Increasing Employment Through the Partial Release of Information*

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April 3, 2021

Abstract

We investigate whether an agency can increase employment by strategically releasing partial information about workers' skills and abilities to employers. Theoretically, we find that such an increase is possible and that there exists a range of employment levels that can be supported in equilibrium. We test this possibility using laboratory experiments with subjects as employers and agencies. We find that full information about workers leads to employer profits that are consistent with theory. Revealing coarser and not necessarily verifiable information about workers increases employment at the expense of the employers' profits but not to the highest theoretically achievable levels.

Keywords: Job placements, lab experiments, institutions, information design, unemployment

JEL codes: C9, D82, J6

*We would like to thank John Ham, John Wooders, and seminar participants at the University of Exeter, University of Haifa, University of Erlangen-Nuremberg, NYU Abu Dhabi, and the Economic Science Association- Tucson as well as the University of Exeter Business School for financial support.

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1 Introduction

Increasing employment and labor force participation is an objective of most democratically elected governments. Labor markets, as is, may not achieve the best feasible outcome due to imperfections. For instance, minimum wages and reasonable work conditions might make it too expensive to hire a worker that would be hired without regulations. Removing such regulations might not be politically feasible. Also, employing workers has positive externalities - the government might save on welfare benefits and have increased tax revenues. Beyond the monetary savings, workers earning wages rather than receiving benefits could lead to better mental health, reduced crime (Heller, 2014; Gelber et al., 2015), and might be preferred by society (Maimonides, 1168). Also, getting an initial job may break a vicious cycle of not being offered a job because one has been long-term unemployed. The government could increase employment by subsidizing the hiring of workers but this may be both expensive and distortionary.

In this paper, we examine another potential way to increase employment – the use of an agency to strategically release information about workers that normally would not be hired. We ask if this agency is able to increase employment by providing coarse information rather than fine information about workers. If an agency releases fine information, then employers will be able to identify less desirable workers, thereby, lowering their chances of employment. If an agency releases coarse information by pooling more and less desirable workers together, then an employer may be willing to hire both of them. We have two related research questions. First, can an agency increase employment by releasing coarser information? Second, if so, does the information need to be verifiable?

Revealing coarse information to increase employment is similar to the use of bundling of goods to increase sales. Stigler (1963) claims that Hollywood studios bundled films to movie theaters in order to increase the number of their films playing. Many supermarkets put fruit in bags rather than sell them individually. This prevents less appealing oranges being left unsold. De Beers has long used a practice of bundling diamonds together. They list only weight and a coarse classification while only allowing buyers to examine the diamonds after the sale (Kenney and Klein, 1983). Similar to the mechanisms in our paper, law schools generally give only partial information about their graduates.[1]

Ratings are commonly used by experts to provide information about restaurants (Michelin), company bonds (Moody, S&P), film and theater (various newspapers) and hotels.[2] Often ratings are coarse, for example, star ratings for movies and UK degree classifications. In principle, the coarseness of these ratings can be used to increase sales and, in the case of students, employment. In many cases, the relationship between ratings and quality is not predetermined. While these cannot be instantly verifiable, over time they can become credible. For instance, with university graduates, employers may learn the capabilities of a student with a 2.1 from the University of Gallifrey.[3]

We use theory and experiments to analyze the following environments where employers care solely about the skill level of their workers.[4] *Full information* - agencies provide the skill level of individual workers. *Bundles* - agencies divide workers into groups and provide the average skill of each group. *Stars* - agencies also divide workers into groups but instead provide a star rating for each group. There is no obligation that a worker's star rating corresponds to the skill of the worker. We consider settings where one agency and one employer interact as well as a setting with competition between agencies and employers.

We start by theoretically exploring the equilibria under the three previously described environments. Using a one-shot, full-information game as a baseline, we find only those with high enough skill are hired. We find that both the bundles and stars environments can have strictly higher employment since low-skill workers can be grouped with higher-

[1] At the time of writing this paper (2021), rules vary from Yale that gives no information to Colorado that gives the ranking of the top 1/3 but does not distinguish among those in the bottom two-thirds. Others like Harvard Law School divide students that graduate with some degree of honors (roughly 25% of the class) to those without honors. providing no additional information. While many law employers would be happy to hire someone who is in the bottom 75% at Harvard, they would not be willing to hire the person at the bottom of the class.

[2] Dranove and Jin (2010) review the literature on quality disclosure and certification. There are also various crowd-sourced ratings such as Trip-advisor, Uber drivers, and sellers on Amazon/eBay.

[3] Another interesting example of bundling to increase acceptances is that MA admission decisions in Israeli universities are not allowed to be based upon undergraduate institution. Technically, if a student took the same courses in Technion (a highly ranked university) and received an 85 they would have the same chance of getting in as a student that received an 85 from the local community college. The logic is to allow students from a more diverse socioeconomic background to have a chance of enrolling. This is essentially bundling the two together.

[4] For simplicity, we assume skill level has one dimension which then makes match quality identical for different firms. With more than one dimension, for example, a worker with high IT skills and low communication skills could be a better fit for a technology company compared to a newspaper.

skilled workers while still making the expected skill profitable for the employer to hire. With repeated play and sufficiently high discount factors, all three environments have a range of equilibria varying from the one-shot full-information equilibrium to a high-employment low-employer-profit equilibrium.

Our laboratory experiment investigated behavior in the three environments. Subjects played the roles of agencies and employers. Since theory yields multiple predictions, laboratory experiments allow us to determine which equilibrium is likely to be selected. A laboratory setting also allows us to precisely control the agencies' and employers' payoffs which is important in understanding the effects of policies.

We experimentally find that coarsening information about workers increases employment, but hurts the employers' profits, and lowers the average skill of the workers employed as suggested possible by our theory. Interestingly, in stars, we found agencies divided employable workers into two categories which gave lower agency profits than the simpler equilibrium where such workers are placed in a single category. In bundles, lower-skilled workers are more likely to be employed when other workers are higher skilled, but in stars, lower-skilled workers are less likely to be employed. Finally, we found that adding competition increases employers' profits under all three environments but had mixed effects on employment.

Our findings could contribute to improving government policy. Governments have long attempted to create programs aimed at increasing employment, for instance, the US Department of Labor, Employment and Training Administration funds job training programs, also the UK's Work and Health Programme (Department of Work and Pension, 2017) has agencies help job seekers join the labor force. Even when unemployment is low overall, it can still be high for certain groups such as those with disabilities and health problems, refugees, ex-offenders.[5] As mentioned earlier, reducing long-term unemployment has economic benefits ranging from increased tax revenue to improved mental health.[6] Our paper suggests an alternative, information-based mechanism, that can be a

[5]See Holzer (2007) for ex-offenders, Dumont et al. (2016) for refugees, and Putz (2019) for disabled workers.

[6]Sen (1997) describes mental and physical health problems, social exclusion and potential loss of freedom from long-term unemployment. Krueger et al. (2014) find that the longer the workers are

complement to the strategies tried thus far and would particularly help those that have difficulties finding employment.

Card et al. (2010, 2018) look at a large group of studies on programs to increase employment, they find that programs that are more effective have a greater human capital accumulation aspect, impacts are greater for women and for individuals with long-term unemployment and for programs during times of recession.[7] We could combine a training program with a mechanism to release coarse information. This would give agencies better information about workers (similar to universities having better information about students). Hence, our mechanism could be used to increase the effectiveness of existing training programs. It also could be used without a training program where the agency just evaluates workers.

There have been a number of studies investigating how information affects hiring in labor markets. Dustmann et al. (2015) find referrals from social networks can lead to better placements evidenced by higher initial wages and lower turnover. There have also been studies using on-line labor markets, which, albeit are a small part of the economy, have lessons that carry over to the larger labor market. Stanton and Thomas (2016) show that agencies can improve the job prospects of workers. In an online field experiment, Pallais (2014) hired workers for a data entry task and then varied the information provided to future employers. Making information less coarse helped the more productive workers but harmed the less productive ones. We study how agencies can use coarse information to increase employment in a setting where it is common knowledge that the agency has an incentive to increase employment.

Laboratory experiments are useful in increasing our understanding of labor markets and improving the design of institutions (see Charness and Kuhn, 2011). Our work is related to the strand of the experimental literature that focuses on how workers are matched with jobs via institutions (Haruvy et al., 2006; Kagel and Roth, 2000) in that we want to design an institution to help workers find jobs. The difference is that as with the literature of search models (Brown et al., 2011; Nalbantian and Schotter, 1995) we

unemployed, the more difficult it is for them to get back to the labor force.

[7]For a survey on the related literature see Crépon and Van Den Berg (2016).

have incomplete information, namely employers do not have complete information about the abilities of workers.[8]

In a similar vein to our paper, Siegenthaler (2017) experimentally confirms the theory of Kim (2012) that cheap talk can increase transactions in a goods market in the presence of asymmetric information and matching frictions. This increase is compared to no information and is still less than it would be under full information. Our paper, on the other hand, shows in our cheap talk treatment (stars) there can be an increased number of transactions over full information as well.

In the next section, we build a theoretical model to examine the environment that we test later in the paper.

2 Theory

2.1 Model

There are n_f employers and n_a agencies. Each agency has a continuum of workers of measure one. We think of these workers as the marginal workers that would not be able to find a job without help of the agencies. Their ex-ante expected productivity is too low to make it worthwhile to hire them. The workers prefer to be employed over being unemployed and have random preferences over employers. There are two states of the world: H and L, with a θ_H chance of the H state and a θ_L of the L state where $\theta_L + \theta_H = 1$ and $\theta_L, \theta_H > 0$. Denote each individual worker i's skill as s_i. The skills of workers have cumulative distribution F_L or F_H (with domain $[0, 1]$) depending upon the state.

An agency knows the skills of the workers which are hidden from the employers. The employer also does not observe the state t (but can perhaps infer the state). We assume that the agency has a specialization in evaluating workers (perhaps through economies of scale) or help provide training for the workers and learn the information in the process. Agencies are paid (by a third party such as the government) a linear function of how many of their workers are hired.

[8] Signalling can also be a means of communication when employers do not have complete information about the worker's abilities (see Miller and Plott, 1985 and Kübler et al., 2008)

We assume the wage is not completely flexible. This assumption can be thought of as a regulated wage, a binding minimum wage, or a wage set by a body outside those making hiring decisions. We capture this in our model by using an exogenous wage $w \in (0,1)$. For each worker hired, an employer earns $s_i - w$. We focus on the case when the wage is higher than the ex-ante expected skill, i.e., $w > \theta \int_0^1 s dF_H(s) + (1-\theta) \int_0^1 s dF_L(s)$. If this condition did not hold, without an agency, there would be full employment, while having an agency that reveals information could decrease employment (such as under full information).

The timing of the model is as follows. First, nature chooses the distribution of workers' skill: either F_L or F_H. Individual skills of workers (and hence the distribution) are seen by the agencies but not the employers. Second, the agencies decide which workers to offer to employers. For each worker offered, a message is sent to all employers. For simplicity, we restrict this message to being a number on $[0,1]$. Formally, for each state t the agency chooses strategy $g_t : [0,1] \to M$ where $g_t(s)$ maps skills into messages M (which includes not making an offer denoted as 0). Let $g = \{g_L, g_h\}$. Denote the set of possible strategy functions as G. There can be restrictions on $g_t(s)$ depending upon the environment (to be described later). Third, the employers observe the messages and decide which of the workers to try to hire. If more than one employer wants to hire a worker, then that worker's preference determines which employer hires him. Fourth, workers are paid wages, employers make profits, and agencies receive payoffs.

We will examine three different environments. In all three environments, agencies can choose whether or not to offer each individual worker to the employers. The environments differ in the form and precision of information that the agencies are able to send.

Full information Agencies must communicate the s_i of each worker, that is, they must tell the exact skill level of the workers offered to the employers. This requires that, for each state, the agency is restricted to using a strategy function $g_t(s) = s$ or 0.

Bundles Under bundles, we restrict the agency to sending a message that equals the average skill of workers with that message – they are bundled together and the average skill of the bundle sent to the employer.

This is equivalent to the following restriction on $g_t(s)$ for each state $t \in \{L, H\}$. For each message $m > 0$ used (that is, there exists an s such that $g_t(s) = m$), if there is a unique s such that $g_t(s) = m$, then $g_t(s) = s$, otherwise we have the following property, which formally is the restriction of the message to equal average skill:

$$m \cdot \int_0^1 \mathbf{1}_{g_t(s)=m} dF_t = \int_0^1 \mathbf{1}_{g_t(s)=m} s dF_t. \tag{1}$$

Stars As with the other environments, the employer does not know the state t directly. With stars, in addition the employer also does not know g_t directly, but does, however, know the distribution of messages.

This can be thought of a star rating for each worker where the rating is the message. The employer sees the star rating but does not know the distribution of skills for each rating, just the distribution of ratings.

There are two key dimensions that separate the environments. First, under full information, the agency is restricted to sending fine information in the sense that if two workers have different skills, the employer will receive two different messages. In bundles and stars, the agency can provide coarse information, meaning that they can send the same message for two workers with different skills. Second, in full information and bundles, the content of the messages is determined by the skills of the workers whereas for stars, the agency can choose the messages regardless of the skills of the workers.

For all three environments, in each state $t \in \{L, H\}$, the employer sees the cumulative distribution of messages $z(m)$ generated by g_t and F_t, that is,

$$z(m) = \int_0^1 \mathbf{1}_{g_t(s) \le m} dF_t. \tag{2}$$

Denote Z as the set of all possible distributions of z. The employer sees a message for each employee and makes a hiring decision based upon that and distribution of messages. Thus, $h : M \times Z \to [0, 1]$, which maps the message and the distribution of messages into a probabilistic hiring decision.

Let $q : G \times \{F_L, F_H\} \to Z$ be such that $q(g_t, F_t)$ and g_t satisfy equation (2) for each $t \in \{L, H\}$. Define $g = (g_L, g_H)$. The expected utility of the agency u_a and employer u_e is as follows:

$$u_a(g,h) = \sum_{t\in\{L,H\}} \theta_t \int_0^1 h(g_t(s), q(g_t, F_t))dF_t,$$

$$u_e(g,h) = \sum_{t\in\{L,H\}} \theta_t \int_0^1 h(g_t(s), q(g_t, F_t))(s-w)dF_t.$$

2.2 Equilibrium concepts

For simplicity, we consider the case of one agency and one employer.

A **Nash equilibrium** is a set of strategies g^* and h^* where g^* maximizes u_a given h^* and h^* maximizes u_e given g^*.

We use sequential equilibria as a refinement since the employer observes the distribution of messages z but not F or g. The employer forms beliefs about g and t from z, which we denote by $b : Z \times G \times \{L, H\} \Rightarrow [0, 1]$. Function b is the employer's belief about the probability of a combination of g and state (L or H) after observing z. We now define expected profits of the employer $w_e(z, h)$ given beliefs:

$$w_e(z,h) = \int_{g\in G, t\in\{L,H\}} b(z,g,t) \int_0^1 h(g_t(s), q(g_t, F_t))(s-w)dF_t.$$

A **sequential equilibrium** is a set of strategies g^* and h^* and beliefs b^* such that (i) h^* maximizes $w_e(z, h)$ given beliefs b^* for all z in Z, (ii) g^* maximizes u_a given h^*, (iii) beliefs b^* are consistent with g^* and θ_t.

2.3 Stage game equilibria

While straightforward, we begin by describing equilibrium behavior under full information in a one-shot setting. If offered a worker of skill s_i, an employer would be willing to hire a worker if $s_i \geq w$ and not willing otherwise. Thus, the employer hiring if and only if $s_i \geq w$ can be an equilibrium strategy. On the other side, if an employer uses this strategy, an agency would offer all such workers and be indifferent to offering the other workers (since they would not be hired). This logic leads to the first Proposition.

Proposition 1. *Under full information, there is a sequential equilibrium where a worker is hired if and only if* $s_i \geq w$.

Proof. Say that the agency uses $g_t(s) = s$ and the employer has consistent beliefs and uses

$$h(m, z) = \begin{cases} 1 & \text{if } m \geq w, \\ 0 & \text{otherwise.} \end{cases}$$

In such a case, neither the agency nor employer has incentive to change their strategy. For the agency, any change would either lower employment or keep it the same. For the employer, any change would either employ workers with skill less than w or not employ workers with skill greater than w. □

Define $F(s) = \sum_t \theta_t F_t(s)$. From Proposition 1, ex-ante each worker has probability $1 - F(w)$ of being hired. Each employer has expected profits of

$$\int_w^1 (s - w) dF(s). \tag{3}$$

We note that there are also other Nash equilibria. These will consist of equilibria where a subset of the workers are not offered and not hired whether or not they are offered. There is no incentive for either agency or employer to change their strategy. These equilibria are less plausible than the sequential equilibrium because the strategy of the employer not hiring all workers where $s > w$ is weakly dominated. Furthermore, given that the employer does not employ a weakly dominated strategy, it is weakly dominant for the agency to offer all workers.

We now look at equilibria under bundles.

Proposition 2. *For any* $\hat{m} \geq w$, *there exists a Nash equilibrium under bundles where: (i) The employer hires a worker in a bundle if the bundle's average skill is at least* $\hat{m}$. *(ii)*

For each state t, the agency offers a single bundle that maximizes the number of workers subject to the average skill of the workers in the bundle is at least $\hat{m}$.

Proof. Say that the employer uses the following hiring decision:

$$h^b(m,z) = \begin{cases} 0 & \text{if } m < \hat{m}, \\ 1 & \text{otherwise.} \end{cases}$$

This means that the employer chooses to hire if the average skill in bundle is $\hat{m}$ or higher regardless of z. Now say that the agency uses

$$g_t(s) = \frac{\int_{s_t^*}^1 s dF_t(s)}{\int_{s_t^*}^1 dF_t(s)}$$

for all $s \geq s_t^*$ and 0 otherwise, where

$$s_t^* = \min\{\hat{s} : \int_{\hat{s}}^1 s dF_t(s) - \hat{m} \int_{\hat{s}}^1 dF_t(s) \geq 0\}.$$

Neither the agency nor employer has incentive to deviate. If the agency increases the number of workers in the bundle, it would lower the average skill to below $\hat{m}$ and none will be hired (and there is no incentive to decrease the number of workers). The employer accepts all profitable bundles sent in equilibrium so deviating to accepting less will be costly and there is no incentive to lower the standard of acceptance to below $\hat{m}$ since in equilibrium those bundles will not be sent. In addition, this maximizes employment for each state t subject to the average skill being at least $\hat{m}$.

□

Corollary 1. *In a Nash equilibrium, employment may be higher in bundles than in full information.*

Proof. Take $F_L(s) = F_h(s) = s$ and $w = 0.6$. With full information, only those with skills above 0.6 will be hired. Under bundles there is an equilibrium where $g_t(s) = 0.6$ for all $s \geq 0.2$. □

Remark 1. *There exists a Nash equilibrium with multiple messages that have workers hired on more than one message. Take* $F_l(s) = F_h(s) = s$ *and* $w = 0.6$*. We can have*

$$g_t(s) = \begin{cases} 0.875 & \textit{if } 0.75 \leq s, \\ 0.625 & \textit{if } 0.5 \leq s < 0.75, \\ 0 & \textit{otherwise.} \end{cases}$$

The employers will accept workers from bundles if the distribution of messages overall has at least half the workers given the message of 0.

An equilibrium with the highest level of employer profit has $g_t^*(s) = 0$ if $s < w$ and w otherwise. This ensures that the employer hires a worker if and only if for his/her skill level it is profitable to do so.

Proposition 3. *Under bundles, the sequential equilibrium results in the Nash equilibrium with the highest level of employment.*

Proof. In a sequential equilibrium, the employer must hire all workers with a message greater than w (and won't hire workers with a message strictly less than w). Thus, so that the agency has no incentive to deviate, they should not be able to add workers to a bundle while keeping the message greater than w. Hence, for each state t, any message where workers are hired should either have an average skill equal to w for that message or all workers are hired for state t (whereupon the average skill could be strictly higher than w). Note that this restriction implies that if some workers are not hired in state t, then all workers hired in state t must be in the same bundle. Let us call this condition **minimum employability**.

Furthermore, if the average skill for a message is w, then there must be **monotonicity** of hiring in skill level - if a worker of level s is hired, then a worker of skill level $s' > s$ is also hired. If monotonicity does not hold, the agency can replace the lower skill worker with a higher skill worker and increase the average skill to strictly above w. This would allow the agency to expand the number of workers since the bundle would then violate the prior condition of minimum employability.

Monotonicity and minimum employability imply that for each state t one message will be sent that includes all workers with skills above a cutoff such that either all workers are included or the average skill above the cutoff equals w.

The outcome of this sequential equilibrium is the same outcome of the Nash equilibrium in Proposition 2 for $\hat{m} = w$. This is the highest employment Nash equilibrium.

□

We now start to examine the equilibria in stars with the following proposition.

Proposition 4. *In stars:*
(i) There exists an equilibrium where a constant fraction of workers are hired (independent of state).
(ii) There does not exist a separating equilibrium where the employer hires different fractions of workers depending upon the state.

Proof. (i) There exists two equilibrium cutoffs s_L and s_H where $F_H(s_H) = F_L(s_L)$ and $\hat{s} = \frac{\theta_L \int_{s_L}^1 sdF_L + \theta_H \int_{s_H}^1 sdF_H}{1-F_L(s_L)}$ for some $\hat{s}$ where $1 > \hat{s} \geq w$ and $F_H(\hat{s}) < 1$. All workers with skill above their respective cutoffs will be hired with the following equilibrium strategies for $\hat{m} > 0$.

$$g_t^*(s) = \begin{cases} \hat{m} & \text{if } s \geq s_t, \\ 0 & \text{otherwise.} \end{cases}$$

The employer only hires worker if the message is $\hat{m}$ and the distribution of messages is $q(g_t^*, F_L)$, that is,

$$h^*(m, z) = \begin{cases} 1 & \text{if } m = \hat{m} \text{ and } z = q(g_t^*, F_L), \\ 0 & \text{otherwise.} \end{cases}$$

Note that F_L and F_H are interchangeable since there is only a binary range of messages with the same fraction of each message.

(ii) Suppose that there exists such a separating equilibrium. If in state t' there is a higher fraction hired than in state t'', the agency can imitate the strategy of state t' when the state is t''. It can do so by sending $g_{t''}(s) = g_{t'}(F_{t'}^{-1}(F_{t''}(s)))$. This sends the same distribution of messages by sending the same message by percentile of skill in each state t'' as in state s'.

□

Corollary 2. *When $F_L = F_H$, there exists a Nash equilibrium where for each state the average skill of those hired is at least w.*

We now wish to refine the set of Nash equilibria, using sequential equilibria with a certain type of beliefs of the employers which we call ***sorted***. Simply put, the employer believes that a higher message implies a weakly higher skill level. In terms of the belief function, $b^*(z, g, t)$, it requires that $b^*(z, g, t) = 0$ if g is not weakly monotonic in skill.

This monotonicity seems natural with star ratings, namely that higher stars imply a high skill level.

We now define the requirement that beliefs have to be feasible. A **feasible** belief $b(z, g)$ has two conditions: (i) If for all z, g and t where $b(z, g, t) > 0$, we have $z = q(g)$, and (ii) For all z, we have

$$\int_{G,t\in\{L,H\}} b^*(z, g, t)dg = 1.$$

Proposition 5. *When $F_L = F_H$, under sorted beliefs, the sequential equilibrium in stars is identical to the sequential equilibrium in bundles.*

Proof. Since $F_L = F_H$, we can have beliefs independent of state which we will denote as $b(z, g)$.

Now we can show the following: *When beliefs are sorted and feasible, for each z, there is a unique g' such that $b(z, g') = 1$ (and hence $b(z, g) = 0$ for all $g \neq g'$.)*

Let us say that there are two functions g' and g'' where $g'' \neq g'$ such that $b(z, g'), b(z, g'') > 0$. For feasibility, we must have $z = q(g') = q(g'')$. Since $g' \neq g''$, there must exist an s' such that $g'(s') \neq g''(s')$. Without loss of generality assume $g'(s') > g''(s')$. Sorted beliefs implies that both g' and g'' are weakly monotonic. Since $q(g') = q(g'')$, we must have that

$$z(g'(s')) = z(g''(s')) = F(s') \tag{4}$$

However, since $g' \neq g''$), there must be an $s'' > s'$ such that $g''(s'') = g'(s')$. From substituting $g''(s'')$ for $g'(s')$ into equation 4 , we have $z(g''(s'')) = F(s')$. We must also have $z(g''(s'')) = F(s'')$ by definition of z. This leads to a contradiction.

Since the employer can now determine which g function is used by the agency, the employer can infer the true expected skill of the worker for each message sent. Thus, the game is equivalent to that under bundles and it leads to the same sequential equilibrium.

□

Proposition 6. *(i) When $F_L \neq F_H$, the sequential equilibrium in stars can lead to higher employment than in bundles.*
(ii) When $F_L \neq F_H$, the sequential equilibrium in stars can lead to lower employment than in bundles.

Proof. We will prove both parts by way of example.

(i) Take F_L is uniform on $[0, 1/2]$ and F_H is uniform on $[1/2, 1]$, $\theta_L = 3/5$, $\theta_H = 2/5$ and $w = 1/2$. It is an equilibrium in stars, if the agency gives its top 80% workers a 5* rating and the 20% rest a 1* rating. Then, the average skill of those workers in the low state and high state are 0.3 and 0.8, respectively. Since $0.3 \cdot 0.6 + 0.8 \cdot 0.4 = 0.5$, the employer would agree to hire. Hence, 80% of the workers will be employed as opposed to 0 under no information and 40% under full information and bundles.[9]

(ii) Take F_L uniform on $[0, 0.1]$, F_H uniform on $[0.9, 1]$, $\theta_L = .6$, and $\theta_H = 0.4$. In this case, no one would be hired under stars while under full information and bundles all those in the high state will be hired. [10]

□

With full commitment by the agency to a strategy (Bayesian Persuasion), the agency can mimic either stars or bundles, whichever does the best. The agency may be able

[9]Example (i) is like the UC system admitting students from California in the top 9 percent of their high school class independent of high school via the Eligibility in the Local Context program (the top 9% was the cutoff at the time of writing of this paper in 2021). This policy allows for more students from public schools to be admitted rather than relying on SATs or discriminating between high schools.

[10]Example (ii) This is like admissions to the top Economics PhD programs. Even the top student from certain universities will not be admitted. It is also true for hiring faculty. The best PhD students from certain lower-ranked schools will not be hired.

to strictly better by committing to a mixed strategy. We see this in the example in the proof of Proposition 6(ii). If the state is L, the agency can send 1* one-third of the time for all the workers and 5* two-thirds of the time for all the workers. If the state is H, the agency can send 5* all the time. With this strategy, the average skill for those with 5* will be precisely 0.5. An equilibrium thus exists with all workers with 5* getting hired. This will have 80% of the workers being hired. This is higher than the 0% employment in stars and 40% employment in bundles.

The preceding arguments lead to the following remark.

Remark 2. *Full commitment by the agency to a mixed strategy (Bayesian Persuasion) will do at least as well as either bundles or stars and can potentially do strictly better.*[11]

We also note that all the above propositions still hold under competition (when there are multiple agencies and employers). However, having more than one agency allows for equilibria with different strategies between agencies. For instance, one agency is offering the workers such that it is in the equilibrium with the highest level of employment, while another agency is offering workers in the equilibrium with the highest level of employer profit.

2.4 Punishment strategy equilibria

Any stage game equilibrium can also be an equilibrium in a repeated setting. We now look at repeated game equilibria, where perhaps a higher level of employment or employer profits can be supported by repeated interaction and punishment. In order to do so, we introduce a discount factor $\delta \in (0, 1)$ into the preferences where a profit of one in period $t + 1$ is worth δ in period t.

Let us first consider the case of no competition where one agency interacts with one employer. In the following proposition, we characterize the range of possible employment levels.

[11] We conjecture that full commitment strictly better if the highest employment equilibrium from either bundles or stars leaves the employer strictly positive profit.

Proposition 7. *When $F_L = F_H$, repeated play can increase the range of equilibrium employment levels compared to one-shot play under full information but not bundles and stars.*

Proof. As with the proof of Proposition 4, let s' be the value that solves $w = \frac{\int_{s'}^{1} s dF}{1-F(s')}$. Under full information, for any ρ satisfying $s' < \rho \leq w$, there exists a large enough discount rate δ, such that there exists an equilibrium where workers with skill level above ρ are employed. Agencies can punish employers by not offering workers (withholding workers). The strongest punishment strategy when implemented yields zero profits to both parties. Hence, any equilibrium with positive profit for the employer can be supported. To see this, denote e as the employer period earnings. Denote m as the maximum profit earned by the employer by deviating from this equilibrium. Deviations are not profitable if $m < \frac{e}{1-\delta}$.

There is no improvement in bundles or stars, since by Proposition 2 and 4, this level is already potentially a Nash equilibrium.

□

While the above proposition states that repeated game effects cannot increase the range of equilibria in bundles and stars when $F_L = F_H$, we can have an improvement when $F_L \neq F_H$ as seen in the next proposition.

Proposition 8. *When $F_L \neq F_H$, the repeated game equilibrium may improve employment over the one-shot equilibrium by using a cutoff skill level for employment (being offered).*

Proof. We will prove this by way of example.

Take F_L is uniform on $[0, 2/3]$, F_H is uniform $[1/3, 1]$, $\theta_H = \theta_L = 1/2$, $w = 2/3$. In the one shot equilibria, the highest employment equilibria will be as follows: under full information, only 25% of the workers will be employed (half the workers in the high state); under bundles, 50 % of the workers will be employed (only the workers in the high state); and under stars, 50 % of the workers will be hired (half in each state).

With repeated game considerations, employment can be increased under all three conditions to 60% by having only workers with skill above 13/30 being offered in either state with employers hiring them. In the low state, the employer hires 35% of workers with average skill of 0.55. In the high state, the employer is hiring workers 85% of workers with an average skill of 0.717. Overall, the average skills of those hired is slightly higher than 2/3. This is better for both parties.

This can be supported by the agency withholding workers if the employer deviates or the employer not hiring if the agency deviates.

□

Now let us consider the case of competition with multiple agencies and multiple employers.

Proposition 9. *In repeated play with bundles and full information, competition does not affect the set of feasible equilibria. However, in repeated play and stars, competition reduces the set of equilibria in favor of the agencies since punishment by employers is now more limited.*

Proof. If employers can coordinate to punish an agency for deviations from the equilibrium and agencies can coordinate to punish an employer for deviations, then the set of equilibria under competition will coincide with the set of equilibria without competition. Under bundles this is indeed possible. Employers can see what bundles each of agency offers. Agencies can see which workers employers hire. Under stars, however, this is not possible. Employers can only see the star ratings placed on workers and cannot see if an agency gave a low-skill worker a high star-rating whom they did not hire. Only the employer, after hiring the worker, can see the worker's true skill, the other agency and non-hiring employer cannot see this. □

In the full information environment, the set of repeated equilibria is larger than the set of one-shot equilibria. In particular, in one-shot, no worker with a skill level strictly under w can be hired in equilibrium, but this can be supported in repeated play by withholding workers to punish the employers. While for bundles and stars, the range of equilibria is the same for both repeated and one-shot games, the mechanism supporting them can be very different. For instance, the high employer profit equilibrium can only be supported as a Nash equilibrium under one-shot with bundles since the employer would not refuse a bundle offering positive profit. However, this can be supported under repeated play since the employer would refuse a lower bundle if it would maintain a higher profit equilibrium in the future.

While in this theory section, we assumed a continuum of workers, our experiment had a finite number of workers. We discuss in Section 4 how this affects our results in particular with bundles for the high employment equilibrium, employers would sometimes have bundles where profits are negative. There is a limit to how much of a loss the employers would be willing to accept.

Finally, we note that our one-shot equilibria have some complementarities in that for a worker of a certain skill it is weakly better for the state to be H than L in bundles, while in stars it is weakly better for the state to be L than H. Both are strictly better for certain skill levels when $F_L \neq F_H$.

3 Design

A total of 240 subjects participated in the experiment, 40 in each of 6 treatments. The experiment was conducted in the FEELE lab at the University of Exeter and subjects were undergraduate students. Subjects played the agencies and the employers in equal numbers over a series of periods. In each period, each agency received five workers each with skill s drawn *iid* from $(0, 1, \cdots, 10)$ with each value equally likely. Employers could hire up to five workers. For each worker hired, the agency earned one point and the employer earned $s - w$ where s was the worker's skill and w represented the wage and was fixed at 6.

The timing of the experiment was as follows. At the start of the experiment, subjects read through a set of paper instructions.[12] Then each participant practiced both the role of the agency and the employer before being assigned a fixed role and group. The worker skill levels were redrawn for each agency each period. However, the same sequences of draws were used for each treatment. For example, agency 3 in period 4 would have the

[12]A sample set of instructions is included as a supplementary file.

same worker skill draws in each of the treatments. An HTML5 user interface was used which enabled agencies and employers to make their decisions by dragging and dropping workers into bundles or rankings. Within each period, agencies chose which workers to offer and what information to reveal about their workers to employers. After seeing information about the workers from the agencies, employers decided which workers to send offers to.

From the 10^{th} period onwards, there was a 10 percent chance of the game ending after each period. the number of periods differed between groups within a treatment but had equivalent groups between treatments. For example, group 2 lasted 17 periods in all treatments, while group 3 lasted 26 periods. The experiment lasted from 11 periods to 30 periods (average of 18.1 periods). Participants were paid for the last 10 periods completed.[13] For example, if the game ends after the 17^{th} period, they would be paid based on their points from periods 8 to 17. Subjects received a show-up fee of £5 and £0.20 for each point earned in the ten paid periods. The experiment lasted between 45 and 75 minutes and the average payment was approximately £10.

We use a 3×2 design consisting of three information structures and two market structures. The information structures vary in how much an agency reveals to the employers about the skills of their workers:

Full information Agencies must tell the precise skill level of the workers offered. In the full-information treatments, the employer observes the skill of each worker before deciding which workers to hire.

Bundles The agency placed the workers into bundles of one or more workers. The mean skill and range of skills of workers in a bundle were revealed. The employers learned the true skill of individual workers only after they were hired.

Stars The agency assigned each worker a star rating (1 to 5). There was no obligation that the star rating corresponded to the skill of the worker. The workers' true skill levels were only revealed to the employer if the employer actually hired them.

[13]Theoretically, this will be no different than paying for all the periods.

See the respective screenshots of each information structure in Appendices B, C, and D.

There are two market structures (in each, agencies had five workers and employers could hire up to five workers):

No-competition One agency interacts with one employer. Employers selected which workers to hire.

Competition Two agencies interact with two employers. Employers were told which agency each worker was from. The employers ranked the workers they were interested in hiring. The ranking could include more than five workers since both employers might be interested in the same workers. To resolve possible competition for workers, a deferred acceptance matching algorithm was used.[14] Workers had a random preference over working for the two employers and employers made the proposals, so it was incentive compatible for the employers to truthfully report their preferences.[15]

The full-information, no-competition treatment can be regarded as the baseline.

4 Predictions

In this section, we apply our theoretical results to the parameters detailed in the design section accounting for a finite number of workers. There is generally a range of equilibria which we highlight below.

[14]The deferred acceptance algorithm (Gale and Shapley, 1962) works as follows. Workers always want to be employed and rank both employers. Employers may not want to hire all the workers and thus rank only those they are interested in. The algorithm goes through a number of iterations. In the first iteration, employers make offers to their top five workers. If a worker gets an offer from both employers, then the least preferred offer is rejected. In the next iteration, if an employer had an offer rejected in the previous iteration, then the employer makes additional offers up to a total of five outstanding offers. Workers with two offers, again must reject one. The algorithm is repeated until no offers are rejected.

[15]There are numerous variations of competition that we could consider. We chose the no competition structure since it is the simplest. We chose competition on both sides of the market since it is the most natural – generally markets would have multiple agencies and employers.

4.1 Stage game equilibria

With full information if subjects play as if they are in a one-shot game, in a subgame-perfect equilibrium all workers with skill 7 or higher would be hired and those with skill 5 or less would not be hired, those with skill 6 could either be hired or not be hired. This results in 36-45% being hired with the corresponding average skill of workers from 8.5 to 8, respectively. The expected employer profits per worker in these cases will be 0.909. These numbers are regardless of whether or not there is competition.

With bundling, in a subgame perfect equilibrium, the agency creates a bundle by adding the worker with the highest skill not in the bundle until adding the worker would cause the bundle average skill to fall below 6. In expectation, this yields 67.2% being hired with average skill 6.5. We note that 11.5% of the workers with skill level 0 and 1 will be hired.

With stars, the highest employment can be achieved in equilibrium when the agency rates the three best workers 5-stars and the rest lower than 5-star (this is sustained since employer beliefs depend upon the number of workers in a particular category). This gives 60% employment and average skill 6.8. We note that 5.5% of workers with level 0 and 1 will be hired in such an equilibrium. The equilibrium with the highest employer profit has only two workers being offered (or given the highest rating) yielding an employer profit of 3.46.

4.2 Punishment strategy equilibria

In addition to the stage game equilibria, in repeated games we can have equilibria sustained with the threat of punishment. The agency can punish employers by withholding workers in subsequent periods. Employers can punish agencies by not hiring in subsequent periods. Punishment is limited by the 10% chance of the experiment ending after the tenth period. Some punishments may be less plausible than others, for instance, under full information an agency withholding workers that would be attractive to an employer or an employer not hiring a worker that would yield profit might not be credible, but under stars this could be more palatable since true skill is not known to the employer.

There is a straightforward equilibrium where employers make their maximal profits. Agencies offer all workers at level 6 or above, 45% of workers (also, 7 or above, 35% of workers, is a similar equilibrium). Employers punish if a worker is offered that does not satisfy this criterion. Agencies do not have an incentive to deviate by offering fewer workers (which would not be detected) and would be punished by offering more workers. This is the case under full information, bundles, and stars.

Under full information, an agency can use the threat of withholding workers to have all workers with 3 or above hired. The employer would still hire all 5 workers even if they all have a skill level of 3. The average skill level of a worker given that they have a skill level of 3 or higher is 6.5. There is an 8/11 chance of a worker having a 3+ skill level. Hence, each period the employer expects to make $(8/11) \cdot 5 \cdot (6.5 - 6)$. Discounting the expected stream of profits yields 16.4 which is higher than the cost of hiring 5 workers with skill level of 3. We note that there are more complicated equilibria where some of the workers with skill level 2 are hired.

With bundles, the agency can increase bundle size up to a certain limit and still have an employer hire everyone in the bundle. By doing so, an employer may lose a certain amount. If the agency limits this amount to L, the employer may be willing to bear this loss if the future expectation of such an arrangement is high enough. For instance, say the agency sets $L = 3$ and if bundling all 5 workers yields a loss larger than 3, the agency will see if offering the best 4 workers yields a loss larger than 3. Again, if so, this can be repeated by offering the best 3 workers and so on. By computation, using $L = 3$ yields an employer profit of 0.020 versus using $L = 2$ yields a profit of 0.656. We see that a loss of 3 would not be tolerable to an employer with a discount rate of 0.9. However, losing 2 today is well worth an expected stream of profits equalling 0.656. In this case, employment will be 75.8% and average skill 6.2.

Under stars, there can be higher employment in equilibrium than with bundles. This is because with stars the employer knows the expected skill when deciding whom to hire and only sees the actual skill after hiring workers. The agency can give a 5-star rating to all those workers with skill level of 2+ (and workers with skill level of 1 or 0 a rating of 1-star). This on average would leave the employer with zero profits but would still be an equilibrium. In each period, after seeing the workers offered, the expected profit would be 0 for an employer.[16] Any deviation by the agency can be detected by the employer and can be punished by no hiring in the future. At most, the agency can have five more workers hired by giving five skill 0 workers a 5-star rating. Doing so, would not be worthwhile since it would lose an average of 4.1 workers being hired in each future period.

Finally, in all cases, there are other equilibria between the two extremes. Note that the use of repeated game strategies can increase employment in equilibrium. Under full information and stars, there will be no skill level 0 and 1 hired in the equilibrium that we examine. Under bundles this would happen some of the time such as when one worker has skill level 0 and the other workers have a skill level of 7+. In our repeated game equilibrium, 20.3% of level 0 and 1 workers will be hired in equilibrium.

With competition, all the above repeated equilibria can be supported. For full information and bundles, both employers can see what is offered and punish deviations accordingly. With stars, only the employer getting a worker with a low skill will see this. However, just one employer punishing in return is enough since at most an agency can place an additional five workers, but punishment from one employer will cost more than one worker per period on average.

5 Results

[Figure 1 about here.]

[Table 1 about here.]

We start by looking at the employment, employer profits and average skill level of employed workers in each treatment. There is a constraint restricting the average skill

[16]We can give an employer an arbitrarily small amount of profit with the following strategy. The agency gives a 5-star rating to all workers with skill level 2 or above when there are two or more workers. When there is a single worker with a skill level of 2+, the agency only gives a 5-star rating to this worker when the skill level is 3+. This can be done every n periods to make the profit arbitrarily small.

of employed workers and the level of employment achievable. The outcomes of each treatment and the employment-average skill trade-off as well as the theoretical limits of employment are illustrated in Figure 1. The frontier (solid line) shows the trade-off and the iso-profit lines show combinations of employment and average skill that give the employer the same profit. Note that points `stage game 1, full info` and `stage game 2, full info` in Figure 1, correspond to the range given in Section 4.1 that are achievable in a stage game equilibrium under full information. Numerical values are reported in Table 1. For employment, the stars with competition did the best while full information without competition did the worst. For employer profits, full information with competition did the best and stars did the worst. For average skill, full information did the best and stars did the worst.[17]

Notice that under full information and competition, the level of employment is close to that of point `stage game 2, full info` (45.4%) in Figure 1. This leads to our first result.

Result 1. *Full information leads to high employer profits with and without competition.*

With full information and competition, employment is on the frontier of the theoretical maximal employer profits with the largest employment (that is, point `stage game 2, full info` in Figure 1). Full information without competition has lower employment and slightly lower employer profits compared with full information with competition. This is mainly due to the reduction in hiring particularly skill level 6 workers (see Table 3 for details). There was some drop in hiring level 7+ skill workers mainly due to the agencies not offering such workers (627 hired out of 642 offered without competition versus 669 hired out of 673 with competition).

Withholding of workers with skill greater than 6 was relatively rare - only three agencies, all in the full information without competition treatment, failed to offer all

[17]In our sample, if all skill 6 and above are employed, the level of employment is 821 (out of 1810) with average skill of 8.02. If only skill 7 and above are employed, the level of employment is 673 with average skill of 8.47. In both cases, there are employer profits of 0.917 per worker (including those unemployed). This compares with section 4.1 prediction of an average skill level of 8 and 8.5, respectively and profits of .909.

workers with skill greater than 6. While withholding is a punishment strategy and in equilibrium would not be used, the equilibrium supported by such strategies are far from the observed behavior, that is, skill levels is much higher than 6.5 and employment is much lower than 73% from what we found in Section 4.2.

Our next result shows that under different treatments when we move away from full information, we increase employment at the expense of hiring workers only with high skill levels.

Result 2. *Coarsening of information about workers increased employment at the expense of employer profits.*

[Table 2 about here.]

[Figure 2 about here.]

[Table 3 about here.]

We can see from Figure 1 and Table 1 that the employment is higher in the bundles and stars treatments where the agencies could release coarse information. This is supported by regression 1 of Table 2 where the probability of employment increases by 5 percentage points if information is coarse (in the bundles or stars treatments) compared to full information. Regression 2 disaggregates the effects of stars and bundles while controlling for competition. The effect sizes for stars and bundles are similar to the effect size of coarse information in regression 1, although for stars, it is not statistically significant at the 5% level (but is at the 10% level). We note that while there is an increase in employment, this is still far from the theoretical possible as one can see in Figure 1.

Looking at employer profits, when we move from the full information and competition, Result 1 indicates that employer profits must be lower when employment increases. This can only happen if workers of level 5 skill or lower are hired. Indeed, Table 3 and Figure 2 show that employment increases are due to more low-skill workers being hired albeit at some cost of less high-skill workers being hired.

We can see the change in both employment and employer profits in Figure 1. The coarsening of information decreased employer profits in all cases. When there was no competition, the coarsening caused the employer profits to drop from 0.808 with full information to 0.522 with bundles and 0.245 with stars. When there was competition, the coarsening of information caused the employer profits to drop from 0.879 with full information to 0.564 with bundles and 0.424 with stars (see Table 1).

The coarsening of information also reduced the average skill of the employed. When there was no competition, the coarsening caused the average skill of workers employed to drop from 8.031 with full information to 7.053 with bundles and 6.578 with stars. When there was competition, the coarsening of information caused the average skill of workers to drop from 7.903 with full information to 7.205 with bundles and 6.775 with stars (see Table 1).

We now examine the effect of competition (two agencies and two employers) within each information condition.

Result 3. *Competition increases employment under full information and stars.*

Looking at regression 2 of Table 2, the probability of being employed is higher in the competition treatments. Breaking this down into the three information conditions in regression 3 of Table 2, we see that this is driven by full information and stars only. While not significant, the sign for bundles and competition is negative.

From Table 3, we see Result 3 in that agencies are helped by the number of workers employed increasing going to competition in both full information and stars. We note that with bundles the number of workers employed actually decreased in going to competition in bundles but this is not significant. Competition led to better bundles which hurt the lower skill workers relative to no competition. In Table 3, we have the number of workers employed based upon their skill level for each of the six treatments.

Table 1 shows the agency and employer profits in each of the treatments. We see in all cases employer profits increased with competition, but none of the increases were significant. With competition employment was highest with stars.

Our next result deals with how the employment of lower-skilled workers is affected by other workers from the same agency.

Result 4. *With bundles, lower-skilled workers benefit when other workers are higher skilled, the opposite occurs in stars.*

The evidence of this result is in Table 4 which displays regressions examining the effect of others' skill on employment of low-skill workers. The dependent variable is being employed. There is one observation per worker with skill less than 6. Separate regressions are run for each of the bundles and stars treatments. There is a positive relationship to the average skill of others with bundles and a negative one with stars. The effect is statistically significant except for bundles with competition.

We see that low-skill workers are a complement to high-skill workers in bundles. This result comes from agencies including low-skill workers in bundles with high-skill workers while ensuring the average bundle skill is greater than 6. When the skill of the other workers goes up, the possibility of forming such a bundle that includes a low-skill worker goes up. This is consistent with the stage-game equilibria analysis for bundles of Section 4.1.

In contrast, high-skill workers are substitutes for low-skill workers with stars. This indicates that the agency is using a target for the number of 4 and 5 stars given out. When they fail to have the number of workers achieving the target with high skill levels, they use low skill levels to increase the number of workers.[18] This is consistent with the stage-game analysis for stars where the highest employment equilibria had the top 3 workers offered each time and the highest employer profit equilibria had the top 2 being offered each period. Hence, low-skill workers act as substitutes for high-skill workers.

[Table 4 about here.]

Our next result was unanticipated and in order to precisely explain it, we need to introduce two definitions. For the star ratings, the agency and employer can think of certain star ratings as a category for outstanding workers, like what we think of 5-stars in regards to hotels. Here we define such an **outstanding category** as one where the

[18]We find empirical support for such behavior in that a regression of a worker being rated a 4-star or 5-star is negative in the average skill of the other workers (with and without competition). For brevity, we leave a table of these results out of the paper.

skill level guarantee's a profit, namely, of skill 7 or higher. We also define a **borderline skill category** as one with skill levels of 5 or 6, for which the employer would be either indifferent or suffer a minor loss for hiring such a worker. We can now use the above nomenclature to describe our next result about how there were different star rating categories.

Result 5. *With stars, there were two categories where workers of employable skills were both classified and employed. The 5-star category was for outstanding workers. The 4-star category was for borderline workers. Competition drove both categories to be more delineated and increased acceptance rates of both.*

This result was surprising since in our theory section, only one star category of employable workers is sufficient to achieve the highest level of employment.

[Figure 3 about here.]

We find support for Result 5 visually in Figure 3. From this figure, we see that competition drove more 7, 8, 9, 10 skilled workers into the 5-star category and away from 3-star and lower. We also see that competition drove more 0, 1, 2 skilled workers away from the 3-star category. For the 5-star rating, 72% of workers offered are outstanding workers compared with 3%, 7%, 15%, and 30%, for 1-star, 2-star, 3-star, and 4-star categories, respectively. For the 4-star rating, 31% of workers offered are borderline skill workers compared with 6%, 8%, 22% and 13%, for 1-star, 2-star, 3-star, and 5-star categories, respectively.

[Table 5 about here.]

We also see that from Table 5, the average skill level of a 5-star bundle is 6.99 without competition and 7.51 with competition and the average skill level of a 4-star bundle is 5.22 without competition and 4.89 with competition. This indicates an increased separation moving from no competition to competition.

We would expect agencies to only make use of the 5-star category, but they put employable workers in the 4-star and 5-star categories. The 5-star is highly profitable for the employer, the 4-star is borderline. Employers respond by almost always hiring the 5-star workers and hiring some of the 4-star workers. We also see from Figure 3 that the shift of higher skilled workers into the 5-star rating led to a higher acceptance of 5-star (and maybe higher 4-star acceptance).

Finally, we note that there is a degree of heterogeneity in individual agency behavior. In Appendix A, Figures 4 and 5 display the range of worker skills for each individual agency for without and with competition, respectively. While most and a strictly positive relationship between skills and star ratings. We see, for instance, Agency 7 in Figure 4 consistently only offered workers of skill 6 and above and only labeled them 5-star. Also, Agency 20 in Figure 5 used star ratings of 1-star, 2-star, and 3-star for skills 0 and 1 and reserved category 4-star and 5-star for the higher skills (although not exclusively).

We wish to know if employers learned about the strategies of the agencies. In other words, whether the agencies create a reputation. We, hence, analyze decisions of the employers based upon the observed skills of the workers previously hired both from the current agency and from workers from the other agency. Our findings are summarized in the following result.

Result 6. *With star ratings, the reputation of an agency affects the employers' willingness to employ a worker, namely, higher previous observed skill in the star category from the same agency increased the likelihood of a worker receiving an acceptance.*

Models are estimated using workers with 4 or 5 star ratings for both competition and no competition. See the regression reported in Table 6. For instance, model (1) considers workers with a 4-star rating from the treatment without competition. The dependent variable is 1 if the employer was willing to hire the worker and 0 otherwise. The explanatory variables are as follows. *Unobserved* is 1 if the employer has never hired a worker with the current star rating from the agency offering the worker and 0 otherwise. *Observed* is the mean skill of workers with the current star rating that the employer has previously hired from the agency offering the worker or 0 if no such workers have been hired. *Period* is the period number. For the treatments with competition, *unobserved other* and *observed other* are the equivalents of *unobserved* and *observed* for the other agency.

The coefficient on *observed* is positive for all models. For four of the six models it is statistically significant. This suggests that employers were more willing to hire workers with a given star rating the higher the skill of previously hired workers from the same agency with the same star rating. This in turn suggests there was some learning rather than immediate coordination between the agency and the employer on the meaning of star ratings.

[Table 6 about here.]

6 Discussion

Our theoretical analysis suggests that there is a range of possible equilibria that may occur in an agency-employer game. We then use experiments to examine what is likely to play out in practice. Doing so, we find that an agency can increase worker employment by only revealing coarse information about workers (our bundle treatment) and this information does not have to be verifiable (our stars treatment). While in theory we found a possible alternative means for increasing employment by an agency punishing employers through withholding high-skill workers, we did not see the high level of employment that this would induce.

In our experiment, bundles and stars both yielded higher employment than full information, but bundles outside the lab might be harder to implement since it requires verification. These results were robust to competition. Our experimental results suggest that this extra cost of using verifiable information might not be necessary. One difference that we find between stars and bundles is that with stars, workers with high and low skills are substitutes whereas with bundles they are complements. This is like being a sprinter in the Olympics. Strong teammates hurt your chances of making the Olympics in an individual event but increase your chances of making the Olympics in the relay races.

One may worry that the our proposed mechanism might only temporarily increase employment. The employer may wish to dismiss workers after discovering that they are low skilled. While indeed an employer may eventually discover this, the employer may still want to retain a significant portion of these workers. There are three reasons for this beyond basic switching costs. First, some workers may learn valuable skills (some firm specific) on the job. This learning may be a result of considerable sunk-cost investment by the firm. Second, some of the workers might be underrated: the initial signal might not fully represent the worker's ability. Once given the chance to prove himself/herself, the worker may shine. This could be particularly true for workers caught in a trap of not given a chance after an initial lower signal or in the case of a first job (see Stanton and Thomas, 2016). Bleemer (2021) finds a similar benefit to these first two points holding for the California ELC program with admissions to the UC universities. While those admitted solely by being in the top 9% of their high school class had test scores only on the 12^{th} percentile of those admitted, there was a significant and substantial benefit to their future earnings.[19] Finally, for worker retention there could be a multiplier effect in that a firm's willingness to hire workers increases with other firms hiring workers (due to increased demand).

There is growing governmental interest in involving the private sector to help with job placements. The success is mixed. In 2010, the UK government adopted a series of steps to help unemployed people back to work. The program which is currently called the Work and Health Programme is designed to help long-term unemployed, people with disabilities, and people who are considered vulnerable find employment.[20] The program includes offering training, help in writing CVs, etc. Providers were paid according to the number of unemployed who were placed. Between November 2017 and November 2019, a total of 121,710 individuals in England and Wales were referred (a fifth of whom were long-term unemployed) and resulted in 10,260 jobs. Given the low success thus far, our results suggest that there is room for a government to delegate job placement to an agency that has the authority to restrict information about workers. This can be a

[19]Being admitted via this program increased in five-year degree attainment by 30 percentage points and annual early-career wages by up to $25,000.

[20]Eriksson and Rooth (2014) confirm with a field experiment the difficulty for the longterm unemployed to get back to work.

low-cost complement to existing government programs.

Our approach could also be used to improve the employment prospects of refugees. Dumont et al. (2016) report that the employment rate of refugees in the EU is nine percentage points lower than native-born persons and that it can take 20 years before refugees have similar employment prospects. While refugees are on average less educated than natives, employed well-educated refugees are more likely to be overqualified for their jobs than natives. This suggests that at least part of the problem relates to information. Employers will often have difficulties evaluating refugees' qualifications, particularly if documentation is missing or not verifiable. It seems there is a natural role for an agency to provide information about skills of refugees in this setting. Our work suggests that full disclosure might not be optimal.

While there is potential to improve employment with our suggestion, care must be taken when trying to implement this as a policy tool. It is possible that those grouped together might be further divided by another characteristic that is observable to the employer. This may make the perceived desirability of workers in one of those subgroups to be too low to be offered a job. Indeed, Doleac and Hansen (2020) find that an attempt to increase the employment of those with criminal records by banning a question about it early in the hiring process had the unintended consequence of decreasing employment of young black men (presumably since they were all grouped together). Also, while we take skills of workers as exogenous, further work may consider the impact the design of the rating system will have on workers acquiring skills. Research by Jin and Leslie (2003) discovered that having food hygiene ratings displayed in restaurant windows led to not only customers switching to more hygienic restaurants but the restaurants themselves improving hygiene.

While our intent was to look at worker placement programs, our results have wider implications. In particular, we shed light on whether or not rating agencies should be regulated. In the US, farm produce quality is classified by the USDA. There is scope for a classification of mixed quality, making it easier to sell low quality produce and avoid waste. For financial products, regulation may be in order since it may be undesirable that high risk bonds, mortgages, etc. are sold (as part of a bundle) without the purchaser being aware of the details. Once purchased, the new owner may not learn the true risk, only the realization of the risk. The ratings of hotels both through a star rating and brand categories such as Marriott, Hilton and IHG (Holiday Inn) tend to be unregulated. Our stars treatment shows that such a mechanism can work even if what makes a 5-star hotel is not always codified.

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Figures

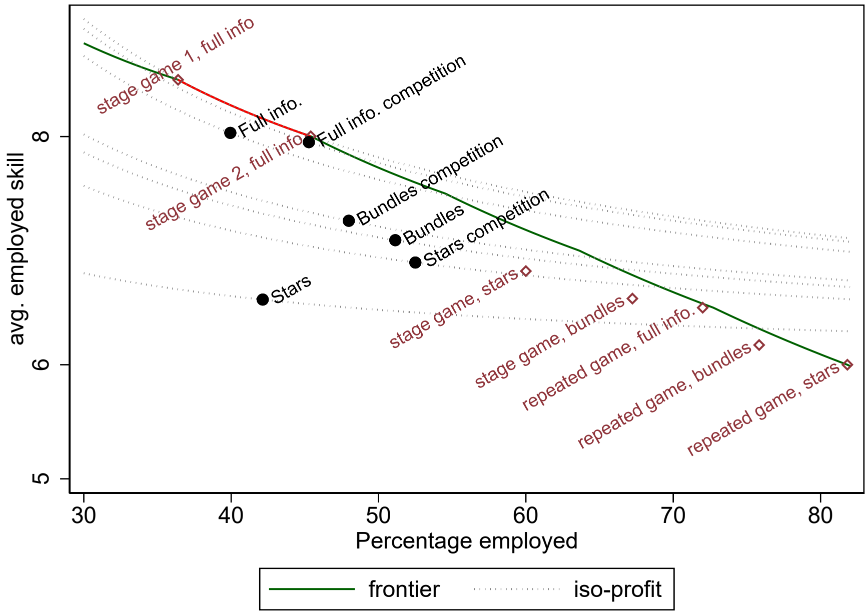


Figure 1: Plot of the average skill level of employed workers versus the number employed for each treatment. The solid dots are the empirical observations, while the hollow dots are the theoretical limits of employment. Treatment averages are the average of group averages, so that all groups have equal weight. The isoprofit curves of employers are dashed. The solid curve is the limit of the feasible possibilities. The points on the section of the curve labeled `stage game 1, full info` and `stage game 2, full info` are the feasible combinations that give the highest profit curve.

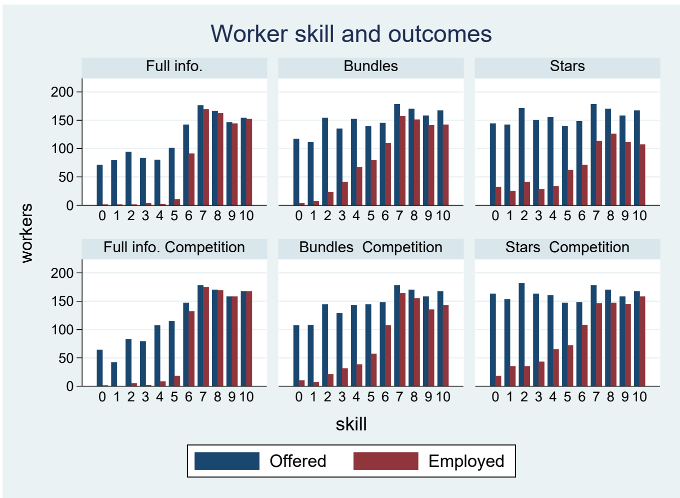


Figure 2: Number of workers offered and employed by skill level for each treatment

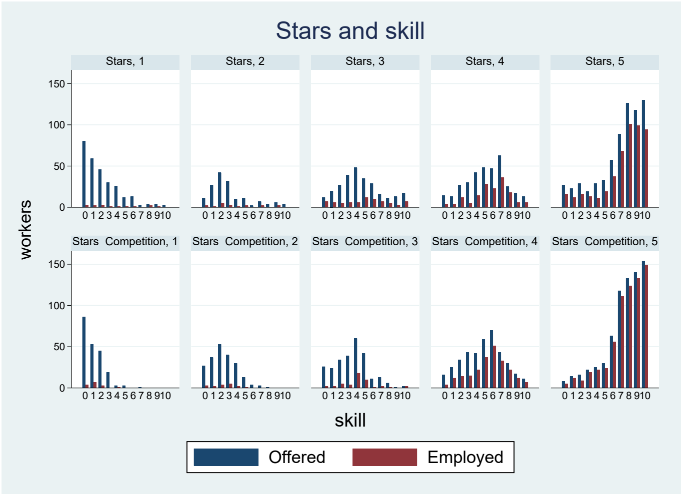


Figure 3: The breakdown of skills offered and hired for each rating star.

Tables

Table 1: Average profits and employed skill for each treatment

treatment	agency-profits	employer-profits	employed avg. skill
full info	0.399	0.808	**8.031**
bundles	0.511	0.522	7.053
stars	0.421	0.245	6.578
full info competition	0.453	**0.879**	7.903
bundles competition	0.480	0.564	7.205
stars competition	**0.525**	0.424	6.775

Notes: Different groups completed different numbers of periods. Hence, treatment averages are calculated from group averages. The highest figure in each column is in bold.

Table 2: Probability of a worker being employed based upon treatment

	(1)	(2)	(3)
coarse-information	0.051**		
	(0.02)		
bundles		0.060*	0.102**
		(0.02)	(0.03)
stars		0.041	0.007
		(0.02)	(0.03)
competition		0.050*	
		(0.02)	
competition × full-information			0.055*
			(0.02)
competition × bundles			-0.029
			(0.04)
competition × stars			0.123***
			(0.04)
constant	0.434***	0.409***	0.407***
	(0.01)	(0.02)	(0.02)
clusters	120	120	120
N	10860	10860	10860

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

Notes: Linear probability models are estimated with one observation per worker per period. The dependent variable is whether the worker is employed. *Coarse information* equals one for the stars and bundles treatments and zero otherwise. *Stars, bundles and full-information* equal one for the respective treatments and zero otherwise. *Competition* equals one for treatments with competition and zero otherwise. Standard errors are shown in parentheses with clustering at the level of agencies.

Table 3: Number of workers employed based upon skill

Treatment	$skill < 6$	$skill = 6$	$skill > 6$	total
full information	18	91	627	736
full competition	34	132	669	835
stars	221	71	457	749
stars competition	268	108	596	972
bundles	220	109	591	920
bundles competition	164	107	597	868

Table 4: Regressions on low-skill workers where the dependent variable is being employed.

	(1) bundles	(2) bundles competition	(3) stars	(4) stars competition
mean others' skill	0.056***	0.017	-0.037**	-0.082***
	(0.01)	(0.01)	(0.01)	(0.01)
period	-0.000	-0.006**	-0.009**	-0.004
	(0.00)	(0.00)	(0.00)	(0.00)
constant	-0.056	0.141*	0.505***	0.734***
	(0.07)	(0.05)	(0.06)	(0.07)
clusters	20	20	20	20
N	989	989	989	989

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

Notes: Linear probability models are estimated with one observation per worker per period. `'Mean other's skill'` is the average skill of the agency's other workers. The model is estimated separately using data from each of the treatments with coarse information.

Table 5: Average skill for each star level

	Offered			Employed		
Star	Competition	No Competition	Combined	Competition	No Competition	Combined
5	7.51	6.99	7.26	7.32	7.66	7.52
4	4.89	5.22	5.05	5.69	5.45	5.55
3	3.46	4.57	4.02	4.92	4.13	4.61
2	2.41	3.13	2.72	3.67	2.24	2.97
1	1.11	2.15	1.71	3.40	1.13	2.27

Table 6: Willingness to hire workers given the observed skill of previous workers with the same star rating

	No competition		Competition			
	(1)	(2)	(3)	(4)	(5)	(6)
	4 stars	5 stars	4 stars	5 stars	4 stars	5 stars
unobserved	0.716*	0.939**	0.125	0.633	0.220	0.717
	(0.29)	(0.26)	(0.20)	(0.33)	(0.17)	(0.32)
observed	0.119*	0.112**	0.078	0.083*	0.074	0.081*
	(0.04)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)
period	-0.013**	0.006*	-0.015*	0.003	-0.016*	0.002
	(0.00)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
unobserved other					0.040	-0.268
					(0.18)	(0.21)
observed other					0.039	-0.015
					(0.03)	(0.02)
constant	-0.075	-0.147	0.243	0.129	0.078	0.282
	(0.25)	(0.25)	(0.19)	(0.32)	(0.31)	(0.36)
clusters	19	20	10	10	10	10
N	339	680	780	1446	780	1446

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

Notes: Linear probability models are estimated with one observation per worker per employer. Models are estimated using workers from a particular treatment with a particular star rating.

A Star Ratings of Individual Agencies

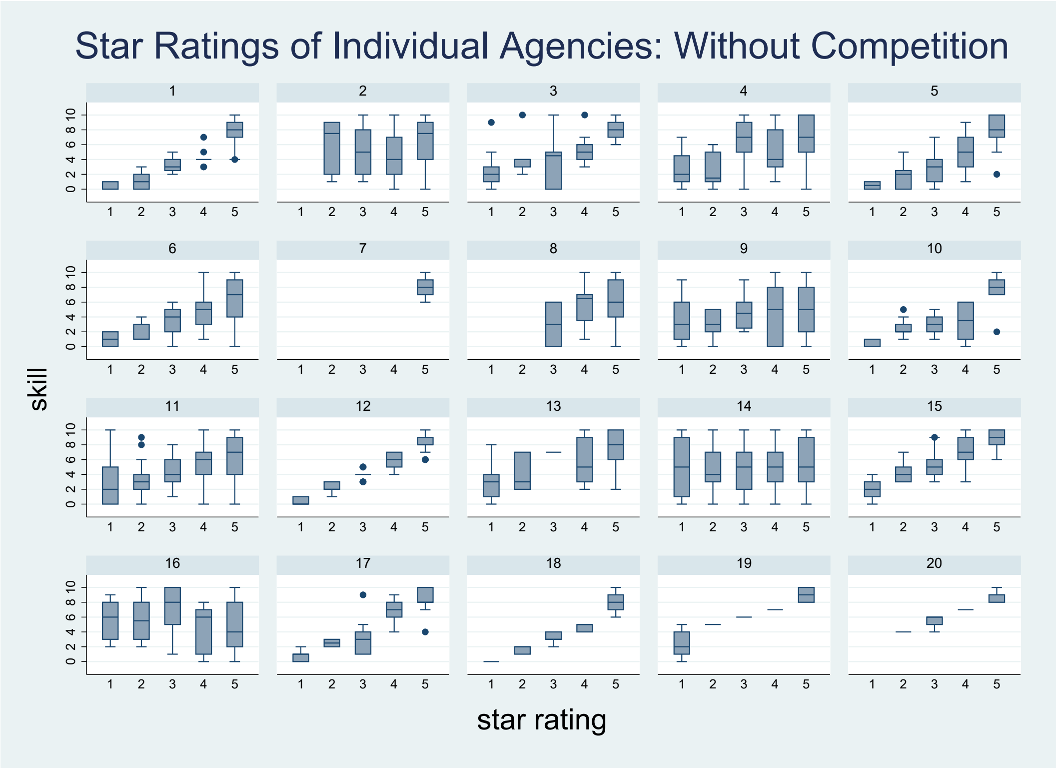


Figure 4: The range of worker skills for star ratings of workers by individual agency without competition.

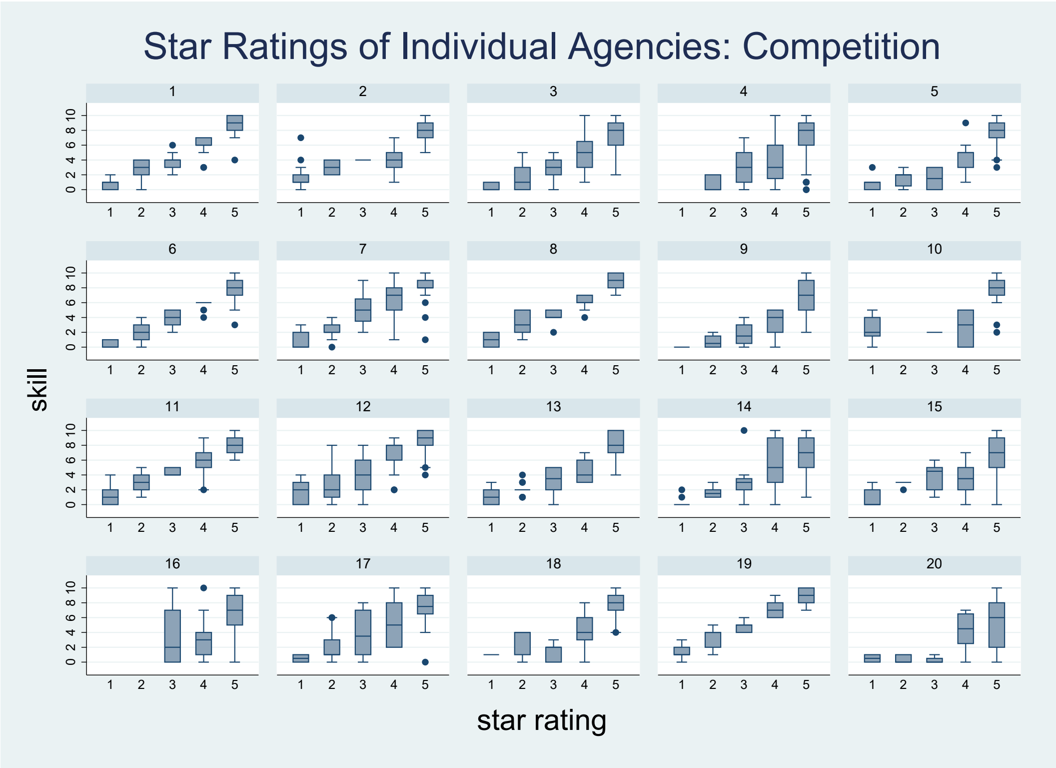
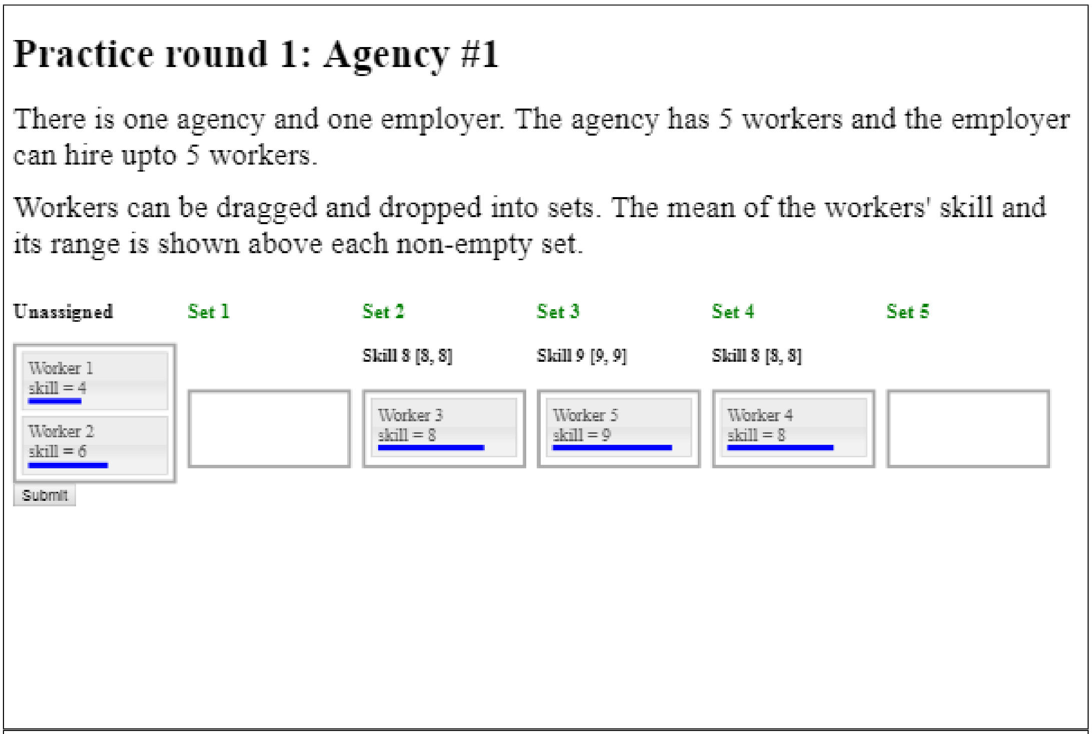
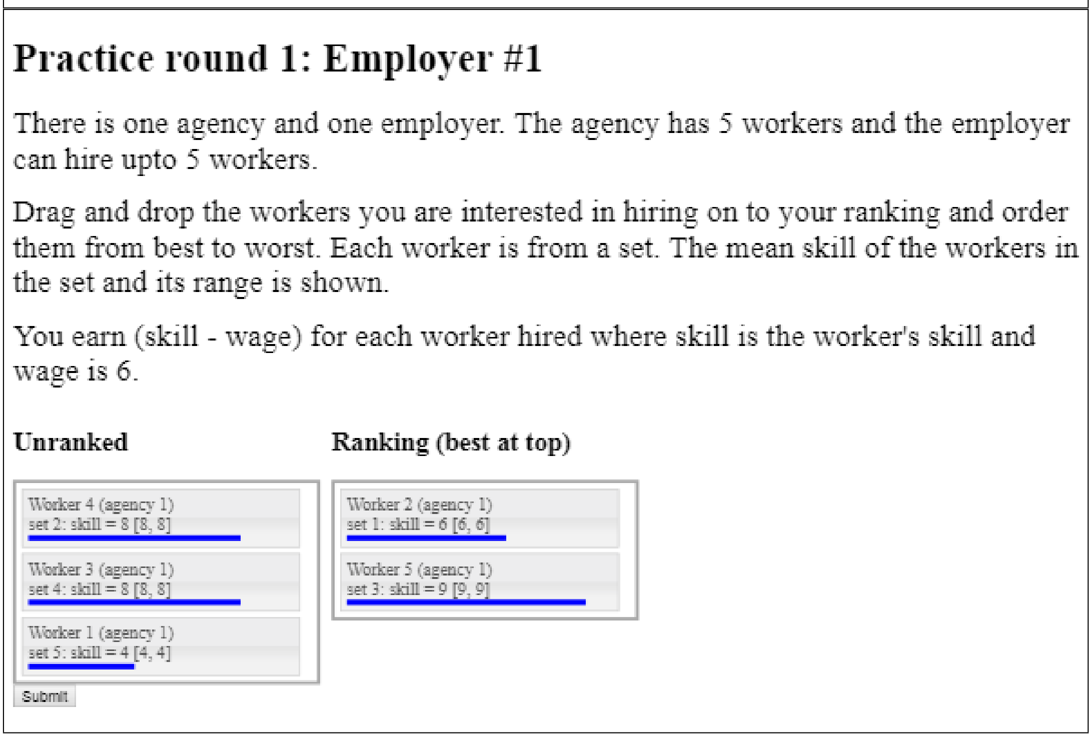


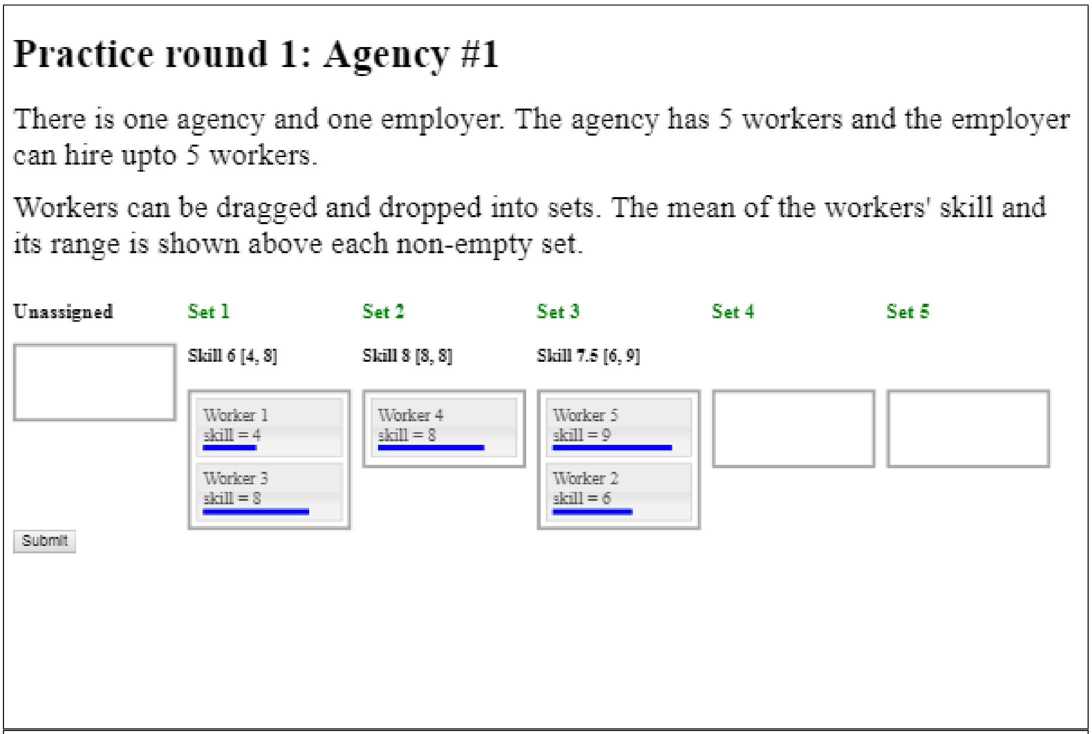
Figure 5: The range of worker skills for star ratings of workers by individual agency with competition.

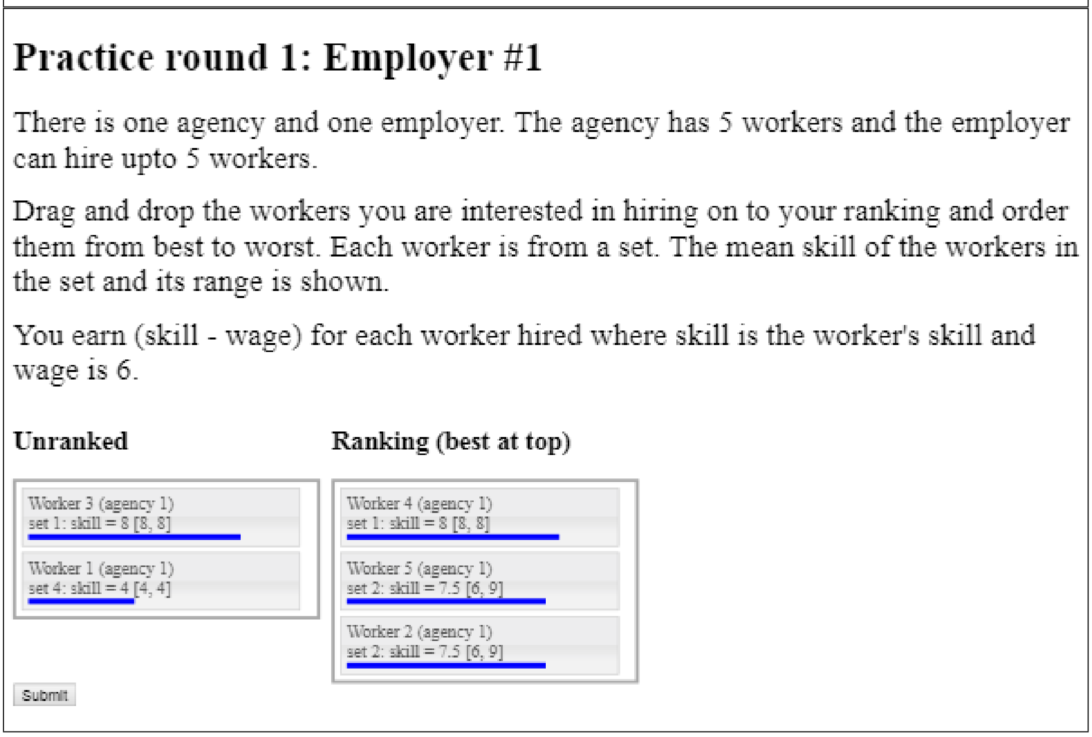
B Screenshots: full information





C Screenshots: bundles





D Screenshots: star ratings