

# INFORMATION NETWORKS AND WORKER RECRUITMENT

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## ABSTRACT

This paper studies experimentally how the existence of social information networks affects the ways in which firms recruit new personnel. Through such networks firms learn about prospective employees' performance in previous jobs. Assuming individualistic preferences social networks are predicted not to affect overall labor market behavior, while with social preferences the prediction is that when bilaterally negotiated: (i) wages will be higher and (ii) that workers in jobs with incomplete contracts will respond with higher effort. Our experimental results are consistent with the social preferences view, both for the case of excess demand and excess supply of labor. In particular, the presence of information networks leads to more efficient allocations.

## Keywords

Labor Markets, Information Networks, Worker Recruitment, Indirect reciprocity, Experiments

## JEL Classification Codes

C90, J30, J40

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## 1. Introduction

When firms are looking to hire new workers, they typically have incomplete information about the relevant characteristics of prospective candidates. Recruiting basically involves finding ways to uncover as much of this information as possible. In practice, firms recruit workers through fundamentally two broad channels. Centralized market institutions are one. In such markets, numerous firms and workers interact at the same time and a substantial part of the information about offers and trades is disseminated to market participants. In many countries, public or private employment agencies provide the services of such centralized exchanges.<sup>1</sup> The other broad recruitment channel consists of informal networks of common acquaintances that facilitate the matching between the two sides of the labor market. In these networks contacts between firms and workers take place in a much more decentralized way.

The choice between recruitment channels involves a trade-off. If a firm decides to find a worker through an informal network, it gives up the transparency of the centralized market with respect to wages as well as the possibility of establishing contacts with a large number of workers. At the same time contacts in the informal network may be able to provide the firm with more accurate information about the prospective workers than what is available in the centralized markets.

*Sociological* research has long shown that for some types of jobs networks generate most job matches (Granovetter, 1974, 1995; Corcoran *et al.*, 1980; Holzer, 1987; Boxman and Flap, 1991; Montgomery, 1991). This literature shows that jobs found via social networks are of higher quality, better paid and higher occupational status than average (Granovetter, 1974; Lin *et al.*, 1981; Lin *et al.*, 2001; Flap and Volker, 2004). Many *economic* studies use search and matching models to analyze recruitment behavior in the labor market.<sup>2</sup> Some of these models account for the two types of channels (Barron and Bishop, 1985; Montgomery, 1991; van Ours and Ridder, 1991, 1992; Gorter *et al.*, 1993; Lindeboom *et al.*, 1994; Chan, 1996; Gorter and van Ommeren, 1999; Russo *et al.*, 2000; 2001; Behrenz, 2001; Rogerson *et al.*, 2002; Kugler, 2003). A number of these studies provide support for the sociologists' findings and suggest that the use of informal channels is more efficient than other forms of

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<sup>1</sup> Recruitment through advertisement in newspapers or web sites also falls in this category (Rees, 1966).

<sup>2</sup> Traditionally, most of the economic research on job matching has focused only on workers' searching behavior (Hicks, 1932; Stigler, 1961, 1962; Phelps, 1968; Phelps 1970; McCall, 1970; Mortensen, 1970; Burdett and Mortensen, 1980; Albrecht and Axell, 1984; Pissarides, 1990; Mortensen and Pissarides, 1999; Bontemps *et al.*, 2000). The strength of this literature lies in the explicit modeling of the costs and benefits related to searching for a job.

recruitment, especially for key positions in firms. However, recruitment through networks can also lead to inefficiencies because of mismatches between a worker's chosen occupation and her comparative productive advantage (Bentolila, *et al.* 2004).

Potential workers may vary in productivity type. In that case, informal channels may reduce firms' information acquisition costs about such types and lead to more efficient hiring outcomes. Moreover, often contracts are necessarily incomplete (*i.e.*, characterized by moral hazard). If this is the case, information that is not merely about (productivity) types of workers may be relevant to a firm. For example, a firm may want to know how trustworthy a worker has been in previous jobs. This aspect has been largely neglected in the economic search models described above. At the moment of recruiting new workers, social networks of various kinds are potential sources of this type of information. In other words, social networks are also information networks, as introduced by Rees (1966) and emphasized by Coleman (1988).

Hence, understanding the role of social networks in facilitating firms' acquisition of information about previous performance is important in improving our knowledge of the workings of the labor market as a whole (Marsden 2001). We present experimental data to this. Laboratory experiments provide an ideal environment to isolate the effect of information about a worker's trustworthiness in the recruitment process. In addition, the laboratory allows one to precisely control the information about the worker that is given to the firm. In our environment firms choose between two recruitment channels when hiring new workers. One of the channels is a centralized double auction market in which firms and workers bid and ask wages until a transaction is agreed upon. The other channel is an informal channel in which firms and workers meet in bilateral negotiations. This is where our set-up is linked to information networks. When a firm is involved in a bilateral negotiation with a potential worker, we provide her with information about this worker's performance in previous job(s).

The relevance of this information may depend on the conditions under which recruitment takes place. To understand some of the ways in which the use of the recruitment channels emerges endogenously, we allow for variation in the environment along two dimensions.<sup>3</sup> First, we vary the direction of market imbalance, *i.e.* whether labor is in excess demand or excess supply in the labor market as a whole. This treatment is directed at capturing different labor market conditions over the business cycle. The tightness of the labor market

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<sup>3</sup> Endogenously chosen market institutions have been studied theoretically (Alós-Ferrer and Kirchsteiger, 2003; Neeman and Vulkan, 2002; Kugler, 2003 presents a theoretical and field-data analysis) and experimentally (see Kugler *et al.*, 2004; Kirchsteiger *et al.*, 2005; Tallroth, 2003). These studies show that both market institutions (*i.e.*, our double auction market) and non-market institutions (*i.e.*, bilateral negotiations) can be stable in the long run. Their (comparative) effect on efficiency remains unclear, however (Tallroth, 2003).

significantly impacts the way in which firms recruit their personnel (Russo *et al.*, 2001). The second variation relates to the type of job that a firm is recruiting for. In many occupations workers have considerable discretion about their performance at a job (*e.g.*, through the amount of effort they exert) (Williamson, 1981; Milgrom, 1988; Baker, 1992; Goldthorpe, 2000; Eguchi, 2005). For such jobs with incomplete contracts the performance history of prospective workers may be relevant information at the time of the recruitment decision. This information pertains directly to actual work-related behavior in the past and therefore it may indicate what effort to expect from a worker in the present. In contrast, if contracts are complete (there are no issues of moral hazard) firms can largely control performance on the job, hence workers' performance histories are largely irrelevant and recruiting through informal channels does not appear to offer any advantages.

If preferences depend only on own income then the existence of information networks should not be expected to alter recruitment behavior. Simply, effort levels will be high under complete contracts and low under incomplete contracts and the information in networks is superfluous. The wages that would arise in this case can also be easily gauged. If the competitive advantage is on the workers' side then they will, in the bilateral wage negotiations only accept a wage equal to what the centralized market would yield them. If, in contrast, the advantage is on the firms' side then they will, if they ever recur to bilateral negotiations, make the same offer they would make in the centralized market.

It is due to the interdependence of preferences that the possibility of recruitment through a bilateral channel may substantially alter the working of the labor market. For this case, the important line of work initiated by Fehr *et al.* (1993, 1998) and continued by, among others, Hannan *et al.* (2002), Falk and Fehr (2003), Charness (2004), Falk and Kosfeld (2004), and Brandts and Charness (2004) has shown that elements of trust and trustworthiness, fairness and reciprocity have a strong influence on behavior and efficiency. Here we want to study the effect of trustworthiness and trust in a specific situation. When contracts are incomplete, trustworthy workers are valuable. Firms may find out about the trustworthiness of a worker being recruited through a social network.

In a related study, Brown, Falk and Fehr (2004) examine the emergence of fixed long-term partnerships between workers and firms under incomplete contracting. They find that markets resemble a collection of bilateral trading islands rather than a competitive market. Firms are willing to invest in workers early on by offering high wages, and workers respond by working hard from the start. If a worker does so, then the firm in question will make a private offer to the same worker again in subsequent rounds, and an on-going relationship

arises based on mutual trust and reciprocity. The crucial difference between Brown *et al.* (2004) and our study is that we investigate the way in which the presence of information networks influences how the recruitment of *new* workers comes about. These networks provide a firm with information about workers with whom they have no previous employment relationship. By allowing for the possibility that a firm offers high wages to workers that worked hard elsewhere in the past, we are able to show that *indirect* reciprocity is essential for initial recruitment (Seinen and Schram, 2006; Engelmann and Fischbacher, 2004, Bolton *et al.*, 2004).<sup>4</sup> In contrast, Brown *et al.* are interested in how *direct* reciprocity fosters an ongoing relationship between worker and firm (where first time contacts are coincidental).

Our experimental results show that the information provided through networks is important for recruitment when contracts are incomplete. Many firms recruit through bilateral negotiations, where wage and effort levels are higher than in the market. Consequently, the possibility of hiring through bilateral negotiations increases efficiency and in some cases even leads to Pareto-superior income levels. One source of the efficiency gain is the direct reciprocation by the worker of the firm's trust. The starting point, however, is a firm offering a high wage in bilateral negotiations to a new worker who exerted high effort to other firms in the past.

To conclude, our experimental design facilitates the study of the separate impact of the information network and, hence, reveals what one misses if one thinks about the labor market purely in terms of centralized institutions. Our results show that information disclosed through social networks can enhance efficiency even if it means that trading is taken out of a competitive market setting. The remainder of this paper is organized as follows. Our experimental design and procedures are described in section 2. Section 3 provides a theoretical framework for our results, which follow in section 4. Section 5 concludes.

## 2. Design and Procedures

The computerized experiment was run at the CREED laboratory of the University of Amsterdam in 8 sessions of approximately 90 minutes, with a total of 21 markets. Average earnings were €24.99, including a €5 show-up fee. The strategic environment is presented to participants without explicit reference to any labor market concepts. See Appendix A for a translation of the instructions. The situation is presented in terms of a market in which an

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<sup>4</sup> In addition, our paper deals with one of the questions that Brown *et al.* (2004) leaves for future research: “how markets where the seller can acquire a general reputation for being trustworthy work” (p. 775). By passing on information on a worker's previous performances via information networks, our study allows for the possibility of reputation building by a worker.

abstract good is traded between buyers and sellers. However, given our focus on recruitment in the labor market, we will henceforth maintain the reference to ‘firms’ and ‘workers’ instead of buyers and sellers, respectively.

The participants in the experiments interact during a total of 30 market rounds; each subject has the constant role either of a firm or of a worker and can be involved in at most one trade per round. Trade can take place in two ways: through a centralized market institution or through bilateral (private) negotiations. There are 7 traders per market: depending on the treatment (either 5 firms and 2 workers, or *vice versa*) with at most two trades per market and round. After the market closes the ‘effort level’ of each worker involved in a trade is determined. This affects the payoffs to firms and workers in a way to be discussed below.

Our design consists of four separate treatments, varying along two dimensions and yielding a full 2x2 factorial design. The first dimension consists in whether or not workers can choose their own effort levels. In what we call the *incomplete contracts* situation workers freely choose either a high or a low effort after having been hired by a firm. In our *complete contracts* treatment workers do not have this possibility and the firms set workers’ effort levels; this represents firms’ complete control in this case and allows us to keep things procedurally parallel. The second dimension along which our treatments differ is in whether there is excess supply (5 workers, 2 firms) or excess demand (2 workers, 5 firms) on the market. Table 1 summarizes our design and gives the number of markets we ran per treatment cell.

**Table 1: Experimental Treatments**

|                                   | Complete Contracts<br>(no moral hazard) | Incomplete Contracts<br>(moral hazard) |
|-----------------------------------|---|--|
| Excess supply: 5 workers, 2 firms | 5 markets, 30 rounds                    | 5 markets, 30 rounds                   |
| Excess demand: 2 workers, 5 firms | 5 markets, 30 rounds                    | 6 markets, 30 rounds                   |

In the first 10 rounds firms and workers interact only through a centralized market institution. This market is organized as a standard double auction with anonymity, in which both firms and workers are able to make public wage proposals at any time during a market period. We chose the double auction, because it is usually considered to be the institution that best embodies the characteristics of well-functioning markets, where prices and transactions come about through an equilibrating process. Bids and asks in the double auction consist of an integer between 0 and 50, inclusive; these wage proposals are public. If a market wage proposal is accepted then a match is established. The transaction wage is denoted by  $w_{DA}$ . Subjects have 90 seconds to make trades. After two trades have been realized or 90 seconds have passed (whichever comes first), the market closes. Then, the worker’s effort level ( $e$ ) is

determined. The two possible effort levels are ‘high’ ( $e=1$ ) and ‘low’ ( $e=0$ ) with resulting payoffs as explained below. After a worker’s effort has been determined, this is communicated only to the firm and worker concerned. Neither knows the identity of those making or accepting offers nor do they know the history –of wage or effort levels– of any of the other market participants.

A firm’s payoff ( $\pi_f$ ) is equal to the revenue resulting from the worker’s effort level,  $r(e)$  minus the wage paid, where the revenue levels resulting from high and low effort are  $r(1)=50$  and  $r(0)=10$ , respectively. A worker’s payoff ( $\pi_l$ ) is equal to the wage received minus the cost of effort  $c(e)$ , which is 20 for high effort ( $c(1)=20$ ) and 0 for low effort ( $c(0)=0$ ). Note that high effort is the socially efficient level. Summarizing:

$$\begin{aligned}\pi_f &= r(e) - w_{DA} \\ \pi_l &= w_{DA} - c(e).\end{aligned}\tag{1}$$

These initial 10 rounds establish a clear expectation about the wage level that arises in a centralized market. After the 10 market rounds are over, subjects receive new instructions in which the following situation was laid out for each of the new 20 rounds. At the beginning of each round firms have the opportunity to either enter the centralized market or access the information network. The centralized market works just like the one for the first 10 rounds. In the case of bilateral negotiations, firms access this channel by expressing a wish to enter negotiations. For every firm that indicates this wish, one worker is randomly selected. If there are more negotiation requests than workers, the firms to engage in negotiations are randomly selected. The selected workers are then asked whether they want to enter the bilateral negotiations. After all workers have reacted, the bilateral wage negotiations and the market open simultaneously. All firms and workers that have not been paired for bilateral negotiations enter the centralized market.

In the firm-worker pairs that are matched for bilateral negotiations each matched firm is informed about the levels of effort exerted by the worker it is matched with in all previous jobs, in order of time.<sup>5</sup> This includes those jobs in which the matching with a firm had taken place through the centralized market but excludes the decisions of the first 10 rounds (where there are no bilateral negotiations). Firms are not informed of wages earned previously by the worker. Firms and workers do not learn the identity of their partners in a matching. We

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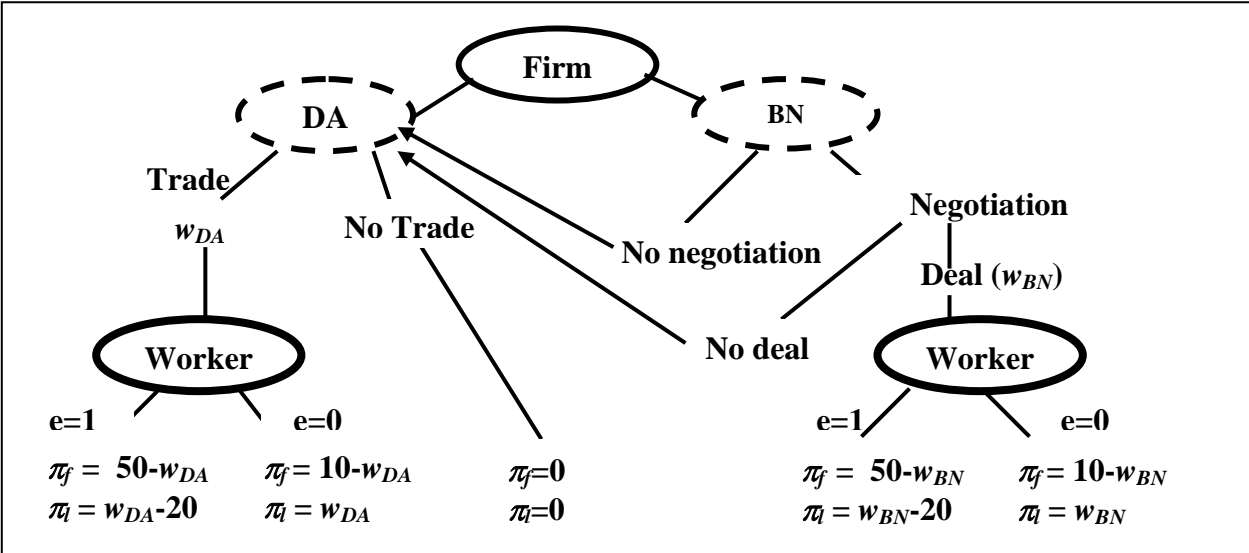
<sup>5</sup> We do not model more in detail the micro-structure of information transmission in the network. Doing this here would complicate the experiment unnecessarily. Our representation captures what for us is the crux of the matter, namely that the network offers more information but fewer contacts. Boorman (1975) and Calvó-Armengol (2004) present theoretical models of information transmission in job contact networks.

imposed this anonymity and the random matching procedure precisely because (contrary to Brown *et al.*, 2004) our focus is not on the formation or dynamics of bilateral relations, but on the impact of information networks on initial recruitment.

After a firm has seen the information about previous effort choices, it makes a network wage offer to the workers they were matched with, which – like in the market - consists of an integer between 0 and 50.<sup>6</sup> Matched workers can then accept or reject the corresponding offer. We denote an accepted wage in the negotiations by  $w_{BN}$ . Those involved in the bilateral wage negotiations can at all times observe the bids and the trades made in the public market. In contrast, participants in the market are not informed about what is happening in the negotiations; this again represents the transparency of a market and the lack of it in information networks. The firms whose offers are rejected and the workers that have rejected immediately enter the centralized market, joining the firms and workers that have not engaged in bilateral negotiations. Each round again lasts for 90 seconds.<sup>7</sup> After the trades have been determined, the effort decision for the workers involved is made. This yields payoffs as in eq. (1), where  $w_{DA}$  is replaced by  $w_{BN}$  for trades in the bilateral negotiations.

A summary of the experimental design is given in Figure 1.

Figure 1: Experimental Design



*Notes.* DA=Double Auction; BN=Bilateral Negotiations; In BN the firm first offers bilateral negotiations to one worker. If this is rejected, the firm and worker participate in DA. The same holds if the offer to negotiate is accepted but the wage offer in BN is rejected by the worker.

<sup>6</sup> Note that the initiative is on firms' side in the information network channel, in the sense that they decide whether to offer negotiations through this channel and also make the wage offers. This asymmetry reflects the basic power relations present in many information networks.

<sup>7</sup> Firms may delay making an offer to make it difficult for workers to reject and still get into the trading in the public market. However, in the experiments very few firms substantially delayed making offers.



### 3. Hypotheses

In this section we present specific hypotheses about wages, effort levels and the use of the two recruitment channels, related to different types of preferences. The main question is what the scope for gift exchange – high wages and high effort – will be and how the presence of an information network will affect gift exchange. In section 3.1 we start by presenting the implications of the interaction of purely individualistic agents. This is one of the commonly used benchmarks and it will be the basis for our null hypotheses. In section 3.2 we present a discussion of the implications for expected behavior of purely inequity-averse participants in the line of Fehr and Schmidt (1999). We also discuss what previous experimental literature suggests will occur in our environment. On the basis of all this we make predictions about what behavior to expect and formulate alternative hypotheses. In both sections 3.1 and 3.2 we begin with the case of complete contracts and move then to incomplete contracts.

#### 3.1. Individualistic Preferences

The theoretical predictions are straightforward if we assume that it is common knowledge that all participants are only interested in their own monetary earnings. High effort will always be chosen when contracts are complete and low effort when they are incomplete, independent of whether the trade is made in the market or through the information network. Wages depend on whether effort is low or high and on whether the market is favorable to firms or workers. Under excess demand for labor, wages are such that all the surplus goes to the workers and the opposite is predicted under excess supply. All the effort and wage predictions for our parameters for any round are shown in table 2.

**Table 2: Equilibrium Predictions, Individualistic Preferences**

|               |                      | Complete Contracts |               | Incomplete Contracts |               |
|---------------|----------------------|--------------------|---------------|----------------------|---------------|
|               |                      | DA                 | BN            | DA                   | BN            |
| <b>Effort</b> |                      | $e = 1$            | $e = 1$       | $e = 0$              | $e = 0$       |
| <b>Wage</b>   | <b>Excess Demand</b> | $w_{DA} = 50$      | $w_{BN} = 50$ | $w_{DA} = 10$        | $w_{BN} = 10$ |
|               | <b>Excess Supply</b> | $w_{DA} = 20$      | $w_{BN} = 20$ | $w_{DA} = 0$         | $w_{BN} = 0$  |

Notes: Numbers denote predictions for the treatment cells distinguished. Predictions hold for all rounds. DA=double auction market; BN=bilateral negotiations.

The most important qualitative implications of what is shown in table 2 – which below will give rise to our null hypotheses - are the following:

- (i) *Effort is higher under complete than under incomplete contracting.*
- (ii) *In all treatments, effort is the same for DA and for BN.*
- (iii) *Wages are higher under complete than under incomplete contracting.*
- (iv) *Wages are higher under excess demand than under excess supply.*
- (v) *In all treatments wages in the DA and those agreed upon in the BN are the same.*
- (vi) *In all treatments, subjects are indifferent between trading via the DA and the BN.*

A few short comments on this. Part (i) of the null hypothesis is quite straightforward; it simply reflects the fact that effort will be determined – after the wage – following the interests of whoever controls it and (ii) states that this will be unaffected by the recruitment channel. Item (iii) is a consequence of (i). In the complete contracting case workers know that firms will impose high effort and, therefore, they need to be offered high enough wages to accept getting into a trade. For incomplete contracting firms know that workers will choose low effort and, hence, firms will only be willing to offer low wages and workers will accept them. Item (iv) just responds to a fundamental feature of the workings of markets, which has been observed in numerous experiments (see Holt *et al.*, 1986 and Davis *et al.*, 1993), though previous experimental evidence suggests that we should not expect contracts exactly at boundary wages (which yield zero profit to one of the partners), but only close to them. Item (v) is quite crucial and is directly related to (ii). Effort will not differ across recruitment channels and, in accordance with this, wages will not differ either. Finally, item (vi) formulates that if both sides have nothing to gain from trading through either of the channels, then they will be indifferent between them.

### **3.2. Other-regarding Value Orientations**

As already mentioned, in many experimental labor environments the predictions based on individualistic preferences have not fared well. Not only that, specific models of other-regarding preferences have been successful in explaining observed behavioral regularities. The inequity-aversion model of Fehr and Schmidt (1999), (henceforth FS99), is one of the most prominent ones.<sup>8</sup> In considering the effects of other-regarding value orientations we, therefore, start with the implications for equilibrium behavior of inequity-aversion. In formulating this we assume a proportion of inequity-averse agents like the one estimated by FS99. This configuration of parameters can account for the regularities in a wide range of games and, for this reason, we think that it is the right starting point. This subsection starts with a heuristic presentation of the main implications of this model. In Appendix B we present a formal analysis of the experimental setting and derive predictions for the parameters of our experiment (Schram *et al.* 2007 derive predictions for general parameters settings). After that we present a wider view of the impact of other-regarding preferences.

Consider inequity-aversion with complete contracts. Here high effort will always be chosen, since it yields the highest surplus and firms will be better off in the high surplus case. In the DA, competition will crowd out inequity concerns (FS99) and the extreme wage pre-

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<sup>8</sup> For example, Camerer (1993, p. 472) advises using this approach when studying wage-setting and bargaining.

dictions for individualistic preferences carry over to this case. In BN, however, inequity-aversion may affect realized wages if firms and workers consider their negotiation partner to be the only relevant reference agent. This is the assumption made in FS99; we think that it is plausible and adopt it here.<sup>9</sup> Since disadvantageous inequity is evaluated more negatively than advantageous inequity, the short side of the market (which ends up with all of the surplus in the absence of inequity-aversion) will in this case end up with more than half of the surplus from trade, but not necessarily with the whole pie. The FS99 equilibrium predictions for complete contracts are shown in the third and fourth columns of table 3.

Next we discuss incomplete contracts. To see whether gift exchange type behavior will emerge in equilibrium, consider first the workers' situation. Inequity-averse workers may be willing to provide high effort in response to a sufficiently high wage, because they dislike the large inequity that would be caused by exploiting the high wage through a low effort choice. Appendix B shows that wages need to be higher than a reservation wage of 30 for this to occur. If firms were certain that workers are inequity-averse they would be willing to offer such a high wage, knowing that any worker would refrain from exploiting the offer. More specifically, appendix B (table B1) shows that in this complete information scenario wage offers in the intervals  $[0,5]$  and  $[30,35]$  can be supported in equilibrium when there is excess supply while this holds for wages in the intervals  $[5,10]$  and  $[35,50]$  with excess demand.

In our experiment, firms cannot recognize whether particular workers are inequity-averse. They can only base their decisions on distributional assumptions. If sufficient workers are inequity-averse, the profit firms make when dealing with these workers compensates for the losses when being exploited by an inequity-neutral worker. However, the existence of the information network introduces the possibility of reputation building. In the repeated game, firms may form beliefs about the inequity-aversion of a worker based on previous effort choices by that worker (which are revealed to the firm in BN). Depending on the assumption about the proportion of inequity-averse workers, in the 20 round game a plethora of equilibria may result. The appendix shows, however, that if we use the proportions of FS99 as an out of sample estimate for this distribution, there is no equilibrium where inequity-neutral workers provide high effort in early rounds in order to appear inequity-averse and obtain high wage offers in subsequent rounds. Moreover, the 'separating' situation where inequity-neutral workers receive low wages and offer low effort whereas inequity-averse workers choose high effort in response to high wages is not an equilibrium either. The case where all wage offers are

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<sup>9</sup> This assumption is also used in Brown *et al.* (2004).

low and are met with low effort is a ('pooling') equilibrium, however. The predictions corresponding to this equilibrium are the ones shown in the incomplete contracts portion of table 3.

**Table 3: Equilibrium Predictions, Inequity-averse Preferences**

|               |                      | Complete Contracts |                      | Incomplete Contracts |                     |
|---------------|----------------------|--------------------|----------------------|----------------------|---------------------|
|               |                      | DA                 | BN                   | DA                   | BN                  |
| <b>Effort</b> |                      | $e=1$              | $e=1$                | $e=0$                | $e=0$               |
| <b>Wage</b>   | <b>Excess Demand</b> | $w_{DA}=50$        | $w_{BN} \in [35,50]$ | $w_{DA}=10$          | $w_{BN} \in [5,10]$ |
|               | <b>Excess Supply</b> | $w_{DA}=20$        | $w_{BN} \in [20,35]$ | $w_{DA}=0$           | $w_{BN} \in [0,5]$  |

Notes: Numbers denote predicted wages for the treatment cells distinguished. DA=double auction market; BN=bilateral negotiations.

The equilibrium predictions shown in the incomplete contracts columns of table 3 posit no gift exchange for an environment in which simple intuition based on a variety of results from previous experimental studies suggests that considerable gift exchange will emerge.<sup>10</sup> Observe also that for incomplete contracts wages are predicted to be the same in the two recruitment channels, so that taking into account the existence of an information network is not predicted to make any difference.

What other considerations need to be taken into account? We need to consider the regularities observed in numerous laboratory studies on labor markets. Previous studies all deal with the stand-alone DA.<sup>11</sup> The DA case with incomplete contracts and excess supply of labor has been extensively studied in the literature, starting with the seminal work of Fehr *et al.* (1993).<sup>12</sup> In these previous studies firms have been found to pay wages substantially above the minimum and workers to – on average - choose effort above the lowest level. This has been observed in the context of numerous design variations and, therefore, we should expect to see similar behavior here. In our setting with binary choices for firms and workers (and a reservation wage of 30 for inequity-averse workers) this translates into a prediction of firms paying wages above 30 and workers frequently choosing the high effort level.

The question arises whether this regularity holds in the same way in an environment with excess demand of labor. We only know of one study that directly deals with this issue. Brandts and Charness (2004) find no difference in completely parallel excess demand and supply conditions. However, we need to consider that this is the result of just one study, with

<sup>10</sup> This crucially depends on the assumed distribution of inequity-aversion, for which we took the FS99 predictions (see Appendix B). For their market with repeated interaction, Brown *et al.* (2004) show that a different assumption can yield equilibria with substantial gift exchange. In our case, this would give a pooling equilibrium where all workers choose high effort in DA and BN until round 27 and only inequity-averse workers would maintain this until the end. Only in the last three rounds does this predict a difference between DA and BN.

<sup>11</sup> For our environment the considerations about behavior in the DA apply both to the rounds with the stand-alone DA and to the rounds where both recruitment channels are available.

<sup>12</sup> Whereas most studies use a one-sided auction market with firms making wage offers, Fehr and Falk (1999) show that there is little difference between behavior in a one-sided and in a two-sided (or double) auction.

different payoff functions than the ones used here, so that perhaps one should interpret it in terms of a weakening of the prior idea of a considerable treatment effect. Wages will leave the larger part of the surplus with the short side of the market, but in a less extreme way than when firms control effort because of the gift exchange taking place with incomplete contracts.

We now move to the comparison of BN and DA for incomplete contracts. The predictions in table 3 are that effort levels will be zero in both the BN and the DA and that wages will be higher (lower) in the DA than in the BN under excess demand (excess supply). However, given the occurrence of gift exchange, it seems hard to believe that providing firms with information about the past effort choices will not affect outcomes. In a different setting, Seinen and Schram (2006) show that indirect reciprocity (rewarding someone for being kind to unknown third parties) can easily be generated in the laboratory by providing subjects with information about their partner's past choices. In our setting this suggests that the higher the proportion of previous high effort choices, the higher wage offers should be expected to be. For the equilibrium shown in table 3, high wage offers would be out of equilibrium. However, if some high wages are offered initially in BN then these offers are more likely to be accepted than low offers. Low offers are more likely to be rejected possibly due to workers attempting to have better luck after switching to the DA. Consequently, the set of accepted BN offers will be a biased subset of all BN offers. We should therefore expect accepted wage offers to be higher in BN than in DA, where competitive forces drive out high offers more quickly. On average effort levels should also be expected to be higher in the BN than in the DA, since at least some of the workers will respond positively to higher wages.

These observations allow us to formulate the qualitative implications of taking into account other-regarding preferences. We capture them in six predictions, which are parallel to the six items that we derived from the case of selfish preferences. From here we will move to the formulation of formal hypotheses:

- (i) *Effort is higher under complete than under incomplete contracting.*
- (ii) *For both treatments with complete contracts, effort is the same for the DA and the BN. For both treatments with incomplete contracts, effort will be higher for the BN than for the DA.*
- (iii) *Wages are higher under complete than under incomplete contracting.*
- (iv) *Wages are higher under excess demand than under excess supply.*
- (v) *Wages are higher in the BN than in the DA.*
- (vi) *The proportion of trade through the BN will be higher with incomplete contracts than with complete contracts.*

Observe that items (i), (iii) and (iv) as well as the first part of item (ii) are the same as those for the case of individualistic preferences, so that we will not propose any formal hypotheses for them. The simple interpretation of this absence of differences is that, in our context, the existence of other-regarding preferences does not affect fundamental economic forces.

The content of the second part of item (ii) and of items (v) and (vi) leads to the following formal hypotheses tests. The null hypotheses stem from the first set of six predictions –shown in section 3.1– corresponding to individualistic preferences, whereas the alternative hypotheses come from the analogous list of six items of this section. Our first test pertains to the difference of effort between BN and DA and stems from item (ii) above:

$$H_0: e_{BN}(IC) = e_{DA}(IC)$$

$$\text{vs. } H_1: e_{BN}(IC) > e_{DA}(IC),$$

where  $IC$  denotes the treatment with incomplete contracts. Next, item (v) gives:

$$H_0: w_{BN}(IC) = w_{DA}(IC)$$

$$\text{vs. } H_2: w_{BN}(IC) > w_{DA}(IC).$$

Finally, (vi) gives the formal hypothesis:

$$H_0: \tau_{BN}(IC) = \tau_{BN}(CC)$$

$$\text{Vs. } H_3: \tau_{BN}(IC) > \tau_{BN}(CC),$$

where  $\tau_{BN}$  denotes the fraction of trades through BN and  $CC$  refers to complete contracts.

A separate question is the efficiency of bilateral trade and, in particular, a comparison of firms' and workers' earnings across recruitment channels. Note that the surplus in case of a high effort (30) is higher than the surplus with low effort (10). When contracts are incomplete high surplus is more likely to be observed in BN than in DA (item *ii*). Hence, we predict higher efficiency in BN. However, the hypotheses about wages and effort levels do not speak to whether this higher surplus benefits both parties or just one. In the equilibrium involving the FS99 proportions of inequity-averse participants, wages that induce high effort are all above 30 (*cf.* Appendix 2) and workers are better off in the high-wage-plus-high-effort case than with low-wage-plus-low-effort. As long as wages are below 40, firms are better off in the former case as well. Hence, both workers and firms are better off in BN for these wages. Wages in the interval [40,50] will only be observed in the excess demand treatment. Even here, firms will –on average– be better off in BN than in DA because inequity-aversion of both parties will yield lower wages in BN. Therefore, with incomplete contracts both parties are better off in BN. This leads us to one additional prediction for the case of other-regarding value orientations.

(vii) *With incomplete contracts, both firms and workers earn more in bilateral negotiations than in double auctions.*

Formally, we test:

$$H_0: \pi_f(BN, IC) = \pi_f(DA, IC)$$

$$\text{vs. } H_{4A}: \pi_f(BN, IC) > \pi_f(DA, IC)$$

$$H_0: \pi_l(BN, IC) = \pi_l(DA, IC)$$

$$\text{vs. } H_{4B}: \pi_l(BN, IC) > \pi_l(DA, IC)$$

Finally, though we started from the FS99 model (eq. *B1* in Appendix 2) as our benchmark regarding preferences in our experiment, we realize that both direct and indirect reciprocity resulting from other motivations than inequity-aversion may affect behavior. If reciprocity affects our comparative static hypotheses at all, it reinforces the predictions discussed above. Therefore, the effects of reciprocity are covered by  $H_1$ - $H_4$ .

## 4. Results

We start with a general overview of some key statistics. This is followed by a comparison of behavior across treatments, considering channel choice, wage levels, effort choices, and efficiency, respectively. Where applicable, these comparisons include formal tests of the hypotheses derived in section 3. These tests are summarized in the final subsection. Unless stated otherwise, tests are either (two-sided) Mann-Whitney (for independent samples) or Wilcoxon (paired samples) tests using market averages across rounds as units of observation.

### 4.1. General Overview

In total, we have data from 21 groups involved in 30 rounds each. Table 4 summarizes the key statistics of our results. In each round there are at most two trades in each market, yielding 1260 possible trades. In aggregate we observed 1214 trades (96.3%), indicating that almost all potential trades were realized. In all treatments, more than 90% of all possible trades were realized. Of these trades, approximately 30% were made through BN when contracts were incomplete but only 10% when contracts were complete. When considering wages, a first thing to notice is that DA wages did not differ much between the first 10 rounds and rounds 11-30. Apparently, the available BN option does not affect the DA. Moreover, wages appear to be higher in BN than in DA when contracts are incomplete but not necessarily so for complete contracts. As for effort, first notice that, almost all firms chose high effort in the complete contracts case.<sup>13</sup> With incomplete contracts, there appears to be a

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<sup>13</sup> The relatively low percentage (82.4%) in BN with excess supply can be attributed to a low number of observations (17; 14 of which were followed by a high quality choice).

clear ranking.<sup>14</sup> The lowest percentage of high effort choices is observed in DA when there is no BN alternative while high effort is chosen most frequently after a bilateral deal. The percentage of high effort choices in DA in rounds 11-30 is somewhere in between.

**Table 4: Key Statistics**

|               |    |        | % of possible trades | % trades in BN | Average DA wage | Average BN wage | % high effort DA | % high effort BN |
|---------------|----|--------|----------------------|----------------|-----------------|-----------------|------------------|------------------|
| Excess supply | CC | R1-10  | 100                  | --             | 21.0            | --              | 96.0             | --               |
|               |    | R11-30 | 99.5                 | 8.5            | 20.8            | 23.4            | 97.3             | 82.4             |
|               | IC | R1-10  | 96.0                 | --             | 15.7            | --              | 26.0             | --               |
|               |    | R11-30 | 96.5                 | 28.5           | 18.3            | 25.9            | 39.1             | 49.1             |
| Excess demand | CC | R1-10  | 100                  | --             | 46.2            | --              | 98.0             | --               |
|               |    | R11-30 | 97.5                 | 10.8           | 46.3            | 40.0            | 100              | 100              |
|               | IC | R1-10  | 95.0                 | --             | 27.4            | --              | 38.6             | --               |
|               |    | R11-30 | 90.4                 | 30.9           | 28.3            | 34.2            | 48.0             | 76.1             |

*Notes.* IC= incomplete contracts; CC= complete contracts. R1-10 refers to first 10 rounds (without bilateral negotiations); R11-30 refers to rounds 10-30. % of possible trades is number of realized trades as percentage of possible trades. % of trades in BN is number of bilateral deals as percentage of realized trades. Average DA wage= average wage realized in the double auction; average BN wage= average wage in bilateral deals. % high effort DA= number of high effort choices after double action trade as percentage of trades in double auction; % high effort BN= number of high effort choices after bilateral deal as percentage of bilateral deals.

To get a further impression of the dispersion in our data, figure 2 shows scatter plots of all trades realized in the various treatment combinations, distinguishing between DA trades and trades in BN. Together with table 4, this gives rise to the following impressions. First, market imbalance matters. With excess supply, wages tend to be between 0 and 5 or 20 and 35 whereas excess demand yields wages between 5 and 10 or 35 and 50. This means that the short side of the market manages to get at least half of the surplus from trade. Second, incomplete contracts lead to more wage volatility and to wages that are closer to the equal split level of 35. Third, both DA trades and BN trades occur. From table 4, we know that wages are higher in BN, though this is hard to discern in the graph. Finally, there may be some adaptation in the first few rounds, but after round 5 the results remain remarkably constant. In particular, there is no obvious effect on DA of introducing BN in round 11 (as observed in table 4).

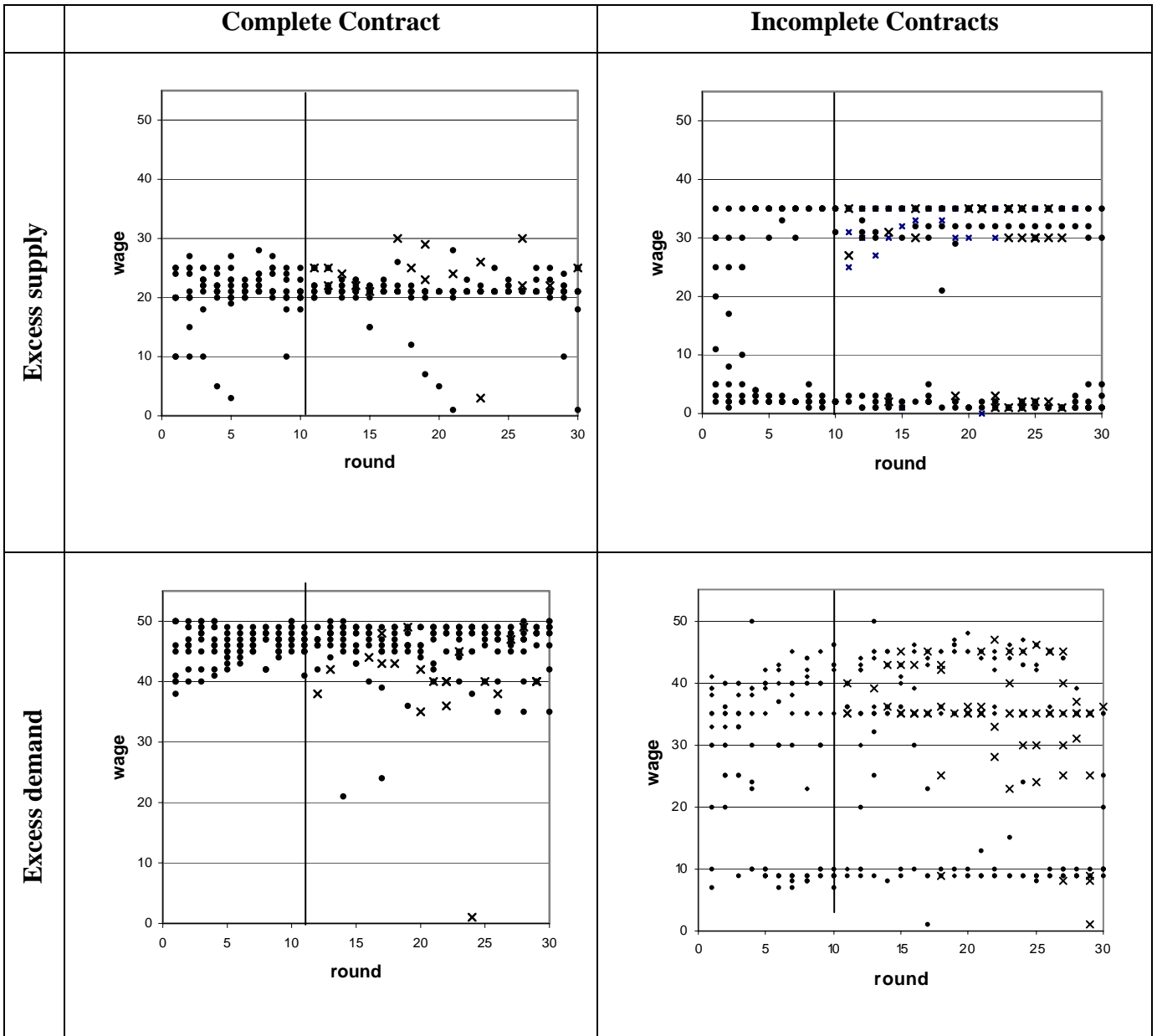
#### 4.2. Channel Choice

We first consider the *process* of choosing bilateral negotiations. Recall that firms could start by offering BN to some unknown worker. The number of firms offering BN varied strongly across treatments. In line with intuition, fewer firms were willing to forgo the market opportunities when there was excess supply (32.3%) than with excess demand (81.8%). For

<sup>14</sup> The observed 39.1% of high effort choices in DA for the excess supply scenario with incomplete contracts reinforces the typical gift exchange observed in many previous experiments (*cf.* section 3 for references).



Figure 2: Trades



Notes. Dots indicate for every round (horizontal axes) all trades in DA (at the prices indicated on the vertical axes) and crosses indicate trades in the BN. In the first 10 rounds (separated by a vertical line) only DA trades were possible. Depending on the treatment, either 10 or 12 trades per round were possible (two for each market; cf. table 1). Multiple observations at the same point are indicated by a single dot or cross.

workers, the effect is reversed. When offered the possibility, 99.5% of the workers seized the opportunity to enter BN in case of excess supply, whereas 50.4% of the workers were willing to negotiate when there was excess demand. These numbers show that the long side of the market is almost unanimously willing to bypass the DA but that the fraction of the short side that is willing to do so is still substantial. Once in the negotiations, the acceptance rate of wage proposals also depends on the market imbalance. Table 5 shows the average BN offer and the acceptance rate per treatment. Whereas wage offers are higher when labor is scarce, they are not high enough, because fewer offers are accepted.

**Table 5: Bilateral Negotiations**

|                          | Excess Supply        |                    | Excess Demand        |                    |
|--------------------------|----------------------|--------------------|----------------------|--------------------|
|                          | Incomplete Contracts | Complete Contracts | Incomplete Contracts | Complete Contracts |
| Average wage offer       | 17.52                | 21.65              | 26.14                | 36.94              |
| Acceptance rate (%)      | 63.2                 | 42.5               | 46.9                 | 25.3               |
| Fraction of trades in BN | 0.28                 | 0.09               | 0.30                 | 0.11               |

The last row of table 5 shows the fraction of trades that were bilaterally negotiated. As observed in table 4, this fraction is higher for the incomplete contract cases than for complete contracts.<sup>15</sup> The market condition does not appear to affect the fraction of trade though BN. Neither for incomplete, nor for complete contracts does a systematic difference occur between excess demand and excess supply. To test  $H_3$  ( $\tau_{BN(IC)} > \tau_{BN(CC)}$ ), we can therefore pool the data across market conditions. This gives 10 observations (average fractions across 20 markets) for complete contracts and 11 for incomplete contracts. The difference is statistically significant at the 1%-level. Thus, we reject the null hypothesis derived assuming (common knowledge of) selfish preferences in favor of the alternative described by  $H_3$ .

### 4.3. Wage Levels

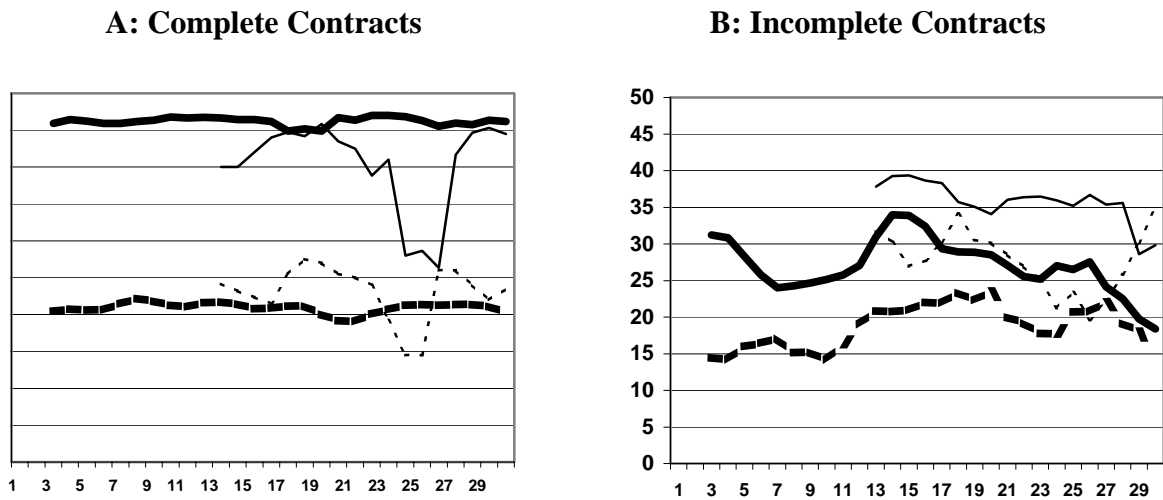
Wages may be affected by expected effort levels as well as by market imbalance and the channel chosen for the transaction. Because high effort is virtually always chosen when contracts are complete whereas many instances of low effort are observed with incomplete contracts, figure 3 shows the development of wages separately for these two treatments. To smooth out short-term volatility, the figures show 3-period moving averages.

We start by comparing wages in incomplete and complete contracts. Recall that both predictions derived from selfish preferences and those based on inequity-aversion are that wages will be higher in the latter case. Statistically, this is supported for DA wages ( $p=0.036$ ) but not for BN wages ( $p=0.132$ ). Distinguishing between excess supply and excess demand shows marked differences, however. When there is excess demand, both DA wages ( $p=0.004$ ) and BN wages ( $p=0.052$ ) are statistically significantly higher with complete contracts, whereas equal wages in complete and incomplete contracts cannot be rejected in either channel when there is excess supply ( $p=0.841$ ,  $p=0.690$ , respectively).

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<sup>15</sup> A round-by-round analysis gives no evidence of a trend across rounds, though there is some indication that fewer trades are made bilaterally in the final two rounds. The numbers are too low to do any statistical analysis, however.

**Figure 3: Average Wages**



*Notes.* 3-period moving averages of observed wages are shown for complete (left panel) and incomplete contracts (right panel). Dashed lines show wages for excess supply and solid line reflect excess demand. Thick lines show wages for trades in DA and thin lines show BN wages.

Next, focus on complete contracts. A first thing to note is the stability of DA wages. These wages allocate most of the surplus to the short side of the market.<sup>16</sup> Wages in BN are slightly less extreme and much more volatile. We saw in section 4.2, however, that the number of trades in BN is low for complete contracts, so it difficult to draw conclusions from these observations.

With incomplete contracts, wages are averaged across trades that workers responded to by choosing high effort and those that yielded low effort. The volatility across time and any treatment effects observed in the right panel of figure 3 may therefore be a consequence of changes in wages for given effort choice or changes in effort choices (*cf.* section 4.4). Nevertheless, two regularities appear. First, wages are higher with excess demand than with excess supply. Second, average wages are higher in BN than in DA (as noticed in table 4). The former observation (which also holds for complete contracts) is predicted both when assuming selfish preferences and for inequity-aversion. The data show that the difference is statistically significant: the average wage in BN is higher with excess demand than with excess supply ( $p=0.085$ ) and the same holds for DA ( $p=0.024$ ).<sup>17</sup> The second observation (higher wages in BN) is predicted by  $H_2 (w_{BN}(IC) > w_{DA}(IC))$ . The formal (Wilcoxon) test of this hypothesis is based on 11 paired observations and shows that the difference is statistically

<sup>16</sup> With excess demand the average wage in DA is 46.2, implying that 87% of the surplus (30) is absorbed by the workers. With excess supply, the average DA wage of 20.8 means that only 3% of the surplus goes to the workers.

<sup>17</sup> We pool data across complete and incomplete contracts to obtain 10 excess supply observations and 11 excess demand observations.

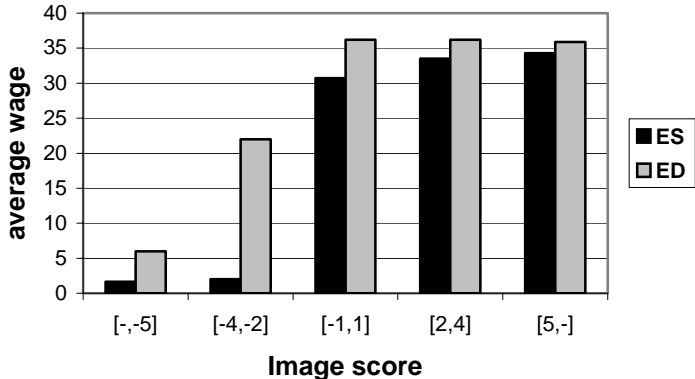
significant ( $p=0.01$ ).<sup>18</sup> Hence, we once again reject the null based on selfish preferences in favor of the alternative hypothesis based in inequity-aversion.

To summarize the results for wages: (1) market imbalance gives most of the surplus to the short side of the market; (2) complete contracts give higher wages in case of excess demand but not for excess supply; (3) wages are higher when bilaterally negotiated than when agreed upon in the market.

Finally, we consider the effect of a worker’s reputation on the transaction wage in BN. Figure 4 shows this relationship. Of course, only the treatment with incomplete information is considered, because there is no worker reputation when contracts are complete. The worker’s reputation is measured through the image score, which is the difference between previous high effort choices and previous low effort choices. This is the score that the firm sees before making a wage offer in BN. It is at the core of our research design as it represents the influence of the firms’ information network.

The results show that firms avoid making high wage offers to workers who previously have tended to choose low effort. It does not seem to matter whether the worker chose high effort more often, as long as the image score is not too negative. When firms compete for scarce workers in the excess demand (ED) treatment, a slightly negative score is often met with a high wage offer.

**Figure 4: Wages and Worker Reputation**



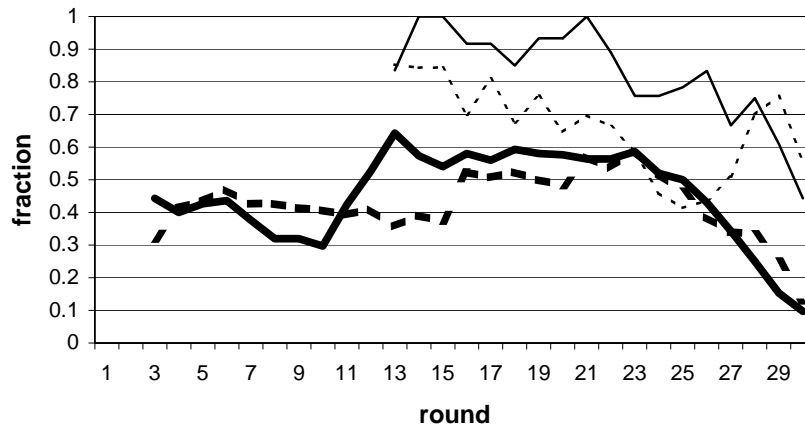
*Notes.* Bars give average realized wages per reputation category. The reputation is measured as the number of times the worker previously chose high effort minus the number of times she chose low effort (only for rounds 11-30). ES=excess supply; ED=excess demand.

<sup>18</sup> Testing separately for excess supply (5 paired observations) and excess demand (6 paired observations) supports this conclusion ( $p=0.043$  and  $p=0.075$ , respectively).

#### 4.4. Effort Choices

Given that the rational high effort choice is virtually always made in the complete contracts case (*cf.* table 4) we focus only on the incomplete contract treatments. To start, figure 5 shows the development over time of the fraction of high effort choices. Once again we present 3-period moving averages to smooth out period-to-period volatility.

**Figure 5: Fraction of High Effort Choices**



*Notes.* The figure shows 3-period moving averages of the fraction of high effort choices. Dashed lines show fractions for excess supply and solid line reflect excess demand. Thick lines show effort choices following trades in DA and thin lines for BN.

The graph shows three noticeable patterns in the dynamics. First, as we saw in table 4, when BN are introduced, workers are more willing to choose high effort, though this occurs more directly with excess demand than with excess supply. Second, there is a clear end effect, especially in DA, with the fraction of high effort choices dropping severely in the last 5 rounds. Third, high effort is chosen more often after a bilateral trade than after a trade on the market.

Because effort choice depends on the wage received, we cannot draw conclusions about the effect of market imbalance or of the channel chosen on effort choice without correcting for the wage. For example, we know from the previous subsection that average wages are higher in BN than in DA. To determine whether the higher effort in BN is only a consequence of the higher wage or that the channel itself also affects the effort level, we ran a random effects probit model explaining (high) effort as a function of wage, market imbalance and channel while correcting for the round of play. The results are presented in table 6.<sup>19</sup>

<sup>19</sup> Because the regression is only concerned with the rounds with BN, we normalize the first of these rounds as 1. To account for the end effect observed in figure 6, we include a quadratic form of the round in the regression

**Table 6: Random effects probit for effort choice**

| Variable                     | coefficient | absolute z-value |
|------------------------------|-------------|------------------|
| Constant                     | -7.539      | 3.07***          |
| (round-10)/10                | 0.078       | 1.222            |
| (round-10) <sup>2</sup> /100 | -0.635      | 2.05**           |
| excess demand                | 5.336       | 2.12**           |
| BN                           | 0.355       | 0.07*            |
| (wage in ES)/10              | 2.371       | 3.22***          |
| (wage in ED)/10              | 0.751       | 7.01***          |

*Notes.* The table presents the results of a random effects probit regression model where the dependent variable is a dummy indicating whether or not worker  $i$  in market  $j$  chose high effort in round  $t$ . Formally, it gives the estimated maximum likelihood coefficient vector  $\beta$  in  $Pr_t^{ij} = \Phi(X_t^{ij} \beta + \mu^j)$  where  $Pr_t^{ij}$  gives the probability that  $i$  of  $j$  chooses high effort in  $t$ .  $\Phi$  denotes the cumulative normal distribution and  $X$  is the vector of independent variables described in the first column of the table.  $\mu^j$  is a (white noise) market-specific error that corrects for the dependencies across individual decision in the same market (the fraction of total variance captured in  $\mu^j$  is captured by parameter  $\rho=0.10$ ). Absolute z-values are in parentheses. \*=statistically significant at 10%-level; \*\*=statistically significant at 5%-level; \*\*\*= statistically significant at 1%-level.

These results show that after correcting for wage offers high effort is more often chosen in ED than in excess supply (ES). What appears to be happening is that workers compensate for their low number of trades in ES by exploiting high wage offers more often than in ED. Moreover –in support of  $H_1$  ( $e_{BN}(IC) > e_{DA}(IC)$ )– high effort is more often chosen after a bilaterally negotiated trade even after correcting for wage differences between BN and DA. Finally, wage does indeed strongly affect the effort chosen, both in ED and in ES. The effect is much larger with excess supply but statistically stronger in ED.

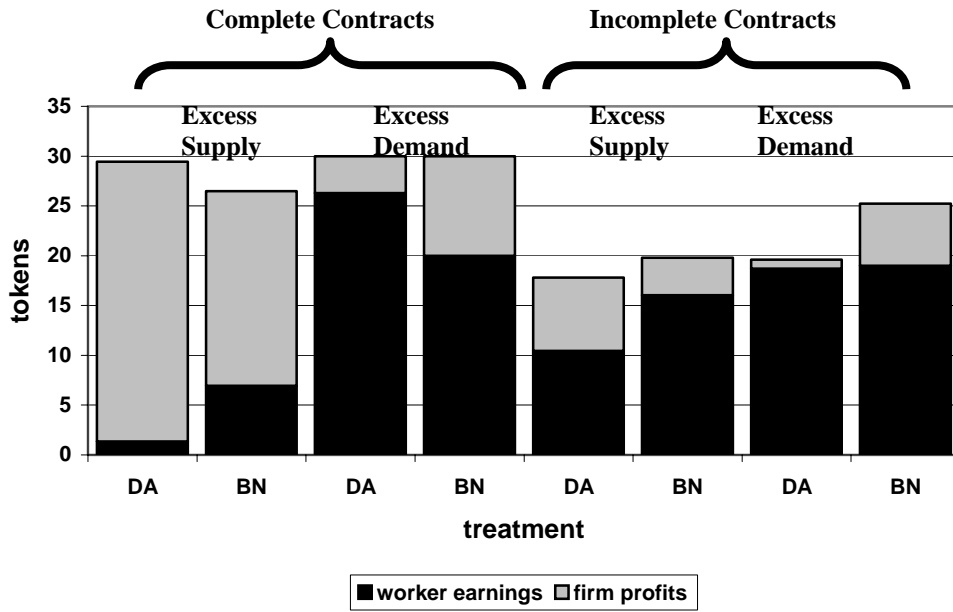
#### 4.5. Efficiency

Finally, we investigate the earnings of firms and workers in BN and DA. Recall that in any treatment, surplus is maximized when high effort is chosen. Consequently, the development of efficiency over time with incomplete contracts is fully determined by the development of high effort choices shown in figure 5. With complete contracts, efficiency is usually 100% because high effort is almost always chosen (*cf.* table 4). The comparative statics observed for effort choice carry over to efficiency as well (*e.g.*, trading bilaterally is more efficient than trading on the market when contracts are incomplete). The next question is which side of the market obtains the larger part of the surplus. Figure 6 shows the division of surplus between workers and firms across treatments.

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equation (the results of which do indeed reflect this end effect). Finally, we allow the effect of wage on effort to

**Figure 6: Surplus Division**



*Notes.* Bars represent average realized surplus in a treatment, which is divided between workers (black segment) and firms (grey). DA=double auction; BN=bilateral negotiations.

A first thing to note from the figure is that surplus is close to its maximum when contracts are complete.<sup>20</sup> In these cases the larger part of this surplus is allocated to the short side of the market, but the division between firms and workers is more equitable in BN than in DA. Note that this latter result supports the assumption made in section 3 that equity concerns are more important in BN than in DA.

For incomplete markets, we know from the analysis in preceding sections that compared to DA, in BN (i) wages are significantly higher; (ii) these higher wages yield significantly higher effort choices; and (iii) even for equal wages, high effort is significantly more likely to be chosen in BN. Hence, surplus is significantly higher in BN than in DA. The question that remains is whether firms and workers both benefit from the higher surplus (as predicted by  $H_{4A}$  ( $\pi_f(BN, IC) > \pi_f(DA, IC)$ ) and  $H_{4B}$  ( $\pi_l(BN, IC) > \pi_l(DA, IC)$ ). Figure 6 shows that with excess demand, both sides of the market earn more in BN than in DA; a true Pareto improvement. With excess supply firms earn less in BN than in DA, however. None of these differences are statistically significant, however. Hence, our data do not allow us to reject  $H_0$  in favor of  $H_4$ .

be different for ED than for ES.

<sup>20</sup> The only exception is when trades are bilateral and there is excess supply, but recall from footnote 13 that this involves only 17 trades.

#### 4.6. Summary of the Results

We summarize our results by comparing behavior in BN and DA for our four treatment cells.

- (1) When contracts are complete and there is excess supply firms face a relatively easy situation. They know that they can create high surplus by choosing high effort (which virtually all of them do) and they have the advantage of being on the short side of the market. We observe that they are hesitant to enter BN. If they do, they offer relatively low wages (at which they would keep most of the high surplus). Because less than 50% of these offers are accepted, in the end roughly only one-tenth of all trades are bilaterally negotiated. Wages in DA allocate almost the complete high surplus to the firm, whereas the few BN trades that take place share approximately 25% of this surplus with the worker.
- (2) With complete contracts and excess demand firms know they will choose high effort (which they do) but they also have to compete with other firms for the scarce workers. Therefore, almost all firms propose negotiations, but 50% of the workers decline the opportunity offered. The workers that do decide to negotiate are offered wages that give them a larger cut of the pie than the firm, but the average offer is relatively low compared to wages on the market. Only 25% of these offers are accepted, resulting in approximately one-tenth of the trades being bilateral. In these bilateral trades, workers receive roughly two-thirds of the surplus whereas they end up with almost 90% of the surplus when they trade on the double auction market.
- (3) The case with incomplete contracts and excess supply is the situation most studied in the literature on gift exchange in the labor market. This is an interesting scenario because the firms have the advantage of being on the short side of the market but the disadvantage of facing the moral hazard of the worker's effort choice. When offered the possibility, firms are hesitant to enter BN. If they do enter, they offer low wages compared to the other treatments but these offers meet with the highest acceptance rate of all treatments. This leads to roughly 30% of all trades bypassing the market. Though wages are relatively low in BN, they are even lower in DA. While the average worker does respond to a higher wage with higher effort (and additionally offers higher effort in BN even when correcting for wage differences), workers do regularly exploit high offers by choosing low effort. Note that due to excess supply any particular worker is, on average, only involved in a trade once every 2.5 rounds. Apparently, some workers take the opportunity to make a high profit when they have a chance to do so. Because of being exploited in some rounds,



firms earn on average less in BN than in DA, though a higher average surplus is observed in BN.

- (4) Finally, when contracts are incomplete and there is excess demand firms are at a disadvantage on two dimensions. They generally offer to trade bilaterally, but only 50% of the workers accept this opportunity. When they do, they typically get a relatively high offer and roughly half of the workers accept the wage, resulting in approximately 30% of all trades being negotiated bilaterally. Wages in DA are lower than in BN because BN offers can be conditioned on the worker's history of effort choices. This indeed yields regular high effort choices, with their likelihood being higher, the higher the wage (and higher in BN even after correcting for wage differences). As a consequence, both firms and workers earn on average more after a bilateral trade than after a trade on the market.

With respect to the formal hypotheses derived in section 3, we rejected the null hypotheses based on selfish preferences in favor of the following alternatives based on inequity-aversion:  $H_3$  (more bilateral trades for incomplete contracts);  $H_2$  (higher wages in BN); and  $H_1$  (more high effort in BN).  $H_4$  (higher earnings in BN) was not supported statistically.

## 5. Conclusions

An important tradeoff that firms face when recruiting new personnel is between the wage transparency of the market and the information transmitted through social networks. Field studies have shown that –contrary to many economists' intuition– firms regularly bypass the market and choose to recruit through their social networks. Our study replicates this observation in a controlled laboratory environment and provides a rationale for it. We show that it is the interaction between social preferences, the incompleteness of contracts and the existence of information about a worker's past performance that provides a reason for firms to forgo market opportunities and bilaterally negotiate with a worker. Given that the information transmitted through a firm's network concerns the worker's trustworthiness in jobs with moral hazard, the network provides an alternative for market trading. We observed that approximately 30% of all job contracts were bilaterally negotiated in this case as opposed to only 10% when contracts were complete.

Our results show that this alternative is welfare increasing; efficiency is higher when trades are bilateral. When labor is scarce the social network information even allows for true Pareto improvements compared to the market, because both firms and workers earn more in bilateral contracts. Of course, this does not imply that a situation with only bilateral trading would be most efficient. The choice of channels is endogenous in our experiment and this

yields an increase in welfare compared to only market trading. How an exogenously imposed limit on market trading would affect welfare is an open question that could be studied in future research. Intuitively, we doubt that such restrictions would have a positive effect on welfare. In our experiments, it is important that bilateral negotiators have the market as an outside option.

Together with the results presented by Brown *et al.* (2004) an interesting picture arises from our results. Whereas we show that information networks increase the efficiency of first time wage contracts, they show that –once a good first match has been found– bilateral trading on extended contracts increases efficiency even further. Hence, firms first call upon their networks to help find a trustworthy employee and offer such an employee a wage based on indirect reciprocation of this worker’s past performance in other jobs. Once they have found a worker, they base their continuing relationship on mutual direct reciprocation where workers respond to high wages with high effort (as we also observe in the one round interaction we study) and *vice versa*.

In our model, the source of reciprocation is the inequity-aversion of workers. If enough workers dislike exploiting high wage offers firms may be willing to take the risk of offering one. Networks are a source of information for firms about the likelihood that a particular worker will exploit a high wage. Because of anonymity this information is not disseminated through a centralized market. This is why centralized market institutions may be imperfect, allowing alternative institutions (*i.c.*, information networks) to increase efficiency.

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## Appendix A

This appendix gives the English translation of the original Dutch instructions for the sessions with incomplete contracts and excess supply of labor. (*Italics indicate places where alternative texts were used for other treatments*). The instructions were programmed as html pages. Horizontal lines indicate page separations.

### At the start of the experiment:

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#### Welcome

You are about to participate in a decision-making experiment. The instructions are simple. If you follow them carefully, you may earn a substantial amount of money. Your earnings will be paid to you in euros at the end of the experiment. This will be done privately, one participant at a time.

The monetary unit in the experiment is '**experimental francs**'. At the end of the experiment francs will be converted to euros at a rate of **1 euro for 15 francs**.

These instructions consist of 8 pages like this one. During the instructions you can page forward or backward by clicking with your mouse on 'previous page' or 'next page'. Sometimes a page will not fit on your screen. In that case you can use the scroll bar to view the whole page.

[Next page](#)

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#### Rounds and Groups

The experiment consists of 30 rounds, preceded by 3 practice rounds. After round 10 additional instructions will be given before we proceed.

In every round you will participate in a market where hypothetical goods are traded. Buyers can buy at most one good and sellers can sell at most one good. How you can make money by trading will be explained below.

In total 7 people participate in the market. There are 2 buyers and 5 sellers. (*There are 5 buyers and 2 sellers*). You will have the same role in every round: either buyer or seller. That will be determined before the first practice round. The other buyers and sellers in your market will be the same other participants in every round. You do not know who they are, however. Because there are more sellers than buyers (*more buyers than sellers*) in each round at least three sellers (*buyers*) will not be able to sell (*buy*) the good.

The composition of markets is anonymous. You do not know with whom you are in the market. Others do not know whether they are with you.

[Previous page](#) [Next page](#)

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#### Buying and Selling the Good

If the buyer buys from a seller s/he pays an agreed upon price. How the price is determined will be explained below.

To deliver the good, the seller may endure costs. There are two possibilities. If the seller delivers a **low quality** good, there are **no costs**. If the seller delivers a **high quality** good the costs are **20 francs**.

If a buyer gets the good s/he receives a revenue in francs. If the buyer buys a **low quality** good this revenue is **10 francs**. For a **high quality** good the revenue for the buyer is **50 francs**. This allows you to calculate earnings in a round, dependent on the quality.

**1. The good has low quality:**

Earnings for the **seller** = agreed upon price

Earnings for the **buyer** = 10 – agreed upon price

**2. The good has high quality:**

Earnings for the **seller** = agreed upon price – 20

Earnings for the **buyer** = 50 – agreed upon price

**If you do not buy or sell anything your earnings are 0.**

[Previous page](#) [Next page](#)

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## Phases

Each round consists of two phases.

In the **first phase** of a round buyers and sellers participate in a public market where each buyer can respond to an offer by any seller and vice versa.

In the **second phase** it is determined whether the good has **low** or **high** quality. This is determined by the **seller** (*buyer*).

[Previous page](#) [Next page](#)

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## Phase 1

Participation in the public market proceeds as follows. Buyers may post an offer for the good and this offer holds for every seller in the market. Sellers may post an ask price en this holds for every buyer.

On the lower half of your screen you wil see two rows of boxes. In the top row there is a box for each buyer. In the lower row there is a box for each seller.

You will recognize your own box by its yellow collar.

**BEWARE: buyers and sellers are randomly reallocated to boxes in every round. Therefore, you cannot keep track across rounds of what specific other participants are doing.**

[Previous page](#) [Next page](#)

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## Phase 1

If a buyer or seller places an offer on the public market, this appears in her or his box.



If you are a seller you will see a button 'accept' next to each buyer's box. By clicking this you indicate that you will sell the good to that buyer at that price. You can only click the button if the buyer concerned is still active on the market. If the buyer has already bought from another seller you can no longer click 'accept' You can still see at what price that buyer bought the good (and you will see the same price in the box of one of the sellers).

**If you enter an ask price lower than the highest bid by any buyer, you will automatically sell the good at the price offered by that buyer.**

If you are a buyer you will see a button 'accept' next to each seller's box. By clicking this you indicate that you will buy the good from that seller at that price. You can only click the button if the seller concerned is still active on the market. If the seller has already sold to another buyer you can no longer click the button. Again, you will still see the price.

**If you enter a bid higher than the lowest ask price by any seller, you will automatically buy the good at the price asked by that seller.**

You may change your bid or ask as often as you like. It does hold that **a buyer may only increase the own bid. A seller may only decrease the own ask.**

The public market will remain open for 90 seconds. You will see the time count down on your screen. Whoever has not bought or sold when the market closes does not buy or sell the good in that round. When no more sales are possible (2 goods have been sold) the clock automatically jumps down to 5 seconds.

[Previous page](#) [Next page](#)

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## **Phase 2**

In phase 2 the seller (*buyer*) determines the quality of the good. S/he does this by clicking either 'high' or 'low' and confirming the choice.

As mentioned before: if the quality is low, the revenue for the buyer is 10 and the costs for the seller are 0. if the quality is high, the revenue for the buyer is 50 and the costs for the seller are 20.

When everyone has finished the next round starts.

[Previous page](#) [Next page](#)

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## **End**

This brings you to the end of these instructions. When everyone is ready we will start the first of three practice rounds. These will not affect your earnings. At the start of the practice rounds we will distribute a summary of the most important parts of these instructions.

When the first practice round starts you will see at the top of your screen whether you are a buyer or seller.

If you have finished these instructions, please indicate this by clicking the button 'ready' (at the bottom of this screen). Then please wait quietly until everyone is ready. That may take a little while, so we ask for your patience.

[Previous page](#) [Back to first page](#)

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## Before Rond 11:

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An Additional Phase

We add a third phase to each of the 20 rounds that will follow.

Therefore, from now on each round will consist of three phases. We will first give a brief overview and then provide more details about each phase.

In the **first phase** each buyer can propose to one seller to **negotiate** a price for the good **separately** from the other participants. The seller will be given an opportunity to indicate whether or not s/he is willing to negotiate bilaterally. The seller may also decide in phase 1 not to negotiate bilaterally with any buyer (but to only participate in the public market, instead).

In the **second phase** of a round buyers and sellers negotiate about a price for the good. If a buyer and seller have agreed to participate in bilateral negotiations, they negotiate privately. Any participant not involved in bilateral negotiations participates in a **public market** like the one in rounds 1-10. Thus, the market is opened at the same time as the private negotiations take place. Those negotiating bilaterally will see what is happening on the public market but cannot participate in it. If the negotiations do not lead to an agreement the buyer and seller concerned can switch and participate in the public market.

No one participating in the public market can observe anything that is occurring in any private negotiations.

In the **third phase** the quality of the good (**low** or **high**) is again determined by the **seller** (*buyer*).

[Next page](#)

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### Phase 1

In phase 1 buyers first indicate whether they want to immediately proceed to the public market or first want to privately negotiate with a seller. This is done using the buttons 'market' and 'negotiate'.

By clicking on 'market' the buyer indicates not wanting any private negotiations.

By clicking on 'negotiate' the buyer indicates a wish to negotiate bilaterally with a seller. Because there are more sellers than buyers (*more buyers than sellers*), not every seller will be invited to negotiate (*it may occur that not every seller who wants to negotiate will be able to do so*). **A random lottery will be used to determine which seller (*buyer*) will be linked to a buyer (*seller*).**

**BEWARE: in every round the sellers are randomly allocated to buyers who wish to negotiate. A buyer can therefore not know whether or not s/he has previously negotiated with a seller and a seller cannot know whether s/he has previously negotiated with a buyer.**

[Previous page](#) [Next page](#)

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## Phase 1

If a seller is offered private negotiations with a buyer s/he must indicate whether or not s/he is willing to participate in them. This is done by clicking 'yes' or 'no' and confirming the decision.

If a buyer and seller thus agree to negotiate bilaterally the buyer is given **information about the seller** before the negotiations start.

This information is **the number of times that the seller chose (*was confronted with*) low quality and the number of times that the seller chose (*was confronted with*) high quality in previous rounds.**

**BEWARE: the count of the numbers of low and high quality starts now. No information will be given about choices in rounds that have at this point been finished.**

[Previous page](#) [Next page](#)

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## Phase 2

In phase 2 buyers and sellers negotiate the price of the good.

In the market, things proceed precisely as in the first 10 rounds. The only difference is that sometimes not everyone is participating. Recall that those involved in private negotiations are not participating in the market. For these buyers and sellers you will see empty boxes in the market.

Here we explain what happens when buyers and sellers negotiate bilaterally. During these negotiations they can continuously see at the bottom of their screen what is happening in the public market.

The negotiations proceed as follows. After the buyer has seen the seller's choices (*experiences*) in previous rounds the buyer places a bid for the good. This number is entered in the location provided after which the button 'confirm' must be clicked.

Next, the seller must indicate whether or not s/he accepts the bid. This is done by clicking 'yes' or 'no' and confirming.

**If the seller accepts the bid**, the buyer and seller must wait until all participants are ready before proceeding to phase 3. Participants in the market only notice this by the fact that the corresponding boxes are never activated. Therefore, no one in the market knows the results of private negotiations.

**If the seller does not accept the bid**, then the buyer and seller can both participate in the public market, if it has not been closed yet. On your screen you will directly enter the market.

[Previous page](#) [Next page](#)

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## Phase 3

In phase 3 the seller (*buyer*) determines the quality of the good. S/he does this, just like in the first 10 rounds, by clicking 'high' or 'low' and confirming.

It still holds that a low quality means that the revenue for the buyer is 0 and the costs for the seller are 0. A high quality means a buyer revenue of 50 and seller costs of 20

When everyone has finished, the next round starts.

[Previous page](#) [Next page](#)

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## **End**

This brings you to the end of these instructions. When everyone is ready we will proceed with round 11 of the experiment. We point out once more that we will start counting sellers' quality choices (*experiences*) now. This information will be made known to buyers if they bilaterally negotiate with the seller concerned.

First, we will distribute a summary of the most important parts of these instructions.

If you have finished these instructions, please indicate this by clicking the button 'ready' (at the bottom of this screen). Then please wait quietly until everyone is ready. That may take a little while, so we ask for your patience.

[Previous page](#) [Back to first page](#)

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## Appendix B: Derivation of the Hypotheses

In a companion paper (Schram *et al.* 2007; henceforth SBG) we provide a theoretical analysis for a general case. In this appendix, we derive hypotheses for the specific parameters of our experiment.

### B1. Inequity-neutral Preferences

To start, note that the theoretical predictions for the *one-shot* case are straightforward if we assume that it is common knowledge that all participants are only interested in their own monetary earnings. High effort will always be chosen when contracts are complete and low effort when they are incomplete, independent of whether the trade is made in the market or through the information network. Therefore,  $w_{DA}, w_{BN} \in [20,50]$  with complete contracts and  $w_{DA}, w_{BN} \in [0,10]$  for incomplete contracts. Where in these intervals wages will depend on the direction of market imbalance in the market as a whole. For the *finitely repeated* game, the assumption of common knowledge of self-interested players together with the usual backward induction arguments imply that the one-shot prediction is expected in every round. More specifically, considering only wages at integer values and assuming that participants will not engage in contracts at boundary wages (which yield zero profit to one of the partners) for our parameters the effort and wage predictions for any round are those given in table 2 in the main text.<sup>1</sup> These predictions yield the null hypotheses ( $H_0$ ) presented in section 3.

### B2. Inequity-aversion

Next, assume that (some) participants are inequity-averse in the sense of Fehr-Schmidt (1999) (FS99). This model has been successful in explaining a good number of experimental results.<sup>2</sup> For our parameters, the model gives the utilities  $U$  attributed to wage  $w \in \{w_{DA}, w_{BN}\}$ :

$$\begin{aligned} U_i(w) &= 50-w - \alpha_i \max\{2w-70, 0\} - \beta_i \max\{70-2w, 0\}, i \in F, \text{ high effort} \\ U_j(w) &= w - 20 - \alpha_j \max\{70-2w, 0\} - \beta_j \max\{2w-70, 0\}, j \in L, \text{ high effort} \\ U_i(w) &= 10-w - \alpha_i \max\{2w-10, 0\} - \beta_i \max\{10-2w, 0\}, i \in F, \text{ low effort} \\ U_j(w) &= w - \alpha_j \max\{10-2w, 0\} - \beta_j \max\{2w-10, 0\}, j \in L, \text{ low effort,} \end{aligned} \quad (\text{B1})$$

where  $\alpha_i > \beta_i > 0 \wedge \beta_i < 1, \forall i \in F$ , and  $\alpha_j > \beta_j > 0 \wedge \beta_j < 1 \forall j \in L$ .  $F$  ( $L$ ) denotes the set of firms (workers). The terms weighted with  $\alpha$  measure disutility attributed to disadvantageous inequity and the terms weighted with  $\beta$  measure disutility caused by advantageous inequity. Note that the term  $2w-70$  measures the difference between a worker's earnings ( $w-20$ ) and a firm's earnings ( $50-w$ ), while  $70-2w$  measures the reverse.

The most commonly used distribution of  $\alpha_j$  and  $\beta_j$  is estimated by FS99 and stems from the accumulated evidence on the ultimatum game (their table III). In their estimates,  $\alpha_j$  takes on values 0, 0.5, 1, or 4 (with respective probabilities 0.3, 0.3, 0.3 and 0.1) and  $\beta_j$  ( $< \alpha_j$ ) is equal to 0, 0.25 or 0.6 with probabilities 0.3, 0.3 and 0.4, respectively. Together, these probabilities imply that  $(\alpha_j, \beta_j)$  takes on the values (0,0), (0.5, 0.25), (1, 0.6), or (4, 0.6), with probabilities 0.3, 0.3, 0.3 and 0.1, respectively. We use these estimates for deriving hypotheses for the case with incomplete contracts.<sup>3</sup>

#### B2.1. Complete Contracts

We first consider complete contracts and once again start with the one shot case. This case is relatively simple since rational firms will fix effort at the high level ( $e=1$ ). The prediction of FS99 is that competition in DA will crowd out inequity concerns and that wages will be those in the first DA column of table 2.<sup>4</sup> In BN, inequity-aversion may affect realized wages, since the firm and the worker may view their trading partner as the only relevant reference agent (*cf.* section 3). However, market imbalance will limit the extent of redistribution. In particular, the short side of the market will not end up with less than half of the surplus from trade (because disadvantageous inequity is considered to be

<sup>1</sup> Typically, experimental results for the type of 'Box Design' applied here are not as extreme as the theoretical predictions. With repetition, prices do converge to these predictions, however (*cf.* Davis and Holt, 1993).

<sup>2</sup> See the discussions in FS99 and Brown *et al.* (2004). Neugebauer *et al.* (2007) present an example where the model predict less well than in most environments.

<sup>3</sup> For obvious reasons, we prefer to use these out-of-sample estimates for the distribution to estimates based on our own data, when deriving predictions for our experiments.

<sup>4</sup> The model by Bolton and Ockenfels (2000) yields a similar prediction. It is consistent with what we know about behavior in double auctions with the so-called box design, as reported in Davis and Holt (1993). Roth *et al.* (1991) find similar results in Bertrand-type auctions.

more severe than advantageous inequity), though inequity-aversion may preclude it from receiving the entire surplus.

Consider the complete contract case of BN with excess demand. Because a wage of 35 splits the high surplus equally, the reasoning above implies that wages will lie in the interval [35,49). For these wages, inequity is advantageous to the worker and disadvantageous to the firm. The linearity of utility in inequity implies that for workers with  $\beta_j > 0.5$  – a high aversion of being ahead - utility is decreasing in the wage, so that they will accept an offer of  $w_{BN}=35$ . All other workers will only accept  $w_{BN}=49$ . Firms' utility is decreasing in  $w_{BN}$ , independent of  $\alpha_i$ . Hence this linear utility predicts wages  $w_{BN} \in \{35,49\}$ .<sup>5</sup> If we allow for some concavity of the utility function in the extent of inequity-aversion, wages in the interior of [35,49] will also be equilibrium wages.<sup>6</sup> A similar reasoning gives the prediction that BN wages will be in the interval [21,35] in case of excess demand. These predictions are summarized in table 3 (main text). Once again, the usual arguments suffice to see that these predictions hold for every round of the repeated game (in particular, note that there is no reason for workers to build a reputation of inequity-aversion; nor is there any way for them to do so).

## B2.2. Incomplete Contracts

For two reasons, the case with incomplete contracts may be more complicated than the cases discussed above. First, inequity-averse workers may choose their effort level differently than inequity-neutral workers and this may affect the firm's wage offer, even in the one shot version of the game. Second, in early rounds inequity-neutral workers may act like their inequity-averse colleagues in an attempt to build a reputation from which they can benefit in later rounds.

Using backward induction, we proceed as follows: (i) we ask how effort (now chosen by the worker) depends on the worker's inequity-aversion and the wage; (ii) we determine the expected utility for firms as a function of the wage. Aside from her own inequity-aversion, this depends on the expectations the firm has about the worker choosing high effort, *i.e.*, on the expected inequity-aversion of the worker; (iii) this will typically yield ranges of wages with positive expected utility for both firm and worker. Market imbalance will select wages from these ranges that favor the short side of the market as predictions. For example, if wages in the range [X,Y] yield positive expected utility for the firm and there is excess demand, then competition among the firms will drive wages up to Y; (iv) finally, we will assemble the pieces of the puzzle and consider behavior across rounds, where workers' decisions may be influenced by the reputation they yield for future encounters.

### Workers' effort choice in the one shot environment

We start with the relationship between effort and wage. There are three distinct intervals of wages  $w \in \{w_{BN}, w_{DA}\}$  for which the effort choice differs (*cf.* SBG).

- 1) Low wages  $w \in [0,5]$  will always yield low effort, since such wages give to the worker less than 50% of the surplus generated by low effort and no level of inequity-aversion can induce a worker to exert high effort.
- 2) For  $w \in [35,50]$  workers obtain at least 50% of the surplus for high effort, so that they will always earn more than the firm (of course the difference is larger if they choose low effort than for high effort). Straightforward calculations (see SBG) show that for these wages workers will exert high effort if and only if  $\beta_j \geq 0.33$ , *i.e.* if they sufficiently dislike coming out ahead.
- 3) When  $w \in (5,35)$ , workers have a reservation wage  $w^r(\alpha_j, \beta_j)$  and they will exert high effort if and only if  $\beta_j \geq 0.33$  and  $w \geq w^r(\alpha_j, \beta_j)$ .<sup>7</sup> In other words, workers have to be sufficiently averse to advantageous inequity (not to exploit the firm by choosing low effort) and the wage must exceed a threshold that is determined by the worker's inequity-aversion (to accept getting the smaller part of the high surplus).

As a consequence, workers with  $\beta_j \leq 0.33$  will never exert high effort. For the FS estimates presented above only the 40% of the workers (those with  $(\alpha_j, \beta_j) = (1, 0.6)$  or  $(\alpha_j, \beta_j) = (4, 0.6)$ ) may do so. For these parameters, we obtain the reservation wages  $w^r(1,0.6)=30$  and  $w^r(4,0.6)=33.26$  (*cf.* eq. 5 in

<sup>5</sup> If workers' inequity-aversion is distributed as in the FS99 estimates, the average observed wage will be  $0.4 \cdot 35 + 0.6 \cdot 49 = 43.4$ .

<sup>6</sup> Throughout the analysis we will assume that such non-lienarities are possible. Similarly, FS99 explain offers in dictator games by dropping the linearity assumption.

<sup>7</sup> For simplicity, we assume in our discussion that workers will exert high effort if they are indifferent.

SBG). Therefore workers with  $\alpha_j=1$  and  $\beta_j=0.6$  (30% in FS99) will exert high effort for any  $w \in [30, 50]$  and those with  $\alpha_j=4$  and  $\beta_j=0.6$  (10%) will give high effort for any  $w \in [34, 50]$ .

### Firms' wage offers in the one shot environment

Given these effort choices, we can determine the implications for firms of engaging in contracts at various wages. Distinguishing between the same three wage intervals, we focus on the wages that lead to positive expected utility. These are the wages that are preferred to not trading at all.<sup>8</sup>

- 1) For any  $w \in [0, 5]$  a firm knows that it will obtain a profit  $\pi_f = 10 - w$  and the worker will earn  $\pi_i = w$ ; inequity is advantageous to the firm ( $\pi_f > \pi_i$ ). Hence, the firm's disadvantageous inequity-aversion,  $\alpha_i$ , is irrelevant. In SBG we show that for any value of advantageous-inequity-aversion,  $\beta_i$ , the firm will obtain for any wage in this interval a positive level of utility. As a consequence, firms are always willing to engage in contracts with  $w \in [0, 5]$ .
- 2) For  $w \in [35, 50]$  to yield positive expected utility a firm must
  - (i) care sufficiently little about the disadvantageous inequity that results from these wages, *i.e.*,  $\alpha_i < 0.25$  (eq. 13 in SBG; this only holds for the 30% with  $\alpha_j=0$  in the FS99 estimates); and
  - (ii) believe that a sufficient number of workers will respond with high effort *i.e.*,  $p_{.,0.6} > 0.625$ ; (eq. 11 in SBG); where  $p_{.,0.6}$  denotes the probability that the trading partner has  $\beta_j \geq 0.33$  (which holds for 40% of the workers in the FS99 estimates).
- 3) For  $w \in (5, 35)$ , the firm forms beliefs about the distribution of reservation wages. For the FS99 estimates, the relevant reservation wages are  $w'(1, 0.6) = 30$  and  $w'(4, 0.6) = 33.26$ . Hence, for wages 30, 31, 32 and 33 it matters how the firm estimates the probability that  $(\alpha_j, \beta_j) = (1, 0.6)$ , which we denote by  $p_{1,0.6}$ . For  $w = 34$ , workers with  $(\alpha_j, \beta_j) = (4, 0.6)$  will also choose high effort and the probability  $p_{.,0.6} = p_{1,0.6} + p_{4,0.6}$  needs to be high enough. Recall that for these wages ( $< 35$ ) inequity is (dis)advantageous to the firm if the worker chooses high (low) effort. The firm's expected utility for contract wage  $w$  is then given by (*cf.* eq. 17 in SBG):

$$EU_i(w) = \Pr(w) \cdot (50 - w - \beta_i(70 - 2w)) + (1 - \Pr(w)) \cdot (10 - w - \alpha_i(2w - 10)),$$

where  $\Pr(w) = 0$  for  $w \in \{5, 6, \dots, 29\}$ ,  $\Pr(w) = p_{1,0.6}$ , if  $w \in \{30, 31, 32, 33\}$ , and  $\Pr(w) = p_{.,0.6}$  if  $w = 34$ . Some straightforward manipulations then show that  $EU_i(w) > 0$  iff:

$$\Pr(w) > \frac{(1 + 2\alpha_i)w - 10(1 + \alpha_i)}{40 - 70\beta_i - 10\alpha_i + 2w(\alpha_i + \beta_i)}.$$

**Table B1: Firms and Positive Expected Utility**

| wage                             | $\alpha_i=0$<br>$\beta_i=0$               | $\alpha_i=0.5$<br>$\beta_i=0.25$           | $\alpha_i=1$<br>$\beta_i=0.6$ | $\alpha_i=4$ $\beta_i=0.6$ |
|----------------------------------|---|--|-------------------------------|----------------------------|
| $\in [0, 10]$                    | All wages yield positive expected utility |  |                               |                            |
| $\in [11, 29]$                   | All wages yield negative expected utility |  |                               |                            |
| 30 ( $p_{1,0.6} >$ )             | 0.500                                     | 0.720                                      | 0.833                         | 0.940                      |
| 31 ( $p_{1,0.6} >$ )             | 0.525                                     | 0.734                                      | 0.837                         | 0.941                      |
| 32 ( $p_{1,0.6} >$ )             | 0.550                                     | 0.748                                      | 0.841                         | 0.943                      |
| 33 ( $p_{1,0.6} >$ )             | 0.575                                     | 0.761                                      | 0.844                         | 0.944                      |
| 34 ( $p_{.,0.6} >$ )             | 0.600                                     | 0.774                                      | 0.847                         | 0.945                      |
| $\in [35, 50]$ ( $p_{.,0.6} >$ ) | 0.625                                     | All wages yield negative expected utility* |                               |                            |

*Notes:* Columns refer to inequity-aversion of the firm. Numbers indicate thresholds for the beliefs about workers' inequity-aversion. For example, if a inequity-neutral firm (second column) believes that the probability that the partner has  $\alpha_j=1$  and  $\beta_j=0.6$  ( $p_{1,0.6}$ ) is equal to 0.54 and the probability that  $\alpha_j=4$  and  $\beta_j=0.6$  is equal to 0.1 (hence,  $p_{.,0.6} = 0.54 + 0.1 = 0.64$ ), then wages 30, 31, and 35 or higher will all yield positive expected utility. Finally, for any wage larger than 10, workers with  $\beta_j=0.6$  will choose high effort and those with  $\beta_j=0$  or  $\beta_j=0.25$  will choose low effort.

\*Because  $\alpha_i > 0.25$  in all of these cases.

<sup>8</sup> Throughout the analysis, we assume that firms are risk-neutral. Risk aversion (seeking) would decrease (expand) the set of acceptable wages, without affecting our comparative static predictions.

Recall that the inequity parameters  $\alpha_i$  and  $\beta_i$  refer to the firm's inequity-aversion. The (expected) inequity-aversion of workers is captured in  $\Pr(w)$ . For the inequity-aversion parameters of FS99, table B1 shows the beliefs that are necessary to make the wages depicted in column 1 yield positive expected utility for the firm.

The table shows, for example, that for inequity-averse firms with  $\beta_i=0.6$  and  $\alpha_i \geq 1$ , only extreme beliefs ( $p_{1,0.6} > 0.83$ ) about the inequity-aversion of the workers will make firms consider any wages higher than 10 to be beneficial. Therefore, more inequity-aversion by firms decreases the probability of high wages being observed. Recall that FS99 estimate  $p_{.,0.6} = 0.4$  and  $p_{1,0.6} = 0.3$ . As a consequence, if firms believe that workers' inequity-aversion is distributed as estimated by FS99, they will not engage in any contracts where the wage exceeds 10.

If wages are observed in this intermediate range, the firms concerned are most likely to be inequity-neutral. The intuition is that the fear of a disadvantageous low effort choice dominates the decision of inequity-averse firms because disadvantageous inequity weighs more heavily than advantageous inequity. Hence inequity-averse firms would have to be very convinced that workers will choose high efforts for them to take the risk of engaging in a high wage contract.

A first conclusion from this analysis is more basic, however: with incomplete contracts low effort and low wages will (at least) sometimes be observed, whereas they are never observed in case of complete contracts.

### **Behavior across rounds**

If the game is played only once and firms believe that workers' inequity-aversion is distributed according to the FS99 estimates, firms will offer low wages and workers will give low effort. In the (finitely repeated) game, inequity-averse workers have a chance to obtain a reputation of giving high effort that allows firms to update their beliefs sufficiently to offer high wages. As a consequence, firms may sufficiently update their beliefs about a worker they are negotiating with in BN (based on this worker's past choices) to offer high wages. This process will not occur in DA, where no information is given. A formal analysis requires a more thorough investigation of possible equilibria, however. In doing so, we distinguish between 'pooling' equilibria and 'separating' equilibria.

#### **Behavior across rounds: pooling equilibrium with low effort**

One simple equilibrium is where all firms offer low wages and all workers choose low effort, in both DA and BN. Firms have no reason to update their prior belief that there is only a 40% chance that a worker is (sufficiently) inequity-averse and act optimally according to this belief. Workers (whether inequity-neutral or inequity-averse) have no incentive to offer high effort.

#### **Behavior across rounds: pooling equilibrium with high effort**

A sequential pooling equilibrium of the Kreps-Wilson (1982) type may exist.<sup>9</sup> If it does, it will involve firms paying high wages and all workers responding with high effort (in early rounds) in BN.<sup>10</sup> We will derive conditions for equilibria where firms only offer low wages (and workers respond with low effort) in DA.<sup>11</sup> Then, in such an equilibrium (if it exists), workers will always accept an offer to enter BN and no trades will take place in DA. We then show that no mutual best responses exist in such a scenario, *i.e.*, unraveling occurs and there is no such pooling equilibrium.

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<sup>9</sup> Note that there are important differences between our game and the Kreps-Wilson sequential game. These differences include: (i) Information about previous choices is not complete in our experiments. In particular, when firms observe the worker's previous record, they do not know for which wage offers the effort levels were chosen. (ii) Because information is not given in the DA, it is not clear what probabilities firms will attribute to the worker being inequity-averse (enough). (iii) Information about previous choices is also not complete because firms do not know whether a previous effort choice by the worker was made after a trade in the market or after a bilateral trade. (iv) Information about previous choices is only given in BN. Because of market imbalance, some workers or firms will be excluded from these negotiations. (v) There is two-sided imperfect information in this game, because firms are characterized by their inequity-aversion as well. Though Kreps and Wilson (1982) discuss an example of two-sided imperfect information, their case does not apply here. In particular, one of their players (the entrant) reveals its type (by not entering) for some actions. This does not hold in our case: irrespective of  $\alpha_i$  and  $\beta_i$ , there are beliefs for which firms rationally choose low or high wages.

<sup>10</sup> Because actions of distinct worker types differ in late rounds, the equilibria we are investigating are not really 'pooling' equilibria. We use this term to ease the discussion.

<sup>11</sup> Note that the only way for firms to distinguish between both types of workers is by selection based on past worker behavior. Because no information is provided in DA, a rational firm will not offer high wages there.



To simplify the analysis we only consider the probability  $p_{.,0.6}$ , *i.e.*, the probability that the worker's inequity-aversion is characterized by  $\beta_j > 0.33$  (which is a sufficient but not necessary condition for a high wage offer to yield positive expected utility to the firm). Let there be  $N$  rounds, and let  $n \leq N$  denote the current round, counting backwards from the start. In our experiments,  $N=20$ . Denote by  $p_n$  the firm's belief about  $p_{.,0.6}$  in round  $n$  (as in Kreps and Wilson 1982,  $p_n$  is a sufficient statistic for the history of play to period  $n$ ). The FS99 estimates imply  $p_N=0.4$ . Because inequity-averse workers (with  $\beta_j > 0.33$ ) will choose high effort after high wage and wages will be high in a pooling equilibrium, an off-equilibrium choice of low effort in round  $n$  ( $e_n=0$ ) suffices to set  $p_t=0$ ,  $t=n-1, \dots, 1$ . Moreover, any refusal to enter BN or any rejection to a high wage offer in BN will make the firm offer a low wage on BN in future rounds. Finally, let  $q_n$  denote the probability that a worker with  $\beta_j < 0.33$  will exert high effort. The pooling equilibrium we are considering involves  $q_n=1$ , for  $n \in \{n^*, \dots, N\}$ ,  $1 < n^* \leq N$ . For a firm, the probability that the worker will respond to  $w$  with high effort in round  $n$  is now  $P_n = p_n + (1-p_n) * q_n$ . Wage  $w_{BN}$  will yield positive expected utility to the firm if  $P_n$  satisfies the condition in the relevant column of table B1.

### *Excess supply of labor*

First consider the case of excess supply of labor (*i.e.*, 5 workers and 2 firms). Note that in this case the larger part of any surplus will go to the firm. Given the reservation wages of inequity-averse workers,  $w_{BN} \in [30, 35]$  if  $P^n$  is large enough, and  $w_{BN} \in [1, 5]$ , otherwise. If the worker is inequity-neutral (the case we are interested because we are studying reputation building), the firm's inequity-aversion determines which wage in these intervals will be realized, with the relative position being the same in the two intervals. We simplify the analysis and assume that  $w_{BN}=30$  or  $w_{BN}=1$ .<sup>12</sup>

First, assume that firms offer  $w_{BN}=30$  to any worker who has a history of only high effort choices,  $w_{BN}=1$  if the worker ever chose low effort and  $w_{DA}=1$ . Consider a inequity-neutral worker being offered  $w_{BN}=30$  in round  $n$ . Let  $\pi_n^*$  denote the expected earnings this worker will make if she chooses the effort level  $e_n^*$  that maximizes expected earnings in the remainder of the game, conditional on the firm using the strategy described. Obviously, for the final round this means  $e_1^* = 0$  and  $\pi_1^* = 30$ . In the penultimate round, low effort yields 30 immediately and  $w_{BN}=1$  in the final round, if she is selected to negotiate (which occurs with probability 0.4 due to excess supply). Hence, her expected earnings from low effort in  $n=2$  are  $30 + 0.4 * 1 = 30.4$ . If she chooses high effort in the penultimate round, she will have immediate earnings of 10 and there is a 40% chance that she will be selected in  $n=1$ , in which case she will be able to obtain  $\pi_1^* = 30$ . Hence, her expected earnings from high effort in  $n=2$  are  $10 + 0.4 * 30 = 22$ . As a consequence,  $e_2^* = 0$  and  $\pi_2^* = 30.4$ . Now, consider her decision in round  $n > 2$ . If she chooses low effort, she earns an immediate 30 followed by  $n-1$  times 1, each time with probability 0.4; expected earnings are  $30 + 0.4 * (n-1)$ . High effort gives an immediate 10,  $\pi_{n-1}^*$  with probability 0.4,  $\pi_{n-2}^*$  with probability  $0.6 * 0.4$ , etc., yielding expected payoff

$10 + 0.4 \sum_{i=1}^{n-1} 0.6^{n-1-i} * \pi_i^*$ . Solving this recursively yields the result that high effort is the optimal

choice for  $n \geq 4$  and low effort for  $n=1, 2, 3$ . Hence, given the firms' 'grim trigger' strategies, inequity-neutral workers best response to high wages is to give high effort in the first 17 rounds of our experiment; *i.e.*,  $q_n=0$ ,  $n \in \{1, 2, 3\}$ ,  $q_n=1$ ,  $n \in \{4, \dots, 20\}$ . Of course, inequity-averse workers will respond to  $w_{BN}=30$  with high effort in every round. In addition, all workers will always accept offers to negotiate in BN.

Such a pooling equilibrium only exists if the firms' best response to the workers' strategies is indeed to reward good reputations in the way described. In particular, the strategies should not unravel in the sense that firms stop offering high wages after round 17 (in which case inequity-neutral workers would resort to low effort in round 16, etc.). Unraveling will take place unless rents exist after round 17 that make it worthwhile to the firm to reward good reputations. *E.g.*, in Brown *et al.* 2004, there

<sup>12</sup> The analysis can easily be repeated for other wages, which yields almost identical results.

are assumed to be enough inequity-averse workers to give firms a positive expected benefit from a high wage offer. In our case, for  $n \in \{4, \dots, 20\}$ ,  $P_n=1$ , which exceeds every value in table B1, so all firms will offer  $w_{BN}=30$ . Because no information is available from rounds 1 to 17 to distinguish between inequity-averse and inequity-neutral workers, rational firms will rely on their priors in round 18 ( $n=3$ ):  $P_3=p_3=p_{20}=0.4$ . Hence, the expected direct return to a high wage offer is  $0.4*(50-30) + 0.6*(10-30) = -4$ . This is lower than the expected direct return to a low wage offer (which is  $10-1=9$ ). However, there are positive spillover effects of a high wage offer in round 18 ( $n=3$ ) to rounds 19 and 20 because those inequity-neutral workers who are selected (and choose low effort) in round 19 will be recognized as such in subsequent rounds. Simple calculations show that these positive effects are not large enough to increase total benefits from a high wage offer in round 18 beyond the benefits of a low offer. *Ergo*, firms will offer low wages to all workers in round 18 and reputation building unravels: no pooling equilibrium exists.<sup>13</sup>

#### *Excess demand for labor*

Unraveling is easier to show with excess demand (2 workers, 5 firms), where the larger part of any surplus will go to the worker:  $w_{BN} \in [35, 49]$  if  $P^n$  is large enough, and  $w_{BN} \in [5, 9]$ , otherwise. Because we again focus on inequity-neutral workers (to determine  $q_n$ ) we assume that  $w_{BN}=49$  or  $w_{BN}=9$  and consider the scenario where firms offer  $w_{BN}=49$  to any worker who has a history of only high effort,  $w_{BN}=9$  if the worker ever chose low effort and  $w_{DA}=9$ .

Consider a inequity-neutral worker being offered  $w_{BN}=49$  in round  $n$ . We again proceed by determining  $\pi_n^*$ . It is easy to see that  $\pi_1^* = 49$ . For  $n=2$ , the worker can either choose high effort (yielding  $29+49$  in the last round) or low effort (yielding  $49+9$ ). Hence,  $\pi_2^* = 78$ . Thus, given the firms' strategy, the worker will offer high effort in rounds 1-19 and low effort in the final round. Obviously, the firms' strategy is not an optimal response to this and reputation building unravels. Once again, no pooling equilibrium exists.

#### **Behavior across rounds: separating equilibrium**

Finally, we consider the possibility of a separating equilibrium where inequity-averse workers choose high effort and inequity-neutral workers choose low effort. For such an equilibrium to exist, it must be possible for firms to distinguish between the two. In particular, inequity-neutral workers should not be able to choose high effort in a subset of rounds in an attempt to be treated as inequity-averse workers. The existence of DA complicates matters in this respect. In DA, firms have no information about the worker's past and cannot condition their choice. Therefore, the most likely candidate for a separating equilibrium is one where wage offers are low in DA. Once again, we consider grim-trigger strategies for the firm, where any low effort choice by the worker in the past is answered by low wage offers only. As a consequence, inequity-averse workers will not engage in any transactions in DA.

Now, assume that a separating equilibrium exists, *i.e.*, inequity-neutral workers trade in DA and BN and receive low wage offers, to which they respond with low effort. Inequity-averse workers only trade in BN, offer high effort the first time they receive a (low) wage offer and always choose high effort after that. Firms start by offering low wage. If they observe (only) high effort choices, they offer the worker a high wage. It is easy to see that this cannot be an equilibrium. A inequity-neutral worker can offer high effort the first time she is selected for BN. This gives a direct loss of 20 (the costs of high effort) but the possibility to gain 30 (with excess supply) or 49 (excess demand) the next time she is selected. Hence, no such separating equilibrium exists.

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<sup>13</sup> Similar results are obtained assuming a more forgiving strategy for the firms than the grim trigger assumed here. The bottom line is that inequity-neutral workers will at some point switch to low effort and the firm cannot obtain sufficient rents in the rounds after that to make it optimal for them to stick to their strategy. Again, unraveling occurs.