**Contractual Incompleteness, Unemployment, and Labor Market Segmentation**

Steffen Altmann, Armin Falk, Andreas Grunewald, David Huffman

*This version: February 2013*

**Abstract**

This paper provides evidence that involuntary unemployment, and the segmentation of labor markets into firms offering “good” and “bad” jobs, may both arise as a consequence of contractual incompleteness. We provide a simple model that illustrates how unemployment and market segmentation may jointly emerge as part of a market equilibrium in environments where contracts are incomplete, in the sense that work effort is not third-party verifiable. Using experimental labor markets that differ only in the verifiability of work effort, we demonstrate empirically that contractual incompleteness can cause unemployment and segmentation. Our data are also consistent with the key channels through which the model explains the emergence of both phenomena. These include firms adopting a particular type of implicit contracting strategy, and feedback from market conditions to worker behavior.

**Keywords:** Contractual Incompleteness, Incentives, Unemployment, Dual Labor Markets, Laboratory Experiment

**JEL codes:** C91, J41, J64, M52, M55

1 Institute for the Study of Labor (IZA) and University of Bonn.

2 University of Bonn and IZA.

3 University of Bonn.

4 Corresponding Author. Swarthmore College and IZA.

Address: Swarthmore College, Department of Economics, 500 College Avenue, Swarthmore, PA 19081-1397. Email: dhuffma1@swarthmore.edu; Phone: +1-610-957-6139.

Financial support from the Deutsche Forschungsgesellschaft through SFB/TR 15 is gratefully acknowledged. We thank Johannes Abeler, Thomas Dohmen, Ernst Fehr, Peter Kuhn, Konstantinos Tatsiramos, and Matthias Wibral for helpful discussions. We also thank conference and seminar participants in Alicante, Bonn, Buch, Graz, Maastricht, Milan, New Brunswick, Oxford, Pittsburgh, Rotterdam, and Zurich for valuable comments.
1 Introduction

This paper provides evidence that two important features of labor markets—the existence of involuntary unemployment, and the segmentation of markets into firms offering “good” and “bad” jobs to apparently similar workers—may have a common underlying cause. In particular, both phenomena may arise jointly when employment relationships are characterized by contractual incompleteness, in the sense that work effort is not verifiable to third parties. We also provide evidence supporting a specific set of mechanisms for how contractual incompleteness can cause these two phenomena, in which there is a key role for the implicit incentive strategies adopted by firms.

Intuitively, when effort is not verifiable, firms may adopt an implicit incentive strategy for eliciting high work effort that involves paying relatively high wages, and conditionally renewing workers’ contracts based on their performance. With diminishing marginal product of labor, however, high wage payments can make it profitable for firms to hire fewer workers than technologically feasible, since the gains from higher overall production might be more than offset by higher wage costs. The result of such job rationing is endogenous involuntary unemployment. If a critical mass of firms rations jobs, however, a secondary employment sector could also emerge, where firms profitably fill all vacancies and pay relatively low wages. Such firms are able to pay lower rents, and elicit relatively lower but non-minimal effort, because of the unemployment pressure in the market. This might give rise to a segmented labor market in which the strategies of offering “good” high-rent jobs and “bad” low-rent jobs are, in equilibrium, equally profitable for firms. We show that the qualitative features of this intuition can be captured in a simple formal model, which builds on the classic efficiency wage frameworks by Shapiro and Stiglitz (1984) and Akerlof and Yellen (1990).

In order to provide empirical evidence on the causal impact of contractual incompleteness on unemployment and market segmentation, we study behavior of firms and workers in competitive experimental labor markets. All firms in our markets share the same production technology which exhibits decreasing returns to scale from labor but ensures that full employment is technologically efficient. In our main treatment, the Incomplete Contracts treatment (IC treatment), work effort is observable to firms but not verifiable to third parties. Firms
may, however, use implicit incentives to elicit non-minimal work effort in this treatment. In a control treatment, the Complete Contracts treatment (C treatment), effort is verifiable and contracts are explicitly enforced. If a worker accepts a contract in this treatment, he thus has to provide the contractually stipulated effort level.

Our first main empirical result is that contractual incompleteness causes a strong increase in the level of unemployment. Our data also reveal important differences in how labor markets function in the presence or absence of explicit contract enforcement. In line with the hypothesized mechanisms, we find that firms in the IC treatment use implicit incentives involving conditional contract renewal and paying strictly positive worker rents. At the same time that they pay high wages, however, some firms choose to offer fewer vacancies than possible. Endogenous unemployment in the IC treatment arises as a byproduct of this job rationing decision. Given that employed workers earn substantial rents, unemployment in the IC treatment is involuntary. In the C treatment where effort is explicitly enforced, labor market outcomes differ substantially along all these dimensions. Firms pay much lower wages and reap the major share of production surplus. Employment relations are shorter than in the IC treatment, and the overwhelming majority of firms does not ration jobs. As a result, endogenous unemployment in this treatment is very low and mostly voluntary, being caused by workers who do not accept existing contract offers. We also find support for the underlying mechanism that is hypothesized to drive these treatment differences, namely an impact of contractual incompleteness on the profitability of different contractual instruments: paying positive rents and using contingent contract renewal increases firm profits in the IC treatment, while being counterproductive or irrelevant for firms in the C treatment.

Our second main empirical finding is that contractual incompleteness leads to a stable coexistence of different job types. After an initial phase in which we observe a trend towards job rationing in the IC treatment, a plateau is reached such that unemployment stabilizes at a high level, and a relatively constant fraction of firms continues to operate without rationing job offers. Whereas in the initial phase job rationing is the more profitable strategy for firms, in this later phase firms earn similar profits regardless of whether or not they ration jobs. Workers, however, earn substantially lower rents and exert lower effort in firms that do not ration jobs. In the long run, the situation in the IC treatment thus resembles a segmented
labor market in which some workers are employed in “primary-sector” jobs characterized by high worker rents, relatively stable employment relationships, and job rationing, while other workers work under less favorable conditions in “secondary-sector” jobs (Doeringer and Piore 1971, Saint-Paul 1996). Given the equal profitability of these alternative firm strategies, the segmentation has the character of a market equilibrium. By contrast, market segmentation is not observed in the C treatment where firms’ strategy of not rationing jobs and paying low worker rents pervades the market. This indicates that the emergence of market segmentation is caused by contractual incompleteness. We also find support for a key mechanism hypothesized to sustain segmentation, which is an impact of unemployment pressure on worker behavior: workers in the IC treatment are significantly less likely to shirk when reduced market activity indicates lower job finding chances.

The first important contribution of our paper lies in empirically identifying a direct causal link between contractual incompleteness and involuntary unemployment. While efficiency-wage theory has long hypothesized that this link may exist (Shapiro and Stiglitz 1984, MacLeod and Malcomson 1989, Akerlof and Yellen 1990), establishing this key claim of the theory is difficult if not impossible using field data. The empirical literature has made important contributions on other aspects of the efficiency-wage hypothesis, particularly the relationship between rents and worker performance (for a survey see Katz 1986). However, evidence on key variables like work effort has necessarily been indirect, because effort is inherently difficult to measure in settings where efficiency wages would be relevant. As a solution, previous field studies have related indirect proxies for effort, such as worker discipline problems or survey measures of workplace performance, to wage premiums (e.g., Cappelli and Chauvin 1991, Campbell III and Kamliani 1997), or to measures of dismissal barriers and firing threat (e.g., Ichino and Riphahn 2005). An experimental approach is complementary to these studies because of the possibility to exogenously vary the degree of contractual incompleteness, and to measure the impact on involuntary unemployment.¹ In our setup we can also induce or accurately measure key variables such as worker effort and ability, or firms’ production technology. Thus, we are able to precisely assess whether contractual

¹For a general discussion of the role of lab experiments in studying labor market institutions see, e.g., Charness and Kuhn (2011).
incompleteness influences worker rents or decisions on job rationing and contract acceptance, as hypothesized in the theory.

The second main contribution of our paper concerns understanding the foundations of dual labor markets. The theoretical literature on dual labor markets has traditionally argued that market segmentation can result from contract enforcement problems and efficiency wages, if monitoring technologies differ exogenously across segments (Bulow and Summers 1986). Some theoretical approaches have made segmentation endogenous, arising due to non-linearities in monitoring technology, differences in setup and adjustment costs, or on-the-job search (e.g., Albrecht and Vroman 1992, Saint-Paul 1996, Board and Meyer-ter-Vehn 2011). We provide further theoretical insights on how market segmentation can emerge endogenously, with diminishing marginal product in the production function, despite homogeneous technology across firms. More importantly, we provide the first empirical evidence on the endogenous emergence of market segmentation due to contractual incompleteness. Some earlier experimental papers have observed firms offering different types of jobs which are more and less attractive from workers’ perspective (Brown et al. 2004, Bartling et al. 2012). Importantly, however, in these studies jobs that are good and bad for workers also exhibit strong and systematic differences in firm profits. In contrast, we find that firms who use the good-job and bad-job strategy are equally profitable, in line with the notion that market segmentation can be supported as a stable equilibrium outcome.

A number of other papers has used experimental techniques to study the consequences of contractual incompleteness in labor market settings (e.g., Fehr et al. 1993, Brown et al. 2004, Brown et al. 2012, Linardi and Camerer 2012). Our paper differs from this literature in that it incorporates an analysis of endogenously arising unemployment. By contrast, unemployment in earlier papers was exogenously given, ruled out by the design of the experiment, or determined by exogenous stochastic shocks. Previous studies have shown that contractual incompleteness can lead to an adoption of implicit incentive strategies that involve rent payments and contingent contract renewal (e.g., Brown et al. 2004).² We add a

²For recent surveys on lab and field experiments that study contractual and non-contractual solutions to alleviate moral hazard in the labor market see Charness and Kuhn (2011) and Bandiera et al. (2011). See Brown and Zehnder (2007) and Brown and Serra-Garcia (2012) for applications in credit markets.
missing dimension to this literature, showing how contractual incompleteness can also affect aggregate-level market outcomes. Our findings thus provide a missing empirical link, illustrating how contractual incompleteness, the use of implicit incentives, unemployment, and market segmentation can all be intimately related.

In the remainder of the paper, we first present the setup and procedures of the experiment, before discussing theoretical hypotheses in Section 3. In Section 4, we present our empirical results, and Section 5 concludes.

2 Design and Procedures of the Experiment

To study the impact of contractual incompleteness on unemployment and market segmentation, we implemented experimental labor markets where we exogenously varied the verifiability of work effort. As our workhorse, we used a variant of the gift-exchange game (Fehr et al. 1993). In the market, firms and workers interacted for 18 periods. Each period consisted of a market phase where firms offered employment contracts and hired workers, and a work phase where work effort was determined. In our main treatment, the IC treatment, effort was not verifiable and workers thus could depart from the contractually agreed upon effort level. By contrast, the effort level stipulated in the employment contract was explicitly enforced in our control treatment, the C treatment. Varying the verifiability of work effort while keeping everything else identical (production technology, supply and demand of labor, etc.) allows us to causally identify the effects of contractual incompleteness on labor market outcomes.

2.1 The Market Phase

Firms were the contract makers in the market phase. To offer a contract, firms stipulated a non-contingent (upfront) wage payment, \( w \), and a desired level of effort, \( \hat{e} \). Firms could make two types of contract offers: public offers that were available to all workers and could also be observed by all other firms, or private offers that were only available to one specific worker. Public offers allowed firms to reach the entire market if they wanted to fill a vacancy regardless of a particular trading partner. Private offers made it possible for firms to target specific workers. This is a necessary feature if firms want to apply a strategy that involves systematic rehiring of workers based on their previous performance. If an employer wanted
to (re)hire a specific worker via a private contract offer, she had to specify the ID of the worker in the contract offer. In this case, only the selected worker was informed about the contract offer, and only this worker could accept the offer.

In a given market period, each firm could hire up to two workers. As long as none of her contract offers had been accepted, a firm could make as many private and public offers as she wanted. A worker could accept any public contract offer available in the market, and any private offer he had received. Workers were not informed about the number of private offers in the market as a whole, but they could infer labor market conditions and the tightness of the market from the number of public offers observed in a given period. Once a worker accepted a contract offer, he was not allowed to accept further offers in this period. Additionally, all other outstanding offers of the respective firm were removed from the list of available contracts. The firm could then decide to open a second vacancy and hire another worker, by entering new contract offers. This feature of opening first and second vacancies sequentially was implemented to prevent “accidental hiring”, such that a firm who wanted to employ only one worker but entered multiple contract offers had a second offer accepted before being able to withdraw her remaining contract offers. Note that while firms and workers could endogenously build up long-term employment relationships by repeatedly offering and agreeing on (private) contract offers, it was not possible for market participants to directly announce or sign a multi-period employment contract.

The market phase ended when all firms had filled both vacancies, or when all firms had indicated that they did not want to offer further vacancies. At the end of the market period, workers received a summary of their own contract terms, and information on whether and under which conditions their firm had employed a second worker. This information was mainly provided to ensure common knowledge within a firm on whether the firm operated as a one-worker or two-worker firm. While complete information regarding co-workers’ wages may not be fully realistic, some degree of transparency is likely present in many work settings: even with a firm policy encouraging wage secrecy, workers may have a reasonably accurate

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3We also had a maximum trading time of 200 seconds for each market phase. This constraint was, however, only binding in few occasions (mostly in the C treatment). The impact of the time limit on unemployment and other market outcomes reported below is thus limited and confined to the control treatment.
idea about co-workers’ earnings.\footnote{Empirically, co-worker wages have no significant impact on workers’ effort choices in our setup. Efforts in the IC treatment strongly depend on a worker’s own contract terms, but they are not significantly related to the wage or the desired effort level of the co-worker (results can be found in Table B.1 of the appendix). The finding that wage inequalities per se might not affect behavior is in line with recent evidence on social comparison processes in similar setups (Charness and Kuhn 2007, Gächter \textit{et al.} 2012).}

\section*{2.2 The Work Phase}

After the end of the market phase, workers who had accepted a contract offer entered the work phase in which actual work effort, $e$, was determined. Since effort was contractible in the C treatment, effort levels corresponding to the contractually stipulated ones were exogenously implemented by the experimenter ($e = \hat{e}$). By contrast, work effort was observable by the firm, but not verifiable to third parties in the IC treatment. Therefore, a worker could exert equal, less, or more effort than stipulated in his employment contract. Workers’ effort choices, together with firms’ wage payments, determined material payoffs of firms and workers. Before the next period started, a firm and its worker(s) were informed about work efforts and the resulting payoffs for the firm and the workers employed by this firm.

\section*{2.3 Parameters and Procedures}

Participants’ roles were randomly assigned at the beginning of the experiment and kept constant throughout all market periods. In every market, we had 17 workers and 7 firms. Since firms could employ at most two workers, this implies that three workers were “exogenously” unemployed in each period.

A worker’s payoff in a given period, $\pi_W$, was given by

$$
\pi_W = \begin{cases} 
   w - c(e) & \text{if worker accepted a contract } [w, \hat{e}] \\
   0 & \text{if unemployed}
\end{cases}
$$

A worker who remained unemployed in a given period received a payoff of 0 points. An employed worker received the wage $w$ specified in his contract and had to bear the cost of the work effort he provided, $c(e)$. The set of feasible efforts and wages was given by $e \in \{1, 2, ..., 10\}$ and $w \in \{0, 1, 2, ..., 100\}$. As illustrated in Table 1, we induced a convex (monetary) effort-cost schedule in the experiment.
A firm’s profit depended on the number of workers hired, the wage(s) paid, and the effort exerted by the worker(s). Firms’ production technology was characterized by decreasing returns to scale. Decreasing returns are often argued to arise with increases in firm size, for instance due to higher bureaucratic or coordination costs in larger organizations. We conceptualized this as a reduction in workers’ productivity if a firm hired two workers. Specifically, each unit of effort by a worker increased output (and the firm’s payoff) by 10 points if only one worker was employed by the firm. If two workers were employed, each unit of effort increased the firm’s payoff by 7 points. This corresponds, for instance, to a work environment where workers in larger firms need to spend some of their time doing administrative tasks that are not directly productive. The payoff of a firm, \( \pi_F \), can thus be summarized as follows:

\[
\pi_F = \begin{cases} 
10e_1 - w_1 & \text{if one worker employed} \\
7(e_1 + e_2) - w_1 - w_2 & \text{if two workers employed} \\
0 & \text{else}
\end{cases}
\]

\( e_1 \) (\( e_2 \)) denotes the effort provided by the first (second) worker, and \( w_1 \) (\( w_2 \)) is the wage paid to the first (second) worker employed by the firm. Note that this specification of the production technology implies that efficiency is maximized when two workers are employed and maximum effort is exerted. Payoff functions \( \pi_F \) and \( \pi_W \), workers’ cost schedule \( c(e) \), and the number of firms and workers in the market were common knowledge.

The experiment was carried out in the BonnEconLab at the University of Bonn. A total of 240 subjects, mainly university students from all majors, took part in the experiments.\(^5\) Every subject participated only in one session, and we conducted five independent market sessions for each treatment. At the beginning of a session, participants received detailed information about the rules of the experiment.\(^6\) The experiment started only after all participants had

\(^5\) For a discussion of methodological considerations about the use of student subjects in economics research, see, e.g., Gächter (2010).

\(^6\) A translation of the instructions is available upon request. To rule out that differences in participants’
answered several control questions correctly. In addition, subjects played one trial period of the market phase to ensure that they understood how to use the computer program. Sessions lasted about 110 minutes and subjects earned on average 25.49 euros (about 35 USD at the time of the experiment), including a showup fee of 8 euros. The experiments were computerized using the software “z-Tree” (Fischbacher 2007); subjects were recruited with the online recruitment system by Greiner (2003).

3 Behavioral Predictions

The treatments described in the previous section allow us to identify the causal impact of contractual incompleteness on unemployment and labor market segmentation in our setting. Furthermore, using the data from the experiment we can investigate whether both phenomena arise in a way that is consistent with a specific type of theoretical equilibrium. A simple model, which is derived in the theoretical appendix, informs our hypotheses. In the model, we show how unemployment and segmentation can be part of a market equilibrium when effort is non-verifiable, and how these aggregate-level outcomes arise along with a very specific set of strategic behaviors by workers and firms. These individual-level mechanisms become additional qualitative predictions, which should be satisfied empirically if unemployment and segmentation are to be explainable by the type of equilibrium formalized in the model.

Our model builds on two important strands of efficiency-wage theory. One is the “shirking version” of Shapiro and Stiglitz (1984), in which materially selfish agents are motivated to work by the prospect of earning future rents, and a threat of being fired in case of shirking. The other is the “gift-exchange version” of Akerlof and Yellen (1990), in which workers are fair-minded, in the sense of experiencing a psychological benefit or cost of fulfilling a contract, depending on the generosity of the rents offered in their current contract. Our model incorporates both motivations: a fraction of agents is assumed to have fairness concerns, while the rest is materially selfish. This assumption is in line with abundant previous evidence from the lab and field, showing that a mix of selfish and fair types is typically present in a given population (see, e.g., Fehr et al. 1993, Bewley 1999, Fehr and Gächter 2000, Cohn et al. experiences from their employment relationships outside the lab could bias our results, instructions were framed in a neutral goods-market language.
To match the experimental setting, our model features a finite horizon.\textsuperscript{7}

### 3.1 Non-verifiable Effort

The presence of both fair and selfish types has important implications for the type of market equilibria that can emerge in finite-horizon settings where effort is non-verifiable, as is the case in our IC treatment. Intuitively, the presence of some fair types may lead firms to pay non-minimal wages in the final period, anticipating that fair agents voluntarily provide non-minimal effort in response to fair wages. This generates a rent from being employed in the final period. The prospect of earning this final-period rent, in turn, opens up possibilities for equilibria in which firms use implicit incentives to motivate agents in the pre-final period(s). There can thus exist equilibria in the IC treatment that involve firms paying rents and conditioning contract renewal on workers’ previous performance; in pre-final periods of such equilibria, selfish and fair types pool and fulfill their contracts in order to qualify for reemployment and earning future rents.

Our model shows how—in an environment where effort is non-verifiable—there exist equilibria in which involuntary unemployment can arise as a byproduct of the implicit-incentive strategies adopted by firms. Intuitively, starting from a situation where unemployment is low, the rents needed to deter shirking may be rather high because shirkers who are fired can relatively easily find another job. If a firm adopts a strategy of paying high wages and worker rents, however, decreasing returns to scale can make it profitable to “stay small”. If wages are high, the absolute increase in wage costs can be larger than the gain in terms of extra output that results from hiring more workers. It can thus be profitable to hire fewer workers than technologically feasible. Endogenous unemployment arises as a byproduct of such job rationing, and since firms pay positive rents, this unemployment is involuntary. The model identifies several key components that should be observed in the IC treatment if such an equilibrium arises. First, the profit-maximizing strategy of firms should involve paying strictly positive worker rents, and conditional contract renewal such that workers who

\textsuperscript{7}For a more abstract model that is tied less directly to the specifics of the experimental design, see the discussion paper version of our paper, in which we show in an infinite-horizon setting how unemployment and segmentation can be part of a stationary labor market equilibrium under contractual incompleteness.
shirk have a higher likelihood of being dismissed than workers who provide the contractually stipulated effort level. Second, from a worker perspective, the long-run costs of shirking in terms of forgone future rents should more than offset the short-run gains due to lower effort costs. Third, unemployment should emerge due to firms deciding to offer fewer vacancies than possible, rather than workers rejecting available job offers.

The model also shows how an equilibrium with non-verifiable effort can involve market segmentation, emerging jointly with involuntary unemployment. Intuitively, as some firms adopt the strategy of eliciting effort with high rents and rationing jobs (“good jobs”), the resulting unemployment reduces the job-finding chances for unemployed workers, and therefore the attractiveness of shirking for those employed. If the unemployment pressure in the market is strong enough, a fraction of firms might be able to operate equally profitably by hiring two workers, and offering jobs involving lower worker rents, and somewhat lower effort levels (“bad jobs”). Importantly, without sufficient unemployment pressure, the low rents of secondary-sector firms might not be able to prevent shirking, and offering bad jobs would thus not be profitable for firms. In the appendix, we derive sufficient conditions for segmentation to be part of a stable market equilibrium, such that the strategies of offering good jobs and bad jobs are equally profitable for firms, and neither type of firm has an incentive to deviate. If a segmentation equilibrium arises in our experiment, the model thus predicts that one-worker firms and two-worker should coexist in the market, and that firms in both segments are equally profitable. Furthermore, the firms who ration jobs should be the ones offering high wages and worker rents, and workers in such firms should exert high effort levels. In firms who hire two workers, wages and offered worker rents are predicted to be lower, as are worker effort levels.

### 3.2 Verifiable Effort

The mechanisms we have described as potential sources of unemployment and market segmentation do not apply in our control treatment where effort is verifiable and thus contractible. In the appendix we discuss equilibrium characteristics for an environment with explicit contract enforcement, as is the case in the C treatment. Holding constant other assumptions besides the verifiability of work effort, the equilibrium is characterized by all firms hiring two workers
and thus zero endogenous unemployment. Firms elicit maximum effort from workers, while paying wages just slightly above worker effort costs. Because effort is explicitly enforced, there is also no need to engage in repeated contract renewal with specific workers. Since all firms use a homogenous strategy of offering bad jobs, there is no market segmentation.

Intuitively, firms can elicit high effort without paying high rents or using conditional contract renewal because contractibility of effort eliminates a source of worker bargaining power: not only are firms on the short side of the market, but workers have no option to shirk once they are employed. The presence of fair types has relatively minor implications for behavior in an environment with explicit contract enforcement, as workers cannot shirk on the job.\(^8\) Firms strictly prefer hiring two workers, due to the efficiency of maximum employment for our production technology. We thus hypothesize that firms in the C treatment operate profitably by paying very low worker rents, and filling both vacancies. Furthermore, repeated rehiring of specific workers should be irrelevant for firm profits, and firms are thus predicted to more heavily rely on public contract offers in the C treatment. When a firm wants to fill a vacancy without concern for who is hired, public offers have the advantage that they reach the entire market.

Our discussion has illustrated how involuntary unemployment and market segmentation can be part of a market equilibrium when effort is not verifiable. It is well known, however, that there are typically multiple possible equilibria in repeated games (see, e.g., Fudenberg and Maskin 1986), and this is true as well in our setup. For instance, there is a range of different equilibria for our IC setting, some of which involve endogenous unemployment and segmentation, but others do not. Alternative equilibria may take forms such as all firms hiring two workers and offering bad jobs, resulting in no endogenous unemployment, or all firms hiring only one worker and offering good jobs. Our model illustrates how the equilibrium characteristics depend on the job separation rate between firms and non-shirking workers.

\(^8\)Fairness could play a role in the decision of whether or not to reject a contract offer. Theories of fairness, and ample empirical evidence, however, indicate that a key motive underlying fairness is a desire to punish unfair actions by an opponent. In a setting like the C treatment, where receivers of offers face competition, rejection of contract offers has limited effectiveness as a punishment strategy, and even offers involving low worker rents are thus likely to be accepted (see, e.g., Fehr and Schmidt 1999).
on which players endogenously “coordinate” in equilibrium. In particular, according to our
model, segmentation equilibria in environments with excess supply of labor always involve
positive equilibrium separation rates, whereas segmentation is not possible with a separation
rate of zero.\(^9\) While equilibrium multiplicity limits the predictive power of repeated game
models, in our view they are nevertheless very useful for heuristic purposes. The specification
of “candidate” equilibria gives rise to additional testable hypotheses for behavior, which must
be satisfied if the data are to be explained by a particular type of equilibrium. For instance,
equal profitability of both firm types and positive separation rates between firms and non-
shirking workers are both necessary features, and thus testable qualitative implications of an
equilibrium involving market segmentation. The presence of multiple equilibria also makes
it even more important to study actual behavior in a tightly controlled environment, as it is
ultimately an empirical question which type of equilibrium emerges.

4 Results

We organize our discussion of results as follows. In Section 4.1 we analyze the impact of
contractual incompleteness on the level of unemployment, and examine in more detail whether
the channels through which unemployment emerges are in line with the mechanisms featured
above. A similar structure applies to Section 4.2, where we study the influence of contractual
incompleteness on labor market segmentation.

4.1 Contractual Incompleteness and Unemployment

Figure 1 depicts the average unemployment rates for the C treatment (black) and the IC
treatment (grey), as well as the fraction of workers who are exogenously unemployed due
to excess supply of labor (dashed grey line). We observe strong differences in unemploy-

\(^9\)As discussed in the theoretical appendix, in the (extreme) case that the no-shirking equilibrium involves
zero job separations, new jobs never open up and there are no labor-market flows. With no flows, shirkers
who are fired can never find a new job again, and the value of unemployment is always zero. In this case the
value of unemployment does not depend on the number of one-worker firms, eliminating a key mechanism for
sustaining segmentation. Zero labor market flows, and a zero value of unemployment, also work against the
equilibrium featuring endogenous unemployment when there is excess supply of labor, because it facilitates
firms being able to elicit effort with relatively low rents, and it may thus be profitable to fill all vacancies.
Figure 1: Unemployment over time. Average unemployment rate in the IC treatment (grey) and the C treatment (black). Fraction of exogenously unemployed workers (dashed grey).

ment between treatments ($p < 0.01$). In the C treatment where contracts are explicitly enforced, unemployment remains close to the minimum possible level: in most periods, the unemployment level lies only 1–5 percentage points above the baseline level that is due to excess supply of labor. The unemployment pattern looks markedly different, by contrast, when effort is not verifiable. In particular, we observe a sharp increase in unemployment over the first seven market periods, before unemployment stabilizes and remains high for the rest of the game. Overall, contractual incompleteness thus causes a strong increase in the

\[ \Delta_t = 3.6 \]

percentage points for the first seven period in the IC treatment ($p = 0.044$). If we do the analog for the remaining periods, the average change is much smaller and insignificant ($\Delta_t = 0.6; p = 0.517$). Not
level of unemployment.

Result 1: We observe strong differences in unemployment between treatment conditions. Under explicit contract enforcement (C treatment), unemployment levels are close to the minimal possible level. When effort is not verifiable (IC treatment), unemployment rises strongly before stabilizing at a relatively high level.

Rows (1) and (2) of Table 2 shed further light on the driving forces behind the differences in unemployment. As could be inferred from the low levels of endogenous unemployment in the C treatment, we find that firms in this treatment almost always try to fill two vacancies (in 96.7% of cases) and, with an acceptance rate of 97.9%, workers essentially always accept. In the IC treatment, by contrast, firms open up only 67.5% of the possible vacancies. At the same time, available contract offers are accepted in 99.8% of cases. Firms’ decision to offer fewer vacancies than possible—i.e., to ration jobs—is thus the main source of endogenous unemployment in the IC treatment.

Rows (3)–(9) of Table 2 summarize further differences in the characteristics of employment relationships, in terms of the contract terms being offered, worker behavior, and the duration of employment relationships. In the C treatment, firms pay worker rents of only 5.7 points, hire workers via public offers in 84% of cases, and elicit effort close to the maximum possible level ($e = 9.7$). In contrast, wages and offered worker rents are substantially higher in the IC treatment, reaching levels of 34.6 and 21.1 points, respectively. In addition, 71.7% of concluded contracts in this treatment are initiated via private offers, and long-term employment relationships are frequently observed. For instance, 60% of firms rehire the same worker for at least 9 consecutive market periods. Effort levels are lower than in the C treatment, but at an average level of 7, they lie far above the minimum. Although effort is not verifiable, surprisingly, the same holds in an estimation framework that uses linear time trends and accounts for a potential “endgame effect” in unemployment in the final period of the IC treatment. We find a significantly positive trend for the first seven periods ($p < 0.01$), but not for the remaining periods or the final-period increase alone ($p = 0.154$ and $p = 0.228$, respectively).

In the few cases in which we observe available contracts offers being rejected, these exhibit very low or even negative worker rents. On average, the rejected contract offers stipulate worker rents of only 0.9 points (1.9 points in the C treatment, and -6.6 points in the IC treatment). As discussed above, rejection of such offers with extremely low worker rents might be an indication of workers’ fairness concerns.

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12 In the few cases in which we observe available contracts offers being rejected, these exhibit very low or even negative worker rents. On average, the rejected contract offers stipulate worker rents of only 0.9 points (1.9 points in the C treatment, and -6.6 points in the IC treatment). As discussed above, rejection of such offers with extremely low worker rents might be an indication of workers’ fairness concerns.
Table 2: Market characteristics. Mean values across treatments. The p-value for row (7) is derived from a linear-probability model where we regress a dummy variable equal to 1 if a given firm has at least one employment relationship for ≥ 9 consecutive market periods during the experiment on a treatment dummy. Reported p-values for all other tests are derived using the procedures described in Footnote 10.

workers in the IC treatment on average deviate from the contractually stipulated level by only 1.2 points. These findings provide first indications that firms in the IC treatment successfully use contract renewal and worker rents to establish implicit performance incentives. The co-existence of high worker rents and job rationing through firms also demonstrates that unemployment in the IC treatment is involuntary. At the same time, the observation of low rents and a lack of repeated contract renewal in the C treatment indicate that firms manage to exploit their high bargaining power when contracts are explicitly enforced.

In Table 3 we investigate two additional hypotheses about differences in the functioning of employment relationships, which cannot be directly inferred from the level differences in Table 2. Columns (1) and (2) report linear-probability estimates on the determinants of firms’ contract renewal decisions. This allows us to examine whether the greater prevalence of long-term relationships in the IC treatment indeed reflects a policy of conditional contract renewal, with rehiring and separation decisions depending on a worker’s previous performance. Comparing rehiring rates across treatments, the positive coefficient for the IC treatment in Column (1) confirms that contract renewal is overall more prevalent when effort is not verifiable. The negative coefficient on the indicator for shirking, however, demonstrates that firms in the IC treatment do indeed strongly condition contract renewal decisions on workers’
Table 3: Rehiring and long-run incentives. Random-effects models; the reported standard errors (in parentheses) account for potential clustering at the individual level. Columns (1)–(2): the dependent variable equals 1 if a firm renews the contract of a worker through a private contract in period t + 1. Columns (3)–(4): the dependent variable “future rents” is the sum of a worker’s earnings from period t + 1 until period 18. “Shirking” is an indicator equal to 1 if the worker deviates from the contractually stipulated effort level in the current period (i.e., \( e_t < \hat{e}_t \)). “Contract renewed” is an indicator equal to 1 if a firm has interacted with the same worker in period t − 1, and rehired the worker through a private contract offer in period t. “IC × Offered rents” and “IC × Contract renewed” are interaction terms of the respective measure with the treatment dummy. Columns (2) and (4) additionally control for a linear time trend, as well as an interaction term of the time trend with the treatment dummy. *** / ** / * indicate significance on the 1-percent / 5-percent / 10-percent level.

behavior. The average likelihood that a contract is renewed drops from 70.9% in the case of contract fulfillment to only 26.8% if a worker deviates from the contractually stipulated effort level. Note that while separations occur less frequently in the case of contract fulfillment, the estimates show that the separation rate after contract fulfillment is still positive in the IC treatment. This is important since, according to our model, equilibria involving endogenous unemployment and market segmentation exhibit non-zero separation rates in equilibrium. Column (2) adds controls for other important characteristics of employment relations, in-
cluding the rents offered in the current period’s contract, and an indicator for past contract renewal, which equals 1 if a firm has already renewed a worker’s employment contract in the current period (via a private contract offer). In this specification shirking continues to be a crucial factor in firms’ contract renewal decisions in the IC treatment.\textsuperscript{13} This indicates that firms in the IC treatment systematically engage in conditional contract renewal rather than, e.g., just having a stronger taste for repeatedly interacting with a given worker. Further estimates (available upon request) show that the results reported in Table 3 are also robust to using alternative measures of worker slacking, such as the degree of deviation from the contractually stipulated effort level.

Columns (3) and (4) of Table 3 show that the observed differences in rent payments and contract renewal strategies have important consequences for workers’ long-term earnings prospects. Confirming the observations from Table 2, the treatment dummy in Column (3) illustrates that workers in the IC treatment generally earn higher future rents than those in the C treatment. More importantly, the coefficient for shirking indicates that—within the IC treatment—the long-run benefits of contract fulfillment in a given period considerably outweigh the short-run gains from shirking.\textsuperscript{14} Controlling for other aspects of contract terms yields similar results (see Column (4) of Table 3). This underlines that workers in the IC treatment face strong implicit performance incentives. The relatively high effort levels in this treatment are thus understandable from a long-term incentive perspective.

The data from the IC treatment also illustrate the relevance of both (implicit) material incentives and fairness concerns. This can best be seen in the final market period, in which the potential for future interactions and the prospect of qualifying for future rents vanish.

\textsuperscript{13}By design, shirking is not possible in the C treatment, and thus we do not include an interaction term between shirking and the treatment dummy. Interestingly, the coefficient of “Contract renewed” in the C treatment is significant and positive (Column 2). This only reflects a small number of firms, however, who engage intensely in contract renewal in this treatment; as illustrated in Column (1), the overall likelihood that a firm in the C treatment rehires her worker is very low. Our estimates from Table 4, discussed below, further indicate that this strategy does not increase the respective firms’ profits.

\textsuperscript{14}For instance, a worker who shirks in period 10 earns on average 96.5 points less during periods 11-18 compared to a worker who provides the contractually stipulated effort in the same period. These losses in future rents are higher than the maximally possible short-run gains of shirking due to reduced effort costs.
Nevertheless, we find that 46.1% of workers in the IC treatment provide above-minimal efforts in this period, on average choosing an effort level of 6.0. This underlines the relevance of voluntary gift-exchange in our setting, paralleling what has commonly been observed in similar labor-market settings in the lab and field (see, e.g., Fehr et al. 1993, Brown et al. 2004, Cohn et al. 2012). At the same time, our data on effort provision also illustrate the importance of future rents and contingent contract renewal for motivating workers in the IC treatment: those workers who only exert minimal effort in the final period on average provide efforts of 7.7 in period 17 in which the potential for future interaction is still intact.

**Result 2:** Firms in the IC treatment pay higher workers rents, engage more heavily in repeated contract renewal, and offer fewer vacancies than firms in the C treatment. The combination of job rationing and high worker rents implies that endogenous unemployment in the IC treatment is involuntary. The strategies of firms in the IC treatment establish implicit performance incentives that imply a cost of shirking.

So far, our findings on treatment differences in worker rents, the prevalence of conditional contract renewal, and other key characteristics of employment relationships are all consistent with our theoretical hypotheses. However, our model also suggests a specific mechanism for why these differences emerge, namely that the absence of explicit contract enforcement makes specific contractual instruments profitable for firms. Table 4 examines this key underlying mechanism. In the estimations, we focus on the types of contractual instruments studied in Table 2, related to worker rent levels and contingent contract renewal. Column (1) shows that higher rent payments decrease the profitability of a contract for firms in the C treatment. In the IC treatment, by contrast, we see a qualitatively opposite relationship. Firm profits are increasing in the level of rents that a firm offers to her worker; this holds up to a point, after which further increases in wage costs dominate the profit increases due to higher work efforts. Column (2) reports estimates on the profitability of repeated contract renewal, using the “renewed contract” indicator from Table 3. We find that firm profits in the IC treatment are strictly higher in employment relationships that involve repeated rehiring. In contrast, firm profits in the C treatment are not systematically affected by whether firms and workers interact repeatedly. In further specifications, we allow for a simultaneous influence of both contractual instruments, and add controls for potential differences in dynamics across
Table 4: Profitability of contractual instruments. Random-effects models; the reported standard errors (in parentheses) account for potential clustering at the individual level. The dependent variable is the level of a firm’s earnings from a given employment contract. See Table 4 for definitions of the remaining variables. Column (4) additionally controls for a linear time trend, an indicator equal to 1 in period 18 to capture a possible endgame effect, as well as interaction terms of the respective variables with the IC treatment. *** / ** / * indicate significance on the 1-percent / 5-percent / 10-percent level.

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offered rents</td>
<td>-0.990***</td>
<td>-0.991***</td>
<td>-0.869***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.121)</td>
<td>(0.116)</td>
<td>(0.112)</td>
<td></td>
</tr>
<tr>
<td>(Offered rents)$^2$</td>
<td>-0.002</td>
<td>-0.002</td>
<td>-0.004</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.002)</td>
<td></td>
</tr>
<tr>
<td>IC $\times$ Offered rents</td>
<td>2.229***</td>
<td>1.894***</td>
<td>1.529***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.203)</td>
<td>(0.186)</td>
<td>(0.193)</td>
<td></td>
</tr>
<tr>
<td>IC $\times$ (Offered rents)$^2$</td>
<td>-0.014***</td>
<td>-0.012***</td>
<td>-0.006</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td></td>
</tr>
<tr>
<td>Contract renewed</td>
<td></td>
<td>-1.596</td>
<td>1.432</td>
<td>0.865</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.909)</td>
<td>(1.437)</td>
<td>(1.297)</td>
</tr>
<tr>
<td>IC $\times$ Contract renewed</td>
<td></td>
<td>17.948***</td>
<td>11.458***</td>
<td>9.802***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4.309)</td>
<td>(2.386)</td>
<td>(2.268)</td>
</tr>
<tr>
<td>IC treatment</td>
<td>-42.961***</td>
<td>-28.971***</td>
<td>-43.105***</td>
<td>-41.695***</td>
</tr>
<tr>
<td></td>
<td>(1.991)</td>
<td>(1.441)</td>
<td>(1.703)</td>
<td>(2.701)</td>
</tr>
<tr>
<td>Constant</td>
<td>52.160***</td>
<td>46.405***</td>
<td>52.087***</td>
<td>49.600***</td>
</tr>
<tr>
<td></td>
<td>(0.520)</td>
<td>(0.755)</td>
<td>(0.552)</td>
<td>(1.659)</td>
</tr>
<tr>
<td>Market period</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Final period</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>N</td>
<td>2,042</td>
<td>2,042</td>
<td>2,042</td>
<td>2,042</td>
</tr>
</tbody>
</table>

Dependent variable: firm profit from a given contract

Result 3: Contractual incompleteness leads to a qualitative change in the profitability of contractual instruments. Paying higher rents decreases profits, and repeated contract renewal is irrelevant for firms when contracts are explicitly enforceable. Paying higher rents and using repeated rehiring has a positive impact on firm profits when work effort is not verifiable.
4.2 Contractual Incompleteness and Labor Market Segmentation

In this section we turn to investigating the impact of contractual incompleteness on labor market segmentation, and we analyze whether individual behavior is consistent with our theoretical hypotheses for how segmentation can be an equilibrium phenomenon. We have already seen in Figure 1 that, after a strong initial increase, the level of unemployment in the IC treatment stabilizes during the later phase of the experiment. Given that endogenous unemployment is almost exclusively driven by job rationing, this also implies that the proportion of firms who ration jobs is increasing initially, but then reaches a plateau. Indeed, a relatively stable fraction of about 25% of firms continues to employ two workers during the later phase of IC treatment. This provides a first indication that there might be market segmentation under contractual incompleteness, with two different firm types coexisting in the long run.

For market segmentation to be an equilibrium phenomenon according to our model, however, it is necessary that the firm strategies characterizing the different market segments are equally profitable. This can occur if the unemployment pressure arising due to job rationing by some firms allows the non-rationing strategy to be viable for other firms. This is exactly what we observe in our data. Job rationing is strictly profitable for firms in the early periods of the IC treatment, in which unemployment pressure is relatively low, and in which we observe strong dynamics towards adopting the one-worker strategy. On average, one-worker firms earn roughly 50% more than two-worker firms during the first seven market periods (average per-period profits are 37.2 and 24.7 points, respectively; \( p < 0.01 \)).\(^{15}\) In contrast, in the remaining periods where unemployment has reached a plateau and the fraction of two-worker firms stabilizes, profits between one-worker firms and two-worker firms do not differ significantly anymore. The average per-period profits for periods 8–18 are 36.7 and 35.3 points in one-worker and two-worker firms, respectively (\( p = 0.361 \)).\(^{16}\) The finding that, in line with the idea that job rationing goes hand in hand with paying high worker rents to elicit high work effort, we observe that 67.4% of firms who switch to a one-worker strategy in the IC treatment at the same time increase their wage payments.

\(^{15}\)In the appendix, we illustrate in more detail how the profitability of the two hiring strategy adapts between the early and late phase of the experiment. We show that two-worker firms initially tend to make

\(^{16}\)The finding that,
in the long run, profits of one-worker firms and two-worker firms are similar is consistent with the emergence of a segmentation equilibrium.

<table>
<thead>
<tr>
<th></th>
<th>C treatment</th>
<th>IC treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-worker</td>
<td>2-worker</td>
</tr>
<tr>
<td>Firm profits</td>
<td>77.1</td>
<td>95.5</td>
</tr>
<tr>
<td>Wages</td>
<td>22.9</td>
<td>21.4</td>
</tr>
<tr>
<td>Rents offered by firms</td>
<td>4.9</td>
<td>3.7</td>
</tr>
<tr>
<td>Realized worker rents</td>
<td>4.9</td>
<td>3.7</td>
</tr>
<tr>
<td>Effort</td>
<td>10.0</td>
<td>9.9</td>
</tr>
<tr>
<td>Fraction of private contracts</td>
<td>0.192</td>
<td>0.170</td>
</tr>
<tr>
<td>Employment duration</td>
<td>1.0</td>
<td>1.9</td>
</tr>
<tr>
<td>Fraction of firms</td>
<td>0.068</td>
<td>0.932</td>
</tr>
</tbody>
</table>

Table 5: Market segmentation in the IC and C treatment. Mean values of market characteristics during the late phase of the experiment (periods 8–18). The reported p-values are derived from random-effects estimations in which the respective dependent variable is regressed on a dummy equal to 1 if a contract comes from a one-worker firm (standard errors account for clustering at the individual level).

While both strategies yield similar profits for firms during the later market phase, workers in two-worker firms face much less favorable contract terms than their counterparts in one-worker firms (see the rightmost columns of Table 5). On average, firms who employ two workers offer about 40% lower worker rents than one-worker firms. At the same time, workers in one-worker firms work somewhat harder: average effort is approximately 20% higher, although this difference turns out to be statistically insignificant. Overall, however, the substantially higher wages in one-worker firms result in much higher realized earnings for workers in those firms.17 Thus, firms using the one-worker strategy and two-worker strategy in the IC treatment offer “good” jobs and “bad” jobs, respectively, consistent with the substantially lower profits, irrespective of the rents they pay to their workers. In the late phase, profits do not depend on firm size anymore if firms choose the respective profit-maximizing rent levels.

17 Notably, we find a negative correlation between wages and firm size in the IC treatment. It is important to bear in mind, however, that our design rules out some of the most important factors that are typically discussed as reasons for positive firm size-wage differentials in labor markets, e.g., larger firms hiring higher-quality workers in terms of observed and unobserved skills, having higher degrees of unionization, or facing stronger monitoring difficulties (e.g., Brown and Medoff 1989, Abowd et al. 1999).
endogenous emergence of a segmented labor market. Interestingly, the two segments in the IC treatment also seem to differ in the general stability of employment relationships: two-worker firms are somewhat more likely to hire their workers through public contract offers, and the overall employment duration in two-worker firms is also shorter (see line (7) and (8) of Table 5).

In contrast to the situation in the IC treatment, we do not see any indication of market segmentation under explicit contract enforcement (see the leftmost part of Table 5). In the few occasions in which firms do hire only one worker in the C treatment, wages and worker rents are only slightly above the values for two-worker firms (the differences are 1.5 and 1.2 points, respectively). Similarly, efforts are about 1% higher, and the fraction of private contracts is 2.2 percentage points higher in one-worker firms. While the latter effect turns out to be weakly significant, the differences between segments are generally much smaller than in the IC treatment. Most importantly, the data on firm profits demonstrate that employing a one-worker strategy in the C treatment is clearly suboptimal from a firm’s perspective. Firms who hire only one worker in the C treatment earn almost 20 points less than the ones employing two workers. This underlines why the latter strategy dominates the market, with 93% of firms using a two-worker strategy when contracts are explicitly enforced.

**Result 4:** Contractual incompleteness leads to a segmentation of the labor market. In the long run, two types of firms coexist in the market when effort is not verifiable. These earn similar profits, but differ qualitatively with respect to wage payments, worker rents and effort provision.

As a final step we investigate more directly a key mechanism underlying our theoretical explanation for segmentation, which is a feedback from unemployment pressure to behavior of workers. The emergence of the secondary sector is possible in equilibrium, because the unemployment pressure arising as a byproduct of job rationing makes workers less likely to shirk and willing to put in higher effort for a given wage. If this is true, we should observe workers being more likely to shirk on the job when they receive information that signals low unemployment pressure and high chances to acquire a job. While workers in the experiment did not have precise information on the level of unemployment or the job acquisition rate in a given period, they could infer the tightness of the labor market from activity in
the contracting stage. The most salient indicator of less favorable market conditions from a worker’s perspective is the number of public contract offers in a given period. Since unemployed workers disproportionally have to rely on public contract offers for finding a new job, a low number of public offers indicates high costs of unemployment and, consequently, higher unemployment pressure for those employed.

<table>
<thead>
<tr>
<th></th>
<th>1 if $e &lt; \hat{e}$</th>
<th>Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td># public offers</td>
<td>0.022*** 0.020*** 0.020**</td>
<td>-0.069** -0.058** -0.070**</td>
</tr>
<tr>
<td></td>
<td>(0.006) (0.006) (0.008)</td>
<td>(0.028) (0.025) (0.033)</td>
</tr>
<tr>
<td>Wage</td>
<td>-0.019*** -0.019*** -0.019***</td>
<td>0.112*** 0.110*** 0.110***</td>
</tr>
<tr>
<td></td>
<td>(0.001) (0.002) (0.002)</td>
<td>(0.007) (0.008) (0.008)</td>
</tr>
<tr>
<td>Desired effort</td>
<td>0.111*** 0.111*** 0.111***</td>
<td>0.223*** 0.223*** 0.222***</td>
</tr>
<tr>
<td></td>
<td>(0.009) (0.009) (0.009)</td>
<td>(0.042) (0.042) (0.043)</td>
</tr>
<tr>
<td>Contract renewed</td>
<td>-0.044 -0.045 0.248 0.274</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.048) (0.048) (0.201) (0.203)</td>
<td></td>
</tr>
<tr>
<td>Market period</td>
<td>-0.000</td>
<td>-0.008</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.023)</td>
</tr>
<tr>
<td>Final period</td>
<td>0.379*** 0.382*** 0.385***</td>
<td>-3.147*** -3.162*** -3.085***</td>
</tr>
<tr>
<td></td>
<td>(0.073) (0.073) (0.087)</td>
<td>(0.490) (0.486) (0.540)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.120* 0.130** 0.135</td>
<td>1.403*** 1.349*** 1.446***</td>
</tr>
<tr>
<td></td>
<td>(0.065) (0.064) (0.089)</td>
<td>(0.229) (0.214) (0.383)</td>
</tr>
<tr>
<td>N</td>
<td>849 849 849</td>
<td>848 849 849</td>
</tr>
</tbody>
</table>

Table 6: Shirking and effort provision in the IC treatment as a function of market conditions. Random-effects models; the reported standard errors (in parentheses) account for potential clustering at the individual level. Column (1) – (3): the dependent variable is a dummy equal to 1 if the worker deviates from the contractually stipulated effort level. Column (4) – (6): the dependent variable is the level of effort provided in a given period. “# public offers” is the number of public contract offers available in the market in a given period. “Final period” is a dummy variable equal to 1 in the final period of the game. *** / ** / * indicate significance on the 1-percent / 5-percent / 10-percent level.

Columns (1)–(3) of Table 6 demonstrate that a decrease in the number of public job offers in the market is associated with a significant reduction in workers’ propensity to shirk. This holds after controlling for the contract terms faced by a worker, an “endgame dummy” to account for the sharp increase in shirking in the final period of the experiment, and a general time trend. Paralleling the observations on shirking, Columns (4)–(6) of Table 6 show that information signaling lower job finding chances is associated with a general increase in
workers’ performance in terms of effort level. This illustrates how changing market conditions feed back into workers’ behavior under contractual incompleteness.

Our data also allow us to rule out alternative explanations for why the secondary-sector strategy becomes profitable. In particular, we find no evidence that workers who are employed in two-worker firms during the late phase of the experiment are inherently more willing to provide higher efforts for a given wage. In other words, there is no support for a sorting explanation in which two-worker firms become more profitable over time, on the basis of eventually finding especially diligent workers. Instead, our data indicate that a within-worker change in the willingness to provide effort under tighter labor market conditions accounts for the increased profitability of two-worker firms.\textsuperscript{18}

\textbf{Result 5:} Workers’ behavior in the IC treatment changes in accordance with tightening market conditions. This contributes to the increasing profitability of two-worker firms and the long-run segmentation of the labor market.

5 Conclusions

In this paper, we provide evidence that involuntary unemployment and labor market segmentation may be caused by contractual incompleteness. A simple model shows how both phenomena can jointly arise in a labor market equilibrium when effort is non-verifiable, and our data are consistent with the key mechanisms of the equilibrium. The findings thus support a perspective in which two fundamentally important aspects of labor markets are intimately related.

Our analysis suggests several avenues for future research. First, it would be interesting to study how unemployment and segmentation are affected by the availability of other explicit enforcement strategies (e.g., piece rates), as well as other contracting schemes that do not require verifiability of work effort, such as voluntary bonus payments or possibilities to sign

\textsuperscript{18}This result comes from restricting the analysis to workers who are mainly employed in two-worker firms during the later phase in the IC treatment. We find that the willingness to provide effort for a given wage for these workers increases between the early and late phase. Thus, we observe a within-worker change, which is consistent with adaption to market conditions, but not with an explanation where two-worker firms eventually found a particularly hard-working group of workers. Results can be found in the appendix.
multi-period employment contracts. Second, our setup could be used to study the impact of institutions such as unemployment insurance or employment protection, which might affect both workers’ on-the-job behavior and employee turnover. This would be especially interesting since our model predicts that the emergence and characteristics of market segmentation depend on the equilibrium job separation rates. Finally, our framework can be used to analyze how hiring decisions, rent payments, and other labor market outcomes interact with the available production technology. Different forms of technology, where productivities are unequal across jobs in a two-worker firm, could generate within-firm segmentation, in the sense of identical workers earning different rents within the same firm. In many labor markets, there are also additional factors that directly influence a firm’s hiring incentives, such as market entry costs, or heterogeneity in outside options for firms, or differences in the substitutability of capital for labor inputs. Studying how these factors affect market performance under contractual incompleteness is a potentially fruitful direction for future work.

References


Appendix A: The model

In this appendix, we provide a model that formalizes the intuition for how contractual incompleteness can cause involuntary unemployment and labor market segmentation.

A.1 Model setup

We denote by $N + U$ the mass of workers and by $\frac{N}{2}$ the mass of firms. Workers and firms interact for $T$ periods in discrete time. All firms can offer up to two vacancies in a given period. Maximum employment is thus $N$, and excess supply of workers implies that the minimum level of unemployment is $U$.\(^{19}\) In any period, each firm offers zero, one or two contracts stipulating a desired level of effort, $\hat{e}$ and a wage, $w$. Firms may either rehire an employee from the previous period, or recruit from the pool of unemployed workers. In the latter case, the worker who receives the offer is randomly drawn from the pool of unemployed agents who have not received an offer yet. Subsequently, workers can either accept or decline the posted contract. If effort is verifiable, the contract determines both the (upfront) wage and the effort level. If efforts are only observable but not third-party verifiable, workers have discretion over their level of effort. We assume that workers are homogeneous in their ability and can choose between $n$ different effort levels $e \in \{e_1, \ldots, e_n\}$, where $e_i < e_{i+1}$ and $c(e_i) = c_i$ denotes the increasing cost of effort.

There are two types of workers: a fraction $\lambda$ of the population is fair ($f$) and a fraction of $1 - \lambda$ is selfish ($s$). The utility of an employed selfish worker in any period is the difference of the received wage and the effort cost:

$$u_s = w - c(e).$$

Fair workers, in contrast, face an additional psychological cost or benefit, $g(w - c(\hat{e}))$, if they fulfill the contract. Utility for fair workers is thus denoted as:

$$u_f = \begin{cases} w - c(e) + g(w - c(\hat{e})) & \text{if the worker fulfills the contract } (e = \hat{e}) \\ w - c(e) & \text{if the worker shirks } (e < \hat{e}) \end{cases}$$

\(^{19}\)While a level of $U > 0$ is implemented in the experiment, all qualitative results also hold for $U = 0.$
We assume that \( g(\cdot) \) is strictly increasing in the rent offered by the firm, and \( g(\tilde{x}) = 0 \) for some \( \tilde{x} \geq 0 \). Thus, more generous contract terms make shirking increasingly less attractive for a fair worker, and \( g(\cdot) \) changes from negative (a cost of contract fulfillment) to positive (an additional benefit of contract fulfillment), when offered rents exceed a benchmark level of fairness, \( \tilde{x} \). This captures in a simple and tractable way the central theme of all reciprocity-based fairness models that fair types reward kind actions and punish unkind actions (e.g., Rabin 1993, Falk and Fischbacher 2006), where in our setting kindness of the firm is captured by the size of offered rents. Denote by \( g^{-1}(\cdot) \) the inverse function of \( g(\cdot) \), which exists and is well defined due to the monotonicity of \( g(\cdot) \).

Firms are characterized by the following production technology, with output increasing in the level of effort:

\[
0 \leq f(e_1) = z_1 \leq \cdots \leq f(e_n) = z_n, 0 \leq f(2e_1) = z_{n+1} \leq \cdots \leq f(2e_n) = z_{2n},
\]

\( z_1 \) to \( z_n \) denote the output of a firm that employs one worker who exerts \( e_1 \) to \( e_n \), and \( z_{n+1} \) to \( z_{2n} \) are the corresponding output levels of two-worker firms.\(^{20}\) Furthermore, we require the production technology to exhibit a weak form of decreasing returns to scale (Part 1 of Assumption 1) and to be efficient (Part 2 of Assumption 1). The latter means that in the one-shot version of the game the wage needed to induce an extra unit of effort by a fair agent is smaller than the induced gain in output.

**Assumption 1.** Let \( z_i < z_j \) be output levels with corresponding effort input \( e_i < e_j \). Then,

\[
\begin{align*}
1. \quad & \frac{z_j - z_i}{e_j - e_i} > \frac{z_{n+j} - z_{n+i}}{2(e_j - e_i)} \\
2. \quad & z_{n+j} - 2(g^{-1}(c_j) + c_j) > z_{n+i} - 2(g^{-1}(c_i) + c_i) > z_i - (g^{-1}(c_i) + c_i) > 0
\end{align*}
\]

We further assume that output translates directly into firm revenue, all firms have access to the same production technology, and maximize total profits (i.e., revenue - overall wage costs). At the end of each period, firms decide whether to renew the contract with their

\(^{20}\)Note that we rule out the possibility that firms hire two workers and elicit different effort levels from each worker. This corresponds to assuming that a single firm does not offer both bad and good jobs. However, allowing for this possibility would not change the existence of the segmentation equilibrium that is our focus, although existence would be for a more restricted range of parameters.
worker(s). As a simplification we assume that a firm which renews the contract of its worker(s) also keeps its size constant. We denote by \( b^t_k \in [0, 1] \) with \( k \in \{1w, 2w\} \) the probability that a one-worker firm (1w) or two-worker firm (2w) separates from a worker if he exerts the desired effort level in period \( t \). Purely for expositional reasons, we assume that firms always separate from workers who deviate from the contractually stipulated effort level \( (a^t_k = 1) \). Workers and firms discount the future at a rate \( r \in [0, 1] \).

A.2 Equilibria with non-verifiable effort

If effort is non-verifiable, the type of equilibrium depends on the shape of firms’ production technology and the psychological cost function for fair workers. Since our main interest is to illustrate how contractual incompleteness can give rise to equilibria involving endogenous unemployment and market segmentation, we concentrate on the existence of these segmentation equilibria. As a first step we show that the endgame of the model features positive continuation values. Second, we characterize the no-shirking conditions for both worker types in pre-final periods. Third, assuming positive continuation values for the last period, we pin down the conditions leading to a segmentation equilibrium in pre-final periods.

A.2.1 Endgame and continuation value

Selfish workers always choose to shirk in the final period. In contrast, fair workers fulfill their contract if their effort cost is smaller than their psychological return from fulfilling the contract. Anticipating this behavior of workers, firms either stay out of the market or offer wages such that fair workers are indifferent between working and shirking. The latter is profitable if there exists at least one effort level \( e_i \) such that either a one- or a two-worker firm expects positive payoffs from inducing \( e_i \), given its belief that it faces a fair worker.

Assumption 2.

\[
\exists \ e_i : \ \lambda z_i - (g^{-1}(c_i) + c_i) > 0 \quad \text{or} \quad \lambda^2 z_{n+i} + 2(1 - \lambda) \lambda z_i - 2(g^{-1}(c_i) + c_i) > 0.
\]

Assumption 2 ensures that there are enough fair types such that firms are willing to offer

\[\text{Endogenizing } a^t_k \text{ would not change the characteristics of feasible equilibria. In particular, no-shirking conditions for separation rates } 0 < a^t_k < 1 \text{ can be derived analogously to conditions (1) and (3) below.}\]
contracts with positive worker rents in the one-shot version of the game. This generates positive continuation values for workers in the pre-final period, if there has not been any screening in previous periods. Note that all firms use homogeneous contracting terms that involve positive rents in the final period. Hence, unemployment is involuntary from a worker’s perspective. We denote the value of a job for a worker of type \( j \) who is employed by a firm of type \( k \) in period \( t \) by \( V_{kj}^t \). The value of unemployment in period \( t \) for a worker of type \( j \) is denoted by \( V_{uj}^t \). We set all continuation values to zero in period \( T + 1 \) and denote by \( L_{1w}^t, L_{2w}^t \) the number of jobs in one-worker and two-worker firms in period \( t \).

A.2.2 No-shirking conditions for workers in pre-final periods

We start the analysis of pre-final periods by characterizing worker behavior. Workers trade off the short-run gains of low effort costs due to shirking against potential long-run costs due to higher risk of dismissal and unemployment. Let \( w_{k}^{t-1} \) and \( c_{k}^{t-1} \) denote the wage and desired effort level, offered by a firm of type \( k \) in period \( t \). For a fair worker, the no-shirking condition in period \( t - 1 \) is then:

\[
\begin{align*}
& w_{k}^{t-1} - c_{k}^{t-1} + g(w_{k}^{t-1} - c_{k}^{t-1}) + (1 - r)[(1 - b_{k}^{t-1})V_{kf}^t + b_{k}^{t-1}V_{uf}^t] \geq w_{k}^{t-1} + (1 - r)V_{uf}^t \quad (1) \\
\Rightarrow & w_{k}^{t-1} \geq g^{-1}[c_{k}^{t-1} + (1 - r)(b_{k}^{t-1} - 1)(V_{kf}^t - V_{uf}^t)] + c_{k}^{t-1}. \quad (2)
\end{align*}
\]

A fair worker’s utility in case of contract fulfillment (left hand side of equation (1)) consists of four components. The worker earns the current period’s wage \( w_{k}^{t-1} \), bears the cost of effort \( c_{k}^{t-1} \), experiences psychological utility \( g(\cdot) \), and receives the continuation value conditional on contract fulfillment. In case of shirking (right hand side of (1)), the worker saves the effort cost and experiences no psychological utility. Furthermore, the current firm does not

\[22\text{Strictly speaking, fair types are not necessary for a final-period rent if workers can generate positive output without incurring effort costs (i.e., if } c_1 = 0 \text{ and } z_1, z_{n+1} > 0, \text{ as was the case in our experimental setting). In this case, firms could profitably offer a minimal, but strictly positive worker rent in the final period, which in turn opens up the possibility for "reputation equilibria", even when all agents are selfish. Empirically, final-period rents are substantially above the minimal possible level, and many workers exert non-minimal effort in the final period; thus, an equilibrium based on fair types is better supported by the data (see our discussion in Section 4.1).}

\[23\text{Since firms have homogenous contracting terms in the last period, we require that either firm type may rehire a worker from the pre-final period, using the final-period contract terms.}\]
The equation illustrates the three components of the value of unemployment $V_{u}^t$ in the next period, which compromises the likelihood of finding a job of either type, and the likelihood of remaining unemployed in that period.

Selfish workers are not subject to the psychological cost, and since wages are paid before efforts are revealed, their effort choice is independent of the current period’s wage. Selfish workers thus exert effort in period $t-1$ if:

$$w_{k}^{t-1} - c_{k}^{t-1} + (1-r) \left[ (1-b_{k}^{t-1})V_{ks}^{t} + b_{k}^{t-1}V_{us}^{t} \right] \geq w_{k}^{t-1} + (1-r)V_{us}^{t}$$

$\iff V_{ks}^{t} - V_{us}^{t} \geq \frac{c_{k}^{t-1}}{(1-r)(1-b_{k}^{t-1})}$.

Denote by $B^t(e_i, V_{us}^t)$ the set of all vectors of separation rates $(b_{1w}^t, b_{2w}^t)$ such that selfish types are willing to exert effort $e_i$ in both types of firms, for a given value of unemployment $V_{us}^t$. Note that $B^t$ may be empty for some effort levels, if future rents cannot compensate selfish types for the respective effort costs in the given period, as it is for instance the case in the final period of the game. Moreover, define the set $\hat{B}^t = B^t(e_n, \max_{e_i} V_{us}^t)$, which constitutes the set of separation rates for which the highest effort level is implementable even in the case of minimal unemployment threat.

In what follows, we derive a necessary and sufficient condition for separation rates to be in $\hat{B}^t$. For a worker of type $j$ in period $t$ the value of unemployment is given by:

$$V_{u}^{t} = \frac{(b_{1w}^{t-1} - 1)L_{1w}^{t-1} + L_{1w}^{t}}{U + (1 + b_{1w}^{t-1})L_{1w}^{t-1} + b_{2w}^{t-1}L_{2w}^{t-1}}V_{1w,j}^{t} + \frac{(b_{2w}^{t-1} - 1)L_{2w}^{t-1} + L_{2w}^{t}}{U + (1 + b_{1w}^{t-1})L_{1w}^{t-1} + b_{2w}^{t-1}L_{2w}^{t-1}}V_{2w,j}^{t}$$

$$+ \left[ 1 - \frac{(b_{1w}^{t-1} - 1)L_{1w}^{t-1} + L_{1w}^{t}}{U + (1 + b_{1w}^{t-1})L_{1w}^{t-1} + b_{2w}^{t-1}L_{2w}^{t-1}} - \frac{(b_{2w}^{t-1} - 1)L_{2w}^{t-1} + L_{2w}^{t}}{U + (1 + b_{1w}^{t-1})L_{1w}^{t-1} + b_{2w}^{t-1}L_{2w}^{t-1}} \right] V_{u}^{t+1}(1-r).$$

The equation illustrates the three components of the value of unemployment in period $t$: finding a new job in either firm type, or remaining unemployed in that period. $V_{u}^{t}$ is endogenously determined in equilibrium. Depending on the contract renewal strategies of either firm type in period $t-1$, it is more or less likely to get hired in a corresponding job in period $t$. The total derivative with respect to the number of one-worker jobs $L_{1w}^{t-1}$, shows that $V_{u}^{t}$ is monotone in $L_{1w}^{t-1}$. Hence, $V_{u}^{t}$ is smaller than the maximum of its boundary values:

$$\lim_{L_{1w}^{t-1} \to \frac{N}{2}} V_{u}^{t} = \frac{(b_{1w}^{t-1} - 1)\frac{N}{2} + L_{1w}^{t}}{U + (1 + b_{1w}^{t-1})\frac{N}{2}}V_{1w,j}^{t} + \frac{L_{2w}^{t}}{U + (1 + b_{1w}^{t-1})\frac{N}{2}}V_{2w,j}^{t} + \frac{U + L_{1w}^{t}}{U + (1 + b_{1w}^{t-1})\frac{N}{2}}V_{u}^{t+1}(1-r),$$

$$= H_{1,j}(b_{1w}^{t-1}, b_{2w}^{t-1})$$

33
and

$$\lim_{t_{1w}^{-1} \to 0} V_{t_{1w}}^t = \frac{L_{1w}^t}{U + b_{2w}^{t-1} N} V_{t_{1w}j}^t + \frac{(b_{2w}^{t-1} - 1)N + L_{2w}^t}{U + b_{2w}^{t-1} N} V_{t_{2w}j}^t + \frac{U + L_{1w}^t}{U + b_{2w}^{t-1} N} V_{t_{1w}j}^{t+1}(1 - r)\).$$

$H_1$ and $H_2$ represent the value of unemployment for maximal and minimal level of unemployment, respectively. Since the maximal value of unemployment is, thus, well defined for each combination of separation rates, so is the set $\bar{B}^t$. A necessary and sufficient condition for a vector of separation rates to be in $\bar{B}^t$ is thus:

$$V_{k_{1w}} - \max \left\{ H_{1,s}(b_{1w}^{t-1}, b_{2w}^{t-1}), H_{2,s}(b_{1w}^{t-1}, b_{2w}^{t-1}) \right\} \geq \frac{c_n}{(1 - r)(1 - b_k^{t-1})}, \quad k \in \{1w, 2w\}.$$ 

In the following, we derive conditions for segmentation equilibria to arise, involving separation rates that induce selfish workers to work. By definition of $\bar{B}^t$, all separation rates in $\bar{B}^t$ are lower than whatever is the separation rate between firms and shirkers, $a_k^t$, because a lower separation rate for non-shirkers is a key component of incentives. As discussed in the text (see p. 19), the data indicate that selfish types are indeed willing to work in pre-final periods of the experiment, before shirking in the final period, consistent with such an equilibrium.

**A.2.3 Sufficient conditions for a segmentation equilibrium in pre-final periods**

We begin by stating a condition that will be the key sufficient condition for a segmentation equilibrium.

**Condition 1.** There exist $(b_{1w}, b_{2w}) \in \bar{B}^t$ such that for all $c_i \leq c_j$:

(a) $\Gamma_1^{t-1}(b_{1w}, b_{2w}, c_j, c_i) < z_{n+i} - z_j < \Gamma_2^{t-1}(b_{1w}, b_{2w}, c_j, c_i)$

(b) $(1 - b_k)N \leq L_k^t$

$\Gamma_1^{t-1}$ and $\Gamma_2^{t-1}$ will be defined in the course of the proof and depend on the fairness consideration of workers. They represent the difference in wages between one- and two-worker firms for the tightest labor market ($\Gamma_1^{t-1}$) and the least tight labor market ($\Gamma_2^{t-1}$). The essence of part (a) of Condition 1 is that the production function is (i) “sufficiently concave” such that the output differential between one-worker and two-worker firms cannot become too large and (ii) steep enough such that a one-worker strategy inducing high effort does not dominate a two-worker strategy with lower effort levels for all possible labor market
conditions. Part (b) of Condition 1 is purely technical: it guarantees that the number of jobs in period \( t \) is larger or equal to the number of workers who have their contract renewed.

In the next step, we prove a lemma (Lemma 1) that states that a segmentation equilibrium exists in an arbitrary pre-final period \( t - 1 \). The lemma assumes that Condition 1 holds for the arbitrary period, along with two additional assumptions. The first additional assumption is about continuation values and ensures that firms enter the market. The second assumption is that firms believe that an arbitrary unemployed worker is equally likely to be a fair type as the currently employed worker (\( \hat{\lambda}_U = \hat{\lambda}_E \)), which rules out screening in previous periods.

In a final step, we will prove a proposition (Proposition 1), that says if Condition 1 holds for all pre-final periods, then there exists an equilibrium with segmentation in every pre-final period, without needing either of the two additional assumptions involved in the lemma.

**Lemma 1.** Suppose Condition 1 is fulfilled, the continuation values satisfy \((1 - r)V_{w_f}^{t+1} < V_{1w,f}^t, V_{2w,f}^t, \text{ and } \hat{\lambda}_U = \hat{\lambda}_E \) for all firms. Then there exist an equilibrium with a segmented labor market in period \( t - 1 \) that exhibits the following properties:

1. Effort levels \( e_{1w}^{t-1} \geq e_{2w}^{t-1} \) are realized in one- and two-worker firms, respectively, with wages \( w_{1w}^{t-1} \geq w_{2w}^{t-1} \) such that fair workers are indifferent between working and shirking.

2. Fair and selfish workers exert effort for the given wages and shirk if they get paid less.

3. There is a number \( L_{1w}^{t-1} > 0 \) of one-worker firms, a number \( L_{2w}^{t-1} > 0 \) of two-worker firms, and a number \( L_{1w}^{t-1} + U \) of unemployed agents.

4. Workers who do not exert the stipulated effort level or who are known to be selfish are fired with certainty, those who exert the contractually stipulated effort have separation rates of \((b_{1w}^{t-1}, b_{2w}^{t-1}) \in B^{t-1} \).

5. From a fair worker’s perspective, high-effort jobs in one-worker firms yield higher rents than jobs in two-worker firms, which in turn yield higher rents than unemployment.

To prove the lemma, we first characterize firms’ optimal wage-effort schedules for given behavior of workers and given separation rates. In a second step, we show that there is an intermediate number of one-worker firms and corresponding separation rates, such that the
derived wage-effort schedules for one-worker and two-worker firms are equally profitable for firms. This gives rise to a segmentation equilibrium, if the offered wage-effort schedules are incentive compatible for workers, which we show in the last step.

In any period, firms decide first on the wage and stipulated effort level. For any level of effort a firm pays wages to set fair workers indifferent between working and shirking. If a firm offered a contract with a lower wage, all workers would shirk, thereby decreasing firm profits. An offer of a higher wage inducing the same effort clearly also diminishes firm profits. We denote by \(e_{1w}^{t-1}, e_{2w}^{t-1}\) the profit-maximizing levels of effort given the value of unemployment and implied wage payments.\(^{24}\) Effort in one-worker firms needs to be higher than in two-worker firms. Otherwise firms could profitably deviate, due to the decreasing returns to scale production function. To see this, suppose the opposite \(e_{1w}^{t-1} < e_{2w}^{t-1}\). From the optimal behavior of the firms we know:

\[
\begin{align*}
    f(e_{1w}^{t-1}) - w_{1w}^{t-1} &\geq f(e_{2w}^{t-1}) - w_{2w}^{t-1} \quad \text{and} \quad f(2e_{2w}^{t-1}) - 2w_{2w}^{t-1} \geq f(2e_{1w}^{t-1}) - 2w_{1w}^{t-1} \\
    \Rightarrow 2(f(e_{2w}^{t-1}) - f(e_{1w}^{t-1})) &\leq f(2e_{2w}^{t-1}) - f(2e_{1w}^{t-1}).
\end{align*}
\]

This is a contradiction to Assumption 1.

We next turn to the entry decision of firms. Note that \((1-r)V_{uf}^{t+1} < V_{2w,f}^{t}, V_{1w,f}^{t}\) together with (4) implies that, for at least one firm type, future rents of employed fair workers exceed those of unemployed fair workers. The fair workers’ no-shirking condition (2) thus implies that there is an incentive compatible wage-effort schedule such that the wage is below \(g^{-1}(c_i) + c_i\). Since the production technology is efficient (Assumption 1), firms will offer the most profitable contract rather than leaving the market. The decision of firms then boils down to deciding whether to employ one worker or two workers. A one-worker strategy is more profitable if:

\[
\begin{align*}
    z_{1w}^{t-1} - w_{1w}^{t-1} &> z_{2w}^{t-1} - 2w_{2w}^{t-1} \\
    \Leftrightarrow 0 &< z_{1w}^{t-1} - (g^{-1}(c_{1w}^{t-1}) + (1-r)(b_{1w}^{t-1} - 1))(V_{1w,f}^{t} - V_{uf}^{t}) + c_{1w}^{t-1} \\
    &- z_{2w}^{t-1} + 2(g^{-1}(c_{2w}^{t-1}) + (1-r)(b_{2w}^{t-1} - 1)(V_{2w,f}^{t} - V_{uf}^{t})) + c_{2w}^{t-1}) \equiv \Delta
\end{align*}
\]

Whether this is the case depends on the difference in outputs between one-worker firms \((z_{1w}^{t-1})\) and two-worker firms \((z_{2w}^{t-1})\), and the tightness of the labor market, which determines \(V_{uf}^{t}\).

\(^{24}\)If firms are indifferent between two or more levels of induced effort, we assume that there is a tie breaking rule that is homogeneous across firms.
Δ is continuous in $V_{u,f}^t$, and therefore a shift in the sign of this inequality leads to at least one level for the value of unemployment such that firms are indifferent between both strategies.\textsuperscript{25} This reversal in the sign of Δ is given if:

\begin{align*}
\Gamma_1^{-1}(b_{1w}, b_{2w}, c_{1w}^{t-1}, c_{2w}^{t-1}) &\equiv 2g^{-1} (c_{2w}^{t-1} + (1-r)(b_{2w}^{t-1} - 1)(V_{2w,f}^t - H_{1,f})) + 2c_{2w}^{t-1} \\
&- g^{-1} (c_{1w}^{t-1} + (1-r)(b_{1w}^{t-1} - 1)(V_{1w,f}^t - H_{1,f})) - c_{1w}^{t-1} \\
< \gamma_{2w}^{t-1} - \gamma_{1w}^{t-1} \\
< 2g^{-1} (c_{2w}^{t-1} + (1-r)(b_{2w}^{t-1} - 1)(V_{2w,f}^t - H_{2,f})) + 2c_{2w}^{t-1} \\
- g^{-1} (c_{1w}^{t-1} + (1-r)(b_{1w}^{t-1} - 1)(V_{1w,f}^t - H_{2,f})) - c_{1w}^{t-1} \equiv \Gamma_2^{-1}(b_{1w}, b_{2w}, c_{1w}^{t-1}, c_{2w}^{t-1})
\end{align*}

Condition 1 ensures that a combination of separation rates from the set $\bar{B}^{t-1}$ exists such that this is fulfilled. Hence, there is a number $L_{1w}^{-1}$ such that firms are indifferent between both strategies. This gives rise to a segmentation equilibrium in which $L_{1w}^{-1}$ firms employ only one worker at a high level of effort. These firms do not fill their second vacancy and thus the equilibrium features endogenous unemployment. Note that the separation rates in any segmentation equilibrium must be larger than zero. If, in contrast, separation rates were zero, firms would renew all their contracts and there would be no vacancies in the next period, independently of the fraction of one-worker firms. The value of unemployment would then be independent of the current fraction of firms that ration jobs ($H_{1,j} = H_{2,j}$). Hence, the profitability of firm strategies would not depend on the labor market conditions ($\Gamma_1^{-1} = \Gamma_2^{-1}$), and one firm size would dominate the alternative strategy throughout.

After firms have observed the effort choice of the worker, they decide whether to renew the contract. In the Lemma we assume firms have no additional information about the type of agent they employ compared to those that are unemployed ($\hat{\lambda}_U = \hat{\lambda}_E$), which is a characteristic of fair and selfish workers pooling. Hence, there is always an “equally good” worker available, implying that firms are indifferent between dismissing the worker and renewing the contract. Hence, all separation rates from the set $\bar{B}^{t-1}$ are incentive compatible (with

\textsuperscript{25}If the optimal induced effort choice changes in the course of varying the number of one-worker firms from zero to $\frac{N}{2}$, the segmentation equilibria may feature three different levels of effort.

\textsuperscript{26}There is also a segmentation equilibrium if $\lim_{L_{1w}^{-1} \rightarrow \frac{N}{2}} \Delta > 0 > \lim_{L_{1w}^{-1} \rightarrow 0} \Delta$. The following analysis is also valid for this case.
Proposition 1, below, we no longer assume \( \hat{\lambda}_U = \hat{\lambda}_E \); rather this follows from the proposition).

Turning to the workers, fair types by construction choose to exert the stipulated effort level. Furthermore, selfish workers comply to the contract, since the separation rates are in \( \bar{B}^{t-1} \). Hence, there exists an equilibrium fulfilling properties 1 to 4 from Lemma 1.

Part 5 of Lemma 1 implies that the segmentation of the market into one- and two-worker firms has strong consequences for workers. First, a fraction of workers is unemployed, and this unemployment is involuntary. This follows since an unemployed agent only receives the discounted value of unemployment from the next period which is less than what an agent in either job receives (cf. equation (1)). Second, from a fair worker’s perspective, there are two types of jobs: “primary-sector” jobs that pay high rents for high efforts, and “secondary-sector” jobs with lower rent payments and lower efforts. This difference arises since workers have some discretion about their effort level. The higher effort levels in one-worker firms imply higher wages, which in turn yields higher rents by the no shirking condition of fair types:

\[
V_{1w,f}^{t-1} \geq V_{2w,f}^{t-1} \quad \Leftrightarrow \quad w_{1w}^{t-1} + (1 - r)V_{uf}^{t} \geq w_{2w}^{t-1} + (1 - r)V_{uf}^{t}.
\]

This concludes the proof of Lemma 1.

**Proposition 1.** If Condition 1 is fulfilled for all pre-final periods, there exists an equilibrium with a segmented labor market and involuntary unemployment in all pre-final periods.

Given that Condition 1 is satisfied for all pre-final periods, there is an equilibrium with a segmented labor market in all pre-final periods, if (i) \( (1 - r)V_{uf}^{t+1} < V_{2w,f}^{t}, V_{1w,f}^{t} \) and (ii) \( \hat{\lambda}_U = \hat{\lambda}_E \) hold for any arbitrary period \( t - 1 \). For the second-to-last period, (i) holds trivially, and maintaining (ii), there is a segmentation equilibrium in that period. But then, the no-shirking condition (2) implies that \( (1 - r)V_{uf}^{t+1} < V_{2w,f}^{t}, V_{1w,f}^{t} \) holds from the perspective of the third-to-last period as well, and there is again segmentation. Using backward induction, and maintaining (ii), (i) is thus satisfied for all periods. Given (i) holds in all periods, workers behave homogeneously in every period, i.e., there is pooling of fair and selfish workers. In the first period firms have the prior \( \hat{\lambda}_U = \hat{\lambda}_E = \lambda \), and due to pooling, this does not change in subsequent periods until the end of the final period, implying that (ii) holds for all periods. Hence, there exists a segmentation equilibrium with involuntary unemployment in all periods.
A.3 Equilibrium with verifiable effort

We now turn to the case of contractible effort. Consider first the final period of the game. In this period, selfish workers accept a contract offer if the wage at least covers the stipulated effort costs. Fair workers will accept a contract if \( w - c(e) + g(w - c(\hat{e})) \geq 0 \).

Given our assumptions about \( \tilde{x} \), firms need to pay positive (but potentially low) monetary rents to induce fair workers to accept an offer. Since the production function is efficient, firms always offer a contract rather than staying out of the market. The optimal terms of the contract depend on the subjective probability of facing a fair worker, \( \hat{\lambda} \). If, for instance, \( \hat{\lambda} = 1 \), a firm expects to face a fair worker with certainty and thus pays wages equal to the sum of effort and the psychological costs. The efficiency of the production technology implies that employment of two workers with maximal effort exertion is optimal in this case. Thus, there exists a cutoff \( \tilde{\lambda} \) such that for all beliefs \( \hat{\lambda} \geq \tilde{\lambda} \), firms use a homogeneous contracting strategy of hiring two workers, that involves paying wages to cover both types of costs, and workers exert the maximum effort level.

Maintaining \( \hat{\lambda} > \tilde{\lambda} \) for all firms, in the second-to-last period backward induction implies that fair workers accept the same offer as before, since they do not expect any future utility rents. In contrast, selfish workers may anticipate a rent in the next period. Nevertheless, they do not accept any offer involving negative current rents, because this would reveal their type. If they did, the firm would have an incentive to renegotiate in the next period, and offer rents equivalent to the value of unemployment, which is zero in the last period. However, selfish workers always accept the contract needed to employ fair types, which ensures positive current and future rents. For any stipulated level of effort, the rent needed to hire selfish workers is therefore weakly larger than in the last period, while the rent for fair types is the same. This makes it even less attractive than in the last period for firms to offer a contract attracting only selfish workers, thus firms offer the same contract terms as in the last period.

Assuming that there are enough fair types in the population such that \( \lambda \geq \tilde{\lambda} \), this argument holds for all previous periods. This implies for all periods that (i) firms offer a wage-effort schedule that induces maximal effort provision, (ii) firms always hire two workers and the level of unemployment is thus minimal, and (iii) all workers accept posted contracts.
Appendix B: Supplementary figures and table

B.1 IC treatment: co-worker comparisons

In Table B.1, we examine empirically whether co-worker wages affect worker behavior. We estimate how worker effort and shirking depend on a worker’s own contract terms (i.e., wage payment and desired effort level), the conditions of the co-worker’s contract, and further controls. The estimates reveal that effort provision strongly depends on a worker’s own contract terms, but that it is not significantly related to either the wage or the desired effort level of the co-worker (see Columns (1)-(3) of Table B.1). The reported results are robust to using an indicator variable for shirking as the dependent variable (Columns (4)-(6) of Table B.1), or using indicators for advantageous or disadvantageous wage inequality instead of the co-worker’s absolute wage level as regressors. This suggests that knowledge of co-workers wages is not crucial for worker behavior in our setup.

<table>
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<tr>
<th>Dependent variable:</th>
<th>work effort $e_i$</th>
<th>1 if $e_i &lt; \hat{e}_i$</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Wage ($w_i$)</td>
<td>0.121***</td>
<td>0.117***</td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>Desired effort ($\hat{e}_i$)</td>
<td>0.248***</td>
<td>0.251***</td>
</tr>
<tr>
<td></td>
<td>(0.066)</td>
<td>(0.066)</td>
</tr>
<tr>
<td>Wage coworker ($w_j$)</td>
<td>-0.004</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.011)</td>
</tr>
<tr>
<td>Desired effort coworker ($\hat{e}_j$)</td>
<td>-0.003</td>
<td>-0.012</td>
</tr>
<tr>
<td></td>
<td>(0.064)</td>
<td>(0.064)</td>
</tr>
<tr>
<td>Contract renewed</td>
<td>0.400</td>
<td>0.239</td>
</tr>
<tr>
<td></td>
<td>(0.279)</td>
<td>(0.287)</td>
</tr>
<tr>
<td>Market period</td>
<td>0.042</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.028)</td>
<td></td>
</tr>
<tr>
<td>Final period</td>
<td>-1.605***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.586)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.771***</td>
<td>0.744***</td>
</tr>
<tr>
<td></td>
<td>(0.243)</td>
<td>(0.230)</td>
</tr>
</tbody>
</table>

Table B.1: Influence of co-worker wage on effort provision. Random-effects models; the reported standard errors (in parentheses) account for potential clustering at the individual level. *** / ** / * indicates significance on the 1-percent / 5-percent / 10-percent level.
B.2 IC treatment: profits in one-worker and two-worker firms

Figure B.1: Predicted total profits of one-worker firms and two-worker firms in the IC treatment, depending on the rents paid per worker. Upper panel: periods 1–7, bottom panel: periods 8–18.

Figure B.1 is based on parameter estimates for firm profits in the IC treatment, depending on whether firms employ one or two workers in a given period. As regressors, we include the rent paid per worker and the squared value of the rent to account for possible non-linearities in the profit-rent relation. In the upper panel, we depict the profit-rent relations in first seven periods of the experiment. In the bottom panel, we depict the estimates for the late phase (periods 8–18). The figure confirms that firm profits tend to increase in rent payments up to a maximum after which it does not pay off for firms to further increase
worker rents. Importantly, the figure shows that—during the early phase in which we observe a trend towards job rationing—two-worker firms tend to earn substantially lower profits irrespective of the wage they pay to their workers. During the later phase of the experiment (bottom panel of Figure B.1), one-worker firms continue to be similarly profitable compared to early periods, but profits for two-worker firms increase substantially. Most importantly, our estimates indicate that two-worker firms can earn similar profits to one-worker firms during the later periods of the experiment.

B.3 IC treatment: change in workers’ behavior

In this section, we explore a potential alternative explanation for the observed increase in two-worker firms’ profitability, and for the coexistence of one-worker firms and two-worker firms in the late phase of the experiment. If workers differ in their inherent willingness to provide effort for a certain wage, it could potentially be the case that two-worker firms found such “less demanding” workers only after some time, explaining the later increase in profitability for two-worker firms. In contrast, our model stipulates that the co-existence of one-worker firms and two-worker firms becomes viable in the late phase of the experiment because workers adapt their behavior to the tightening of the labor market (see Section 4.2).

To disentangle the two explanations, we first analyze individual behavior of workers who are predominantly employed in two-worker firms during the late phase of the experiment. That is, we concentrate on workers who work in a two-worker firm in at least 50% of their employment spells between period 8 and 18. If selection of workers who are willing to perform for low wages is the explanation for the increase in profits of two-worker firms, these workers should already exhibit high efforts for a given wage level in the early phase of the experiment. If, in contrast, labor market segmentation and the increased profitability of two-worker firms are due to market feedback mechanisms under contractual incompleteness, we should observe a change in the behavior of the workers in response to changing market conditions. More precisely, we should observe an increase in effort for a given wage between the early phase and the late phase of the experiment.

Figure B.2 compares behavior of workers who are mostly employed in two-worker firms during the late phase to the behavior of the same workers earlier in the experiment. The
Figure B.2: Average effort for a given wage. Values for workers who predominantly work in two-worker firms during the late phase of the experiment. To account for the general decline in wages and efforts that is observed across both firm types during the ultimate period (“endgame-effect”), the graph is based on values for periods 1–17 only.

The figure shows an increase in effort provision between the early and the late phase for the workers under consideration, supporting an explanation in which workers adapt. Estimation results confirm that these workers increase their effort for a given wage significantly during the later phase of the experiment (Random-effects estimation accounting for clustering on individual level: $\beta = 0.707$, $p = 0.027$). The limited role of worker selection is further underlined by the fact that, if anything, workers who are later on predominantly employed in two-worker firms tend to exert lower efforts for a given wage in the early phase of the experiment, compared to the workers who later are mostly employed in one-worker firms (see Figure B.3). These results indicate that the increase in two-worker firms’ profitability and the stable segmentation of the market in the IC treatment are indeed attributable to a response of workers to the tighter labor market conditions in the late phase, rather than to two-worker firms finding workers who have an inherently higher willingness to provide effort.
Figure B.3: Average effort for a given wage during periods 1–7. Workers who work predominantly in one-worker firms vs. workers who work predominantly in two-worker firms during the late phase (i.e., in more than 50% of their employment spells in periods 8–18).