Implicit Contracts, Unemployment, and Labor Market Segmentation†

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Abstract

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—may have a common underlying cause. In particular, in the prevalent case that work effort is not verifiable, the implicit contracting strategies adopted by firms may simultaneously generate involuntary unemployment, and labor market segmentation. We develop a simple model that illustrates these mechanisms, and we empirically test for a causal impact of contractual incompleteness on unemployment and market segmentation, using experimental labor markets that differ in the verifiability of work effort. Our data demonstrate that involuntary unemployment is much higher when explicit contract enforcement is not feasible. Moreover, we show that the necessity to provide implicit performance incentives can lead to a segmentation of the labor market. Firms in both segments earn similar profits, but workers in the secondary sector face much less favorable conditions than their counterparts in primary-sector jobs.

Keywords: Incentives, Implicit Contracts, Unemployment, Dual Labor Markets, Laboratory Experiment

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

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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, in the prevalent case that workers' performance is not verifiable, the implicit contracting strategies adopted by firms may simultaneously generate involuntary unemployment, and labor market segmentation. Intuitively, contractual incompleteness can cause unemployment if firms adopt an incentive strategy that involves eliciting high worker effort by paying above market-clearing wages and rationing jobs. If a critical mass of firms adopt this strategy, however, a secondary employment sector could 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 created by primary sector firms who pay high rents, and ration jobs. In equilibrium, strategies of offering "good" high-rent jobs and "bad" low-rent jobs can, under certain conditions regarding firms' production technology, be equally profitable. We show that the qualitative features of this intuition can be captured in a simple formal model that builds on the framework of Shapiro and Stiglitz (1984).

In order to provide empirical evidence on the causal impact of implicit contracting on unemployment and market segmentation, we study behavior of firms and workers in competitive experimental labor markets. All firms in the market share the same production technology which exhibits decreasing returns to scale from labor but ensures that full employment is technologically efficient. We consider two treatment conditions in which we exogenously vary the verifiability of work effort. In our main treatment (*IC treatment*), firms can observe but not verify their workers' effort. Firms thus have to rely on implicit incentives to elicit work effort. In a control treatment, concluded contracts are explicitly enforced; i.e., a worker's effort must be equal to the contractually agreed upon effort level (*C treatment*). In other words, effort is verifiable and there is no contract enforcement problem in this treatment. In all other respects, such as production technology and worker characteristics, the markets in the two treatment conditions are identical.

Our first main result shows that there is virtually zero unemployment when contracts are

explicitly enforced, whereas unemployment is much higher when the contracting parties have to rely on implicit performance incentives. We show that the difference in unemployment is attributable to differences in how labor markets function under explicit and implicit contract enforcement. When third party contract enforcement is not feasible, firms generate implicit performance incentives by paying strictly positive rents to their workers, and employing a policy of contingent contract renewal. In such relational contracts, high-performing workers are rewarded by being re-employed and earning positive rents in future periods; shirking workers are punished through dismissal. Moreover, at the same time that they pay high wages, many firms ration jobs and offer fewer vacancies than feasible. Job rationing together with the presence of high worker rents reveals that unemployment in the IC treatment is involuntary. In the C treatment where effort is verifiable and explicitly enforced, labor market outcomes differ substantially along all these dimensions. Firms pay wages close to the market clearing level 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, unemployment in this treatment is very low and mostly voluntary, being caused by workers who do not accept existing contract offers.

Our second main result 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. We show that employment relationships in the different firm types differ in several important dimensions other than the extent of job rationing. In particular, workers earn substantially lower rents and exert lower effort in firms which 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 are working under less favorable conditions in "secondary sector" jobs.[1] By contrast, market segmentation is not

[1]See, e.g., Doeringer and Piore (1971), or Saint-Paul (1996).

observed in the C treatment where contracts are explicitly enforced, and firms' strategy of not rationing jobs and paying low worker rents pervades the market. This indicates that the emergence of market segmentation is directly linked to firms' and workers' behavior under implicit performance incentives.

The third and final portion of our analysis shows how the endogenously arising unemployment pressure generated by firms that ration jobs helps making the alternative strategy of filling all vacancies and paying low worker rents become equally viable. The key finding is that changing market conditions lead workers to adjust their behavior. We show that while workers in secondary sector firms often shirk and generate low firm profits when unemployment is low, by the time that unemployment stabilizes at a high level these same workers exert more effort, and are less likely to shirk. These within-worker changes make it viable for secondary-sector firms to fill all vacancies, because the lower marginal valuation of worker output under decreasing returns to scale is compensated for by the ability to elicit effort with low wage payments. Providing further evidence of the importance of market tightness for worker behavior, we show that information about labor market conditions in a given period has a significant impact on subsequent worker choices; workers provide higher effort levels, and are less likely to shirk, following information that job offers are relatively scarce.

In summary, the paper makes several novel contributions: (1) We provide some of the first direct evidence on a causal impact of contractual incompleteness on the emergence of involuntary unemployment, and we can tie this directly to the implicit contracting strategies adopted by firms as a response to incompleteness; (2) we show that market segmentation arises under implicit contracting, but not in a setting with verifiable effort, indicating that unemployment and market segmentation can arise jointly in equilibrium from the same underlying cause; (3) we provide evidence that feedback from market conditions to worker behavior is a key mechanism through which contractual incompleteness can lead to the endogenous emergence of market segmentation. This is important because it indicates that heterogeneity in firm technologies, or worker abilities, is not necessary for market segmentation to arise.

A crucial advantage of an experimental approach to studying the implications of implicit contracting is that it enables us to exogenously vary the verifiability of work effort, thereby allowing for direct causal inference (Falk and Heckman 2009, Gächter and Thöni 2010, Char-

ness and Kuhn 2011). To the best of our knowledge, ours is the first study that demonstrates a direct causal impact of contractual incompleteness on involuntary unemployment. Previous experiments have investigated implicit contracting strategies in settings with incomplete contracts (e.g., Fehr, Gächter, and Kirchsteiger 1997, Brown, Falk, and Fehr 2004, Linardi and Camerer 2010), but unemployment in these studies was exogenously given or determined by exogenous stochastic shocks.

Efficiency wage theories have long postulated that the absence of explicit contract enforcement can lead to involuntary unemployment (Shapiro and Stiglitz 1984, MacLeod and Malcomson 1989, Akerlof and Yellen 1990). So far, however, evidence suggesting that this link might exist has been relatively indirect. The empirical literature on efficiency wages using field data has made important contributions (for a survey see Katz 1986), for example by showing that wage premiums are related to worker turnover, or indirect proxies for worker effort such as discipline problems (e.g., Cappelli and Chauvin 1991, Campbell 1993). Our approach is complementary, as it relies on exogenously varying the degree of explicit contract enforcement, while controlling for or measuring differences in variables such as worker effort and ability, effort costs, or firms' production technology and hiring decisions. This allows us to directly test whether wage premiums and rents are caused by contractual incompleteness, and whether the need to provide implicit performance incentives causes unemployment.

Our finding of an endogenous segmentation of the labor market under contractual incompleteness also contributes to understanding the foundations of dual labor markets. The theoretical literature on dual labor markets has argued that market segmentation can be an implication of contract enforcement problems and efficiency wages, if enforcement technologies or setup and adjustment costs differ across segments, or given some non-linearity in monitoring technology (e.g., Bulow and Summers 1986, Saint-Paul 1996, Albrecht and Vroman 1992). To our knowledge, we are the first to empirically show an endogenous emergence of labor market segmentation as a direct consequence of contractual incompleteness and the associated implicit contracting strategies of firms. Our findings thus provide a missing empirical link, showing that incompleteness, unemployment, and market segmentation are all intimately related.

The remainder of the paper is organized as follows. The following section outlines the

setup and procedures of the experiment, and section 3 derives theoretical hypotheses on how contractual incompleteness can influence unemployment and labor market segmentation. In sections 4 to 6, we present our empirical results. Section 7 concludes.

2 Experimental Design and Procedures

To study the impact of contractual incompleteness on unemployment and labor market segmentation empirically, we implemented experimental labor markets where we exogenously varied the verifiability of work effort. As our workhorse for the experiment, we used a variant of the gift-exchange game (Fehr, Gächter, and Kirchsteiger 1997). In each market, firms and workers interacted during 18 market periods. Each of the 18 periods consisted of two stages: a market phase where firms offered employment contracts and hired workers, and a work phase where work effort of employed workers was determined. The experimental treatments differed only in the degree to which work effort in the second phase was third party enforceable. In our main treatment, henceforth called *Incomplete Contracts Treatment* (or *IC treatment*), third party contract enforcement was absent 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, henceforth called *Complete Contracts Treatment* (or *C treatment*). Keeping everything else identical (production technology, supply and demand of labor, etc.) while varying the verifiability of work effort 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. When offering a contract, firms stipulated a non-contingent wage payment w and a desired level of effort $\hat{e}$. To study the relevance of dismissal and re-employment of workers in the different treatment conditions, firms could make two types of contract offers: public offers which were available to all workers and could also be observed by all other firms, or private contract offers that were only available to one specific worker. The former type of contract offers allowed firms to reach the entire market if they wanted to fill a vacancy without caring about trading with a particular worker. The latter type of offers allowed firms to target specific workers, e.g., to build up long-term em-

ployment relationships. In the beginning of the experiment each worker and each firm thus received an identification number (ID) which was held constant throughout the whole experimental session. 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 addition to the wage and desired effort level when entering 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 employer could hire up to two workers. As long as none of her contract offers had been accepted, an employer could make as many private and public offers as she wanted. A worker could accept any contract offer available to him, i.e., all public offers that were not yet accepted and private offers that firms had addressed to him. While workers were not informed about the number of private offers in the market as a whole, they could infer labor market conditions and the tightness of the market through the number of public offers observed in a given period. Once a worker accepted a contract offer, the contract between this worker and the respective firm was concluded. After concluding a contract, a worker was not allowed to accept further contract offers in this period. Additionally, all other outstanding offers of the respective employer were removed from the list of available contracts in the moment where one of her contract offers was accepted. The employer could then decide to hire a second worker by entering new contract offers. This market feature was implemented to prevent that an employer who wanted to employ only one worker but entered multiple contract offers had two offers accepted before being able to withdraw her remaining contract offers.

The market phase ended when the maximum number of contracts had been concluded or when all firms had indicated that they did not want to make additional contract offers.[2] At the end of the market period, the worker(s) of a given firm were informed about the contracts concluded by their firm, i.e., each worker received a summary of his own contract terms as well as information on whether and under which conditions his firm had employed a second worker.

[2]We also implemented 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 constraint on the level of unemployment and other market outcomes reported below is therefore limited and confined to the control treatment with explicit contract enforcement (see section 4).

2.2 The Work Phase

After the end of the market phase, employed workers entered the second stage of a market period—the work phase. In this stage, actual work effort e was determined. Since effort was contractible in the complete contracts treatment, workers who had accepted a contract offer in this treatment had to comply with the contract terms. The desired effort level $\hat{e}$ stipulated in their contract was thus explicitly enforced; i.e., $e = \hat{e}$ was exogenously implemented by the experimenter. By contrast, work effort was observable to the firm, but not verifiable in our main treatment (IC treatment). Therefore, a worker could choose any feasible level of effort in the work phase, i.e., he could exert 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 actual work efforts and the resulting payoffs for the firm and the workers employed by this firm.

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.[3]

A worker's payoff in a given period, π_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

[3]This exogenous unemployment was intended to create some baseline unemployment pressure. This makes the design "conservative" in the sense that this unemployment pressure should if anything make it easier for firms to elicit good performance from workers, and achieve full employment, in both treatments. The fact that we nevertheless see firms strongly rationing jobs in IC, and high unemployment (see below), highlights the powerful impact of contractual incompleteness on market outcomes.

$e \in \{1, 2, ..., 10\}$ and $w \in \{0, 1, 2, ..., 100\}$. Effort costs $c(e)$ increased convexly in the level of actual work effort (see Table 1).

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

Table 1: *Schedule of effort costs.*

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. Specifically, each unit of effort by a worker increased production (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. The contractually stipulated wage payments diminished firms' profits. The payoff of a firm, π_F, can therefore 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: the second worker's marginal productivity per unit of effort is 4 whereas the marginal cost of effort lies between 1 and 3 points. Payoff functions π_F and π_W, workers' cost schedule $c(e)$ as well as the number of firms and workers in the market were common knowledge.

The experiment was carried out in the BonnEconLab, the laboratory for economic experiments at the University of Bonn. We conducted five sessions each for the IC treatment and the C treatment. A total of 240 subjects, mainly undergraduate university students from all majors, took part in the experiments. Every subject participated only in one of the treatment conditions. At the beginning of an experimental session, participants received detailed information about the rules and structure of the experiment.[4] The experiment started only

[4] A translation of the instructions can be found in the appendix. To rule out that differences in participants'

after all participants had 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 setup of our experiment allows us to empirically analyze whether contractual incompleteness is indeed a key factor that causally impacts both the level of unemployment, and the degree to which the labor market is segmented into a primary and secondary sector where firms offer "good" and "bad" jobs, respectively. Our predictions in this section are informed by a simple model. The model, which builds on the framework of Shapiro and Stiglitz (1984), is developed formally in the appendix.[5] We use the model to provide qualitative predictions about the relationship between contract enforcement problems, and the emergence of involuntary unemployment and labor market segmentation, building on a well-established theoretical paradigm.

In a setting where effort is not verifiable, as is the case in the IC treatment, the model predicts that involuntary unemployment will arise as the result of how firms try to mitigate moral hazard problems. When explicit contract enforcement is precluded, firms have to rely on implicit, self-enforcing contracts to reduce or prevent worker shirking. In other words, the expected future earnings of a worker who provides the contractually desired effort level have to be higher than those of a shirking worker. Our analysis identifies three key components of how such implicit performance incentives can be generated under contractual incompleteness. First, firms in the IC treatment should pay strictly positive worker rents such that the long-run costs of shirking in terms of forgone future rents outweigh a worker's short-run gains from

experiences from their employment relations outside the laboratory could bias our results, instructions were framed in a neutral goods-market language.

[5]The main deviations from the original Shapiro and Stiglitz (1984) model are allowing for multiple effort levels, rather than just a binary choice to shirk or work, and assuming some curvature for the production function, specifically diminishing returns to scale.

saving effort costs through shirking. Second, firms should condition re-hiring of a given worker on his past performance. That is, workers who are observed shirking should have a higher likelihood of being dismissed than workers who provide the contractually stipulated effort level. In our design, the only way for firms to implement such a strategy of contingent contract renewal is to use private contract offers targeted to a particular worker; thus the prevalent use of private offers and emergence of long-term employment relationships is predicted for the IC treatment. A third prediction for the IC treatment is that it might be profitable for firms to ration job offers and employ fewer workers than possible, thereby giving rise to strictly positive levels of unemployment. Intuitively, when there is no unemployment, the threat of being fired for the employed workers is zero, giving them incentives for opportunistic behavior. Since firms in the IC treatment are expected to ration job offers, and at the same time employed workers earn strictly positive rents, the resulting unemployment is involuntary.

A second main prediction for the IC treatment is that market segmentation can emerge, jointly with involuntary unemployment. The model demonstrates how there can be an equilibrium with heterogeneous firm strategies coexisting under contractual incompleteness: some firms pay high rents, elicit high effort levels, and ration jobs, leading to involuntary unemployment; other firms pay lower rents, elicit lower (but non-minimal) effort levels, and fill all vacancies. Intuitively, firms hiring only one worker have a high marginal valuation of the worker's output, due to diminishing returns to scale, and thus elicit high effort by paying high rents. These firms offer "good jobs" from a worker's perspective. Due to diminishing returns, firms find it unprofitable to hire two workers paying such high worker rents. A sufficient number of one-worker firms, however, could create enough unemployment pressure in the IC treatment such that other firms can operate equally profitable by hiring two workers, and offering "bad jobs" involving lower rents, and somewhat lower effort levels; without sufficient unemployment pressure, these low rents would not be able to prevent shirking. The model shows how there can be a level of unemployment such that both strategies are equally profitable, with neither type of firm having an incentive to deviate, giving rise to stable market segmentation in equilibrium.

In a setting corresponding to the C treatment, the model predicts that all firms use a homogenous contracting strategy involving no job rationing, and eliciting high effort by

paying workers wages just sufficient to cover their effort costs. As a result, there is predicted to be no endogenous involuntary unemployment in the C treatment, little reliance on relational contracting, and no market segmentation because all jobs are "bad jobs" involving minimal rents for workers. Intuitively, firms can elicit high effort without job rationing, or paying rents, in the C treatment 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 efficiency of full employment implies that firms should strictly prefer hiring two workers, and because contingent contract renewal is not necessary, firms are predicted to more strongly rely on public offers than in the IC treatment. When a firm wants to fill a vacancy without concern of hiring a particular worker, public offers have the advantage that they reach the entire market, as opposed to private offers, which must be targeted individually to each specific worker.

To summarize, we have four main predictions for behavior in the experiment, which can be derived from our model: (1) Involuntary unemployment in the IC treatment, in contrast to maximum employment in the C treatment; (2) firms in the IC treatment using job rationing, strictly positive rent payments, and conditional contract renewal with private offers as a strategy to provide implicit incentives, in contrast to firms in the C treatment using minimal rents, and relying on public offers rather than relational contracting; (3) segmentation of the market in the IC treatment, such that firms earn similar profits but differ qualitatively with respect to worker rents, effort, and job rationing, in contrast to no segmentation in the C treatment with all jobs involving minimal rents; (4) the secondary-sector strategy in the IC treatment being supported by unfavorable market conditions, which make workers willing to provide non-minimal effort for low rents.

The discussion of our empirical results in the following sections will be structured according to these main predictions. We first analyze the causal impact of third party contract enforcement on the level of unemployment, and analyze whether the driving forces behind unemployment are in line with our predictions. We then investigate whether market segmentation, with a stable coexistence of good and bad jobs, emerges in the absence of explicit contract enforcement. Finally, we investigate the mechanisms underlying market segmentation.

4 Contract Enforcement and Unemployment

We first turn to the question whether the absence of explicit contract enforcement causally impacts the level of unemployment. Figure 1 depicts the level of "endogenous unemployment"[6] for the two treatment conditions. After the first few periods, we observe a strong increase in unemployment in the IC treatment, while the level of unemployment stays close to zero when contracts are third party enforceable. As a consequence, the overall level of unemployment differs substantially across treatment conditions. When effort is not verifiable, the average unemployment rate is higher than 30% while it is only about 5% in the C treatment. In all sessions of the IC treatment unemployment is higher than in any of the C sessions. The difference between treatments is statistically significant (Mann-Whitney U-Test, $p < 0.01$).[7] It is worth emphasizing that that the production function, and worker characteristics, were identical across treatments and thus incompleteness must be the source of the difference in 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.*

The absence of third party contract enforcement has a strong impact on the level of unemployment. We have hypothesized above that this might be the result of differences in how labor markets function under explicit and implicit contract enforcement. In particular, we have argued that firms in the C treatment should operate most profitably if they hire the maximum possible number of workers and minimize wage costs for a given—explicitly enforced—effort level. We therefore should expect low rent payments to workers and high

[6] Recall that, in both treatments, 3 workers were unemployed "by design" in every session and every period due to excess supply of labor. To measure "endogenous unemployment" we therefore calculate the total number of unemployed workers *minus* 3 and divide by the number of possible jobs (given that each of 7 firms could offer 2 vacancies in every period, the number of possible jobs in each market is 14).

[7] All non-parametric tests use session averages as independent observations. Reported p-values are always two-sided.

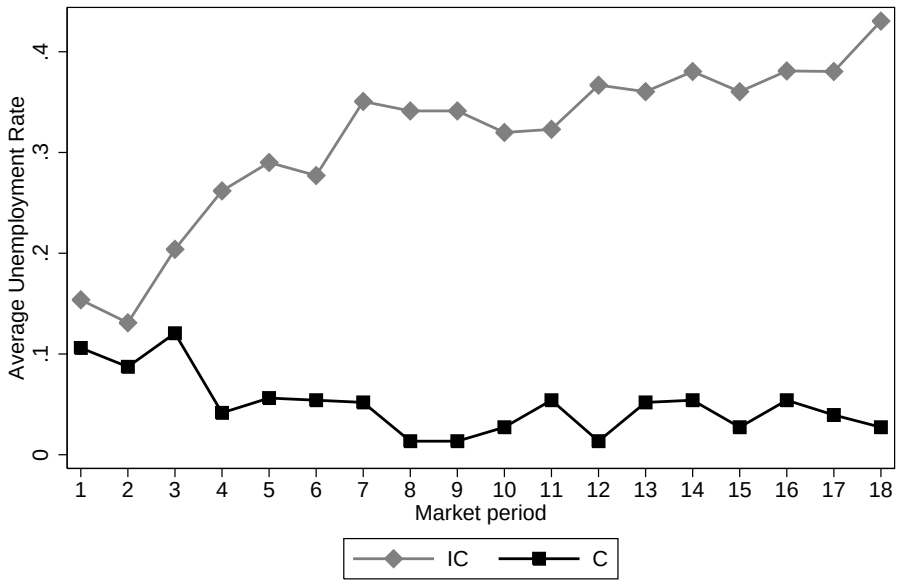

Figure 1: *Evolution of average unemployment over time.*

effort levels in this treatment. Furthermore, since effort is contractually enforceable, firms have no reason to hire specific workers via private contract offers and build up long-term employment relationships with the selected workers. We should thus see more public contract offers and shorter employment spells in comparison to the IC treatment.

In contrast to this, firms in the IC treatment have to rely on a combination of positive rents and an implicit threat of dismissal to elicit work effort. We hypothesized that firms will use private contract offers to implement a policy of contingent contract renewal that combines an implicit promise of future rent payments with a threat of contract termination when a worker shirks. To qualify for future employment, workers are expected to respond to these implicit incentives by providing the contractually desired level of effort.

Table 2 shows that our hypotheses on differences in market characteristics are borne out by the data. When contracts are third-party enforceable, markets are characterized by low (offered and realized) worker rents, efforts are close to the maximum level, and firms frequently hire workers via public contract offers. In contrast, the IC treatment is characterized by a substantially higher wage level (Mann Whitney U-test, $p < 0.01$). As a consequence, both offered and realized rents for workers are strictly above the ones under explicit contract enforcement ($p < 0.01$ in each case). Moreover, long-term employment relationships initiated through private contract offers play a more important role under implicit incentives.

		C treatment	IC treatment
(1)	Wages	22.80	34.60
(2)	Rents offered by firms ($w - c(\hat{e})$)	5.74	21.12
(3)	Realized worker rents ($w - c(e)$)	5.74	23.59
(4)	Effort	9.65	6.97
(5)	Fraction of private contract offers	0.305	0.765
(6)	Fraction of firms with employment relationships ≥ 9 market periods	0.029	0.600
(7)	Fraction of possible vacancies offered	0.986	0.679
(8)	Fraction of offered vacancies accepted	0.961	0.992

Table 2: *Market characteristics. Mean values across treatments.*

Firms are more selective in hiring specific workers, in order to form long-term employment relationships. Consequently, the fraction of private contract offers is substantially higher in the IC treatment ($p < 0.01$). Analyzing the hiring strategy at the firm level underlines these differences: 60% of firms in the IC treatment rehire the same worker in at least half of the market periods without interruption. The corresponding fraction of firms who does so in the C treatment is merely 3% ($p < 0.01$).

The re-hiring data also demonstrate how firms use rent payments together with a policy of contingent contract renewal to build up an implicit threat of firing in the IC treatment. Columns (1) and (2) of Table 3 report results from probit estimates on the determinants of firms' contract renewal decisions. Column (1) illustrates that a worker's likelihood of being rehired by his current firm strongly decreases if he does not provide the contractually stipulated effort level, $\hat{e}$. The average likelihood of being rehired drops from 70.9% in the case of contract fulfillment to only 26.8% if a worker's performance falls short of the contractually stipulated level. After controlling for other important characteristics of worker-firm interactions, such as the previous duration of employment, worker shirking continues to be a crucial factor in firms' contract renewal and dismissal decisions (see Column (2) of Table 3). Shirking does not only have important consequences for a worker's likelihood of being rehired, but also for his future earnings prospects. Columns (3) and (4) of Table 3 provide evidence on

	Dependent variable:			
	1 if worker is re-hired in $t+1$		Future rents	
	(1)	(2)	(3)	(4)
Shirking	-0.441***	-0.265***	-98.729***	-79.304***
	(0.078)	(0.080)	(16.674)	(14.545)
Wage		0.010***		2.634**
		(0.002)		(0.792)
Employment duration		0.063***		0.926
		(0.021)		(2.308)
Market period		0.008		-14.978***
		(0.008)		(1.048)
Constant			188.837***	220.614***
			(16.821)	(14.272)
N	806	806	849	849
(Pseudo) R^2	0.140	0.355	0.112	0.451

Table 3: *Implicit incentives in the IC treatment. Columns (1) and (2): determinants of contract renewal in the IC treatment; probit estimations, reporting marginal effects. Columns (3) and (4): OLS regressions; the dependent variable "future rents" is the sum of a worker's earnings from period $t+1$ until period 18. "Shirking" is a dummy equal to 1 if the worker shirked in the current period (i.e., if $e < \hat{e}$ in period t). "Wage" refers to the wage in period t. "Employment Duration" is the number of consecutive periods that a firm has employed the current worker until period t. *** indicates significance on the 1-percent level, ** significance on the 5-percent level, * significance on the 10-percent level. Reported standard errors (in parentheses) are adjusted for clustering on session level.*

the dynamic incentives that workers in the IC treatment face in terms of future rents. In the regressions, we analyze how shirking in a given period affects the sum of future rents earned by a worker. The estimates indicate that the long-run benefits of contract fulfillment in a given period outweigh the short-run gains from shirking considerably.[8] This underlines that, although effort is not verifiable, workers in the IC treatment face strong implicit performance incentives. It is therefore not surprising that firms in the IC treatment are generally quite

[8]Repeating the analysis from Column (3) of Table 3 for single market periods, we find that the difference in future rents between those workers who fulfill their contract and those who shirk is positive for each individual market period. While the regressions yield positive and sizeable point estimates throughout the experiment, standard errors in some of the market periods are relatively high due to low numbers of observations.

successful in eliciting above-minimum work effort (see Line (4) of Table 2). While efforts are significantly lower than under explicit contract enforcement ($p < 0.01$), workers in the IC treatment choose an effort level of 8–10 in more than 50% of cases, and minimum effort is observed in only 12% of cases.

The treatment difference in the number of contract offers reported in the final two lines of Table 2 deserves additional attention. We have argued that the emergence of unemployment in the IC treatment might be due to firms' decision to ration job offers. When effort is not verifiable, job rationing increases the cost of being unemployed, thereby strengthening workers' implicit performance incentives in the IC treatment. The results on offered and accepted contracts are in line with this prediction. In both treatments, the number of potential vacancies that firms could offer is 1260. Nearly 99% (1242 out of 1260) of these vacancies are actually offered under explicit contract enforcement. By contrast, firms in the IC treatment make only 68% (856 out of 1260) of the possible contract offers (Mann Whitney U-test, $p < 0.01$). At the same time, workers in both treatments hardly ever reject an offered vacancy. The corresponding fraction of accepted vacancies is even slightly higher in the IC treatment ($p = 0.015$).

Figure 2 sheds more light on firms' decision to ration jobs in the IC treatment. The dashed lines depict the fractions of firms who offer a second vacancy in a given period. The solid lines indicate the fractions of second vacancies filled, i.e., offers which are accepted by some worker. Paralleling the observation on the unemployment level, the fraction of firms who seek to hire two workers is initially similar in both treatments. After a few periods, this fraction increases to more than 90% in the C treatment, but fewer firms decide to employ two workers in the IC treatment. The solid lines confirm that unfilled vacancies, which would be an indication for voluntary unemployment, are rarely observed in either treatment. If anything, the fraction of rejected contract offers is somewhat higher in the C treatment.[9]

The prevalence of job rationing, the strictly positive rents paid to workers, and the low frequency of rejected job offers under contractual incompleteness underscore that unemployment in the IC treatment is involuntary.

[9]cp. Line (8) of Table 2. Most of the rejected offers are contracts which offer zero or negative rents to the workers.

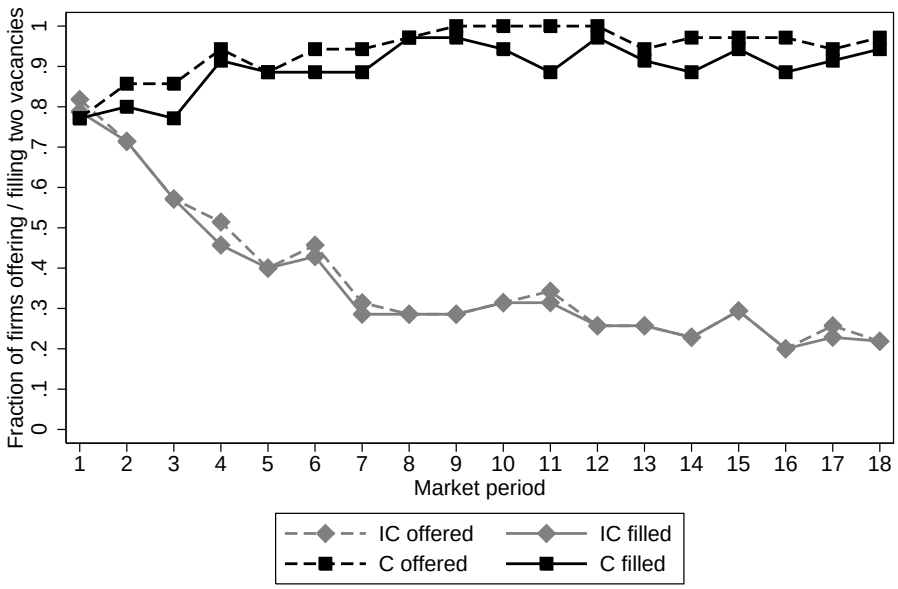

Figure 2: *Fraction of firms offering / filling two vacancies.*

Result 2: *When contracts are not explicitly enforceable, firms tend to ration job offers and use strictly positive rent payments and contingent contract renewal to generate implicit performance incentives for workers. The resulting unemployment in the IC treatment is involuntary.*

5 Labor Market Segmentation as a Consequence of Contractual Incompleteness

In the previous section we have seen that essentially all firms hire two workers and there is nearly full employment when contracts are explicitly enforced. Firms in the C treatment also pay wages close to the market clearing level and extract the major share of rents from production. Under contractual incompleteness (IC treatment), we have argued that it is attractive for firms to rely on job rationing, conditional contract renewal, and the payment of strictly positive rents. Furthermore, firms need not employ homogeneous strategies in terms of size or rents being offered to workers if there is sufficient unemployment pressure to make firms indifferent between various hiring and rent-sharing policies.

A closer inspection of Figure 2 confirms that in the C treatment nearly all firms employ two workers. By contrast, in the IC treatments there are strong dynamics towards a one-

worker strategy in the first seven periods. In this phase, the decline in the fraction of firms who use a two-worker strategy is sizable and statistically significant (t-test, $p < 0.01$).[10] However, the number of firms who employ two workers in a given period does not go all the way down to zero in later periods. Rather, after the initial strong decline in the number of two-worker firms a plateau is reached where a relatively stable fraction of about 20–30% of firms continue to employ two workers. In this later phase (periods 8–18), the decline in the fraction of two-worker firms is essentially zero and not significant anymore ($p = 0.219$). In other words, after a first phase where we observe strong dynamics towards adopting a one-worker strategy, two types of firms coexist in later periods of the IC treatment. In contrast, all firms tend to employ the same hiring strategy in the C treatment.

An explanation for the observed dynamics in the IC treatment would be that two-worker firms were relatively less profitable than one-worker firms in the early phase of the experiment, but that in the long run both strategies yielded similar profits for firms. A convergence of profits between the different firm types might explain why some firms choose to adopt a two-worker strategy even in the long run. In fact, there is a strong difference in firm profits during the first seven periods: in this phase, one-worker firms on average earn 37.22 points per period—12.55 points more than firms who employ two workers. The difference in firm profits is statistically significant (t-test, $p = 0.010$). In contrast, during the late phase of the experiment profits between one-worker firms and two-worker firms do not differ significantly anymore (the average difference is 1.42 points; $p = 0.847$). This convergence in firm profits is due to an increase in two-worker firms' profitability. While profits of one-worker firms remain virtually unchanged (profits fall insignificantly by 0.48 points; $p = 0.843$), two-worker firms earn on average 10.65 points more than in the early phase of the experiment ($p = 0.036$).

Figure 3 (top panel) illustrates the profit differences between one-worker firms and two-worker firms in early periods. The figure is based on parameter estimates for firm profits in the first seven periods of the IC treatment, depending on whether firms employ one or

[10] All reported test statistics of parametric tests account for potential clustering of standard errors on the session level; reported p-values are always two-sided. The p-values reported here were derived by regressing the fraction of two-worker firms in a given period and a given session of the IC treatment on a linear time trend for the early phase (periods 1–7) and late phase (periods 8–18), allowing for different slopes and intercepts for the different phases.

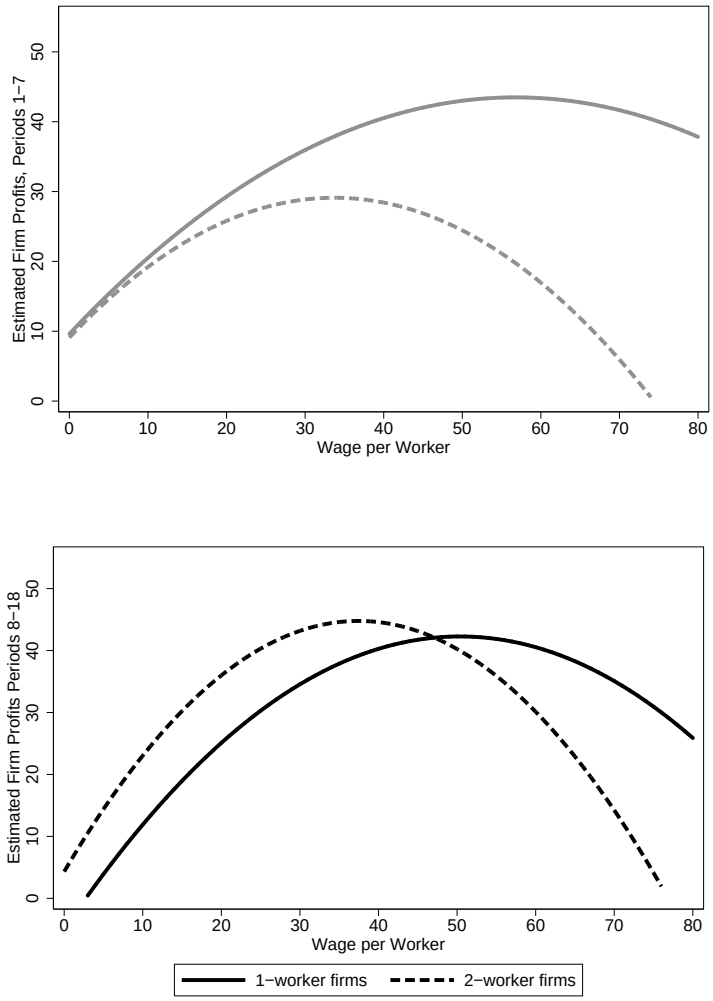

Figure 3: *Predicted total profits of one-worker firms and two-worker firms in the IC treatment, depending on the wage paid per worker. Upper panel: periods 1–7, bottom panel: periods 8–18.*

two workers in a given period. As regressors, we include the wage paid per worker and the squared value of the wage to account for possible non-linearities in the profit-wage relation. In line with the idea of efficiency wages, the figure confirms that firm profits tend to increase in wage payments up to a maximum after which it does not pay off for firms to further increase worker rents. Importantly, the figure shows that two-worker firms tend to earn substantially lower profits irrespective of the wage they pay to their workers. Consequently, the profit-maximizing strategy for firms during the early phase is to employ only one worker at a relatively generous wage.

Turning to the *later phase* of the experiment (bottom panel of Figure 3), one-worker

firms continue to be similarly profitable compared to early periods. However, profits for two-worker firms increase substantially. According to our estimates, two-worker firms earn similar profits as one-worker firms in this phase when choosing the profit-maximizing wage. The fact that—in the long run—profits of one-worker firms and two-worker firms are similar suggests that the lack of explicit contract enforcement in the IC treatment causes a segmentation of the labor market. Under contractual incompleteness, two different firm strategies coexist in the same market environment. A majority of firms ration job offers, employing a one-worker strategy. At the same time, a second segment exists, consisting of firms who use a different hiring and contracting strategy that turns out be be equally profitable.

		C treatment		IC treatment	
		1-worker	2-worker	1-worker	2-worker
(1)	Firm Profits	77.12	95.46	36.74	35.32
(2)	Wages	22.88	21.40	42.33	27.70
(3)	Rents offered by firms $(w - c(\hat{e}))$	4.88	3.74	26.90	16.00
(4)	Realized worker rents $(w - c(e))$	4.88	3.74	29.21	17.55
(5)	Effort	10.00	9.88	7.91	6.48
(6)	Fraction of private contract offers	0.192	0.170	0.900	0.775
(7)	Employment duration	1.00	1.87	6.76	4.48
(8)	Fraction of firms	0.068	0.932	0.738	0.262

Table 4: *Market Segmentation in the IC and C treatment. Mean values of market characteristics during the late phase of the experiment (periods 8–18).*

Indeed, considering the later market phase of the IC treatment, the two segments qualitatively differ in several important dimensions other than firm size. While both strategies yield similar profits for firms, workers in two-worker firms face much less favorable contract terms than their counterparts in one-worker firms (see the two rightmost columns of Table 4). Wages in one-worker firms are on average 42.33 points—14.63 points higher than those for workers employed in two-worker firms (t-test, $p = 0.068$). This difference indicates that one-worker firms pay higher rents than two-worker firms. Indeed, rents offered to workers in one-worker firms are almost 70% higher than those offered by firms who employ two work-

ers ($p = 0.037$). At the same time, workers in one-worker firms work harder, on average providing an effort of 7.91 as opposed to 6.48 in two-workers firms. Average effort is thus approximately 20 percent higher, although this difference turns out to be statistically insignificant ($p = 0.347$). Overall, however, the substantially higher wages in one-worker firms result in much higher realized rents for workers in those firms. On average, net earnings for workers employed in one-worker firms are 29.21 points per period. This compares to only 17.55 points for workers in two-worker firms ($p = 0.023$). Together with firms' policy of contingent contract renewal, these instantaneous differences in worker rents amount to strong differences in the long-run earnings prospects for workers in the different market segments.

Interestingly, the two segments in the IC treatment also seem to differ in the general stability of employment relationships. On average, workers in one-worker firms have been in an ongoing employment relationship with the same employer for 6.76 periods.[11] This value compares to only 4.48 periods for workers in two-worker firms ($p = 0.036$). Paralleling this observation, our data also suggests that two-worker firms tend to use public contract offers more strongly. 90.04% of firm-worker matches in one-worker firms are initiated through private contract offers, whereas this is the case for only 77.5% of hiring decisions in two-worker firms. This difference, however, turns out to be statistically insignificant ($p = 0.354$).

In contrast to the situation in the IC treatment, we do not see any indication of market segmentation when explicit contract enforcement is feasible. In the few occasions where firms do hire only one worker in the C treatment, contract terms for the worker are very similar to the ones in two-worker firms (see the first two columns of Table 4). This holds both with respect to wage payments and effort levels. The average wage in one-worker firms of 22.88 is only 1.48 points above the value for two-worker firms in the later phase of this treatment ($p = 0.306$). Average effort in one-worker firms is 10 as opposed to 9.88 points in two-worker firms ($p = 0.268$). Since effort can be explicitly enforced, a threat of unemployment is not necessary for incentive provision. Consequently, worker rents are consistently and homogenously very low, amounting to 4.88 points per period in one-worker firms and 3.74

[11] Since the formation of long-term employment relations based on conditional contract renewal can only meaningfully be analyzed for private contracts, this number is conditional on a worker being hired via a private contract offer.

points in two-worker firms ($p = 0.329$). This also indicates that the expected future value of having employment in period t is close to zero in the C treatment. Finally, firm profits demonstrate that employing a one-worker strategy under explicit contract enforcement is clearly suboptimal from a firm's perspective. With an average of 77.1 points per period, firms who hire only one worker in the C treatment earn almost 20 points less than the ones employing two workers ($p < 0.01$). This underlines why the latter strategy dominates the market, with more than 90% of firms using a two-worker strategy, and there is no market segmentation when contracts can be explicitly enforced.

Result 3: *The absence of explicit contract enforcement leads to a segmentation of the labor market. In the long run, two types of firms coexist in the market with incomplete contracts. These earn similar profits, but differ qualitatively with respect to wage payments, worker rents and effort provision.*

6 Market Segmentation and Workers' Response to Market Conditions

Our evidence so far has shown that the absence of explicit contract enforcement causes both involuntary unemployment and a segmentation of the labor market. In this section we explore whether the mechanisms through which market segmentation comes about in our experiment are also in line with the mechanisms underlying our theoretical predictions on market outcomes in the IC treatment. Under the implemented decreasing-returns-to-scale production technology, we hypothesized that market conditions are important for the emergence of market segmentation: the secondary-sector contracting strategy involving low worker rents is feasible only when unemployment pressure is high enough. For our experiment, this would imply that two-worker firms are profitable in the late phase of the experiment because workers *adapt* their behavior to the less favorable market conditions, by reducing shirking and providing higher levels of effort for a given wage compared to the early, low-unemployment phase of the experiment.

An 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, is that workers might differ in their inherent willingness to provide effort for a certain wage. To operate successfully under decreasing returns to scale, firms who employ a two-worker strategy have to find workers who are willing to provide high effort for a lower wage than firms who employ only one worker. This selection process of "less demanding" workers into two-worker firms might take some time, and therefore the profitability of two-worker firms might increase only once appropriate workers have been found.

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 4 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 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. An OLS regression shows that, for a given wage, these workers on average increase their effort by almost one unit during the later phase of the experiment ($\beta = 0.928$, $p = 0.040$). 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 5 in the appendix). 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 firms selecting workers who have an inherently

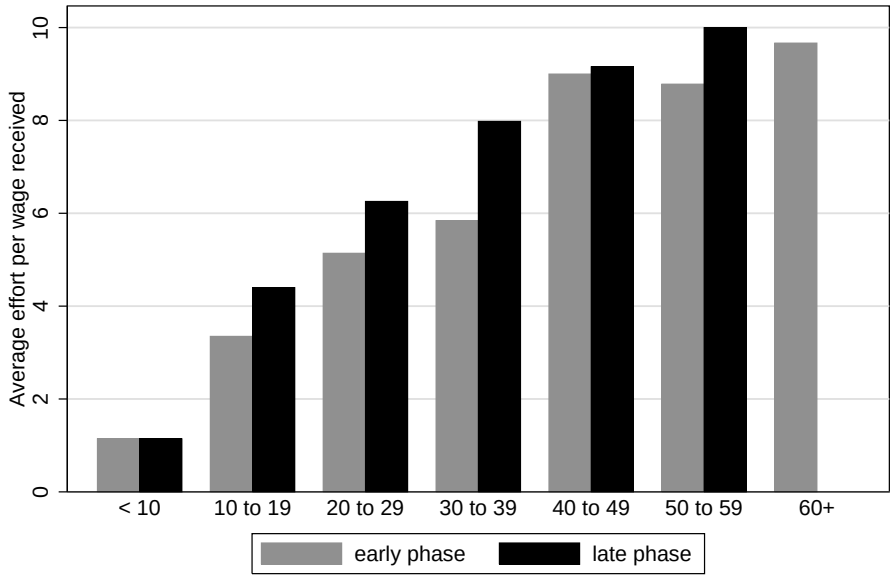

Figure 4: *Average effort for a given wage. Values for workers who predominantly work in two-worker firms during the late phase of the experiment. To account for the general decline in wages and efforts that is observed across both firm types during the ultimate period ("endgame-effect"), the graph is based on values for periods 1–17 only.*

higher willingness to provide effort.

The association between changing market conditions and worker behavior can also be seen by analyzing the impact of workers' information about market tightness. While workers in the experiment did not have precise information on the level of unemployment in a given period, they could infer the tightening of the labor market and the associated increase in the cost of unemployment 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 an increase in the cost of unemployment and, consequently, higher unemployment pressure for those employed.

In Table 5, we provide estimates on the relationship between the number of public offers in a given market period and workers' behavioral reaction in terms of shirking and effort provision. Columns (1) and (2) of Table 5 demonstrate that a decrease in the number of publicly available job offers in the market is associated with a significant and sizeable reduction in workers' propensity to shirk. This holds after controlling for the increase in shirking

	Dependent variable:			
	1 if $e < \hat{e}$		Effort	
	(1)	(2)	(3)	(4)
# public offers	0.049***	0.042***	-0.095*	-0.105**
	(0.011)	(0.006)	(0.038)	(0.037)
Wage	-0.014***	-0.013***	0.148***	0.117***
	(0.003)	(0.003)	(0.007)	(0.006)
Employment Duration		-0.014*		-0.007
		(0.008)		(0.028)
Final Period		0.287*		-2.912***
		(0.145)		(0.456)
Desired Effort				0.284***
				(0.035)
Constant			2.110***	1.063**
			(0.350)	(0.301)
Observations	849	849	849	849
(Pseudo) R^2	0.197	0.208	0.614	0.675

Table 5: *Shirking and effort provision in the IC treatment as a function of market conditions. Column (1) and (2): Coefficients are marginal effects from probit estimations; the dependent variable is a dummy equal to 1 if a worker shirked (i.e., provided less than the contractually stipulated effort level) and zero otherwise. Column (3) and (4): OLS regressions; 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. "Wage" refers to the wage in period t. "Employment Duration" is the number of consecutive periods that a firm has employed the current worker until period t. "Final period" is a dummy variable for the final period of the game. "Desired effort" is the contractually stipulated effort level, $\hat{e}$. *** indicates significance on the 1-percent level, ** significance on the 5-percent level, * significance on the 10-percent level. Reported standard errors (in parentheses) are adjusted for clustering on session level.*

in the final period of the experiment ("endgame effect") and other important characteristics of a worker's employment relationship, such as the wage received or the previous length of the employment relationship. Paralleling the observations on shirking, Column (3) and (4) of Table 5 show that a tightening of labor market conditions is associated with a general increase in workers' performance in terms of effort. This illustrates how changing market conditions feed back into workers' behavior under contractual incompleteness.[12] Firms' strategy

[12]If we restrict the analysis of Table 5 to workers who are predominantly employed in two-worker firms,

of combining rent payments with job rationing and contingent contract renewal increases unemployment, and the threat of becoming unemployed for employed workers. This in turn generates strong incentives for workers to fulfill their contracts, leading to a segmented labor market in which primary and secondary sector contracting strategies coexist.

Result 4: *Labor market segmentation and the increase in two-worker firms' profitability are attributable to a change in workers' behavior in accordance with tightening market conditions in the IC treatment.*

7 Conclusions

In this paper, we have analyzed the relationship between contract enforcement and the emergence of involuntary unemployment and labor market segmentation. In an experimental labor market where trading parties can form long-term relationships, we compared a work environment where contracts were not third party enforceable to a control treatment where effort was verifiable and explicit contracts were feasible.

Our main results show that unemployment and labor market segmentation can be causally linked to contractual incompleteness. Unemployment is much higher in the treatment without explicit contract enforcement. Moreover, unemployment in this treatment is involuntary, being caused by the firms' employment and contracting policy. Firms pay high wages and build up long-term employment relations, but offer fewer vacancies than is possible and technologically efficient. This strategy leads to an increase in unemployment, but at the same time provides strong implicit performance incentives for the employed workers. Under explicit contract enforcement, wages are close to the market clearing level, firms do not ration jobs, and unemployment is basically absent. Thus, our results empirically establish a direct causal link between contract enforcement, the nature of employment relations, and the emergence of unemployment—a link which has long been discussed in theory (Shapiro and Stiglitz 1984, MacLeod and Malcomson 1989, Akerlof and Yellen 1990, Sobel 2006).

Our findings also contribute to the literature on the efficiency-wage foundation of dual

we observe that, paralleling our previous findings, the association between market conditions and worker behavior is particularly pronounced.

labor markets (Bulow and Summers 1986, Albrecht and Vroman 1992, Saint-Paul 1996). Although firms face identical technological constraints in our setup, we observe a segmentation of the labor market, resulting from contractual incompleteness: when third party contract enforcement is not feasible, many firms ration the number of jobs and build up long-term employment relationships which are characterized by relatively high worker rents. The resulting unemployment allows a fraction of firms to operate successfully without rationing job offers. Tighter market conditions help these firms since less favorable market conditions are associated with reduced shirking and higher effort provision by workers. Interactions between these firms and their workers resemble those in secondary segments of the labor market. In contrast to one-worker firms, successful two-worker firms are characterized by lower worker rents and generally less stable employment relationships.

Our analysis suggests several avenues for future research. It would, for instance, be interesting to analyze how the level of unemployment, and the relative size of the different market segments, depend on the amount of excess supply or demand for labor. One could vary the number of exogenously unemployed workers in the market, or else implement a setting with more firms than workers, to see how this affects the operation of the market. Another possibility is to extend our baseline setting to investigate how obstructing or facilitating implicit contracting will influence market outcomes under contractual incompleteness. For instance, one could restrict firms' ability to provide implicit performance incentives via contingent contract renewal, by preventing firms from identifying workers across market periods. Alternatively, firms could be given even more information about past worker performance, which potentially influences worker mobility between market segments. Finally, it would be interesting to study how the availability of different contractual instruments, such as discretionary bonuses, affect implicit contracting and thus unemployment and market segmentation (e.g., MacLeod and Malcomson 1998, Gibbons 2005).

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8 Appendix A

In this appendix, we provide a model that formalizes the intuition for how contractual incompleteness can lead to unemployment and labor market segmentation. We use a variant of the efficiency-wage model by Shapiro and Stiglitz (1984). Rather than deriving point predictions to be tested in our empirical analysis, our main aim is to illustrate how contract enforcement problems can affect the emergence of involuntary unemployment and labor market segmentation, building on a well-established theoretical paradigm.

Before presenting the details of the model, it is useful to identify the key moving parts that will drive our results. The result that there can be an equilibrium with endogenous involuntary unemployment, is already possible in the Shapiro and Stiglitz model. While full employment would involve workers shirking with certainty, firing workers and reducing firm size increases unemployment, thereby increasing the cost of being unemployed and reducing the attractiveness of shirking for employed workers. The first important modification to the Shapiro and Stiglitz framework is allowing for multiple effort levels, rather than just a binary choice to shirk or not shirk. Second, our model includes some curvature of the production function, in particular diminishing returns to scale. Both modifications are important since they enable us to study whether firms use different contracting strategies in terms of the number of workers employed, the wages and rents paid per worker, and the induced level of effort. Under decreasing returns to scale, the choice of firm size has implications for the marginal incentives to elicit high, versus moderate, effort. This leads to the possibility for some firms to offer "good" high-rent jobs, and other firms to offer "bad" low-rent jobs, in equilibrium.

It is also worth noting that our experimental labor market has a finite number of market periods whereas the model is set up in continuous time with an infinite horizon. Standard backwards induction arguments would imply that long-term worker retainment and punishment strategies are not credible in finite games, given perfect rationality, material selfishness, and common knowledge thereof, and that firms pay minimal wages and workers exert minimum effort in all periods. However, it is well known that the presence of some "fair types", or beliefs that such types are existent, can generate what is effectively a continuation value even for the final period of a game (see, e.g., Kreps, Milgrom, Roberts, and Wilson 1982,

Brown, Falk, and Fehr 2004). When some workers voluntarily provide non-minimal effort in return to rent payments, firms might be willing to pay positive rents even in the final period, which in turn generates performance incentives for workers by making the threat of firing credible in earlier periods. A substantial body of evidence both from laboratory (e.g., Fehr and Gächter 2000, Brown, Falk, and Fehr 2004) and field studies (e.g., Bewley 1999, Kube, Maréchal, and Puppe 2011, Cohn, Fehr, and Götte 2008) indicates that fair types exist. Thus, in our experimental setting we expect that it is feasible for firms to adopt a strategy of paying rents, and credibly threatening to fire, similar to the case of an infinite horizon.[13] Moreover, our data will allow us to explicitly test whether firms try to implement such a strategy, and whether it is profitable for them to do so (see section 4).

8.1 Model Set-up

Turning to the details of the model, we denote the size of the workforce by N, drawn from $\mathbb{R}$. Workers are assumed to be homogeneous, i.e., each worker has the same productivity when employed by a firm. When contracts are not third-party enforceable, workers have some discretion on their level of effort. We assume that workers can choose between three different effort levels, i.e., they can either shirk ($e = e_l = 0$), or provide medium ($e = e_m$) or high ($e = e_h$) levels of effort.[14] We denote the disutility corresponding to every effort level by $c(e_i) = c_i$, assuming that $c(e_l) = 0$.

There are $\frac{N}{2}$ firms who choose to employ either one or two workers.[15] Firms are homoge-

[13]Notably, the correlation between offered worker rents and effort levels in the experiment is about fifteen percentage points lower in the final period of the IC treatment compared to the overall average correlation, indicating that removal of firing threat affects average behavior. But the correlation is still sizable, and highly significant ($\rho = 0.587$; $p < 0.001$), consistent with the presence of some fair workers who put in non-minimal effort even in the final period.

[14]The results extend to allowing a greater number of effort levels.

[15]We assume this ratio of firms to workers for simplicity. The equilibrium with good and bad jobs still exists if there are $K < \frac{N}{2}$ firms, as is the case in our experiment. With a very tight labor market, there can arise the possibility for an additional type of equilibrium with some firms hiring one worker and others hiring two but both offering bad jobs. Extending the model to allow for more than two firm sizes complicates the analysis, but in that case there are still restrictions on the production function that will ensure the existence of the equilibrium with good and bad jobs.

neous and face the following production technology:

$$f(e_l) = f(2e_l) = 0 < f(e_m) = z_1 < f(e_h) = z_2 < f(2e_m) = z_3 < f(2e_h) = z_4$$

For simplicity, shirking workers are assumed to produce zero output. z_1 denotes the output of a firm that employs one worker who exerts an intermediate level of effort, z_2 denotes the output of a one worker firm with a high-performing worker, and z_3 and z_4 are the output levels of two worker firms whose workers exert medium and high effort levels, respectively. The profit of a firm is the difference of output and the wage payments.[16]

As in the experiment, we assume that the production function exhibits decreasing returns to scale, but that provision of high effort and full employment is efficient:

$$\begin{aligned} z_3 < 2z_1;\ \ z_4 < 2z_2;\ \ z_4 - z_3 < 2(z_2 - z_1) &\qquad \text{(decreasing returns)} \\ c_h - c_m < \frac{z_4 - z_3}{2}\ \ ;\ \ c_h - c_m < z_2 - z_1 &\qquad \text{(high effort efficient)} \\ z_2 - c_h < z_4 - 2c_h\ \ ;\ \ z_1 - c_m < z_3 - 2c_m &\qquad \text{(full employment efficient)} \end{aligned}$$

Following Shapiro and Stiglitz (1984), we assume that a worker who deviates from the contractually stipulated effort level when effort is not verifiable is fired with probability $0 < q + b < 1$, whereas with probability $b > 0$ workers are fired independently of their effort level.[17]

For ease of exposition, the model is denoted in continuous time, and workers and firms discount the future at a rate r. When effort is not perfectly verifiable, workers trade off the short-run gains of low effort costs due to shirking versus potential long-run costs due to higher risk of dismissal and unemployment. More precisely, let w_h and w_m denote the wages that firms use to induce high and intermediate effort by workers. For these wages to be incentive compatible, the following set of no-shirking conditions needs to be fulfilled.

[16]Note that, as another simplification, we rule out the possibility that firms hire two workers and elicit medium effort from one worker and high effort from the other. This corresponds to assuming that a single firm does not offer both a bad and a good job. However, allowing for this possibility would not change the existence of the equilibrium with good and bad jobs that is our focus, although existence would be for a more restricted range of parameters.

[17]The firing probabilities are determined endogenously due to firms' worker retainment decisions in the experiment (see Table 3 in section 4).

$$V_h^W = \frac{w_h - c_h + bV_u}{r+b} \geq \frac{w_h + (b+q)V_u}{r+b+q} = V_h^S$$

and

$$V_m^W = \frac{w_m - c_m + bV_u}{r+b} \geq \frac{w_m + (b+q)V_u}{r+b+q} = V_m^S$$

V_u denotes the value of unemployment, V_h^W and V_m^W denote the worker's continuation values of fulfilling the contract by providing e_h and e_m, respectively. V_h^S and V_m^S denote the continuation values for shirking workers. In comparison to a worker who fulfills the contract, a shirking worker saves the effort cost (c_m or c_h), but increases the risk of being dismissed from b to $b+q$. Note that workers who are offered a high wage–high effort contract will never exert intermediate effort because this would mean they get fired with the same probability as if they shirk, but that they have to bear the higher cost of intermediate effort ($c_m > c_l$).

Denoting an unemployed worker's probability to find a new job with high wage or intermediate wage by a_h and a_m, respectively, we get:

$$rV_u = a_m(V_m^W - V_u) + a_h(V_h^W - V_u)$$

which is the value of unemployment.

8.2 Equilibrium with verifiable effort

As a first step, we look at the market equilibrium when effort is contractible and there is no contract enforcement problem. We then analyze the case of non-verifiable efforts, concentrating on the question whether two types of firms (high wage–high effort and medium wage–medium effort firms) can co-exist in a no-shirking equilibrium of the model.

Since the number of workers equals the number of potential vacancies in the market, firms have all of the bargaining power when effort is verifiable. Hence, firms will set the value of a job equal to the value of unemployment and reap the entire gains from trade. Workers will be paid their effort costs $w_m = c_m$ and $w_h = c_h$. Since full employment and exertion of high effort is efficient, all firms will use a homogeneous contracting strategy of hiring two workers, and all workers are employed at a high effort level.

8.3 Equilibria with non-verifiable effort

If effort is non-verifiable and thus not contractually enforceable, the type of the equilibrium depends on firms' production technology. We will argue in the following that only two types of equilibria are possible: (i) either all firms employ only one worker or (ii) one-worker and two-worker firms coexist in equilibrium. Under decreasing returns to scale, which of the two will emerge depends on the parameter values of the production function. Since our main interest is to illustrate how contractual incompleteness can give rise to equilibria involving market segmentation, we concentrate on a range of parameter values such that $\frac{z_4-z_3}{2} < (c_h - c_m)\frac{r+b+q}{q} < z_2 - z_1$. Thus, the production function exhibits strongly but not "too strongly" decreasing returns to scale. First, note that it is relatively more profitable for a two-worker firm to induce medium efforts compared to high efforts if the difference $z_4 - z_3$ is relatively small. The bound $\frac{z_4-z_3}{2} < (c_h - c_m)$ and the wages derived form the non-shirking conditions imply that firms can never profitably induce high effort provision by two workers although high effort is efficient:

$$z_4 - 2w_h = z_4 - 2rV_u - 2\frac{(r+b+q)c_h}{q} < z_3 - 2rV_u - 2\frac{(r+b+q)c_m}{q} = z_3 - 2w_m$$

Similarly, $(c_h - c_m)\frac{r+b+q}{q} < z_2 - z_1$ ensures that firms who hire only one worker will induce high effort levels, since the marginal incentives on this part of the production function are large:

$$z_2 - w_h = z_2 - rV_u - \frac{(r+b+q)c_h}{q} > z_1 - rV_u - \frac{(r+b+q)c_m}{q} = z_1 - w_m$$

The decision of firms boils down to deciding whether to employ only one worker at a high wage and high effort, or to employ two workers at the intermediate wage-effort combination. The difference in firm profits for the two cases is given by:

$$z_2 - w_h - (z_3 - 2w_m) = z_2 - z_3 + \frac{(r+b+q)}{q}(2c_m - c_h) + rV_u \tag{1}$$

One can see that, which of the two is more profitable depends on the difference in productivities z_2 and z_3, and the tightness of the labor market. The key variable is V_u, which decreases in the number of firms who employ one worker, as we will show in the following. Let L_h and L_m denote the workforce employed in high effort and medium effort jobs respectively. In a

no-shirking equilibrium, the flow into both types of jobs has to equal the flow out of the jobs:

$$a_h(N - L_h - L_m) = bL_h \qquad\qquad a_m(N - L_h - L_m) = bL_m$$

Since the number of unemployed workers equals the number of firms who ration jobs, L_h, it follows that $a_h = b$ and $a_m = b\frac{L_m}{L_h}$. Using the values of the different jobs in equilibrium we get the value of unemployment:

$$rV_u = \frac{b(w_h - c_h) + b\frac{L_m}{L_h}(w_m - c_m)}{r + b + b\frac{L_m}{L_h} + b} = \frac{b}{q}\left(c_h + \frac{N - 2L_h}{L_h}c_m\right)$$

The derivative of the value of unemployment with respect to the number of unemployed workers is:

$$\frac{\partial V_u}{\partial L_h} = -\frac{b}{qr}\frac{N}{L_h^2}c_m < 0$$

It is directly clear that V_u and thus also the difference of profits converges to infinity for $L_h \to 0$. Hence, full employment cannot be part of an equilibrium, since the value of unemployment and therefore the wages necessary to induce effort would tend to infinity.[18] There are two possible situations left. Either the difference in profits of one-worker firms and two-worker firms is positive for all V_u, and there are only high wage jobs with unemployment being $L_h = \frac{N}{2}$, or there is a separating equilibrium with indifferent firms and a segmented labor market. The first situation arises if and only if

$$\begin{aligned} & z_2 - z_3 + \frac{r + b + q}{q}(2c_m - c_h) + rV_u \geq 0 \qquad \forall V_u \\ \text{with} \quad & \min rV_u = \frac{b}{q}c_h \\ & z_3 - z_2 \leq \frac{r + b + q}{q}2c_m - \frac{r + q}{q}c_h = C \end{aligned}$$

If the difference in output between two workers exerting intermediate effort and one worker exerting high effort $(z_3 - z_2)$ is above the threshold C, there is a unique equilibrium in which firms are indifferent between a one-worker and a two-worker strategy. The insights of the preceding argumentation are summarized in the following proposition.

[18] Intuitively, if all workers are employed, it is very easy to find a job. This makes shirking very attractive, hence wages needed to prevent shirking tend to infinity.

Proposition 1. *(Effort non-verifiable) If* $\frac{z_4-z_3}{2} < (c_h - c_m)\frac{r+b+q}{q} < z_2 - z_1$*, there exists a unique pure strategy equilibrium. Depending on the parameter values, the equilibrium can be of two different types:*

1. *For* $z_3 - z_2 \leq C$*, all firms choose to employ only one agent in a high-wage job.*

2. *For* $z_3 - z_2 > C$*, firms with high- and medium-wage jobs coexist.*

The latter case gives rise to equilibra where both types of firms employ different contracting strategies, by paying different wages and asking for different effort levels. This indicates that contract enforcement problems can not only lead to strictly positive levels of involuntary unemployment, but also to a segmentation of the labor market. Although firms are technologically identical, they employ different contracting strategies in equilibrium. Proposition 2 shows that this segmentation of the labor market into one-worker firms and two-worker firms has strong consequences for workers. First, a fraction of workers is involuntary unemployed, i.e., they receive lower rents than any of the employed workers. Second, from a 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 in which effort is also lower.

Proposition 2. *In any equilibrium with a segmented labor market the following holds:*

1. *Unemployment is involuntary.*

2. *From a worker's perspective, high-effort jobs yield strictly higher rents than jobs with intermediate effort, which in turn yield rents strictly above the value of unemployment*

3. *Firms are indifferent between offering one high-rent job and offering two low-rent jobs.*

Since workers have some discretion about their effort level, employers need to pay workers rents to prevent them from shirking. The rent of workers in a no-shirking equilibrium in a low rent job is

$$V_m^W = \frac{w_m - c_m + bV_u}{r+b} = V_u + \frac{c_m}{q} > V_u$$

Consequently, employed workers extract strictly larger rents compared to unemployed agents, implying that unemployment is involuntary. Similarly, agents need to be overcompensated

for an increase in effort from e_m to e_h, to induce compliance to the stipulated effort level.

$$V_h^W - V_m^W = \frac{w_h - c_h + bV_u}{r+b} - \frac{w_m - c_m + bV_u}{r+b} = \frac{c_h - c_m}{q} > 0$$

Summing up our findings, our theoretical analysis has shown that under explicit contract enforcement, the market equilibrium is characterized by full employment, and a unique contracting strategy by firms, involving high effort levels and minimal worker rents. By contrast, in the absence of explicit contract enforcement, there can be situations in which the need to provide implicit performance incentives leads to, both, involuntary unemployment and a segmentation of the labor market. Firms provide performance incentives by paying strictly positive rents to workers and condition a worker's re-employment on his previous performance. In these equilibria, firms are indifferent between employing a primary or secondary sector contracting strategy. Importantly, this is the case although firms are identical in terms of the production technology available. The workforce splits up into (i) workers who receive high rent payments and exert high levels of effort, (ii) workers who receive strictly positive, but lower rents and exert lower, but non-minimal levels of effort, and (iii) workers who are involuntarily unemployed and receive the lowest rents. Our analysis has also isolated the conditions under which such an equilibrium is most likely to prevail. These conditions are: (i) firms operate under decreasing returns to scale, (ii) the production technology is "concave enough" to make inducing high effort provision prohibitively expensive at high employment levels, and (iii) the production technology is "steep enough" such that one-worker firms inducing high effort levels do not dominate two-worker firms with intermediate effort levels, at least for very high levels of unemployment.

9 Appendix B: Additional Figures

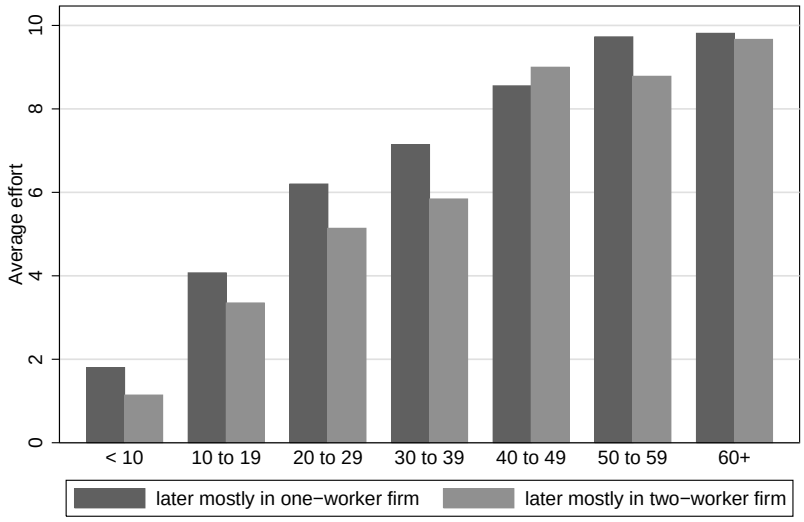


Figure 5: *Average effort for a given wage during periods 1–7. Workers who work predominantly in one-worker firms vs. workers who work predominantly in two-worker firms during the late phase (i.e., in more than 50% of their employment spells in periods 8–18).*

10 Appendix C: Instructions of the Experiment (IC Treatment)

In what follows, we present a translation of the instructions for buyers (i.e., employers) in the IC treatment. The instructions for workers in this treatment had a similar structure. The instructions of participants in the C treatment differed only in the description of the second stage (i.e., the work phase).

Instructions for Buyers

You are now taking part in an economic experiment. Please read the following instructions carefully. Everything that you need to know to participate in this experiment is explained below. Should you have any difficulties in understanding these instructions please raise your hand. We will answer your questions at your cubicle.

At the beginning of the experiment you receive an initial endowment of **8 euros**. During the experiment you can increase your income by earning **points**. The amount of points that you earn during the experiment depends on your decisions and the decisions of other participants. All points that you earn during the experiment will be converted into euros at the end of the experiment. The exchange rate is:

1 Point = 4 cents

At the end of the experiment, the amount of money that you earned during the experiment will be paid out in cash.

The experiment consists of several periods. In each period you have to make decisions which you enter in a computer. There will be 18 periods in total.

Please note that communication between participants is strictly prohibited during the entire experiment. In addition we would like to point out that you may only use the computer functions which are required for the experiment. Violations of these rules will lead to exclusion from the experiment. In case you have any questions we shall be glad to assist you.

Prior to the experiment, the 24 participants were divided into 2 groups: buyers and sellers. There are 7 buyers and 17 sellers in the experiment.

You will be a buyer for the entire duration of the experiment. All participants have received an identification number which they will keep for the entire experiment. You can find your identification number on the documentation sheet in front of you.

Short Overview of the Experimental Procedures

In each period of the experiment every buyer can trade a product with zero, one, or two sellers. The seller earns profits when he sells the product at a price which exceeds his production costs. The buyer earns profits when the price she pays for the product is less than her valuation of the product. The production costs of the traded product as well as the buyer's valuation of the product depend on the quality of the product. In addition, the value of the product for the buyer depends on the number of products bought. Two products of a certain quality are worth more, but not twice as much as one product of the same quality.

The experiment lasts for 18 periods. In each period, procedures are as follows.

1. Each period commences with a **trading phase** that lasts for 200 seconds. During this phase buyers can submit trade offers which can be accepted by sellers. When submitting an offer a buyer has to specify three variables:

- Which price she offers to pay
- which product quality she desires
- and finally, which sellers she wants to submit the offer to. Buyers can submit two types of offers: private offers and public offers. **Private offers are submitted to one specific seller** and can only be accepted by that seller. **Public offers are submitted to all sellers** and can be accepted by any seller.

As a buyer you can submit as many offers as you like in each period. Once submitted, offers can be accepted at any time. **Each seller can at most conclude one trade agreement in each period. Each buyer can at most conclude two trade agreements per period.** As there are 7 buyers and 17 sellers in total, some sellers will not trade in each period.

2. After the trading phase, every seller who concluded a trade agreement has to determine which product quality he provides to his buyer. **The seller does not have to provide the product quality desired by the buyer.**

Once every seller has chosen his product quality, earnings of all participants for the given period are determined. Subsequently, the next period starts. Earnings of all 18 periods will be summed up at the end of the experiment, converted into euros and paid out in cash together with your initial endowment.

The Experimental Procedures in Detail

There are 7 buyers and 17 sellers in the experiment. You are a **buyer** for the entire duration of the experiment. During the experiment you enter your decisions in a computer. In the following, we describe in detail how you make your decisions in each period.

1. The Trading Phase

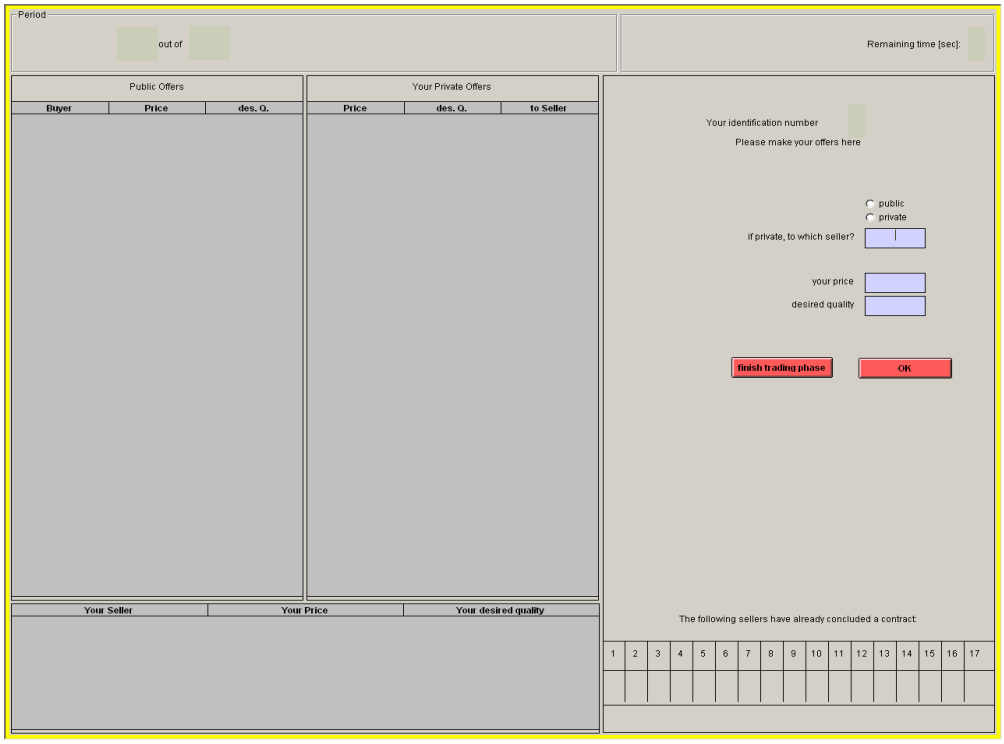
Each period begins with a trading phase. During the trading phase the buyers can conclude trade agreements with the sellers. In order to do so, **each buyer can submit as many trade offers as she wishes.** In each trading phase you will see the following screen.

In the top left corner of the screen you will see the current period of the experiment. In the top right corner of the screen you will see the time remaining in this trading phase, displayed in seconds. **The trading phase in each period lasts 200 seconds.** When this time is up the trading phase is over, and no further offers can be submitted or accepted in this period. Once you see the screen displayed, the trading phase starts. As a buyer, you now have the opportunity to submit trade offers to the sellers. In order to do so you have to enter three variables on the right hand side of the screen:

(A) First, you have to specify whether you want to submit a public or private offer:

Public offers

Public offers are communicated to all participants in the market. All sellers see all public offers on their screens. A public offer can therefore be accepted by **any seller**. As a buyer, you will also see all public offers submitted by the other buyers. If you want to submit a public offer, please click on the field "public" using the mouse.



Private offers

Private offers are submitted to **one seller** only. Only this seller will be informed about the offer and only this seller can accept the trade offer. No other seller or buyer will be informed about the offer. If you want to submit a private offer, please click on the field "private" using the mouse. In the next field, you have to specify **to which seller you want to submit the offer.** Each of the 17 sellers has an identification number (Seller1, Seller2, ..., Seller17). Each seller keeps his identification number for the entire duration of the experiment. To submit an offer to a specific seller, please enter the number of that seller (e.g. "4" for Seller4).

(B) Once you have specified who you want to submit an offer to, you have to determine **which price you offer.** You enter the price into the field "your price". The price you offer must not be below 0 or above 100:

$$\mathbf{0 \leq Price \leq 100}$$

(C) Finally, you have to specify which product quality you desire. You enter this in the field "desired quality". **Your desired quality** cannot be lower than 1 or higher than 10.

$$\mathbf{1 \leq \text{Desired quality} \leq 10}$$

After you have fully specified your trade offer, you have to click the "OK" button to submit it. As long as you have not clicked "OK" you can still change your offer. After you click "OK" the offer will be displayed to all sellers to whom it has been submitted.

On the left side of your screen you see the heading "public offers". All public offers in the current trading phase will be displayed here—your public offers as well as the public offers of all other buyers. You can see which buyer submitted the offer, which price she offered and which quality she desired. All buyers also have an identification number that they keep throughout the experiment (Buyer1, Buyer2, ..., Buyer7).

In the middle column of the screen, under the header "your private offers" you will see all private offers that you have submitted in the current trading phase. Here you can see to which sellers you made an offer, which price you offered and which quality you desired.

As long as none of your offers has been accepted by a seller, you as a buyer can submit as many private and public offers as you wish in a given period. Each offer that you submit can be accepted at any time during the trading phase.

As soon as one of your offers has been accepted, you are informed which seller accepted the offer and which of your offers has been accepted. In the bottom left corner of your screen the identification number of the seller who accepted the offer will be displayed, together with your offered price and your desired quality. At the same time all your other offers will be automatically canceled.

You can then decide whether you want to conclude another trade agreement. **Each buyer can conclude zero, one, or two trade agreements in each period.** If you want to conclude another trade agreement you can submit further offers to the sellers. As long as none of your offers has been accepted by a seller you can offer as many private and public offers for the second trade as you wish.

If you do not want to conclude another trade agreement you can press the button "finish trading phase". This reduces the length of the trading phase in case no other buyer wants to submit further offers. By pressing the button, the offers you have already submitted will

be automatically canceled and you can not submit further offers. Trade agreements which were already accepted by a seller of course persist. In addition, you will continue to see the screen of the trading phase until it is over.

Each seller can conclude at most one trade agreement in a given period. You will be constantly informed which sellers have not yet concluded a trade agreement. In the table with the title "The following sellers have already concluded a contract" you can see 17 fields. Once a seller has accepted an offer, a "+" will appear in the field below his identification number. You cannot submit private offers to a seller who has already accepted an offer.

The trading phase is over as soon as one of the following occurs: 200 seconds have elapsed, or all buyers have concluded two trade agreements, or the remaining buyers have signalled that they do not want to conclude trade agreements anymore by pressing the button "finish trading phase".

No buyer is obliged to submit trade offers, and no seller is obliged to accept a trade offer.

2. Determination of actual product quality

After the trading phase, all sellers who have concluded a trade agreement determine which product quality they will supply to their buyer. First, the sellers see again the price and the desired quality on a new screen. If you have concluded two trade agreements in a given period your sellers can also see the price and the desired quality of your other seller. The sellers then decide independently which actual product quality to choose for their product.

The product quality which you desired in your trade offer is not binding for your seller(s). Your seller can choose exactly the quality you desired, but he can also choose a higher or lower product quality. The product quality that your seller chooses has to be an integer between 1 and 10:

$$\mathbf{1 \leq \text{Actual product quality} \leq 10}$$

While the sellers determine the actual product quality, we will ask you on a separate screen to specify which quality(ies) you expect him (them) to supply. In addition we ask you to state how sure you are about this expectation.

How are incomes calculated?

Your income:

If you **have not concluded a trade agreement** during a trading phase you earn an income of **0 points** in this period.

If you have concluded **one** trade agreement, your income depends on the price you paid and the product quality your seller supplied to you. Your income equals 10 times the actual product quality minus the price you paid. Your income thus amounts to:

Your income = 10*Actual product quality - Price

If you have concluded **two** trade agreements, your income depends on which prices you paid to the sellers and which product qualities were supplied to you. The value of the products **in total** can be higher for you if you conclude two trade agreements, but the value of **each individual** product is lower in this case.

In other words, two products of a certain quality are worth more to you than one product of the same quality; but they are not worth twice as much as one product of the same quality. If you buy **one** product you earn 10 times the chosen product quality. If you buy **two** products you earn 7 times the quality of the first product and 7 times the quality of the other product. Of course, when you buy two products you also have to pay two prices. Your income if you conclude two trade agreements is thus calculated as follows:

Your income = 7*Actual product quality Product 1
+ 7*Actual product quality Product 2 - Price 1 - Price 2

An example: If you conclude **one** trade agreement and the actual product quality is 8, your income is 80 minus the price you paid. If you conclude **two** trade agreements and both actual product qualities are 8 your income is 112 (=7*8+7*8) minus both prices. If, for instance, one actual product quality is 8 and the other quality is 1, your income is 63 (= 7*8 + 7*1) minus both prices.

As you can see from the above formula your income generally increases in the product quality actually supplied by the seller(s). At the same time your income is higher, the lower the price(s) you have to pay for the product(s).

Income of your seller:

If a seller has not concluded a trade agreement during a trading phase he earns an income of 0 points in this period.

If a seller has accepted a trade offer his income will equal the price he receives minus the production costs he incurs for supplying the product The income of your seller is determined as follows:

Income of your seller = Price - Production Costs

The production costs of a seller are higher, the higher the quality of the product he chooses. The production costs for each product quality are displayed in the table below:

Quality	1	2	3	4	5	6	7	8	9	10
Production costs	0	1	2	4	6	8	10	12	15	18

The income of your seller increases in the price he receives. Furthermore, his income is higher, the lower the product quality he supplies.

The incomes of all buyers and sellers are determined in the same way. **Each buyer can therefore calculate the income of his seller(s) and each seller can calculate the income of her buyer.** In addition, buyers and sellers are informed of the identification number of their trading partner in a given period.

Please note that buyers and sellers can also incur losses in each period. These losses have to be covered from your initial endowment or from earnings in other periods.

You will be informed about your income and the income of your seller on a separate **"income screen"**. On the screen the following information will be displayed:

- Which seller(s) you traded with
- Which price(s) you paid
- Your desired quality(ies)
- The actual product quality(ies) supplied by your seller(s)

- The income of your seller(s) in this period
- Your income in this period.

Please enter all of the information from this screen into the documentation sheet on your desk. After the income screen has been displayed, the period is finished. Thereafter the trading phase of the following period starts. Once you have finished reading the income screen please click on the "OK" button.

The sellers also see an income screen which displays the above information. They see the ID of their buyer, the price, the desired and actual product quality as well as their own income, your income and—if you have concluded two trade agreements—the income of your other seller.

The experiment will not start until all participants are completely familiar with all procedures. In order to make sure that this is the case we ask you to solve the exercises below.

In addition we will conduct a **trial period of the trading phase** to familiarize you with using the computer. This trial phase will not be added to the results of the experiment, and will not be remunerated. After the trial phase, the experiment which lasts for 18 periods will start.