered. Employers are restricted to fair wages $\hat{w}(\tilde{e})$ if they want to get beyond minimum effort from the p fair workers. Since there is an

⁹Roe and Wu (2004), replicating the BFF findings, correlated relational contracting with individual social preferences measured independently. Their results justify the concept of different "homemade" worker preference types and show solid evidence linking such preferences measured independently with behavior in the BFF environment.

excess supply of labor, employers can choose the most profit maximizing wages out of all possible $\hat{w}(\tilde{e})$. The employers' problem is then to choose $\tilde{e}$ to maximize

$$\max_{\tilde{e}} \pi(\tilde{e}) = 10(p\tilde{e} + (1-p)1) - w(\tilde{e})$$

Taking a derivative over $\tilde{e}$ and setting it to 0 after substituting the definition of $w(\tilde{e})$, we arrive at:

$$\frac{\partial \pi}{\partial \tilde{e}} = 10p - 5 - \frac{c'(\tilde{e})}{2} = 0$$

And hence an employer's profit is maximized when $c'(\tilde{e}) = 20p - 10$, which implies employer should offer $\hat{w}(\tilde{e})$ with any $\tilde{e}$ that satisfy the condition above. Solving this for the menu of effort costs, we arrive at $c'(\tilde{e}) = 1$ when $p = 0.55$, $c'(\tilde{e}) = 2$ when $p = 0.60$, and $c'(\tilde{e}) = 3$ when $p \geq 0.65$. $\square$

Proposition 2 Consider a game of T period with excess supply of labor: $F \geq 2$ employers and $W > F$ worker. When a worker accepts an employer's contract, both worker and employer cannot contract with anyone else in that period. employers experience a publicly observable downturn where they cannot hire for $k = 1$ period with probability $\delta \geq 0$. At any period $t \leq T$,

- The probability that an employer will be in the market for the first time at period $t \geq 1$, $First_t$ is $\delta^{t-1}(1 - \delta)$.
- The probability that an employer is able to extend an immediate contract renewal to its incumbent worker at period t , $Renew_t$, is $(1 - \delta)^2$ for $t \geq 2$, 0 otherwise.
- The probability that an employer is returning at period t from a downturn to a market where he has an incumbent worker, $Return_t$, is $(1 - \delta)(\delta - \delta^{t-1})$ for $t \geq 1 + k = 2$, 0 otherwise.
- Suppose employers prefer contracting with an incumbent worker but if unable to do so, would randomly send an offer to any *available* worker (workers whose incumbent employer is under downturn or has not contracted yet). Then the probability that an available worker receive an offer (from a non-incumbent employer) can be recursively determined by:

$$r_t = \frac{(Return_t r_{t-1} + First_t)F}{W - (Renew_t - Return_t(1 - r_{t-1}))F} \quad (1)$$

which for $t \geq 1 + k = 2$ simplifies to the following

$$r_t = \frac{(1 - \delta)(\delta^{t-1} + (\delta - \delta^{t-1})r_{t-1})F}{W - (1 - \delta)(1 - \delta + (\delta - \delta^{t-1})(1 - r_{t-1}))F} \quad (2)$$

Proof. • The probability that an employer enter the market for the first time at period t is the probability of experiencing $t - 1$ downturns (δ^{t-1}) and getting out at period t . Therefore $First_t = \delta^{t-1}(1 - \delta)$.

- The probability that an employer can contract at any period is $(1 - \delta)$. Hence the probability of a continuous 2-period contract is $(1 - \delta)^2$.
- The probability that an employer enter the market at period t as a returning employer is the probability that an employer that is in a downturn enters the market $\delta(1 - \delta)$ minus the probability that this is its first time $First_t$. Therefore $Return_t = (1 - \delta)\delta - First_t = (1 - \delta)(\delta - \delta^{t-1})$
- First consider the number of employers that will make offers to non-incumbent workers. $First_t F$ employers will make such offers since they have not yet contracted with any workers. In addition, the $Return_t F$ employers will be reentering the market at period t . The probability that their worker has switched employer in their absence is r_{t-1} , resulting in $Return_t r_{t-1} F$ unmatched employers.
- Now consider the number of workers that will be targeted for these offers. Employers will avoid the $Renew_t F$ workers that have an incumbent employer from period $t - 1$ since these pairs will reconnect unless the workers shirk. $Return_t(1 - r_{t-1})F$ other workers will receive reconnection offers from a returning incumbent employer. This leaves $W - (Renew_t - Return_t(1 - r_{t-1}))F$ workers available for contracting.
- The chance that any available worker will receive an offer is therefore as in Eq. 1. Substituting and simplifying we arrive at Eq. 2.

□

Proposition 3 Consider a game of T period with excess demand of labor: $F \geq 2$ employers and $W > F$ worker where $p = 0.55$ workers are fair. There may be exogenous interruption in hiring: with probability $\delta \geq 0$, employers experience a downturn and cannot hire for $k = 1$ period. We assume that when faced with two identical offers, a worker prefer his incumbent employer: i.e the employer that has just contracted with him. Similarly, when faced with two ex-ante identical workers (e.g. no history of shirking), an employer prefers her incumbent worker. The following strategies and beliefs constitute a Perfect Bayesian Equilibrium in which both worker types perform requested effort in all non-final periods.

- employers not under downturn offer the contract $\hat{w}(\tilde{e}) = 11$ for $\tilde{e} = 2$ at period T . Fair workers perform $e = 2$ while selfish workers shirk (perform $e = 1$).
- Let $V_t(\neg\text{shirk})$ (or $V_t(\text{shirk})$) be the cumulative future payoff of not shirking (or shirking) at t . At period $t < T$, employers offer their incumbent workers $\hat{w}(\tilde{e}_t)$ that satisfy the condition below if the worker has neither shirked nor contracted with other employer at $t - 1$.

$$c(\tilde{e}_t) \leq V_t(\neg\text{shirk}) - V_t(\text{shirk})$$

If their incumbent worker has shirked or is no longer available, the employer offers the same contract to available workers (workers with no active incumbent employer). If there are no available workers left, employers offer $(5, 1)$ to any workers.

- At period $t < T$, workers accept offers from incumbent employers and perform requested effort. When a worker's incumbent employer is hit by a downturn, and if the worker receives an identical offer from another employer (which happens with probability r_t), then the worker switches employer.
- At period $t = 1$, $(1 - \delta)F$ employers make public offers of $\hat{w}(10)$. Workers unmatched at $t = 1$ becomes employed at period t with probability r_t .
- Off-equilibrium beliefs: Employers assume all workers that shirk are selfish types. employers also assume that all workers that have just contracted with other employers are unavailable to them (since workers prefer their incumbent employer); a worker that accept a non-incumbent employer's offer when his incumbent employer is not under downturn is assumed to have shirked against his incumbent employer. If there are no $\tilde{e}_t$ that satisfy the condition such that selfish types do not shirk, employers behave as if they are in a one period game.

Proof. • Step 0: period $t = T$. See Proposition 1

- Step 1: (behavior of fair workers at $t < T$)
Fair workers will provide the requested effort regardless of whether the hiring employer is an incumbent employer or a new employer since in equilibrium all employers will only offer fair wages.
- Step 2: (behavior of selfish workers at $t = T - 1$)
At period $T - 1$ selfish workers who receive an offer of $\hat{w}(e_{T-1})$ decides whether or not to shirk. From Proposition 2, the probability that a worker receive an offer from an employer that is not its incumbent employer is r_t .

A worker that does not shirk will need to bear the cost of effort this period but will receive $\hat{w}(\tilde{e}_T)$ at the last period if his incumbent employer are able to hire, which occur with probability $1 - \delta$. If his incumbent employer is in a downturn, with probability r_T the worker may still get an offer of $\hat{w}(\tilde{e}_T)$ from an employer that has not contracted with him before. This leaves $\delta(1 - r_T)$ as the probability that a worker that does not shirk in period $T - 1$ is left without an offer in period T , earning only the unemployment pay of 5.

$$u_{T-1}(\neg \text{shirk}) = \hat{w}(e_{T-1}) - c(e_{T-1}) + (1 - \delta)\hat{w}(\tilde{e}_T) + \delta(r_T\hat{w}(\tilde{e}_T) + (1 - r_T)5)$$

If the selfish worker shirk at $T - 1$, he will not receive an offer from his incumbent employer at T . But if his incumbent employer happens to go

on a downturn, this covers up his shirking and he may still receive an offer from another employer with probability r_T .

$$u_{T-1}(\text{shirk}) = \hat{w}(e_{T-1}) + \delta r_T \hat{w}(e_T) + (1 - \delta r_T)5$$

Subtracting $u_{T-1}(\text{shirk})$ from $u_{T-1}(\neg\text{shirk})$, we find that to get non-minimal effort from selfish workers at period $T - 1$, an offer has to satisfy:

$$c(e_{T-1}) \leq (1 - \delta)(\hat{w}(e_T) - 5)$$

- Step 3: (behavior of selfish workers at $t < T$)
Generalizing to any $t < T$, equilibrium offer that keeps selfish types from shirking $\hat{w}(e_t^*)$ must satisfy:

$$c(e_t) \leq V_t(\neg\text{shirk}) - V_t(\text{shirk}) \quad (3)$$

If no $c(e_t)$ satisfy Eq 3, the employer's best choice is to treat the game as a series of one-shot games.

To compute $V_t(\neg\text{shirk})$, note that a worker that does not shirk will get an offer at $t + 1$ if the employer is not affected by the downturn. If the employer is affected (with probability δ), the worker switch employers with probability r_t or remain unemployed but still connected to the incumbent employer with probability $1 - r_t$.

$$\begin{aligned} V_t(\neg\text{shirk}) = & (1 - \delta)u_{t+1}(\text{offer}) + \delta(r_{t+1}u_{t+1}(\text{offer}) \\ & + (1 - r_{t+1})(5 + V_{t+1}(\neg\text{shirk}))) \end{aligned} \quad (4)$$

Because there is no shirking in equilibrium until $t = T$, the payoff to the selfish type of getting an offer is:

$$u_t(\text{offer}) = \begin{cases} \hat{w}(e_T) & \text{if } t = T \\ \hat{w}(e_T) - c(e_T) + V_t(\neg\text{shirk}) & \text{otherwise} \end{cases}$$

Similarly, the future payoff of shirking at period t is:

$$\begin{aligned} V_t(\text{shirk}) = & \delta r_{t+1}u_{t+1}(\text{offer}) \\ & (1 - \delta r_{t+1})u_{t+1}(\neg\text{offer}) \end{aligned} \quad (5)$$

where,

$$u_t(\neg\text{offer}) = \begin{cases} 5 & \text{if } t = T \\ 5 + r_{t+1}u_{t+1}(\text{offer}) + (1 - r_{t+1})u_{t+1}(\neg\text{offer}) & \text{otherwise} \end{cases}$$

□

The four sub-figures in Figure 1 below provide simulation results illustrating the dynamics of new employment opportunities (r_t , left panel) and equilibrium

effort level (e_t^* , right panel) in time. The top panel illustrates the effect of one-period interruptions ($k = 1$) while the bottom panel illustrates interruptions that last for three periods ($k = 3$). We use 9 employers and 10 workers in this simulation. Together, the propositions and the simulation results allow us to predict the effect of stochastic interruptions on bilateral contracts and derive some testable implications for a human subjects experiment.

Figure 1 about here.

Testable Implications

Below we present six testable implications from the theory. We include simulation results for r_t and equilibrium effort level e_t^* for various δ and k below.

1. *Decline in new offers:* The probability of getting an offer from a new employer, r_t , is decreasing in time t (Fig 1 Left panel). Intuitively, this is first driven by the drop in the number of employers that are contracting for the first time. But as r_t decreases, the number of unmatched returning employers in the next period decrease as well, reducing the number of offers in the market, which further decreases r_t . We will run the regression:

$$\text{NewOffer}_{tj} = a + b_1 \text{Period}_{tj} + b_2 \delta_j + \epsilon_{tj} \quad (6)$$

where NewOffer_{tj} is the number of new offers in period $t \in \{1, \dots, 30\}$ of session j . From Proposition 2, we hypothesize that $b_1 < 0$.

2. *Downturn probability slows down decline in new offers:* As the probability of interruption δ increases, the window of opportunity for workers to start a new relationship with a non-incumbent employer extends further into the game. For example, in our simulation in the top left panel of Fig 1 ($k = 1$), we find that $r_t > 0$ for only the first period when $\delta = 0$, for the first six periods when $\delta = 0.1$, and for the first ten periods for $\delta = 0.5$. We will test this with the regression:

$$\text{NewOffer}_{tj} = a + b_1 \text{Period}_{tj} + b_2 \delta_j + b_3 \text{Period} \times \delta_{tj} + \epsilon_{tj} \quad (7)$$

where $\text{Period} \times \delta_{tj}$ is an interaction term. From Proposition 2 we hypothesize that $b_3 > 0$.

3. *Downturn probability increases the number of partners needed for the same level of market activity.* Due to r_t , instability in relationships (e.g. number of trading partners) increases with δ , especially in the early periods.

$$\text{Uniqueemployers}_{ij} = a + b_1 \delta_j + b_2 \text{NumContracts}_{ij} + b_3 \text{NumContracts} \times \delta_{ij} \quad (8)$$

where $\text{Uniqueemployers}_{ij}$ is the number of unique employers that worker i contracted with in session j and NumContracts_{ij} is the number of period where the worker was employed for. From Proposition 2 we hypothesize that $b_3 > 0$ and that the magnitude of b_3 in the early periods is larger than what it is in the later periods.

4. *Employers use downturns to poach other employers' workers:* employers distinguish between available and unavailable workers. Workers get more offers from new employers when incumbent employers are in a downturn. We will run the regression:

$$\text{NewOffer}_{ijt} = a + b_1 X_{jt} + b_2 \text{employerDturn}_{ijt} \quad (9)$$

where NewOffer_{ijt} is the number of new offers worker i gets in period t . X_{jt} are the control variables Period, δ , and Numemployers (number of employers that in the market at period t). $\text{employerDturn}_{ijt}$ is a binary variable indicating if worker i 's incumbent employer is under downturn. Our hypothesis is that $b_2 > 0$.

Prop 3 also suggests that one consequence of this "poaching" will be that employers returning from a downturn will be less likely to attempt to reconnect with incumbent workers that worked for other employers during the downturn period. We will test this as well.

$$\text{ReconnectionOffer}_{ijt} = a + b_1 X_{jt} + b_2 \text{ContractedWOthers}_{ijt} \quad (10)$$

5. *Shirking is not increased by downturns:* Even though relationships take longer to form, there are not more shirking due to δ because in equilibrium there is no shirking in all of them.

$$e_{ijt} - \tilde{e}_{ijt} = a + b_1 \text{Period}_{tj} + b_2 \delta_j + b_3 \text{Last5Per}_{tj} + b_4 \text{Last5Per} \times \delta_j \quad (11)$$

where $e_{ijt} - \tilde{e}_{ijt}$ is the degree of shirking worker i engaged in in his contract at period t and Last5Per_{tj} is a binary variable that is 1 if period $t > 25$, the period where unraveling is predicted to start from the simulation of $k = 3$. Note that we expect lower effort but no shirking but since the employers in equilibrium are aware of the earlier unravelling with greater δ and adjust their requested effort accordingly. From Proposition 3 we hypothesize that $b_2 = 0$ and $b_4 = 0$.

6. *Efficiency is not decreased by downturns (except in the last few periods):* Though the market unravels earlier with an increase in δ , market efficiency is generally unharmed because shirking does not become more prevalent. Because market efficiency is the surplus generated by a trade compared to the maximum possible surplus,¹⁰ effort in itself is a sufficient proxy for efficiency.

$$e_{itj} = a + b_1 \text{Period}_{tj} + b_2 \delta_j + b_3 \text{Last5Per}_{tj} + b_4 \text{Last5Per} \times \delta_j \quad (12)$$

¹⁰Market efficiency is $[10e - c(e)]/[10e_{max} - c(e_{max})]$ where $e_{max} = 10$

where e_{ijt} is the effort level delivered by worker i in period t in session j . From Prop 3 and Fig 1 right panel we hypothesize that $b_2 = 0$ but $b_4 < 0$.

3 Experimental Design

We implemented the following three conditions to test the robustness of relational contracts to exogenous stochastic interruptions. All session consists of 9 employers and 10 workers,¹¹ who traded for 30 periods. We utilize a large number of employers, workers, and periods in order to have enough employers to contract during periods of stochastic interruptions.

Our baseline treatment, a labor market without interruptions ($\delta = 0$), is a replication of BFF1's incomplete contract condition with reputation formation. This is a finitely repeated game where employers and workers are assigned a fixed ID that will persist for the entire game. Employers make contract offers, specifying wages (w) and desired effort level ($\tilde{e}$). An employer can offer the same contracts to all workers at once using a publicly posted offer, observable to everyone in the market (including employers). An employer can also address its offer to a specific worker using private contracts sent to the worker's ID.¹²

An employer 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.¹³ After accepting a contract, the worker chooses the effort level he wants to deliver (e). Since third party enforcement is absent, the worker does not have to abide by the effort level requested by the employer. The cost of effort and payoffs for both employers and workers, which follows the theoretical model in the previous section, are then displayed to both parties.¹⁴

We implement two levels of stochastic interruptions, $\delta = 0.10$ and $\delta = 0.50$. Here there is commonly known probability (δ) of an employer-specific shock, which prevents contracting for several periods. As explained in the introduction, this treatment modeled idiosyncratic employer-specific shocks that exogenously interrupt relationships and provide other employers with an opportunity to contract with temporarily "laid-off" workers. An employer that is experiencing this interruption cannot make any offers, and therefore cannot hire any workers. However, this employer is able to observe the market and is therefore aware of other employers' public offers and of all workers' employment status. To eliminate the employer's misrepresentation of its ability to hire, the identities of the employers who are experiencing a shock in the current round are public knowledge to all employers and workers.

¹¹Except for one $\delta = 0.5$ session where we had 18 subjects and hence ran with 9 employers and 9 workers. While there is little power to test whether this session produced different results than the other four, there are no substantive differences so all sessions were pooled in our analyses.

¹²A screenshot of the employer's contracting screen can be seen in Fig A1 in the Appendix.

¹³The worker's screen can be seen in Fig A2 in the Appendix.

¹⁴The outcome screen can be seen in Fig A3 in the Appendix.

We chose to implement a three-period interruption ($k = 3$). This duration is short enough to have a small effect on payoffs, but long enough that a laid-off worker and his new employer — if she finds one — may develop a new relationship. For analytical tractability, we have modeled only the $k = 1$ case in the theoretical section. Briefly, the $k = 3$ case proceeds similarly: at $t = 1$, δF employers will experience downturn and hence are prevented from making their first offers until period $t = 1 + k$. $(1 - \delta)F$ employers make their initial matches. At $t = 2$, $(1 - \delta)\delta F$ of these matched employers are unable to contract, and at $t = 3$, another $(1 - \delta)^2\delta F$ employers also experience downturn. Then at $t = 4$ the δF employers that were knocked out of the market in the first period $k = 3$ will make initial offers in the market. They could be matched with any of the $W - F(1 - \delta)$ workers that have never contracted, or the workers whose incumbent employers are under downturn. If they matched with workers whose employers are under downturn, these workers will stay with these δF employers as their new incumbent. Therefore at period $t = 5$ there will potentially be $(1 - \delta)(\delta)F$ returning employers that are now unmatched, and hence are now looking for new workers. Even though our model shows one equilibrium where these interruptions need not affect market equilibrium, one can see how these interruptions could have a similar effect to random rematching, which has been shown to adversely affect efficiency in a different type of coordination game (Van Huyck et al., 1990).

Because the interruption “knocks out” employers for several periods, as in lifelike labor market shocks, the average demand for labor at a given period will be lower as δ increases. Demand for labor can be measured by the ratio of employers to workers (a low ratio indicates less demand by employers). The ratio of employers to workers across all periods (after accounting for the interruptions) is 0.45 for $\delta = 0.50$, 0.81 for $\delta = 0.10$, and 0.90 for $\delta = 0$ is 0.76. To partially account for the effect of lower demand for labor, we calculate the number of employers that are active at every period ($\text{NumEmployers}_{t,j}$ in Eq.8) and ran the regressions with and without them, finding no substantive changes in our conclusions.¹⁵

The experiment was programmed and conducted with the z-Tree software, based on the BFF1 original software. Figure A.1-3 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 employer and seller. Each session lasted approximately 100 minutes and subjects earned, on average, \$35. We conducted 5 sessions of each treatment at the University of Pittsburgh. In the Appendix we include data from pilot experiments at 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. The Caltech sessions provide a comparison of $\delta = 0$ and $\delta = 0.05$, while the UCLA sessions include $\delta = 0$ and $\delta = 0.1$.

¹⁵Brown, Falk and Fehr (2012) found that relational contract persist under different firm worker ratio, even when there is excess demand for labor rather than excess supply of labor.

4 Results

Our results section is organized as follows: Tables 1-2 show summary statistics. Table 1 reports statistics at the session level (with each session average contributing one data point). Table 2 reports reports statistics at the worker level (with each worker contributing one data point). Figure 2 provide the empirical version of r_t , private offers from new employers, and e_t , effort level, that were simulated in Figure 1 (bottom panel, $k = 3$). Table 3-6 present regressions testing the six testable implications from the theoretical model, which is then summarized in Table 7.

Table 1 shows that employers offer wages averaging 35-40 and request effort a bit above 7 in all treatments. Workers deliver a little more than 6 units of effort, shirking by a little more than 1 effort unit. Because effort is below the surplus-maximizing value of 10, market efficiency is around 60%. These results so far are not statistically different across the three values of δ (at $p < .10$ two-tailed).

Table 1 here.

Figure 2 depicts two main time trends across the 30 periods in the sessions. There are a lot of private offers from new employers in the first ten period (about .2/worker), dwindling to .05 in later periods except when $\delta = 0.5$.¹⁶ Delivered effort drifts up over time to a surprisingly similar degree across all δ conditions, starting around 5 units and increasing to 7 (except for a sharp downturn in the end).

Figure 2 here.

However, there *are* some indication of differences in the underlying relationship dynamics. As a starting point we will follow other studies in this framework in examining the difference between private and public offers. Recall that private offers are made to a specific number-identified worker; public offers can be accepted by any worker. Other studies as well as ours find that private offers pay a higher wage and delivered efforts tend to increase over time for private offers (as they become ongoing relational contracts) but decline over time for public offers (see Figure A5-A8).¹⁷

The bottom half of Table 1 shows that private offers, which make up about 30-36% of all contracts, pay significantly less in $\delta = 0.5$, suggesting some difficulties in long term contracting. Shirking in private contracts is slightly larger

¹⁶Note the similar pattern of spikes in this overture to new relationships as predicted by the simulation in bottom left panel of Fig 1.

¹⁷Note, however, that we made no directed hypothesis about public offers since our theoretical model predicts that it will be used only at $t = 1$.

in $\delta = 0.5$ though not significantly so, but decreased shirking in public contracts makes up for it: delivered effort went from being 2.7 units less than requested effort when $\delta = 0$ to only 1.9 units less when $\delta = 0.5$.¹⁸ This results in workers giving up more of the surplus to employers as we go from $\delta = 0$ to $\delta = 0.5$ (70% to 63%).

Table 2 shows worker-level statistics. There is a gradation of accepting offers from new employers in the first half of the sessions, which is most active for $\delta = 0$ (4.28 employers) and least for $\delta = .5$ (2.86). In the second half this difference reverses, as workers tend to stick with incumbent employers (only .22 new employers) when $\delta = 0$ but find new employers .96 times when $\delta = .5$. This suggests a delay in forming long-term relationships when there are more downturns.

Table 2 here.

The types of offers accepted by these workers are similar across treatments, except that there are much fewer immediate renewals— that is, employers offering a private contract to the same worker as in the previous period— when there are downturns (37% with $\delta = 0.10$ and 9% with $\delta = 0.50$), compared to 53.2% when there are no downturns. However, the lack of continuity does not lead to more shirking: outside of the last 5 periods, the gap between delivered effort and requested effort are *not* larger as δ increases.

We now move to the regression analysis that tests the six empirical implications of the theory developed above. First, Table 3 indicates the time trends in the opportunities for new contracting relationships. The coefficients of *Period* across Model 1-4 indicate that both private offers from new employers and public offers becomes less frequent over time. Our model predicts that because downturn extend the supply of unmatched employers, the decline in new offers across periods will not as strong for higher δ . However, Model 2 and 4 shows a positive but insignificant coefficient on *Period* $\times$ δ , suggesting that higher δ did not significantly extend the window of time where there are opportunities of new employers.

Table 3 here.

In Table 4 the total number of unique employers a worker has contracted with is regressed against the total number of contracts he received in the session. Interestingly, in Model 1 the number of contracts is not generally correlated with the number of employers a worker has had, and δ , which knocks out employers from the market, does not significantly decrease contracting partners. Model 2 explains why. The coefficient on *Number of contracts* show that in market

¹⁸The improved public market can be see in Fig A7 in the Appendix.

with no interruptions, more contracts are associated with fewer employers since they arise from stable long term relationships. But as interruptions increases, long term relationships are harder to obtain and a worker need to explore more employers *Num contracts* $\times$ δ to maintain the same level of labor market activity. This instability is largely confined to the first half of the session ($t < 16$), as indicated by comparing *Num contracts* $\times$ δ term in Model 3 and 4.

Table 4 here.

Table 5 shows that employers are discerning of who they contract with. Model 1 shows that whether employers at t renew contracts with the workers they had at $t - 1$ at is strongly predicted by $e - \tilde{e}$. The employer is 11% more likely to attempt an immediate renewal for every point of bonus effort: effort delivered by the worker beyond the employer's request. Shirkers, for whom $e - \tilde{e} < 0$, will then be more likely to be seek new employers to contract with.

How then, should an unmatched employer find a good worker and avoid shirkers? Model 2 shows that the number of private offers from new employers goes up by 0.033 when a worker's previous employer has just entered a downturn. Given that each worker receives on average only 0.104 private overtures from new employers each period, this is a substantial increase. It appears that employers notice suddenly-unemployed workers and try to "poach" them with new offers.

How would the incumbent employer react to this poaching? Our model describe an equilibrium where all agents prefer to continue contracting with whoever they contracted with last, supported by off-equilibrium beliefs that workers that do not do so have shirked. This implies that employers returning from downturn are reluctant to reconnect with workers that worked for other employers, since they now have new employers. This reluctance to reconnect is expressed by the negative coefficient on the variable *Workers contracted w/others* in Column (3).

Table 5 here.

Finally, Table 6 investigates the dynamics of shirking, defined as a negative difference between delivered effort and actual effort and delivered effort. (Delivered effort e is highly correlated with surplus efficiency, which is $10e - c(e)$.) Model 1 shows that in the beginning, workers deliver effort that is -2.26 units less than what is requested. Workers shirk less in later periods (*Period*), except for an expected endgame drop in the last period (*Last period*). Contrary to what is often seen with random rematching but in line with our model, shirking does not increase with δ . This is true even at the last period *LastPer* $\times$ δ_j or the last 5 periods *LastPer* $\times$ δ_j . Effort, however, is significantly lower at the last 5 periods. Note, however, that the coefficient for Model 3 and 4 are essentially the same. Our intuition is that contrary to what our model predicted, there is

indeed more shirking at the last 5 periods due to δ , but we are underpowered to estimate that effect precisely. We suspect that employers are not completely aware of how early the high equilibrium would unravel due to δ and may not have adjusted requested effort fast enough.

Table 6 here.

Table 7 plucks out and organizes coefficients from Tables 3-6 which test the six theoretical predictions from section 2. These predictions generally go in the right direction, but we appear under-powered to detect (or reject) some of them. For example, the regression didn't find that downturn significantly slows down the decline of private offers from new employees (Row 1) though there is a positive estimated effect and the graph of private contracts illustrates it. Similarly, we believe that the insignificant coefficient on shirking at the last few periods (*b4* on the 5th row) would probably be significant with larger sample. Overall, a model in which employers and workers may respond to stochastic interruptions by randomly — but selectively — re-matching does a fair job capturing many of the dynamics about the types of offers, the exploration of new employer partners, and actual efforts that are seen in the data.

Table 7 here.

5 Conclusion

These experiments explore robustness of gift-exchange markets to a lifelike type of interruption. In these experimental markets employers offer a promised (enforceable wage) and request effort from workers. Effort is costly for workers and valuable for employers; surplus is created if workers accept jobs and choose high effort. Surplus creation is strictly increasing in worker effort.

Previous experiments have shown that efficiency can be quite high, especially when workers are identified and employers can repeatedly contract by making a private worker-specific offer. These are relational contracts because while the employers can request effort, there is moral hazard on the worker side because there is no explicit contractible short-run penalty if a worker chooses low effort (in order to reduce effort costs).

The key experimental treatment is a change in the probability with which employers suffer a three-period “downturn” and cannot hire workers. Many disruptions are possible in these markets. The short-run shocks to labor demand are just a starting point for an experimental program of understanding how robust these markets are to other kinds of business-cycle like changes.

As has been seen in earlier experiments, in the typical healthy market for relational contracts an employer first hire a worker, then renew contracts privately if the worker does not shirk. Downturns pose a challenge to this efficient

regime of relational contracting by exogeneously breaking such contracts. In this paper we present a theory in which firms challenged by this downturn navigate through selfish, strategic workers, who co-exist with fair-minded ones (who always provide requested effort), and manage to maintain the high equilibrium. This model has several testable implications. General patterns in the data are consistent with these predictions. Selective re-matching from the employer manage to right the ship and keep workers from shirking, creating an overlapping series of new relational contracts even when the downturn rate is as high as $\delta = .5$.

We conclude with two remarks. First, the statistical power to identify differences across δ conditions is limited. As is well-known in experimental economics, the error structure in observations from individuals and periods in complicated markets are complicated to analyze (e.g. Frechette 2011). A conservative way to treat these data is that one experimental session is a single observation (see Table 1). Nonetheless, the main observations in these 15 sessions were also evident in a large number of sessions in two previous student subject pools:¹⁹ stochastic interruptions do not harm high equilibrium (Appendix Table A1), terminate the relationship of less optimal employer-worker pairs (Appendix Table A2), and improve the short term market (Appendix Fig A5-8).

Second, it is always the case that these markets have equilibria in which employers expect all workers to completely shirk, so employers offer the lowest profitable wage, workers do shirk, and no relational contracts form. In this paper we present a theoretical model predicting minimal harm to market equilibrium. However, our intuition in beginning this research was that it is also quite possible that exogenous downturns could inject enough strategic uncertainty to undermine formation of relational contracts and market efficiency, tilting the markets toward the low wage-effort equilibrium. The mere chance of downturn implemented by δ could act as a correlating device that influences collective beliefs about effort reciprocity in response to wages (much as examples of previous market behavior influenced apparent beliefs in Bartling et al 2018). Such pessimistic beliefs could be self-fulfilling. However, even with high rates of expected downturns these markets achieve substantial efficiency. Efficiencies were 62-67% across all values of δ (excluding the typical drop from endgame anticipation in the last 5 periods). The main thing we learned is that these markets are surprisingly resilient to exogenous interruptions.

Finally, during the extreme condition with $\delta = .5$, employers were often in downturns, creating involuntary unemployment among workers. As a result, a large number of subjects— both employers and workers— in those experimental sessions were visibly bored and not very happy. It has been known for a long time that unemployment is bad for mental health (Eisenberg and Lazarsfeld, 1938; Paul and Moser, 2009) and causes a host of other negative social outcomes. Unemployment strongly reduces measured subjective well-being (DiTella, MacCulloch and Oswald, 2001; Kahneman and Krueger, 2006) and negative effects can be long-lasting (Lucas et al (2004). Observing these miserable subjects sug-

¹⁹These data are treated as pilots and reported only in an Appendix.

gests that the labor market experimental paradigm could conceivably be used to study the psychology and even consequences such effects. Similarly, successful relational contracting between pairs of people may generate a sense of social closeness, camaraderie, endogeneous group affiliation or empathy (what Adam Smith called fellow-feeling). Experimental observation of these psychological and emotional forces could be done combining the usual observations of choice and effort with self-reports and biological measures. Such measures, combined with theory, could bring more scientific precision to concepts that are often relegated to areas of public health or organizational psychology and are important, but not present in most economic contracting models (cf. Brandts, Cooper and Weber, 2015 on legitimacy).

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Fig 1: Simulation results of r_t (Prop 2) and $\tilde{e}_t^*$ (Prop 3) for $k=1,3$ and $0 \leq \delta \leq 0.7$

Right: the probability that a worker receives a private offer from a new employer remains positive longer as interruption probability increases ($0 \leq \delta \leq 0.7$). Top right: new private offer probabilities when interruptions last one period ($k=1$). Bottom right: three period interruptions ($k=3$) further extends the relationship formation period. The pattern of spikes at period $t=1,4,7,\dots$ is due to the start of the first set of interruptions at $t=1$.

Left: the high equilibrium starts unravelling earlier as interruption probability increases. Top left: equilibrium effort levels in the last 5 periods with one-period interruptions ($k=1$). Bottom left: early unravelling becomes more pronounced with the three period interruptions ($k=3$)

Fig 2: Experimental Results: new private offers and effort across periods.

Top: The average number of private offers from new employers (i.e., employers who had not previously hired the same workers) per worker at each of 30 periods for each experimental treatment. This number goes down over time, but decreases more slowly for higher values of the downturn probability δ . Bottom: The average level of delivered effort on contracts at each period. There is an upward drift and a one-period endgame drop in period 30.

Table 1: Session level summary statistics (Each session contributes one data point.)

Probability of employer downturn	$\delta=0$		$\delta=0.1$		$\delta=0.5$	
Number of experimental sessions	N=5		N=5		N=5	
	Mean	SE	Mean	SE	Mean	SE
Contracts:						
Offered wages from employer	38.99	1.96	39.41	2.59	34.42	3.72
Requested effort	7.14	0.29	7.61	0.35	7.28	0.57
Delivered effort from workers	6.21	0.24	6.64	0.4	6.25	0.64
Market efficiency:						
At the last period	0.61	0.03	0.37**	0.08	0.41*	0.1
During last 5 periods	0.71	0.03	0.73	0.03	0.63	0.06
Before last 5 periods	0.62	0.03	0.67	0.04	0.65	0.06
% of contracts from private offers	63%	0.05	71%	0.03	68%	0.09
Private offers wages	46.82	0.81	45.33	2.44	37.38***	3.09
Delivered-requested effort:	-0.76	0.11	-0.67	0.08	-0.89	0.28
Public offers wages	24.25	3.87	24.92	1.67	25.49	4.18
Delivered-requested effort:	-2.73	0.21	-2.78	0.18	-1.91*	0.4
Worker's share of surplus	0.72	0.03	0.67	0.06	0.63*	0.03

Wilcoxon test of treatment differences from $\delta=0$. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2: Worker level summary statistics

Probability of employer downturn	$\delta=0$		$\delta=0.1$		$\delta=0.5$	
Number of workers	N=50		N=50		N=49	
	Mean	SE	Mean	SE	Mean	SE
Number of contracts	26.46	0.55	20.5***	0.81	10.7***	0.87
Number of new employers:	4.54	0.23	4.60	0.20	3.86**	0.23
During the 1st half	4.28	0.22	4.00	0.17	2.86***	0.23
During the 2nd half	0.22	0.07	0.54***	0.1	0.96***	0.15
Contracts from:						
Private offer from new employers	0.086	0.01	0.09	0.01	0.10	0.01
Public offers	0.382	0.04	0.33	0.04	0.37	0.04
Immediate renewal offers	0.532	0.04	0.37***	0.04	0.09***	0.01
Reconnection offers	0	0.00	0.03***	0.01	0.084***	0.01
Delivered-requested effort:						
Before last 5 periods	-1.67	0.20	-1.47	0.18	-1.64	0.28
During last 5 periods	-1.33	0.28	-1.85	0.28	-2.34**	0.44

T-test of treatment differences from $\delta=0$. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3: Opportunities to start contracting with new employers are reduced over time, and an increase in downturn probability does not significantly change this trend.

VARIABLES	# of private offers from new employers		# of public offers	
	(1)	(2)	(3)	(4)
Period (per 10)	-0.057*** (0.015)	-0.076*** (0.023)	-0.025* (0.015)	-0.046** (0.021)
δ (per 0.1)	0.012 (0.010)	-0.003 (0.016)	-0.036*** (0.011)	-0.053*** (0.008)
Period x δ		0.009 (0.007)		0.011 (0.007)
	0.013*** (0.004)	0.012*** (0.004)	-0.001 (0.006)	-0.001 (0.006)
Constant	0.093* (0.050)	0.125** (0.060)	1.003*** (0.055)	1.041*** (0.049)
Observations	4,470	4,470	4,470	4,470
R-squared	0.038	0.042	0.064	0.068

Bootstrapped standard errors (50 replications) in parentheses clustered at the session level (15 sessions).

Note: Data from 30 periods of observation from 149 workers (and 135 employers). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. We rescaled the period indicator to be in units of 10 periods and the probability of downturn to be in units of 0.1 for the regressions.

Table 4: Workers interact with more employers per contracts as downturn probability increases. This instability is more pronounced in the first half (3) than the second (4).

VARIABLES	Number of unique employers			
	(1) All periods	(2) All periods	(3) 1st half	(4) 2nd half
Number of contracts (per 10)	-0.000 (0.038)	-0.836*** (0.265)	-0.579 (0.592)	-0.434*** (0.156)
δ (per 0.1)	-0.152 (0.152)	-0.773*** (0.158)	-0.760*** (0.142)	0.003 (0.062)
Num contract x δ		0.376*** (0.122)	0.806*** (0.228)	0.135* (0.070)
Constant	4.643*** (0.979)	6.559*** (0.784)	4.859*** (0.586)	0.817*** (0.175)
Observations	149	149	149	149
R-squared	0.044	0.152	0.326	0.151

Bootstrapped standard errors in parentheses clustered at the session level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Note: In model (4), we reset total contracts so far to the second half by subtracting the number of contracts the worker has by period 15.

Table 5: Employers are discerning about the workers they contract with: (1) employers renew contract with workers that provide the requested effort level or above, (2) employers looking for new employees target workers whose employer is unable to hire to do a downturn, and (3) employers returning from a downturn are less likely to try to reconnect with their incumbent workers if the worker has contracted with other employers during the downturn period.

VARIABLES	(1) Employer renew contract immediately	(2) # of private offers from new employers	(3) Employer try to reconnect after downturn
Delivered-requested effort	0.109*** (0.008)		
Worker's employer is in downturn		0.033*** (0.007)	
Worker "poached" during Incumbent employer's downturn. Period (per 10)	0.126*** (0.012)	-0.063*** (0.017)	-0.054** (0.021)
δ (per 0.1)	-0.035** (0.017)	0.007 (0.009)	0.108*** (0.016)
Number of employers able to hire this period	-0.000 (0.005)	0.012*** (0.003)	-0.012 (0.013)
Constant	0.580*** (0.052)	0.104** (0.049)	0.002 (0.013)
Observations	2,426	3,834	674
R-squared	0.319	0.044	0.045

Bootstrapped standard errors in parentheses clustered at the session level. *** p<0.01, ** p<0.05, * p<0.1

Table 6: Changes in shirking (when delivered– requested effort<0) and effort over periods and its sensitivity to δ .

VARIABLES	Delivered-requested effort			Delivered effort
	(1)	(2)	(3)	(4)
Period (per 10)	0.059*** (0.010)	0.059*** (0.011)	0.076*** (0.009)	0.127*** (0.017)
δ (per 0.1)	0.037 (0.049)	0.046 (0.055)	0.080 (0.071)	0.006 (0.166)
Last period	-2.607*** (0.593)	-2.247*** (0.678)		
Last period x δ		-0.260 (0.202)		
Last 5 periods			-0.943*** (0.221)	-1.078*** (0.207)
Last 5 periods x δ			-0.194 (0.119)	-0.196** (0.099)
Constant	-0.014 (0.023)	-0.014 (0.022)	-0.010 (0.018)	-0.042 (0.044)
Observations	2,872	2,872	2,872	2,872
R-squared	0.068	0.070	0.057	0.071

Bootstrapped standard errors in parentheses clustered at the session level. *** p<0.01, ** p<0.05, * p<0.1

Note: Workers do not generally shirk more in response to higher interruption probability (i.e., the coefficient on δ is positive and insignificant by itself (1), when interacted with Last Period (2) and when interacted with Last 5 Period (3)). However, as predicted by theory the market does unravel earlier with higher δ : delivered effort in the last 5 periods fell an additional 0.196 points for every 10% interruption probability.

Table 7: Summary of results of six testable implications

Hypothesized effect	Text eq'n	Hypothesized coefficient	Estimated coefficient (std. error)	Source of coefficient
Decline in new offers in time	(6)	$b_1 < 0$	-.057(.008)	T3, column (1)
Downturn probability slows down decline in new offers	(7)	$b_3 > 0$	.009 (.007)	T3, column (2)
Downturn probability increases the number of partners needed for the same level of market activity.	(8)	$b_3 > 0$ $ b_3(t < 15) > b_3(t > 15) $	.376 (.122) .806 (.228) > .135(.070)	T4, column (2) T4, columns (3-4)
Employers use downturns to poach other employers' workers. Incumbent employers do not reconnect with poached workers.	(9) (10)	$b_2 > 0$ $b_2 < 0$	.033 (.014) -.054 (.024)	T5, column (2) T5, column (3)
Shirking is not increased by downturns (even in the last few periods)	(11)	$b_2 = 0$ $b_4 = 0$	.080 (.071) -.194 (.119)	T6, column (3)
Delivered effort is not increased by downturn (except in the last few periods)	(12)	$b_2 = 0$ $b_4 < 0$	.006 (.166) -.196 (.099)	T6, column (4)

Note: T6 refers to Table 6, etc.

Appendix

Figure A1. Employer's contracting screen

Employer submit private and public offer in this screen. At the top of the screen, employers can see their ID, the period number, and remaining time at this stage. At the two leftmost columns, employers can see the list of public offers in the market and the private offers the employer has sent out. At the bottom right of the screen the employers can see which employers has gone into downturn and the availability of all the workers in the market. (The former row of checkboxes is not present in the $\delta=0$ treatment.) If a worker accepted an employer's offer, the contract will be displayed under list of workers and the employer will not be able to make any other offers this period.

Period

1 out of 11

Remaining time

Public Offers			Private Offers								
Buyer	Price	Quality	Price	Quality	To Seller						
<div> <div>Your ID number: 2</div> <div>Here you make your offers</div> <div> ☐ public ☒ private </div> <div>If private, to which Seller: <input type="text"/></div> <div>Your price: <input type="text"/></div> <div>Desired quality: <input type="text"/></div> <div>OK</div> </div>											

Buyers facing downturn

☐ B1
 ☐ B2
 ☐ B3
 ☐ B4
 ☐ B5
 ☐ B6
 ☐ B7
 ☐ B8
 ☐ B9

Sellers with contracts

☐ S1
 ☐ S2
 ☐ S3
 ☐ S4
 ☐ S5
 ☐ S6
 ☐ S7
 ☐ S8
 ☐ S9
 ☐ S10

Your seller	Your price	Your des.Q

Figure A2. Worker's screen

Here worker sees her own private offers and all the available public offers. At the top half of the screen the employer can see a row of checkboxes indicating which employer has gone into downturn. (This feature is not present in the $\delta=0$ treatment.) Worker chooses which offer to accept. After accepting an offer, the worker proceeds to an effort screen where he enters an effort level (between 1 and 10). Effort cost increases in effort level.

Period
3 out of 11

Remaining time: 7

Your ID number 2

Buyers facing downturn
☐ B1
☐ B2
☐ B3
☐ B4
☐ B5
☐ B6
☐ B7
☐ B8
☐ B9

Private Offer			Public Offers		
from Buyer	Price	Desired Quality	from Buyer	Price	Desired Quality
			2	3	3
Accept			Accept		

from Buyer	Price	Desired Quality
1	10	2

Figure A3. Employer and worker's earnings screen. Both contracting partners can see each other's payoff.

Period: 1 out of 1 Remaining time(sec):

Your ID-number

The following offer has been accepted

ID-number of your seller

Price

Desired quality

Actually chosen quality

Income of your seller

Your income =

continue

Figure A4. Simulation of numerator (Top) and denominator (Bottom) of r_t (Prop 2) for $k=3$

Table A1: Summary statistics table for pilot sessions at other experimental sites

Probability of employer downturn	$\delta=0$		$\delta=0.05$		$\delta=0$		$\delta=0.10$	
Location	Caltech		Caltech		UCLA		UCLA	
Number of experimental sessions	N=4		N=4		N=2		N=2	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Contracts:								
Offered wages from employer	43.23	3.05	45.06	2.54	37.01	0.16	35.20	3.55
Requested effort	8.56	0.45	9.09	0.30	8.07	0.09	7.53	1.03
Delivered effort from workers	8.10	0.23	8.11	0.24	6.45	0.14	6.14	0.22
Worker's share of surplus	0.52	0.04	0.58	0.03	0.57	0.03	0.61	0.07
% of contracts from private offers	0.79	0.03	0.82	0.04	0.78	0.07	0.72	0.04
Private offers wages	48.18	3.03	48.09	2.88	42.59	3.55	38.68	2.96
Delivered-requested effort:	-0.28	0.30	-0.69	0.09	-1.03	0.25	-1.05	0.60
Public offers wages	24.01	3.16	32.01	2.89	20.17	6.29	25.66	7.06
Delivered-requested effort:	-1.32	0.66	-2.11	0.36	-3.54	0.36	-2.16	1.18
Market efficiency:								
At the last period	0.45	0.07	0.38	0.07	0.60	0.08	0.65	0.07
During last 5 periods	0.80	0.03	0.69	0.08	0.71	0.07	0.72	0.03
Before last 5 periods	0.82	0.03	0.85	0.01	0.65	0.00	0.62	0.04

Note: market efficiency is generally unharmed by stochastic interruptions before the last five periods (e.g., 82% versus 85% in Caltech sample; 65% versus 62% in UCLA).

Table A2 Characteristic of pre-interruption contract by post-interruption reconnection status.

	Post interruption reconnection attempt					
	No attempt by employer		Attempted by employer			
			Rejected by worker		Accepted by worker	
Pre-interruption statistics	Mean	S.E.	Mean	S.E.	Mean	S.E.
CALTECH $\delta=0.05$ (4 sessions)						
Offered Wage	38.75	4.79	47	N/A	50.2	3.08
Offered Surplus	0.26	0.03	0.29	N/A	0.37	0.02
Delivered Surplus	0.97	0.45	0.43	N/A	0.45	0.02
Observations	12		1		20	
UCLA $\delta=0.1$ (2 sessions)						
Offered Wage	27.32	3.56	23.5	6.65	44	6.89
Offered Surplus	0.41	0.07	0.33	0.07	0.44	0.05
Delivered Surplus	0.73	0.14	0.38	0.12	0.52	0.05
Observations	19		4		12	
Pitt $\delta=0.1$ (5 sessions)						
Offered Wage	22.09	1.81	21.25	10.08	49.39	2.12
Offered Surplus	0.22	0.03	0.15	0.12	0.36	0.02
Delivered Surplus	0.76	0.1	0.32	0.12	0.49	0.02
Observations	32		4		49	
Pitt $\delta=0.5$ (5 sessions)						
Offered Wage	27.95	1.66	28.77	6.3	39.69	1.41
Offered Surplus	0.27	0.02	0.29	0.06	0.32	0.01
Delivered Surplus	0.74	0.07	0.4	0.04	0.39	0.01
Observations	106		13		113	

Note: Across the three different subject pools, we observe that employer-worker pairings that survive interruptions are generally very different than those that do not. Resilient employer-worker pairings feature more generous employers and workers that deliver fair effort. The employers offer higher wages and more generous surplus sharing to workers. These offers are, however, still below the ideal 50-50 sharing but the workers remedy this by choosing effort level that brings surplus sharing close to equality.

Fig A5: Private and public effort at Caltech with $\delta=0$ and $\delta=0.05$

Fig A6: Private and public effort at UCLA with $\delta=0$ and $\delta=0.10$

Note: we also observe across our three different subject pools that whenever the private market perform a little worse due to the interruptions, workers start delivering high effort level in the public market, therefore maintaining the overall efficiency of the labor market.

Fig A7: Private and public effort at Pitt with $\delta=0$ and $\delta=0.10$

Fig A8: Private and public effort at Pitt with $\delta=0$ and $\delta=0.50$