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Sorting via Screening versus Signaling: A Theoretic and Experimental Comparison

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Abstract

Similar to Kübler et al. (2008, GEB 64, p. 219-236), we compare sorting in games with asymmetric incomplete information theoretically and experimentally. Rather than distinguishing two very different sequential games, we use the same game format and capture the structural difference of screening and signaling only via their payoff specification. The experiment thus relies on the same verbal instructions. Although the equilibrium outcomes coincide, greater efficiency losses off the equilibrium play due to sorting under signaling, compared to screening, is predicted and confirmed experimentally.

Keywords: sorting, screening, signaling, wage bargaining, off-equilibrium play
JEL: C9, D82, J24, J40

1. Introduction

Asymmetric incomplete information can cause no trade results (e.g. Akerlof (1970); Samuelson and Bazerman (1984)) in spite of its efficiency when not being able to sort and differentiate the types of the informed parties. Whether such sorting is possible depends partly on the the rules of the game, and partly on its equilibria. There may or may not be sorting equilibria and, even when sorting equilibria exist, they may coexist with pooling equilibria which do not

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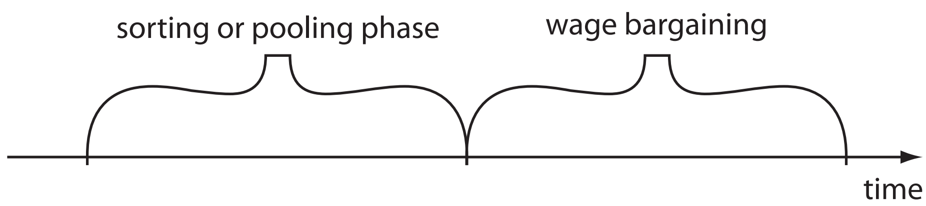

Figure 1: The basic dynamic interpretation

distinguish the types of the better informed parties. In our analysis, we focus on the latter case by studying a setup where sorting and pooling equilibria coexist.

Although we finally will abstract from any specific interpretation, our setup and terminology has been inspired by the analysis of Spence (1973, 1976) of a worker, who is privately informed about his exogenously given productivity and who may or may not be hired by an employer. Sorting is possible since more productive workers find it less costly to invest in education, even if education has no productivity effect at all. Thus, sorting by education relies on inefficient (education) investments.

After the sorting stage wage bargaining takes place whose analysis is simplified by substituting hiring competition of several employers by granting granting ultimatum power to the worker. The worker anticipates the posterior productivity beliefs of the employer after pooling, respectively sorting, and demands (in equilibrium) the wage corresponding to this expected productivity. The employer, in turn, accepts all wage demands not exceeding this productivity expectation. This form of wage bargaining is common to the two institutional settings we distinguish, namely screening and signaling. The basic process is illustrated in Figure 1.

Screening and signaling mainly appeal to different decision processes: Screening means that the (uninformed) employer moves first and offers a menu of employment contracts, one (possibly equivalent) contract for each education level.

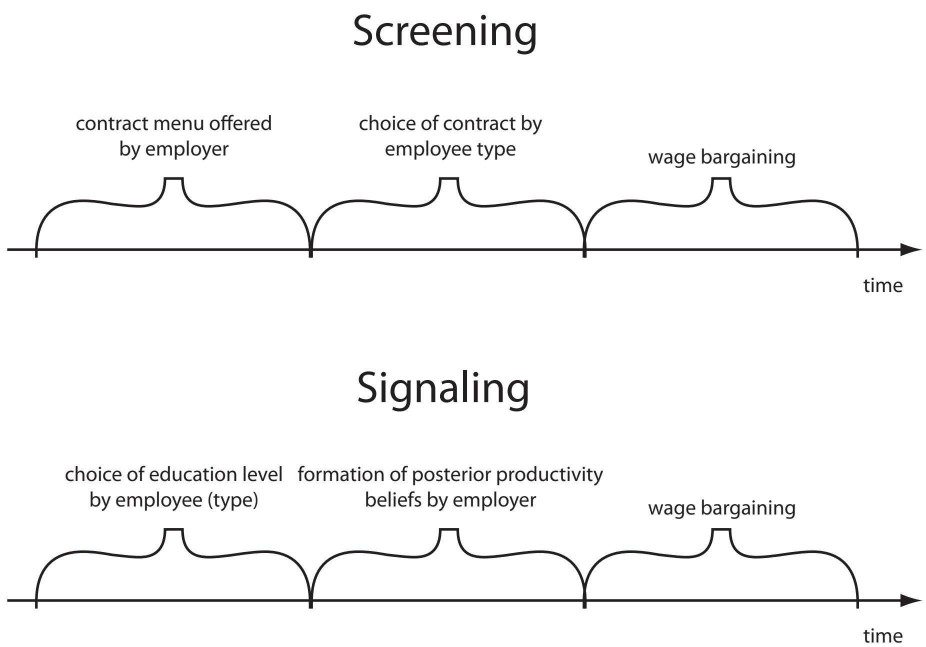

Figure 2: The process structure of Screening and Signaling.

Later, the worker, who is informed about the education costs determined by his productivity, chooses from this menu and invests in his education only as much as necessary for the given contract (see Figure 2 a).

Compared to this, signaling reverses the two phases (Figure 2 b) by letting first the worker, aware of his productivity, choose his education level and then confront the employer with a wage demand.

Our study is closely related to the experimental comparison of screening and signaling by Kübler et al. (2008). We test the robustness of their main findings by minimizing the differences between treatments. While the previous study implemented two different decision sequences as in figure 2 with specific verbal instructions and possibly different demand effects (see Zizzo (2010) for a discussion of demand effects), we will implement an experimental design that avoids unnecessary differences when comparing screening and signaling. More specifically, we present a common game format where both parties decide simultaneously and where the screening and the signaling treatment differ only in two subtle details, one referring to what a specific choice implies and one determining which party can condition its choice on the other party's choice.

Moreover, our study is designed to capture the different levels of efficiency associated with the two institutions. Thus, we are able to say something about the effects of both institutions on the investment behavior (as in Kübler et al.) but in addition to their study we are able to investigate the institutions' indirect effects on the relative share of mutual beneficial wage bargaining.

Investing into sorting is collectively wasteful since it is costly but does not increase the worker's "quality". We expect to observe more over-investment under the signaling institution off the equilibrium play as compared to screening. If the worker cannot be sure which education level the employer demands, he may educate himself slightly more than needed, which is costly for him and finally inefficient. Under screening, however, the worker knows the requested education level for a given wage already before his investment, such that there is simply no reason to over-invest in the signal: If it is beneficial for him to signal, he should invest *exactly* the requested level, otherwise he should abstain *completely* from investing.

Next, we will introduce a general framework for analyzing signaling and screening games (section 2) and present their benchmark equilibria in section 3. We focus on the best pooling and best sorting equilibrium for both institutions and show how they differ off their equilibrium plays. Section 4 describes the two experimental protocols only differing in subtle details due to the same simultaneous game format. In our view, this still allows for much more specific conclusions whether and, if so, why screening and signaling yield different results. Specifically, the same abstract game format should minimize explicit and implicit demand effects which are to be expected when implementing different choice sequences with specific verbal instructions (see Kübler et al., 2008).

Section 6 analyzes the data, especially whether or not they confirm that screening is superior to signaling. The conclusions in section 7 compare our results to those of Kübler et al. (2008) and discuss the methodological issue of how to limit uncontrolled explicit or implicit experimental demand effects.

2. The Game Format

The game involves two players, referred to as λ-type (the "worker") and *Other* (the "employer"). Only the λ-type is privately informed about his productivity λ. For the sake of simplicity and consistent with our experimental design, we focus on just two λ-types $\underline{\lambda}$ and $\overline{\lambda}$ with $1 \leq \underline{\lambda} < \overline{\lambda}$. *Other* only knows the prior probabilities p of type $\underline{\lambda}$ and $1-p$ of type $\overline{\lambda}$ with $0 < p < 1$ what is common knowledge.

In line with Spence (1973), λ-types choose a message, for example an educational level $y_\lambda \geq 0$ and demand a wage $w = w\left(y_\lambda\right) \geq 0$ for that signal. *Other* chooses two wages $\underline{w}$ and $\overline{w}$ and a threshold $Y \geq 0$ with the following interpretation:

$\underline{w}$: the maximally acceptable wage demand w for $y < Y$,

$\overline{w}$: the maximally acceptable wage demand w for $y \geq Y$,

Y: the threshold investment separating the region of investment levels y triggering the high wage $\overline{w}$ from the one for the low wage $\underline{w}$ in case of $\underline{w} \neq \overline{w}$, where for $\underline{w} = \overline{w}$ we impose $Y = 0$ and for $Y = 0$ we impose $\underline{w} = \overline{w}$.

The crucial difference between λ-types results from their λ-dependent costs of education, given by

$$c_\lambda\left(y_\lambda\right) = \lambda^{-1} y_\lambda$$

Other can only observe the investment y, but not the type $\underline{\lambda}$ or $\overline{\lambda}$ choosing this y. Let $q_{\underline{\lambda}}(y) \geq 0$, respectively $q_{\overline{\lambda}}(y) \geq 0$ with $q_{\underline{\lambda}}(y) + q_{\overline{\lambda}}(y) > 0$ denote the probability of using y by $\underline{\lambda}$ or $\overline{\lambda}$. Then, *Other's* posterior beliefs concerning the worker's productivity type λ when observing y, are well-defined.[1] They are given by

$$\text{Prob}(\underline{\lambda}|y) = \frac{q_{\underline{\lambda}}(y)\,p}{q_{\underline{\lambda}}(y)\,p + q_{\overline{\lambda}}(y)\,(1-p)},$$

respectively

$$\text{Prob}(\overline{\lambda}|y) = \frac{q_{\overline{\lambda}}(y)\,(1-p)}{q_{\underline{\lambda}}(y)\,p + q_{\overline{\lambda}}(y)\,(1-p)}.$$

These two posterior probabilities obviously become 1 or 0 when only one λ-type chooses y with positive probability what would allow for separating or sorting the λ-types.

Granting ultimatum power in wage bargaining to the λ-type obviously implies wages $w(y)$ corresponding to the posterior expected productivity, namely $w(y) = \underline{\lambda}\text{Prob}(\underline{\lambda}|y) + \overline{\lambda}\text{Prob}(\overline{\lambda}|y)$. Thus if

$y < Y$ *Other* accepts and pays the required wage $w(y)$ only if $w(y) \leq \underline{w}$; the λ-type earns $w(y) - \lambda^{-1}\widetilde{y}$ and *Other* earns $\lambda - w(y)$.

$y < Y$ and $w(y) > \underline{w}$, there is no agreement and λ earns $-\lambda^{-1}\widetilde{y}$ and *Other* zero.

$y \geq Y$ *Other* accepts and pays the required wage $w(y)$ only if $w(y) \leq \overline{w}$, so that λ earns $w(y) - \lambda^{-1}\widetilde{y}$ and other $\lambda - w(y)$.

$y \geq Y$ and $w(y) > \overline{w}$, there is no agreement and λ earns $-\lambda^{-1}\widetilde{y}$ and *Other* zero.

The notation $\widetilde{y}$ above indicates that one usually will assume $\widetilde{y} = y$, but this must not necessarily be the case. For example, one could assume for the

[1] For $q_{\underline{\lambda}}(y) + q_{\overline{\lambda}}(y) = 0$ such beliefs can be analyzed (see Güth and van Damme (1991)) by approximating the game via perturbed games in the spirit of perfect equilibria (Selten, 1975). Another approach can be found in Truyts (2012), who avoids the problem of out-of equilibrium beliefs by assuming imperfect signal transmission. Here we will not analyze the game in such systematic ways but rather focus in the next section on the obvious pooling and sorting equilibria.

screening treatment $\widetilde{y} = 0$, wherever $y < Y$ and $\widetilde{y} = Y$ wherever $y \geq Y$, since 0 and Y are the requested education levels, set by the employer.

As indicated already above, screening and signaling can differ in how the payoff relevant investment level $\widetilde{y}$ is determined. In signaling one naturally assumes $\widetilde{y} = y$ (or $\widetilde{y}_\lambda = y_\lambda$ for $\lambda = \underline{\lambda}, \overline{\lambda}$), whereas for screening one may assume $\widetilde{y} = 0$ and $\widetilde{y} = Y$, respectively, depending on $y < Y$ or $y \geq Y$.[2]

The different decision sequences of screening and signaling are captured by letting the choice of one player depend on the choice of his opponent: λ-types condition on the demanded education level Y in case of screening, whereas *Other* conditions his choice on the observed education level y in signaling. Thus, the same simultaneous choice framework accommodates both sorting institutions, screening and signaling. What differentiates them is

1. who can condition on the other's choice, captured by $y(Y)$ in case of screening and $Y(y)$ in case of signaling, and
2. whether, in case of screening, $\widetilde{y}$ is given by y, respectively y_λ, or $\widetilde{y} = 0$ for $y < Y$ and $\widetilde{y} = Y$ for $y \geq Y$.

3. Benchmark Equilibria

There exists an abundance of equilibria, of which some can be eliminated by ad-hoc requirements or more systematic refinements (see Güth and van Damme (1991) and Truyts (2012)). In the games described above, the two obvious equilibrium benchmarks are based on optimal pooling (not sorting the λ-types), respectively on efficient sorting.

In general, sorting requires Y such that

$$\overline{w} - \underline{\lambda}^{-1} Y \leq \underline{w} \leq \overline{w} - \overline{\lambda}^{-1} Y$$

or

[2] In screening types can condition on Y so that every other y_λ choice is strictly dominated and would not be available after eliminating such strategies.

	Strategies of		
Benchmark	$\underline{\lambda}$	$\overline{\lambda}$	*Other*
best pooling	$y_{\underline{\lambda}} = 0, w(y_{\underline{\lambda}}) = \lambda_0$	$y_{\overline{\lambda}} = 0, w(y_{\overline{\lambda}}) = \lambda_0$	$\lambda_0, \lambda_0, Y = 0$
best sorting	$y_{\underline{\lambda}} = 0, w(y_{\underline{\lambda}}) = \underline{\lambda}$	$y_{\overline{\lambda}} = Y^*, w(y_{\overline{\lambda}}) = \overline{\lambda}$	$\underline{\lambda}, \overline{\lambda}, Y^* = (\overline{\lambda} - \underline{\lambda})\underline{\lambda}$

Table 1: The benchmark solutions.

$$\overline{\lambda}^{-1} Y \leq \Delta \leq \underline{\lambda}^{-1} Y \text{ with } \Delta := \overline{w} - \underline{w}.$$

It should not pay for the $\underline{\lambda}$-type to aim at the high wage $\overline{w}$ compared to earning $\underline{w}$ and invest nothing ($y_{\underline{\lambda}} = 0$), nor for the more productive $\overline{\lambda}$-type to receive the lower wage $\underline{w}$ by choosing $y_{\overline{\lambda}} = 0$. Thus, one must have $\Delta\underline{\lambda} \leq Y \leq \Delta\overline{\lambda}$ for $Y > 0$.

Best pooling results from $Y = 0 = y_\lambda$ or $\Delta\overline{\lambda} < Y$for both λ-types and wage demands $w(y_\lambda)$ at the level of the prior expected productivity $\lambda_0 = p\underline{\lambda} + (1-p)\overline{\lambda}$ by both λ-types, i.e., $w(y_\lambda) = \lambda_0$ for $\lambda = \underline{\lambda}, \lambda$. More specifically, all best pooling equilibria rely on $y_\lambda = 0$ and $w(y_\lambda) = \lambda_0$ for $\lambda = \underline{\lambda}, \overline{\lambda}$ and, for instance, the choice of $(\lambda_0, \lambda_0, Y = 0)$ by *Other*.

Best sorting assumes the minimal Y in the range $\Delta \cdot \underline{\lambda} \leq Y \leq \Delta \cdot \overline{\lambda}$. Since $\underline{\lambda} = \underline{w}$ and $\overline{\lambda} = \overline{w}$ are the expected productivities in case of sorting, and therefore the maximally acceptable wages, for $\Delta = \overline{\lambda} - \underline{\lambda}$ the lowest and therefore optimal sorting level is $Y^* = (\overline{\lambda} - \underline{\lambda})\underline{\lambda}$. The best sorting equilibrium predicts the choices $y_{\underline{\lambda}} = 0, w(y_{\underline{\lambda}}) = \underline{\lambda}, y_{\overline{\lambda}} = Y^*, w(y_{\overline{\lambda}}) = \overline{\lambda}$ by the λ-types and $(\underline{\lambda}, \overline{\lambda}, Y^*)$ by *Other*.

The best pooling and screening equilibrium is given in Table 1. Thus from the viewpoint of all players sorting is inefficient since it asks the $\overline{\lambda}$-type to invest in education which has no productivity effect whatsoever. According to best pooling, both λ-types earn the same payoff, i.e. wage income minus education costs of λ_0. For best screening the earnings are $\underline{\lambda}$ for the $\underline{\lambda}$-type and

$$\overline{\lambda} - \frac{Y^*}{\overline{\lambda}} = \overline{\lambda} - \frac{(\overline{\lambda} - \underline{\lambda})\underline{\lambda}}{\overline{\lambda}}$$

for the $\overline{\lambda}$-type. *Other* always gets nil in expectation due to the worker's ultimatum power.[3] The condition that the $\overline{\lambda}$-tape earns more than the $\underline{\lambda}$-type is equivalent to $\overline{\lambda} > \underline{\lambda}$ and thus always holds in the best screening equilibrium.

of *Other* and the choices

$$\left(y_{\underline{\lambda}}\left(Y^*\right) = 0, w\left(y_{\underline{\lambda}}\left(Y^*\right)\right) = \underline{\lambda}\right),$$

respectively

$$\left(y_{\overline{\lambda}}\left(Y^*\right) = Y^*, w\left(y_{\overline{\lambda}}\left(Y^*\right)\right) = \overline{\lambda}\right)$$

by the λ-types.

Similarly, the <u>best signaling equilibrium</u> relies on the choices

$$\left(y_{\underline{\lambda}} = 0, w\left(y_{\underline{\lambda}}\right) = \underline{\lambda}\right)$$

and

$$\left(y_{\overline{\lambda}} = Y^*, w\left(y_{\overline{\lambda}}\right) = \overline{\lambda}\right)$$

by the λ-types and the choices

$$\left(Y^*\left(\cdot\right), \underline{w} = \underline{\lambda}, \overline{w} = \overline{\lambda}\right)$$

with $Y^*(\cdot)$ meaning $\forall y \geq 0 : Y(y) = Y^*$ by *Other*, i.e., *Other* accepts only wage demands $w(y) \leq \underline{\lambda}$ for $y < Y^*$ and $w(y) \leq \overline{\lambda}$ for $y \geq Y^*$. This justifies the

[3] The optimal sorting level of Y^* does not depend on the assumption of full exploitation. If we consider a case where the employer always (and independent of the investments into sorting) demands a positive and fixed share ρ of the expected productivity, the worker's equilibrium earnings in case of sorting are given by $\overline{\lambda} - \rho - \frac{Y^*}{\overline{\lambda}}$. Then, the optimal sorting level is given by $Y^* = (\overline{\lambda} - \underline{\lambda})\underline{\lambda}$, which is the same as we obtain if we assume zero profits for the employer.

claim that sorting in the sense of best screening and best signaling equilibria imply the same outcome and differ in their efficiency only off the equilibrium plays.

In screening, choices $y \notin \{0, Y^*\}$ are obviously wrong, since only $y_\lambda = 0$ and $y_\lambda = Y$ can be optimal. In the main screening treatment we have ruled cost consequences of out such wrong choices $y \notin \{0, Y\}$, whereas in the control screening treatment this has not been assumed. In case of signaling, λ-types may not be sure which Y *Other* chooses, what is captured by not allowing λ-types to condition their education choice y_λ on Y. Of course, the uncertainty in signaling renders choices of $y_\lambda \notin \{0, Y^*\}$ more likely, such that we also introduced a signaling control treatment which rules out cost consequences of non-solution play. Of course, these choices refer to non-solution play only, which we however expect to observe in the experiment with high probability. This suggests

Hypothesis 1. *Screening is socially more efficient than signaling, i.e. losses due to investment behavior are lower in screening than in signaling, especially in the main treatments.*

Hypothesis 1, of course, presupposes that participants do not exclusively rely on pooling. Since best pooling is socially more efficient, participants might not try to sort out the λ-types. *Other* does not care at all whether the best pooling or the best separating equilibrium applies, since in equilibrium he always earns nil. If players rely on pooling rather than sorting, and thereby do not decrease what later can be shared, this could indicate some cooperativeness, by which *Other* might gain.

Hypothesis 2. *Investments increase efficiency losses due to ultimatum wage bargaining.*

Thus, we essentially predict that generosity towards *Other* is triggered by more efficiency which, in turn reduces *Other's* exploitation by using ultimatum power in the final wage bargaining.

4. Experimental Protocols

In order to test our hypothesis we implemented the 2×2 full factorial design displayed in Table 2. The experiment was conducted using the *z-Tree* (Fischbacher, 2007). Alltogether 240 undergraduate students from Jena-University (Germany), recruited from a wide range of academic disciplines via ORSEE (Greiner, 2004) participated in our experiment, lasting for about 2:10 h on average with average earnings of about 14.25 Euro.

Table 2 summarizes how the *institutional setup*, screening or signaling, allows either the worker to condition his investment on the employer's investment demand (screening), or vice verca (signaling). The major differences of the two institutions are once again listed in Table 2. It all depends on who can condition on whom:

- in Screening (Sc), where *Other's* choice Y precedes y_λ, the λ-types set the reaction vector $y_\lambda(Y)$ for every possible Y (in the strategy method)[4],
- in Signaling (Si), where the λ-types choice y_λ precedes the choice of Y, we similarly elicit (in strategy method) how the reaction vector $Y(y_\lambda)$ depends on the worker's choice of y.

Another variation manipulates the *costs of investments*, such that workers (i) had to pay the full cost , or (ii) only the cost of the required investment if $y \geq Y$ or 0 if $y < Y$. Whereas excessive investments ($y \notin \{0, Y\}$) are unlikely under screening, they may be more likely under signaling where the required investment is not known.

Participants in both roles submit high and low wage demands ($\overline{w}_\lambda, \underline{w}_\lambda$ for the workers), respectively maximal acceptable wages ($\overline{w}, \underline{w}$ for the employers). Thus, in case of insufficient investments ($y_\lambda = y_\lambda(Y) < Y$), the wage demand is $\underline{w}_\lambda$ which is only accepted if $\underline{w}_\lambda \leq \underline{w}$. If, however, $y_\lambda = y_\lambda(Y) \geq Y$, the

[4]Selten (1967)

costs of investment	**Institution** Signaling	Screening
Threshold: $c(0)$ for $y < Y$, $c(Y)$ for $y \geq Y$	SiT	ScT
Signal: always $c(y)$	SiS	ScS

choice format	**Institution** Signaling	Screening
worker's λ-type	$\underline{w}_\lambda, \overline{w}_\lambda, y_\lambda$	$\underline{w}_\lambda, \overline{w}_\lambda, y_\lambda(Y)$
employer (*Other*)	$\underline{w}, \overline{w}, Y(y_\lambda)$	$\underline{w}, \overline{w}, Y$

Table 2: The 2×2 design, varying the institutions signaling and screening and the costs for off the equilibrium play (left), and differences in the choice format of λ-types and *Other* in the screening and signaling mode (right).

wage demand is $\overline{w}_\lambda$ which is accepted by *Other* only in case of $\overline{w}_\lambda \leq \overline{w}$. If wage demands are not accepted, the λ-type earns $-\lambda^{-1} y_\lambda(Y)$ and *Other* earns nothing. In case of acceptance, the λ-types earn $\underline{w}_\lambda$, respectively $\overline{w}_\lambda$, minus the costs of investments $-\lambda^{-1} y_\lambda(Y)$ and *Other* λ minus the wage $\underline{w}_\lambda$, respectively $\overline{w}_\lambda$.

In order to allow for learning effects in this rather complicated setup, subjects played 40 rounds, with immediate feedback after every round (see Table 3 which lists all the parameters used in the experiment). Since losses due to over-investments and wage bargaining conflicts were likely, we decided to pay all 40 periods rendering negative payoffs unlikely (which in fact never occurred).

When designing the instructions (see Appendix), we took great care to use the same verbal instructions for all conditions. They only differ in two paragraphs describing who conditions on whom and how the costs of investments are calculated.

5. Relation of our experiment to the experiment by Kübler et al.

Before comparing our findings with the findings of Kübler et al. (2008), let us clearly list all the differences in the experimental designs. Although both stud-

Parameter	Description	Values
λ	productivity, high or low	10, 20
$\overline{w}_\lambda, \underline{w}_\lambda$	low, high wage demand	$0 \leq \overline{w}_\lambda \leq \underline{w}_\lambda \leq 20$
$\overline{w}_\lambda, \underline{w}_\lambda$	low, high wage threshold	$0 \leq \overline{w} \leq \underline{w} \leq 20$
y	investment of λ-type (worker)	$0, 50, 100, 150, 200$
Y	investment demanded by *Other* (employer) for high wage	$0, 50, 100, 150, 200$
Y^*	separating investment $((\overline{\lambda} - \underline{\lambda})\underline{\lambda})$	100
costs of Investment: Threshold		
	cost of investment if $y < Y$	0
	cost of investment if $y \geq Y$	$\frac{Y}{\lambda}$
costs of Investment: Signal		
	cost of investment	$\frac{y}{\lambda}$
Periods		40

Table 3: Experimental parameters

ies compare screening and signaling for a simple hiring situation, as originally analyzed by Spence (1973, 1976), the experimental protocols differ substantially (see Table 4). Our implementation of the hiring market aims to minimize the differences between the screening and the signaling institution, both theoretically and methodologically. From a theoretical perspective, we allowed for separating and pooling equilibria under both institutions, while Kübler et al. face separating and pooling equilibria in the signaling game, but only separating equilibria in the screening game.

Both studies capture what could be called and "worker market" in that the worker has much more bargaining power.

Whereas Kübler et al. achieve this by hiring competition, the study at hand does this by granting ultimatum power in wage bargaining to the worker. Both imply 0-payoffs for the employer(s) in equilibrium, but off the equilibrium an employment contract may be more or less profitable for the employer. Here, our design allows us to study off the equilibrium bargaining in much more detail than the Kübler et al. study.

Aspect	Kübler et al.-protocol	our protocol
players	two, resp. three employers, one employee	one employer, one employee
wage bargaining	hiring competition of employers (largest wage offer automatically accepted)	ultimatum power of worker
	single wage offer in case of signaling, two in case of screening	two wage demands by worker and two acceptance thresholds by employer
sorting	play method with only two levels for both, screening and signaling	strategy method for one party by employing a coarse grid on investment levels
incentives	flat fee for non-chosen employer, earnings depending on contract for chosen employer and employee	variable earnings of employer and employee, depending on agreement contract
equilibria	pooling and separating equilibria in signaling, only separating in screening	pooling and separating equilibria in both treatments
roles	role switching after fixed number of periods	fixed roles
number of rounds played	48 rounds	40 rounds

Table 4: Major differences of the experimental protocols used in the study by Kübler et al. (2008) and ours.

Furthermore, Kübler et al. elicit only one wage offer in signaling but two in screening (of course of two/three employers). In order to minimize the changes between the two protocols, we decided to avoid this change by employing the same choice format in wage bargaining (two wage demands, two acceptance thresholds) in the screening as well as in the signaling protocol.

The major difference is, however, how sorting is implemented: Kübler et al. let participants decide sequentially (play method), whereas we apply the strategy method for the reacting party.[5] Thus, we believe that our design is much more obliged to minimize the differences between the screening and the signaling protocol than that by Kübler et al.. In our view, this will be important when discussing which qualitative effects are confirmed by both studies and which differ when comparing screening and signaling. In the latter case, there are good reasons to believe that this could be due to the different explicit and implicit demand effects of the screening and signaling protocol used in the Kübler et al.-study.

[5]The strategy method is often referred to as eliciting decisions in a "cold" mood (Brandts and Charness, 2000). This may in our case even increase the validity of our findings, as job decisions are rarely made on the spot (Rauhut and Winter, 2012, 2010)

6. Results

6.1. Investment Behavior

We start our discussion of the results by looking at the investment behavior y_λ of workers and the investments Y demanded by the employers. Figure 3 displays the education choices by high and low productivity workers (top) and the education requests by the employers (bottom) split up by signaling and screening. High type workers invest slightly more under both institutions, though the mode is clearly $y_\lambda = 0$ for both λ-types. This observation is confirmed by the left ordinal logit model in Table 5, estimating the odds ratios of investing at a given level as a function of worker productivity.[6] Moreover, and not surprisingly, workers invest less if they have to carry the full costs y_λ of signaling as compared to the treatments with $\widetilde{y} \in \{0, Y\}$, and investments decrease over time. This leads us to

Result 1. ***(Investment Behavior of workers)***

a High-productivity workers invest more than low-productivity workers.

b Workers invest less if they have to cover the full costs ($\widetilde{y} = y$) than when paying the investments demanded by the employer $\widetilde{y} \in \{0, Y\}$.

c Investments decrease over time.

Employers, on the other hand, ask for very high investments under screening and for high or non-separating investments ($y = 50$) under Signaling (see Figure 3). The differences between the two institutions or the different cost structures of investment are, however, not statistically significant. However, while workers lowered their investments over time, employers tend to ask for higher investments in later periods.

Result 2. ***(Investment Demands by Employers)***

[6] Since the possible investments can only take 5 distinct values (0,50,100,150 200),, normality assumption of the OLS-model are violated, rendering an ordinal logit regression suitable.

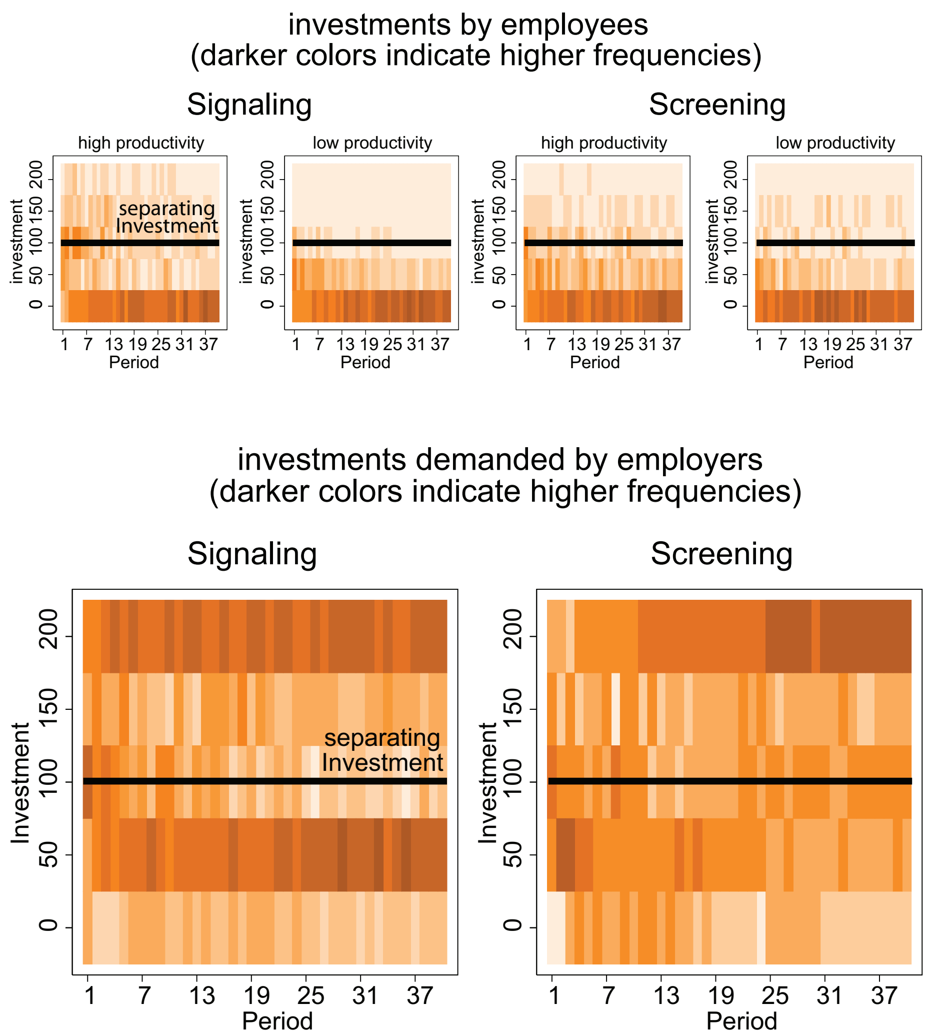

Figure 3: Heatmap Plots of investments into sorting and demands of investments respectively. Darker colors indicate a higher frequency of the respective investment level chosen in a given period.

	employee investment odds ratios	employer demanded investment odds ratios
productivity (high==1)	2.326***	
	(7.73)	
institution (screening = 1)	0.890	0.966
	(-0.41)	(-0.12)
costs of investment (investment = 1)	0.258***	1.049
	(-4.91)	(0.17)
period	0.959***	1.009*
	(-6.61)	(2.22)
cut points		
cut 1	0.907	0.151***
	(-0.40)	(-7.16)
cut 2	2.371***	0.764
	(3.70)	(-1.13)
cut 3	6.257***	1.384
	(7.86)	(1.31)
cut 4	23.83***	2.433***
	(10.01)	(3.32)
Choices	4480	4480
L_2-cluster	112	112

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Investment behavior of workers (left) and demanded investments by employers (right). Parameter estimates are displayed as odds ratios, ordinal logit model with subject-clustered standard errors.

a *The investments Y demanded by employers do not differ significantly between treatments*

b *The investments Y demanded by the employers often does not allow for separating λ-types and is stable over time*

Since workers (on average) do not invest at all, and employers demand non-separating investments, the combination of Results 1 and 2 leads to

Result 3. *Pooling equilibria dominate.*

6.2. Wage Bargaining

We continue our analysis by investigating the dynamics of wage bargaining. Table 6 reports separate random effects estimates of wage demands (low and high). Compared to the theoretical prediction of exploiting ultimatum power (0 profit for the employer), the wage demands are relatively modest. Low productivity workers start on average with 5.3 of the 10 tokens as low wage demand and 8.5 out of 20 tokens as high wage demand, while high productivity type's wage demands are on average only about 0.1 tokens higher.

Investing increases the worker's high demands but not the low demands (the pooling wage). Since different levels of investments in education have only marginal impact on the wage demands, it seems more important whether one invests at all rather than how much. With more experience, low wage demands increase, while high wage decrease. This finding is consistent with strong evidence of pooling behavior, becoming more and more important over time.

Finally, since we had no clear prediction about the impact of the signaling institution (signaling or screening) on wage demands, we can only report the surprising negative effects of screening on the low wage demands, which also holds for the workers wage offers.

Result 4. ***(Wage Bargaining)***

a *High and low wage demands converge over time.*

	employee low demand	employee high demand	employer low offer	employer high offer
fixed part				
(demanded) signal = 50	-0.132	0.764***	0.390**	0.685***
	(0.232)	(0.000)	(0.004)	(0.000)
(demanded) signal = 100	0.178	1.501***	0.886***	1.105***
	(0.192)	(0.000)	(0.000)	(0.000)
(demanded) signal = 150	0.389*	2.187***	0.818***	1.269***
	(0.023)	(0.000)	(0.000)	(0.000)
(demanded) signal = 200	0.224	1.580***	1.635***	1.133***
	(0.363)	(0.000)	(0.000)	(0.000)
institution (screening = 1)	-1.293***	-0.829*	-3.531***	-1.989***
	(0.000)	(0.047)	(0.000)	(0.001)
costs of investment (investment = 1)	0.410	0.353	1.603**	2.337***
	(0.168)	(0.399)	(0.002)	(0.000)
productivity (high==1)	0.106***	0.186***		
	(0.000)	(0.000)		
period	0.0227***	-0.0178***	0.0545***	0.0167***
	(0.000)	(0.000)	(0.000)	(0.000)
constant	5.298***	8.496***	7.194***	11.62***
	(0.000)	(0.000)	(0.000)	(0.000)
Random Effects				
ln(L_2-variance)	1.534	2.173	2.686	3.111
Choices	4480	4480	4480	4480
L_2-cluster (Subjects)	112	112	112	112

p-values in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6: Random effects estimators for worker's low and high wage demands (left) and employers low and high wage offers (right).

b *Investments trigger higher wage demands but similar or lower acceptance thresholds and thus leads to lower acceptance rates.*

Both, high and low acceptance thresholds by the employers are much higher than the wages actually demanded by the workers. While workers demand on average roughly 5.5 (8.5) tokens in the first period as their low (high) wage, workers are willing to pay up to 7.1 (11.6) tokens. High wage offers are positively correlated with the the required education level Y, although efficient sorting does not suggest such a dependency. It seems that the employers are more guided by an attempt to reward the worker for investing into the signal, although investments are by no means productivity enhancing.

We observe lower wage offers under screening than under signaling, what nicely parallels the findings for the worker's wage demands, but may be also due to the different histories of wage bargaining under signaling and screening.

Employer's wage offers increase over time from an already high level, as can be seen in the positive and significant estimate for the "period" in Table 6. Note, that the magnitude of the time effect is consistently higher for employers than for workers, such that conflicts in wage bargaining should decrease over time.

This is confirmed in Table 7, where we report the odds ratios of accepting an offer in different treatments. Here, the odds ratios of accepting a wage offer increase over time. In turn, since wage demands increase with investments in signals, acceptance rates in wage bargaining decrease in investments y. The lower acceptance rates under screening found in Table 7 may be explained by the different strength of the effects on wage demands and offers under both institutions. Whereas wage demands decrease under screening, wage offers decrease even stronger, which renders conflicts in wage bargaining more likely.

Result 5. ***(Acceptance rates)***

a *Acceptance rates decrease with investments into sorting y.*

b *Acceptance rates are significantly higher under Signaling than under Screen-*

	employee wage offer accepted	employer wage offer accepted
fixed part		
(demanded) Investment = 0	reference	reference
(demanded) Investment = 50	0.692**	0.640**
	(-3.02)	(-2.85)
(demanded) Investment = 100	0.565***	0.807
	(-3.95)	(-1.23)
(demanded) Investment = 150	0.539***	0.628*
	(-3.34)	(-2.36)
(demanded) Investment = 200	0.259***	0.985
	(-5.20)	(-0.08)
institution (screening = 1)	0.553***	0.521***
	(-4.42)	(-3.43)
costs of investment (investment = 1)	1.044	1.173
	(0.32)	(0.85)
period	1.044***	1.052***
	(12.21)	(13.82)
Random Effects		
ln(L_2-variance)	-1.120***	-0.232
	(-5.34)	(-1.21)
Choices	4480	4480
L_2-cluster (Subjects)	112	112

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7: Acceptance rates. Random effects logit estimators for acceptance rates in wage bargaining for workers (left) and employers (right). Effects are displayed as odds ratios, clusters on the subject level.

ing.

6.3. Efficiency and sources of efficiency losses.

Finally, we will compare the social and individual profitability of both institutions. Table 8 displays the net payoffs per period and its determinants. Note first, that any positive level of investment behavior is not only socially wasteful, but also for the individual worker. On the other side, demanding positive investments ($Y > 0$) is payoff increasing for employers: As the high types invest more than the low types, the benefits of requiring some level of investments are significant in magnitude.

Result 6. ***(Efficiency)***

a Average payoffs are significantly higher for workers with high productivity and for employers hiring workers with high productivity.

b Average payoffs are significantly lower for workers under Screening than under Signaling.

Figure 4 disentangles the two sources of efficiency losses: Losses due to conflicts in wage bargaining are always higher than losses due to inefficient investments, even though both decrease over time and investment related losses virtually vanish. Moreover, conflict costs are higher in screening than in signaling (t-test, $p < 0.001$, clustered errors) and losses related to education investments are higher under signaling than under screening (t-test, $p = 0.038$, clustered errors), decreasing over time.

Result 7. ***(Sources of Efficiency Losses)***

a Efficiency losses due to conflict in wage bargaining are consistently higher than losses due to investments into sorting.

b Efficiency losses due to conflict in wage bargaining are higher in Screening than in Signaling

c Efficiency losses due to investment behavior are higher in Signaling than in Screening.

	employee payoff	employer payoff
(demanded) Investment = 0	reference	reference
(demanded) Investment = 50	-1.683***	1.221***
	(-8.65)	(4.42)
(demanded) Investment = 100	-2.544***	1.865***
	(-10.53)	(6.07)
(demanded) Investment = 150	-3.471***	1.773***
	(-11.47)	(5.26)
(demanded) Investment = 200	-6.790***	2.141***
	(-15.34)	(7.05)
institution (screening = 1)	-1.119***	0.437
	(-4.39)	(1.55)
costs of investment (investment = 1)	-0.475	-0.146
	(-1.84)	(-0.52)
employee's productivity	0.0225*	0.674***
	(1.97)	(51.04)
period	0.0892***	0.0382***
	(18.01)	(6.70)
constant	4.244***	-6.672***
	(14.15)	(-16.53)
Random Effects		
ln(L_2-variance)	3.880	4.546
Choices	4480	4480
L_2-cluster (Subjects)	112	112

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8: Net payoffs for workers and employers. Random effects estimators for net payoffs after wage bargaining and investments for workers (left) and employers (right). Clusters on the subject level.

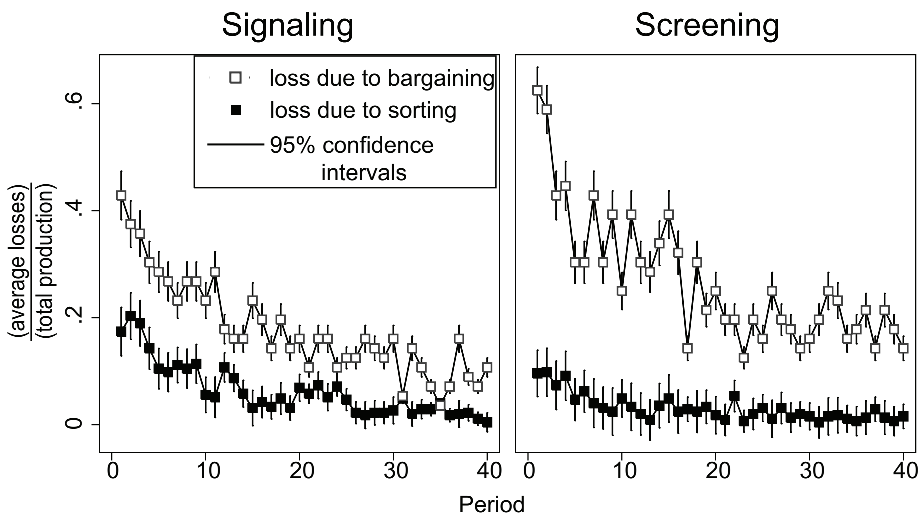

Figure 4: Different sources of efficiency losses under Signaling and Screening.

7. Discussion

In this paper, we present a theoretical and experimental comparison of two sorting institutions in games of incomplete information: Signaling, where the informed party moves first by investing into sorting which allows the uninformed to infer the informed parties type, and screening, where the uninformed party moves first by demanding an investment level and the informed party sorts himself into the respective conditions by choosing his investment.

There are two important contributions of this study: Firstly, we present an experimental design which investigates the two institutions of Screening and Signaling in almost exactly the same choice formats to the participants, despite of the different dynamic interpretations. This experiment can thus be regarded as a robustness check of the experimental results reported in Kübler et al. (2008), who have two rather different choice formats for screening and signaling. Most of the main results of the latter study can be confirmed by our experiment: More productive employees invest higher amounts into screening, where Kübler et al. find that they invest more often. As in their study, productive employees earn more than their less productive counterparts. Moreover, the investment behavior does not differ between screening and signaling, but screening reduces the share of separating outcomes and increases the share of pooling outcomes as compared to signaling.

One important difference remains: While Kübler et al. report that screening significantly increases wages paid to the employees as well as their overall payoffs, and significantly decreases the employers profits, we find the exact opposite. In our study, screening reduces the employees wages and profits, while the employers' profits are not affected by the institutional setup.

Secondly, our design allows us to disentangle the welfare losses associated with investments into sorting on the one hand, and with conflicts in wage bargaining on the other. Both kinds of losses are closely intertwined in labor markets: After years of investment in education, new potential workers may be disappointed by low wages offered to them, while employers are often surprised by the wage demands of freshly graduated workers. This mismatch between employee's demands and employer's willingness to pay leads to our finding that losses associated with wage bargaining conflicts are consistently higher than those caused by investments in else wasteful investments into sorting.

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