Do workers benefit from wage transparency rules?*

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Abstract

Wage transparency rules arguably enable workers better to assess their contribution to firm value, allowing them to make wage demands that more accurately reflect their value for the employing firm. This paper contains a formal analysis of transparency rules and their effects on wages. We find that these rules induce firms to behave strategically with the aim of manipulating the information workers receive. We identify a large class of rules that yield an identical equilibrium outcome. For productivity distributions with decreasing (increasing) hazard rate, transparency rules increase (potentially decrease) workers' payoff.

JEL Codes: J31, J71, K31, M51

Keywords: Wage-setting, transparency rule, payoff, strategic effect, learning effect

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1. Introduction

Wage transparency rules have been advocated by politicians around the world and introduced in many countries as an instrument to lower the wage disparities within jobs.[1] The idea is that transparency rules equalize workers' perceptions of their actual contributions to firm profit, leading to more equal wage demands of workers with comparable skills and tasks.

Wage transparency rules, however, could also have some unintended consequences. The reason is that they provide information to workers about their value for their firm, with the consequence that the firm may wish to manipulate the information that workers receive to affect their wage demands. Little research has been done on the effects of wage transparency rules on wage-setting within firms, and the corresponding effects are thus not well understood. The goal of the current paper is to provide a formal analysis of (wage) transparency rules and their effects on the wage-setting in firms. Based on this analysis, we aim to understand in which situations workers benefit from these rules. An important finding of our paper is that transparency rules may backfire and lower the payoffs of the targeted workers. The intuition is that these rules may induce firms to strategically reject the wage demands of some profitable hires to signal a low "ability to pay" to future applicants.

We begin by proposing a simple model of wage bargaining. There is a firm that lives for multiple periods and interacts with workers who live for one period. In each period, the firm privately learns its productivity (i.e., the value of the output of workers) and productivity is correlated across periods. Workers privately learn their reservation values while the firm only knows the distribution of reservation values across all workers. At the beginning of a period, workers make wage demands to the firm, and the firm then decides which demands to accept and which to reject. The situation is intransparent in that workers do not receive any information about past periods. The latter assumption implies that there is no strategic

[1] One example is Germany's Pay Transparency Act, which was enacted in 2017 and which mandates firms with more than 200 employees to provide information to workers about the wages of other workers performing similar tasks. Another example is Colorado's Equal Pay for Equal Work Act, which came into force in 2021. Among other things, the act requires that all job postings disclose information about salary and benefits.

linkage between periods such that, in equilibrium, the firm does not behave strategically, meaning that it accepts all wage demands below the productivity level.

Having presented our baseline model, we turn to our main research question and we analyze the effects of transparency rules. We model such a rule by allowing workers to observe some "indicator" or signal about past periods. Examples include the highest wage that a worker receives, the average or median wage, and the size of the workforce. We make three primary contributions. First, we show that all monotone and continuously differentiable indicators lead to the same equilibrium behavior, and the result can be explained as follows. Workers correctly anticipate the firm's equilibrium strategy. Given their knowledge of the model primitives and their correct anticipation of the firm's behavior, a monotone and continuously differentiable indicator allows the workers correctly to infer the firm's past productivity, regardless of the specific structure of the indicator. As an immediate consequence, equilibrium behavior is the same for all these indicators.

Second, we observe that the firm behaves strategically once a transparency rule is in place, which means that it sets the wage threshold, i.e., the cutoff up to which it decides to employ workers, different from the productivity level. The reason is that the firm wishes to manipulate the information that the workers receive about productivity to lower their wage demands. One would conjecture that the firm wishes to signal a low productivity to trigger relatively lower wage demands. Surprisingly, we find that this is not always the case, and the firm's exact behavior depends on the hazard rate of the productivity. If the hazard rate is increasing, the intuition is confirmed and the firm wishes to signal a low productivity. It does so by reducing the hiring threshold below the productivity level, repelling some workers who were profitable hires. On the contrary, if the hazard rate is decreasing, the firm wishes to signal a relatively high productivity and it therefore decides to hire some workers whose wage demands exceed their productivity, thereby suffering a loss.

The intuition why the firm's strategic behavior depends on whether the hazard rate of productivity is increasing or decreasing is as follows: The hazard rate determines how likely it is that a marginal increase in a worker's wage demand leads to a rejection of that demand. If the hazard rate is relatively large, the corresponding likelihood is large as well, meaning that workers act cautiously by demanding relatively low wages. As a result, the firm wishes to manipulate the information that workers receive such that they believe that productivity is in the region where the hazard rate is large. The direction in which the firm wishes to manipulate the workers' information then depends on whether productivity has an increasing or decreasing hazard rate.

Third, and most importantly, we study the impact of the transparency rule on the workers' payoff. There are two effects, which we label the strategic effect and the learning effect. The strategic effect captures the change in the workers' payoff resulting from the firm's adaptation of the hiring threshold once a transparency rule is in place. The direction of this effect depends on whether the firm lowers or raises the threshold which is determined by the slope of the hazard rate of productivity. When the firm lowers (raises) the threshold, the workers' payoff becomes lower (higher).

The learning effect takes into account that workers learn the firm's past productivity from the information that they receive due to the transparency rule, and that what they learn has an impact on their wage demands and, thus, on their payoff. The direction of the learning effect is unambiguously positive, meaning that the workers' payoff increases. The workers are able to tailor their wage demands to the information they receive about the firm's productivity. This allows them to make better decisions than if they stayed uninformed, leading to a relatively greater payoff. Taken together, when productivity has an increasing hazard rate, the strategic and the learning effect oppose each other, and the change in the workers' payoff depends on the dominating effect. In contrast, when the hazard rate is decreasing, the workers' payoff surely increases.

The paper is organized as follows. Section 2 summarizes the related literature, and Section 3 contains the description of the baseline model and the equilibrium characterization. The subsequent sections introduce a transparency rule into the baseline model. In Section

4, we start with a two-period model, which allows us to isolate the strategic effect (which occurs in the first period) and the learning effect (which occurs in the second period). In Section 5, we turn to a model with more than two periods to allow the two effects to be present at the same time. Section 6 concludes. If not stated otherwise, proofs are relegated to the Appendix.

2. Related literature

Our paper contributes to a growing theoretical literature studying how governmental regulation aimed at tackling labor market discrimination affects the wage-setting in firms and workers' payoff. In particular, the effects of affirmative action policies such as employment and promotion quotas have been investigated (e.g., Milgrom and Oster 1987, Coate and Loury 1993a,b, Moro and Norman 2003, Fang and Norman 2006, Gürtler and Gürtler 2019, and Bijkerk et al. 2021), and it has been shown that these policies can actually hurt the people they are intended to benefit. To date, however, there is very little theoretical research on how transparency rules affect the wage-setting within firms.[2]

The most closely-related paper to ours is Cullen and Pakzad-Hurson (2021) which contains a theoretical and empirical analysis of the effects of wage transparency rules on the wage-setting within firms. In their theoretical analysis, transparency is modeled by means of a Poisson arrival process, according to which workers learn information about the wage structure within their firm with a certain probability, and where greater transparency corresponds to a process with a larger arrival rate. They find that greater transparency always leads to lower and more equalized (average) wages and also lower worker surplus. An important difference between the two models is that productivity is fixed over time in their model, whereas it changes in our model and the productivity levels in different periods are positively, but imperfectly, correlated. As a direct consequence, once the wage structure is

[2]There are several experimental studies that have investigated wage transparency rules. See, e.g., Greiner et al. (2011) and Werner (2019).

known, the workers' wage demands are always accepted in their model, whereas the negotiations can still fail in our model. The potential failure of negotiations leads to different conclusions and a dependence of the workers' wage demands on the hazard rate of the firm's productivity distribution.[3] Importantly, the results of Cullen and Pakzad-Hurson (2021) are reversed in the case of a decreasing hazard rate, where the firm sets a higher hiring threshold and, accordingly, workers always benefit from the introduction of a transparency rule.

The literature on social learning in sequential negotiations between unions and firms is also closely related to our paper (Gu and Kuhn 1998, Kuhn and Gu 1998, 1999). The literature considers wage negotiations between pairs of unions and firms, where the firms' productivity is positively correlated. As a consequence, unions that negotiate relatively late and are thus able to observe the outcomes of the preceding negotiations, receive valuable information about the own firm's productivity. This is similar to the learning effect in our model. Kuhn and Gu (1998) further study a situation with firm collusion, meaning that the firms negotiating early take into account the effect of their decisions on other firms' profit. In this situation, a strategic effect akin to the one that we identify comes into play. Kuhn and Gu (1998) assume binary productivity distributions, and binary distributions always have an increasing hazard rate. As a result, the strategic effect makes firms "tougher" so that they reject some wage demands that they would accept if the outcome of the negotiations could be kept secret. As we highlighted before, an important contribution of our paper is to show that these results are reversed if the productivity distribution has a decreasing hazard rate.

When a transparency rule is introduced into the model, the workers observe a signal about the firm's productivity, which the firm wishes to manipulate to trigger lower future wage demands. Accordingly, there is also a relation between the current paper and the literature on labor-market signaling (e.g., Spence 1973, Holmström 1982). The relation is

[3] Cullen and Pakzad-Hurson (2021) consider a model extension, where productivity differs between workers and where negotiations possibly fail as well. The focus of this model variant, however, is on inducing high-productivity workers to choose the wage cutoff designed for the low-productivity workers.

particularly close to the literature on promotion signaling that originated in the work of Waldman (1984).[4] In this literature, a worker is hired by an employer who privately learns the worker's ability and then decides whether or not to promote the worker. External firms wish to hire the worker away from the current employer, and they observe the promotion decision and use it as a signal about the worker's ability, revising the ability assessment upwards in the case of a promotion. As a consequence, the employer distorts the promotion threshold, promoting the worker only in those cases where he or she is much more productive in the high-level than in the low-level job.

The promotion-signaling distortion is similar to the distortion that we observe in our model. In our model, the firm strategically changes the wage threshold up to which it hires workers to manipulate the information that future workers receive about the firm's productivity. As in the model by Waldman (1984), the goal is to lower the future wage costs. Interestingly, it is possible that the firm tries to signal a rather high productivity, whereas in the promotion-signaling model firms always want to signal that their employees have low ability.

Finally, our result that workers correctly infer the firm's past productivity for any monotone and continuously differentiable indicator is reminiscent of an 'unraveling' result in the literature on voluntary disclosure of product quality. In this literature, firms can either disclose or withhold private information about the quality of their product, and it is shown that all firms (with the exception of those offering the lowest quality) have an incentive to disclose the information if disclosure is costless and information is verifiable (e.g., Grossman 1981, Milgrom 1981).[5] So, in our model and in this literature, the private information of firms about past productivity or product quality is always revealed to the market. A notable

[4]Further contributions to the promotion-signaling literature include Bernhardt (1995), Zábojník and Bernhardt (2001), Owan (2004), Ghosh and Waldman (2010), DeVaro and Waldman (2012), Zábojník (2012), Waldman (2013, 2016), Gürtler and Gürtler (2015, 2019), DeVaro and Kauhanen (2016), Ekinci et al. (2019), and Waldman and Zax (2020).

[5]Bederson et al. (2018) contains a recent empirical analysis of firms' disclosure decisions regarding product quality. Although the assumptions of costless disclosure and verifiable information are met in their study, they observe incomplete revelation of information.

difference is that in our model the firm tries to manipulate the information that workers receive, whereas in the literature on voluntary disclosure of product quality such manipulation of information is not possible given the verifiability of information. In equilibrium, however, workers are not fooled by the firm and they are thus able correctly to infer the true productivity.

3. Baseline model

3.1. Model description

We consider a dynamic model in discrete time with two periods $t \in \{1, 2\}$. There is one risk-neutral firm which lives through both periods and, in each period t, there is a continuum I_t of risk-neutral workers who live for one period. The continuum I_t is of measure n_t, with workers indexed by $i_t \in I_t$. The distribution of the workers' reservation values r_{it} is given by the distribution function F_{r_t} and density f_{r_t}. Firm productivity V_t is an absolutely continuous random variable with distribution function F_{V_t} and density f_{V_t}.[6] More precisely, we assume $V_2 = \lambda_1 V_1 + \lambda_2 \Theta$, where $\lambda_1, \lambda_2 > 0$ and $\Theta \sim F_\Theta$ is an absolutely continuous productivity shock that is assumed to be independent of V_1. These assumptions imply that V_1 and V_2 are positively correlated, and the degree of correlation depends on λ_1 and λ_2. All distributions are common knowledge. Supports are given by $supp(f_{V_t}) = (\underline{v}_t, \bar{v}_t)$, $supp(f_\Theta) = (\underline{\theta}, \bar{\theta})$ and $supp(f_{r_t}) = (\underline{r}_t, \bar{r}_t)$ with $\underline{v}_t, \bar{v}_t, \underline{\theta}, \bar{\theta}, \underline{r}_t, \bar{r}_t \in \mathbb{R} \cup \{\pm\infty\}$.

Each period proceeds in the following way. At the beginning, the firm privately learns the realization v_t of V_t, and the workers privately learn their own reservation value r_{it}. Workers $i_t \in I_t$ then make wage demands w_{it} in form of a take-it-or-leave-it (TIOLI) offer to the firm, which in general depend on the reservation value, hence $w_{it} = w_{it}(r_{it})$. The firm

[6] Note that, while our model is similar to the model of Cullen and Pakzad-Hurson (2021) in several ways, a crucial difference is that we assume productivity to vary over time while it is constant in their model.

decides which workers to accept and which to reject.[7] Workers who are accepted by the firm receive their wage demand w_{it}, while those workers whose demand is rejected receive their reservation value r_{it}.

The firm maximizes its total profit across both periods and discounts second-period profit by $\delta \in (0, 1]$. Workers maximize their (expected) payoff.

Before turning to the equilibrium characterization, we define the hazard rate of a distribution, which plays an important role in our later analysis. For a random variable with cdf F and pdf f, the hazard rate h is defined as $h(x) = \frac{f(x)}{1-F(x)}$; it specifies the "likelihood" that the random variable is realized at x given that it is not realized at some smaller value. An exponentially distributed random variable represents a special case in that the hazard rate is constant, and this is due to the exponential distribution being "memoryless". In the case of the uniform distribution, the hazard rate is increasing, and the reason is that the region where the realization can occur gets smaller as x increases because of the bounded support of the uniform distribution. A decreasing hazard rate requires that the bulk of the probability mass is located at relatively low values so that realizations become less likely to occur once higher values are reached; the Weibull distribution (with appropriately chosen parameters) fulfills this requirement and has a decreasing hazard rate. As we will show later, the results of our model crucially depend on whether the hazard rate h_Θ of the productivity shock Θ is increasing or decreasing. Regarding h_Θ, we introduce the additional assumption that $(h_\Theta(\theta))^2 + h'_\Theta(\theta) > 0$ for all $\theta \in supp(f_\Theta)$. This assumption ensures that wage demands are always increasing in the reservation value.[8]

[7] Note that by our bargaining protocol workers have full bargaining power. In an extension (which is available upon request), we also consider an adaptation of our model in which the firm has full bargaining power. We show that, in such a model, a wage transparency rule does not affect equilibrium behavior. This is in line with Cullen and Pakzad-Hurson (2021), who show that transparency about coworkers' wages and the firm's bargaining power are substitutes. Therefore, to study the effects of transparency rules, some bargaining power for the workers is required. To simplify the analysis, we restrict attention to workers having full bargaining power.

[8] As we explain in the first paragraph of the next section, we focus on equilibria with monotonically increasing strategies.

3.2. Equilibrium characterization

Throughout the paper, we focus on symmetric, pure-strategy Perfect Bayesian Equilibria that satisfy the following conditions. First, the firm is restricted to choose a cutoff wage $\bar{w}_t = \bar{w}_t(v_t)$ such that it accepts all workers i_t whose wage demands are below $\bar{w}_t(v_t)$. Second, workers are assumed to demand at least their reservation value. Furthermore, if worker i_t's reservation value exceeds the firm's maximal cutoff, that is, if $r_{it} > \bar{w}_t(v_t)$ for all v_t, the worker is assumed to demand the reservation value $w_t(r_{it}) = r_{it}$. Analogously, if the firm's productivity is below the workers' minimal wage demand, that is, if $v_t < w_t(r_{it})$ for all r_{it}, the firm is assumed to set the cutoff equal to its productivity. Third, the firm's cutoff $\bar{w}_t$ and the workers' wage demand w_t are strictly increasing and continuously differentiable almost everywhere for all $t \in \{1, 2\}$. We proceed to characterize such equilibria in the baseline model, in which second-period workers do not receive any information about first-period decisions.

First, we consider the firm. In $t = 2$, since the second period is the last period, it is optimal for the firm to accept a worker i_2's wage demand w_{i2} if and only if $w_{i2} \leq v_2$. Hence, it sets the cutoff $\bar{w}_2(v_2) = v_2$. Since there is no informational linkage between the periods, the firm does not have any incentive to shade its productivity in the first period either and therefore sets the cutoff $\bar{w}_1(v_1) = v_1$.

Next, we consider the workers. In contrast to the firm, each worker only lives for one period and thus maximizes the expected payoff in that period. Denoting a period-t worker's belief about the cutoff $\bar{w}_t$ by $\hat{w}_t$, the expected payoff is given by

$$\begin{aligned} U_{it}(w_{it}, r_{it}) &= \mathbb{P}[w_{it} \leq \hat{w}_t(V_t)]w_{it} + \mathbb{P}[w_{it} > \hat{w}_t(V_t)]r_{it} \\ &= (1 - F_{\hat{w}_t}(w_{it}))\, w_{it} + F_{\hat{w}_t}(w_{it}) r_{it}, \end{aligned} \tag{1}$$

where $F_{\hat{w}_t}$ denotes the distribution function of the distribution of cutoffs, that is, $\hat{w}_t(V_t) \sim F_{\hat{w}_t}$, and $\mathbb{P}$ denotes a probability measure. The first-order condition with respect to w_{it} is given by $0 = -f_{\hat{w}_t}(w_{it})w_{it} + (1 - F_{\hat{w}_t}(w_{it})) + f_{\hat{w}_t}(w_{it})r_{it}$, which is equivalent to

$$w_{it} = r_{it} + \frac{1 - F_{\hat{w}_t}(w_{it})}{f_{\hat{w}_t}(w_{it})} = r_{it} + \frac{1}{h_{\hat{w}_t}(w_{it})}, \tag{2}$$

where $h_{\hat{w}_t}$ denotes the hazard rate of the distribution of the belief regarding the cutoff. When the workers marginally increase their wage demand, they benefit from a higher wage if the demand is accepted. At the same time, they face a higher risk of rejection, in which case they would only receive the reservation value. The larger the hazard rate $h_{\hat{w}_t}$, the more important the latter effect becomes, and the lower is the optimal wage demand.

In equilibrium, beliefs are correct. Hence, it holds that $\hat{w}_t(v_t) = \bar{w}_t(v_t) = v_t$ for all $v_t \in supp(f_{V_t})$, and the following Proposition 1 can be stated without further proof.

Proposition 1. *In equilibrium, for all $t \in \{1, 2\}$, the firm sets $\bar{w}_t(v_t) = v_t$ and worker i_t demands w_{it} given by*

$$w_{it} = r_{it} + \frac{1 - F_{V_t}(w_{it})}{f_{V_t}(w_{it})} = r_{it} + \frac{1}{h_{V_t}(w_{it})}. \tag{3}$$

Before we proceed to analyze the effects of different transparency rules on equilibrium behavior, we present an example to illustrate the results of the baseline model.[9]

Example 1. Let $V_1 \sim U[0, 1]$ and $V_2 = V_1 + \Theta$, where $\Theta \sim U[0, 1]$. Furthermore, let $n_t = 1$ and $f_{r_t}(x) = \mathbb{I}_{[0,1]}(x)$ for $t \in \{1, 2\}$.

Equilibrium strategies can be summarized as follows. The firm sets $\bar{w}_1(v_1) = v_1$ and $\bar{w}_2(v_2) = v_2$, workers demand

$$w_1(r_{i1}) = \frac{1}{2} + \frac{r_{i1}}{2} \quad \text{and} \quad w_2(r_{i2}) = \begin{cases} \frac{r_{i2}+\sqrt{r_{i2}^2+6}}{3}, & \text{if} \quad 0 \leq r_{i2} \leq \frac{1}{2}, \\ \frac{2r_{i2}+2}{3}, & \text{if} \quad \frac{1}{2} \leq r_{i2} \leq 1. \end{cases} \tag{4}$$

Next, we calculate the workers' expected equilibrium payoff. In the first period, the

[9] All derivations regarding the examples are available from the authors upon request.

workers' expected payoff as a function of their reservation value r_{i1} is given by

$$U_1(w_1(r_{i1}), r_{i1}) = \frac{r_{i1}^2}{4} + \frac{r_{i1}}{2} + \frac{1}{4}. \tag{5}$$

In the second period, the workers' expected payoff, conditional on the realization v_1 of V_1, as a function of the workers' reservation value is given by

$$U_2(w_2(r_{i2}), r_{i2}, v_1) = \begin{cases} \frac{r_{i2}+\sqrt{r_{i2}^2+6}}{3}, & \text{if} \quad r_{i2} < \frac{3v_1^2-2}{2v_1}, \\ \frac{(r_{i2}+3v_1+3)\sqrt{r_{i2}^2+6}+r_{i2}^2+(3-6v_1)r_{i2}-6}{9}, & \text{if} \quad \frac{3v_1^2-2}{2v_1} \leq r_{i2} \leq 1/2, \\ \frac{r_{i2}(2r_{i2}-3v_1+4)+6v_1+2}{9}, & \text{if} \quad 1/2 \leq r_{i2} \leq \frac{3v_1+1}{2}, \\ r_{i2}, & \text{if} \quad \frac{3v_1+1}{2} < r_{i2} \leq 1. \end{cases} \tag{6}$$

Note that v_1 is unknown by the workers and therefore they maximize the expected payoff with respect to the unconditional distribution F_{V_2} of $V_2 = \lambda_1 V_1 + \lambda_2 V_2$. The conditional expected payoff that we calculated here enables us to consider the effect of introducing a transparency rule on the workers' payoff in Example 4 in the next section.

4. Transparency rules

We now introduce a wage transparency rule into the model and study its effects on employment decisions and wage structures. In this section, we begin our analysis by considering a broad class of transparency rules that are shown to be equivalent and thus yield the same equilibrium behavior.

4.1. Indicator

We model a transparency rule by supposing that, at the beginning of the second period, workers now observe an **indicator** $X_{F_{w_1}}(\bar{w}_1)$, where the function $X_{F_{w_1}} : \mathbb{R} \to \mathbb{R}$, $\bar{w}_1 \mapsto X_{F_{w_1}}(\bar{w}_1)$ is assumed to be strictly monotone and differentiable in the firm's cutoff for all wage demand functions w_1 and where $F_{w_t} = F_{r_t} \circ w_t^{-1}$ denotes the distribution of wage demands in period t. Note that, in addition to standard examples such as the first period's mean wage, our notion of an indicator also includes transparency rules in which workers do not receive any direct information about the period-1 wage structure, but rather about the fraction of accepted workers. Before discussing specific examples in more detail, we state our equivalence result precisely.

Proposition 2. *Let the second-period workers observe an indicator $X_{F_{w_1}}(\bar{w}_1)$. Then, in equilibrium, second-period workers infer the first-period productivity v_1 correctly, that is, their belief $\tilde{V}_1$ about the productivity is a deterministic function of the firm's cutoff decision given by $\tilde{V}_1 = \tilde{v}_1 = v_1$, and it holds that*

$$\tilde{v}_1'(\bar{w}_1) = \frac{1}{\bar{w}_1'(v_1)}. \tag{7}$$

The result is intuitive. Recall our assumption that the distribution of reservation values is common knowledge among workers. Thus, given strictly increasing beliefs about first-period wage demands and the firm's hiring cutoff, any transparency rule in the above sense provides the second-period workers with information which is a one-to-one correspondence with the firm's cutoff decision.[10] Hence, the second-period workers' belief about first-period productivity is a deterministic function of the cutoff. Therefore, in equilibrium, when beliefs are confirmed, second-period workers are able to infer the first-period productivity correctly.

Furthermore, the meaning of the condition $\tilde{v}_1'(\bar{w}_1) = \frac{1}{\bar{w}_1'(v_1)}$ is that the firm can affect the workers' belief regarding the first-period productivity by deviating from the equilibrium cutoff, but that the effect of a marginal change in the cutoff on the belief is the same for all indicators. As we will see once we have introduced the equilibrium conditions in Section 4.2, an immediate consequence of this result is that equilibrium behavior is the same for all of

[10] Note that this result holds only for equilibria in strictly increasing strategies to which we restrict attention throughout the paper. In other situations in which e.g. the firm decides on a cutoff independent of the productivity level, second-period workers cannot correctly infer the first-period workers' value for the firm.

the above transparency rules. In the following, we present examples of corresponding (wage) transparency rules.

Example 2 (Transparency about wages)**.** We consider three common examples of wage transparency rules. First, suppose that second-period workers observe the mean wage

$$\mu_{w_1} = \frac{1}{F_{w_1}(\bar{w}_1)} \int^{\bar{w}_1} x \, dF_{w_1}(x) \tag{8}$$

of all workers who are accepted by the firm in the first period. If the firm sets a cutoff between the minimum and maximum wage demand, that is, if $w_1^{\min} = w_1(\underline{r}_1) < \bar{w}_1 < w_1(\bar{r}_1) = w_1^{\max}$, the mean wage μ_{w_1} of all accepted workers is strictly increasing in the firm's cutoff and hence $X_{F_{w_1}} = \mu_{w_1}$ is an indicator, as defined above.[11] Thus, by Proposition 2, we have $\tilde{v}_1 = v_1$ and $\tilde{v}_1'(\bar{w}_1) = 1/\bar{w}_1'(v_1)$ in equilibrium.

Second, assume that second-period workers are provided with the median wage $\mathrm{m}_{w_1}(\bar{w}_1)$ of all workers who are accepted by the firm in the first period, which is given by the equation

$$\int_{w_1^{\min}}^{\mathrm{m}_{w_1}} dF_{w_1}(x) = \int_{\mathrm{m}_{w_1}}^{\bar{w}_1} dF_{w_1}(x). \tag{9}$$

Again, it can be shown that for all $w_1^{\min} < \bar{w}_1 < w_1^{\max}$ the median wage $X_{F_{w_1}} = \mathrm{m}_{w_1}$ is an indicator such that Proposition 2 applies.

Third, suppose that the workers observe the maximum wage paid by the firm in the first period. If the cutoff does not exceed the maximum wage demand in that period, the highest wage paid coincides with the firm's cutoff and hence also serves as an indicator in the above sense.

In Example 2, we considered transparency rules that contain information about the firm's

[11]Note that if the cutoff is below the lowest wage demand in the first period, no workers are accepted by the firm and the mean wage is not defined. If the cutoff is above the highest wage demand, all first-period workers are employed and thus the second-period workers cannot perfectly infer the first-period workers' value v_1 to the firm anymore. Instead, in equilibrium, they infer that $w_1^{\max} \leq \bar{w}_1(\tilde{V}_1)$, which yields a lower bound on the possible values of v_1, and hence the updated belief is a random variable with a distribution given by the truncation of F_{V_1}. Similar arguments apply for the other transparency rules.

wage structure. In the following Example 3, we show that information about the firm size can also serve as an indicator and therefore yield the same equilibrium outcome.

Example 3 (Transparency about firm size)**.** Assume that, at the beginning of the second period, workers observe the measure $m_1 = n_1 F_{w_1}(\bar{w}_1)$ of workers who are accepted by the firm in the first period. It is immediate that, if $w_1^{\min} < \bar{w}_1 < w_1^{\max}$, the measure of accepted workers is strictly increasing in the firm's cutoff $\bar{w}_1$. Hence, $X_{F_{w_1}} : \bar{w}_1 \mapsto n_1 F_{w_1}(\bar{w}_1)$ is an indicator, as defined before, and Proposition 2 can be applied.

So far, we have only considered examples of indicators that are increasing in the firm's cutoff. However, Proposition 2 also includes indicators that are strictly decreasing in $\bar{w}_1$. As an example, suppose that, at the beginning of the second period, the workers observe the measure $n_1 - m_1 = n_1 \left(1 - F_{w_1}(\bar{w}_1)\right)$ of workers who are rejected by the firm in the first period. Obviously, this indicator is strictly monotone in the relevant range, and thus Proposition 2 is applicable.

4.2. Equilibrium characterization

In the following, we derive necessary equilibrium conditions. First, we consider the workers. Again, denote the period-t workers' belief about the firm's cutoff by $\hat{w}_t$ and the corresponding distribution of cutoffs by $F_{\hat{w}_t} = F_{\tilde{V}_t} \circ \hat{w}_t^{-1}$, where the random variable $\tilde{V}_t$ denotes the period-t workers' belief about the firm's productivity in period t.[12] Then, the workers' objective function is the same as in the baseline model. They maximize their expected payoff

$$\begin{aligned} U_{it}(w_{it}, r_{it}) &= \mathbb{P}[w_{it} \leq \hat{w}_t(\tilde{V}_t)] w_{it} + \mathbb{P}[w_{it} > \hat{w}_t(\tilde{V}_t)] r_{it} \\ &= \left(1 - F_{\hat{w}_t}(w_{it})\right) w_{it} + F_{\hat{w}_t}(w_{it}) r_{it}. \end{aligned} \tag{10}$$

In the first period, workers do not have any additional information about the productivity, hence $\tilde{V}_1 = V_1 \sim F_{V_1}$. Second-period workers now observe an indicator at the beginning of the period. We have shown in Proposition 2 that any indicator leads to a deterministic belief

[12] The distribution of the firm's actual cutoff $\bar{w}_t$ is denoted by $F_{\bar{w}_t}$.

$\tilde{v}_1$ about the first-period productivity. Since $V_2 = \lambda_1 V_1 + \lambda_2 \Theta$, the workers' updated belief about their value to the firm is therefore given by $\tilde{V}_2 = \lambda_1 \tilde{v}_1 + \lambda_2 \Theta \sim F_{\tilde{V}_2}$.

Next, we consider the firm. In the second period, it is again optimal for the firm to accept a worker i_2's wage demand w_{i2} if and only if $w_{i2} \leq v_2$. Since the second period is the last period, there are no informational spillovers affecting future workers, and therefore the firm has no incentive to reject any profitable wage demands. In the first period, this no longer holds true. Denoting the firm's belief about the workers' wage demands by $\tilde{w}_t$ and its period-t profit by π_t, in the first period after receiving the wage demands w_1, its total (expected) profit Π is given by

$$\begin{aligned} \Pi(\bar{w}_1, v_1) &= \pi_1(\bar{w}_1, v_1) + \delta \mathbb{E}\left[\pi_2(\bar{w}_2, V_2) \middle| V_1 = v_1\right] \\ &= n_1 \int^{w_1^{-1}(\bar{w}_1)} v_1 - w_1(r)\, dF_{r_1}(r) \\ &\qquad + \delta \mathbb{E}\left[n_2 \int^{\tilde{w}_2^{-1}(\bar{w}_2)} \lambda_1 v_1 + \lambda_2 \Theta - \tilde{w}_2(r)\, dF_{r_2}(r) \right]. \end{aligned} \tag{11}$$

Note that, although second-period profit π_2 does not explicitly depend on the first-period cutoff $\bar{w}_1$, it does so implicitly, since the second-period wage demand will depend on the realization of the indicator and therefore on first-period decisions.

Proposition 3 characterizes equilibrium in the model with a transparency rule.

Proposition 3. *Suppose the second-period workers observe an indicator. Then, in equilibrium, the first-period workers' wage demand w_1 and the firm's first-period cutoff $\bar{w}_1$ satisfy the respective first-order conditions*

$$\begin{aligned} &(w_1(r_{i1}) - r_{i1})\, f_{\bar{w}_1}(w_1(r_{i1})) = 1 - F_{\bar{w}_1}(w_1(r_{i1})) \quad \textit{and} \\ &n_1\left(v_1 - \bar{w}_1(v_1)\right) f_{w_1}(\bar{w}_1(v_1)) = \frac{\delta n_2}{\bar{w}_1'(v_1)} \int \int^{w_2^{-1}(\lambda_1 v_1 + \lambda_2 \theta)} \left.\frac{\partial w_2}{\partial \tilde{v}_1}\right|_{\tilde{v}_1 = v_1} (r) dF_{r_2}(r) dF_\Theta(\theta). \end{aligned} \tag{12}$$

In the second period, the workers' wage demand w_2 and the firm's cutoff $\bar{w}_2$ fulfill

$$(w_2(r_{i2}) - r_{i2})\, f_\Theta\left(\frac{w_2(r_{i2}) - \lambda_1 v_1}{\lambda_2}\right) = \lambda_2\left(1 - F_\Theta\left(\frac{w_2(r_{i2}) - \lambda_1 v_1}{\lambda_2}\right)\right) \quad \textit{and} \\ \bar{w}_2(v_2) = v_2. \tag{13}$$

4.3. Effects of transparency rules

We now proceed to study the effects of transparency rules on equilibrium behavior in more detail. From the firm's first-order condition in equation (12), it can be seen that its cutoff is determined differently than in the baseline model. The reason is that now the firm has to take into account the effect of its first-period decisions on the next period. In the following, we further characterize the firm's period-1 decision depending on the properties of the random shock Θ.

Definition 1 (Strategic behavior by the firm)**.** We say that the firm **behaves strategically** in period $t \in \{1, 2\}$, if it sets a cutoff different from the workers' value to the firm, that is, if there is a $v_t \in supp(f_{V_t})$ such that $\bar{w}_t(v_t) \neq v_t$.

Proposition 4 shows that the firm behaves strategically.[13]

Proposition 4. *Suppose there is a realization $\theta \in supp(f_\Theta)$ of the random shock such that $w_2^{\min} < \lambda_1 v_1 + \lambda_2 \theta$. Then, if the hazard rate h_Θ is not constant, the firm behaves strategically in the first period.*

The proposition shows that the firm sets a cutoff different from the workers' value to manipulate the second-period workers' belief about its productivity to trigger lower wage demands in the second period. In equilibrium, the workers are not fooled by the firm and infer the true productivity.[14]

[13] The assumption in the first sentence of the proposition is required for the following reason. If there exists no $\theta \in supp(f_\Theta)$ such that $w_2^{\min} < \lambda_1 v_1 + \lambda_2 \theta$, then, for all realizations of the second-period productivity shock, it must hold that $\lambda_1 v_1 + \lambda_2 \theta \leq w_2^{\min}$. This means that, for all realizations $\theta \in supp(f_\Theta)$, the firm rejects (almost) all workers in the second period, and the random shock has no effect on the firm's employment decisions in the second period. Therefore, the firm does not influence the second-period profit by marginally changing the period-1 cutoff and thus has no incentive to behave strategically in the first period.

[14] The latter is a standard result in signal-jamming models and was pointed out by Holmström (1982).

To understand the firm's behavior better, we first need to understand how the second-period workers' wage demands depend on their belief $\tilde{v}_1$ about the productivity. The following Lemma 1 considers this question.

Lemma 1. *Suppose that the hazard rate h_Θ of the random shock is increasing (constant, decreasing).*[15] *Then, in equilibrium, whenever $w_{i2} > r_{i2}$, we have $\frac{\partial w_{i2}}{\partial \tilde{v}_1} > (=, <)\, 0$.*

To understand the intuition behind the lemma, notice that the first-order condition determining the workers' period-2 wage demand can be rewritten as

$$w_{i2} = r_{i2} + \frac{\lambda_2}{h_\Theta\left(\frac{w_{i2}-\lambda_1\tilde{v}_1}{\lambda_2}\right)}. \tag{14}$$

Similar to our argumentation in the baseline model, by marginally increasing the wage demand, workers benefit from a higher wage if they get hired, but at the same time increase the probability of being rejected. The larger the hazard rate h_Θ, the more important is the latter effect and the lower is the optimal wage demand. Notice that the hazard rate is evaluated at $\frac{w_{i2}-\lambda_1\tilde{v}_1}{\lambda_2}$, which is decreasing in $\tilde{v}_1$. The reason is that workers already anticipate being hired at a low θ when they believe that v_1 is large. Now, if h_Θ is increasing, then $h_\Theta\left(\frac{w_{i2}-\lambda_1\tilde{v}_1}{\lambda_2}\right)$ is decreasing in $\tilde{v}_1$, and the wage demands get larger as $\tilde{v}_1$ increases. Similar arguments apply when h_Θ is constant or decreasing.

As the sign of $\frac{\partial w_{i2}}{\partial \tilde{v}_1}$ depends on the hazard rate of Θ, one would expect the direction of the firm's incentive to shade its productivity in the first period also to depend on h_Θ, since the expected profit in the second period is decreasing in the workers' wage demands. The following Proposition 5 confirms this intuition.

Proposition 5. *Suppose there is a realization $\theta \in supp(f_\Theta)$ of the random shock such that $w_2^{\min} < \lambda_1 v_1 + \lambda_2\theta$. Then, the following holds: If the hazard rate h_Θ is increasing, the firm*

[15] Note that we assume the hazard rate to be globally monotone across the full support of the distribution. While this is not a necessary condition and the result should also hold under weaker conditions, even the stronger requirements are met by standard distributions such as the uniform distribution (with an increasing hazard rate) or the Weibull distribution (with a decreasing hazard rate).

sets $\bar{w}_1(v_1) \leq v_1$ for all $v_1 \in supp(f_{V_1})$ with strict inequality for some v_1. If h_Θ is constant, the firm sets $\bar{w}_1(v_1) = v_1$, and if the hazard rate is decreasing, it sets $\bar{w}_1(v_1) \geq v_1$ for all $v_1 \in supp(f_{V_1})$ with strict inequality for some v_1.

So far, we have considered the effects of transparency rules on equilibrium behavior. We now proceed to our main research question, and we analyze the effect of transparency rules on the workers' payoff.

In Proposition 5, we have shown that, depending on the hazard rate of the second-period productivity shock, the firm's reaction to a transparency rule is to behave strategically and set a cutoff that is different from the workers' value in the first period. Therefore, the first-period workers' expected payoff when applying at the firm is affected by the transparency rule. We denote this as the *strategic effect* of the transparency rule on the workers' payoff.

Proposition 6. *Suppose that the hazard rate h_Θ is increasing (decreasing). Then, the expected payoff of all first-period workers who demand a wage that is strictly larger than their reservation value decreases (increases).*

When h_Θ is increasing, the firm reacts to the introduction of the transparency rule by decreasing the hiring threshold, as explained before. This means that the workers find it more difficult to get hired and to receive a wage rather than their reservation value. Whenever their wage demand exceeds the reservation wage, their payoff thus declines. The intuition is analogous when h_Θ is decreasing. Here, the workers find it easier to get hired, since the firm sets a higher hiring threshold, leading to a greater payoff for the workers.

Since the second period is the last period, the firm accepts all workers whose wage demand does not exceed the productivity. This holds true for the baseline model as well as for the model with a transparency rule. Therefore, transparency does not affect the second-period workers' payoff through a change in the firm's behavior. The transparency rule, however, allows the workers to infer the period-1 productivity, providing them with more accurate information about their own value for the firm. This enables workers to tailor their wage demands to the information that they receive, leading to better decisions and, thus, higher expected payoffs. We denote this as the *learning effect* of the transparency rule.

Proposition 7. *For every first-period productivity, the expected payoff of all second-period workers increases due to the transparency rule. Furthermore, the average (across all types of firms) expected payoff of every second-period worker increases, compared to the baseline model.*

Observe that the strategic effect of the transparency rule has an impact on the first-period workers, whereas the learning effect affects the second-period workers. That is, there are no workers for whom both effects play a role. This is an artefact of the restriction to two periods. In Section 5, we thus extend the model to more than two periods, where workers are impacted by both the strategic and the learning effect.

Before we do so, we revisit Example 1 to illustrate our general findings on the introduction of a transparency rule into the model.

Example 4 (Equilibrium behavior with a transparency rule)**.** To be able to compare the results between the models with and without a transparency rule, we impose the same parameters and distributional assumptions as in Example 1. Let $V_1 \sim U[0,1]$ and $V_2 = V_1 + \Theta$, where $\Theta \sim U[0,1]$ (and note that the hazard rate h_Θ is increasing). Furthermore, let $n_t = 1$ and $f_{r_t}(x) = \mathbb{I}_{[0,1]}(x)$ for $t \in \{1,2\}$.

Since there is now an informational linkage between the periods, the firm still accepts all workers with wage demands less than or equal to the productivity in the second period, but it behaves strategically in the first period. Thus, the first-period workers' strategies also adapt. Furthermore, the second-period workers now learn the first-period productivity and, since productivity is correlated across periods, have a different belief about their value to the firm than in the baseline model. Equilibrium strategies can be summarized as follows.

In period $t = 1$, it holds that

$$
\begin{aligned}
w_1(r_{i1}) &= \begin{cases} \frac{2+3\sqrt{2}}{16} + \frac{1}{2}r_{i1}, & \text{if} \quad r_{i1} \in \left[0, \frac{2+3\sqrt{2}}{8}\right], \\ r_{i1}, & \text{if} \quad r_{i1} \in \left[\frac{2+3\sqrt{3}}{8}, 1\right], \end{cases} \\
\bar{w}_1(v_1) &= \frac{\sqrt{2}-2}{8} + \frac{\sqrt{2}+2}{4}v_1,
\end{aligned} \tag{15}
$$

while in the second period

$$
w_2(r_{i2}) = \frac{v_1+1}{2} + \frac{1}{2}r_{i2} \quad \text{and} \quad \bar{w}_2(v_2) = v_2. \tag{16}
$$

We again calculate the workers' expected equilibrium payoff. In the first period, the workers' expected payoff U_1^{tr} as a function of their reservation value r_{i1} is given by

$$
U_1^{tr}(w_1(r_{i1}), r_{i1}) = \begin{cases} \frac{r_{i1}\left(32r_{i1}+2^{\frac{7}{2}}+48\right)+3\cdot 2^{\frac{3}{2}}+11}{32\left(\sqrt{2}+2\right)}, & \text{if} \quad r_{i1} \in \left[0, \frac{2+3\sqrt{2}}{8}\right], \\ r_{i1}, & \text{if} \quad r_{i1} \in \left[\frac{2+3\sqrt{2}}{8}, 1\right]. \end{cases} \tag{17}
$$

The left panel of Figure 1 shows the workers' expected payoff U_1 in the baseline model, given in equation (5), as well as the expected payoff U_1^{tr} in the model with a transparency rule, given in equation (17), as functions of the reservation value in the first period. As h_Θ is increasing in the case of the uniform distribution, the transparency rule has a negative strategic effect on the workers' payoff. Accordingly, the workers receive a lower payoff irrespectively of their reservation value.

In the second period, the workers' expected payoff as a function of their reservation value r_{i2} is given by

$$
U_2^{tr}(w_2(r_{i2}), r_{i2}, v_1) = \frac{r_{i2}^2}{4} + \frac{r_{i2}}{2} - \frac{r_{i2}v_1}{2} + \frac{v_1^2}{4} + \frac{v_1}{2} + \frac{1}{4}. \tag{18}
$$

The right panel of Figure 1 shows the expected second-period payoff U_2 in the baseline model, given in equation (6), and the expected payoff U_2^{tr} in the model with a transparency rule, given in equation (18), conditional on $V_1 = v_1 = 0.75$, as a function of the workers' reservation value. Due to the positive learning effect, for all reservation values r_{i2} the workers' payoff is relatively larger when the transparency rule is in place.

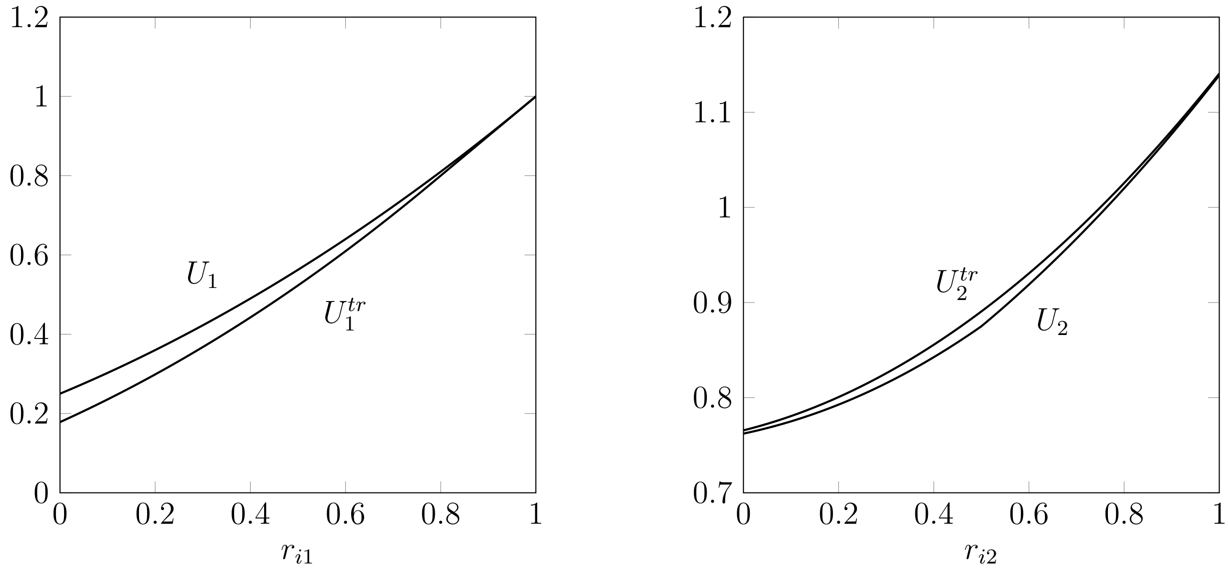

Figure 1: Expected payoff as a function of the workers' reservation values

5. Multi-period model

In this extension, we consider a model with $T > 2$ periods. We determine the equilibrium in the model without a transparency rule for a general number of periods, and we also allow for a general number of periods when stating the workers' and the firm's objectives in the model with a transparency rule. When we determine the equilibrium in that model, however, we restrict attention to the case $T = 3$. This is mainly for expositional convenience, and it would be relatively easy to go beyond three periods.

With a general number of periods, the workers' value to the firm in period $t \in \{1, ..., T\}$ is recursively defined by $V_1 = \Theta_1$ and $V_t = V_{t-1} + \lambda_t \Theta_t \sim F_{V_t}$ for $t \geq 2$, where Θ_t are iid random variables with $\Theta_t \sim F_\Theta$ and $\lambda_t \geq 0$, for all $t \in \{1, ..., T\}$.[16]

5.1. Baseline model

Note that, in the baseline model without a transparency rule, the addition of periods does not change equilibrium behavior. By analogous arguments as in Section 3, equilibrium behavior can be summarized as follows:

Proposition 8. *In equilibrium, for all $t \in \{1, 2, .., T\}$, the firm sets $\bar{w}_t(v_t) = v_t$ and worker i_t demands w_{it} given by*

$$w_{it} = r_{it} + \frac{1 - F_{V_t}(w_{it})}{f_{V_t}(w_{it})} = r_{it} + \frac{1}{h_{V_t}(w_{it})}. \tag{19}$$

5.2. Transparency rule

In the two-period version of the model, we imposed the assumption that the introduction of a transparency rule allows the second-period workers to observe an indicator or signal about the first-period decisions. We extend this assumption to the case of more than two periods by assuming that the period-t workers observe an indicator about each previous period $1, ..., t-2, t-1$.

We begin by considering the workers and we continue to denote the period-t workers' belief about the firm's cutoff by $\hat{w}_t$ and the corresponding distribution of cutoffs by $F_{\hat{w}_t} = F_{\tilde{V}_t} \circ \hat{w}_t^{-1}$, where the random variable $\tilde{V}_t$ denotes the period-t workers' belief about the firm's productivity in period t. The workers' objective function is then the same as in the baseline model. They maximize their expected payoff

$$\begin{aligned} U_{it}(w_{it}, r_{it}) &= \mathbb{P}[w_{it} \leq \hat{w}_t(\tilde{V}_t)]w_{it} + \mathbb{P}[w_{it} > \hat{w}_t(\tilde{V}_t)]r_{it} \\ &= (1 - F_{\hat{w}_t}(w_{it}))\, w_{it} + F_{\hat{w}_t}(w_{it}) r_{it}. \end{aligned} \tag{20}$$

[16] The productivity process differs slightly from the process in the two-period model, in that the weight of the previous productivity V_{t-1} in the definition of V_t is normalized to 1. We make this assumption for notational convenience; the results do not change qualitatively.

In the first period, workers do not have any additional information about the productivity, hence $\tilde{V}_1 = V_1 \sim F_{V_1}$. Second-period workers now observe an indicator at the beginning of the period. We have shown in Proposition 2 that any indicator leads to a deterministic belief $\tilde{v}_1$ about the first-period productivity, and the same holds here. Since $V_2 = V_1 + \lambda_2 \Theta_2$, the workers' updated belief about their value to the firm is therefore given by $\tilde{V}_2 = \tilde{v}_1 + \lambda_2 \Theta_2 \sim F_{\tilde{V}_2}$. Turning to $t \in \{3, ..., T\}$, recall that workers observe an indicator about each previous period. With arguments analogous to those in the proof of Proposition 2, one can then show that period-t workers have a deterministic belief $\tilde{v}_{t-1}$ about the productivity in the previous period. Since $V_t = V_{t-1} + \lambda_t \Theta_t$, the workers' updated belief about their value to the firm is therefore given by $\tilde{V}_t = \tilde{v}_{t-1} + \lambda_t \Theta_t \sim F_{\tilde{V}_t}$.

Next consider the firm. In the T'th period, it is again optimal for the firm to accept a worker i_T's wage demand w_{iT} if and only if $w_{iT} \leq v_T$. Since the T'th period is the last period, there are no informational spillovers affecting future workers, and therefore the firm has no incentive to reject any profitable wage demands. In the $(T-1)$'th period, this no longer holds true. Since workers in the subsequent period receive information in form of the indicator, the firm takes this into account in the decision on the optimal cutoff in period $T-1$. More precisely, in the second-to-last period after receiving the wage demands w_{T-1}, its total (expected) future profit Π_{T-1} is given by

$$\begin{aligned} \Pi_{T-1}(\bar{w}_{T-1}, v_{T-1}) &= \pi_{T-1}(\bar{w}_{T-1}, v_{T-1}) + \delta \mathbb{E}\left[\pi_T(\bar{w}_T, V_T) | V_{T-1} = v_{T-1}\right] \\ &= n_{T-1} \int^{w_{T-1}^{-1}(\bar{w}_{T-1})} v_{T-1} - w_{T-1}(r)\, dF_{r_{T-1}}(r) \\ &\quad + \delta \mathbb{E}\left[n_T \int^{\tilde{w}_T^{-1}(\bar{w}_T)} v_{T-1} + \lambda_T \Theta_T - \tilde{w}_T(r)\, dF_{r_T}(r) \right], \end{aligned} \tag{21}$$

where the firm's belief about the workers' wage demands is denoted by $\tilde{w}_t$ and its period-t profit by π_t. Note that, although the period-T profit π_T does not explicitly depend on the previous period cutoff $\bar{w}_{T-1}$, it does so implicitly, since the period-T wage demand will depend on the realization of the indicator and therefore on previous decisions. For a generic period $t \in \{1, ..., T-1\}$, the total expected future profit Π_t is analogously given by

$$\begin{aligned}
\Pi_t(\bar{w}_t, v_t) &= \pi_t(\bar{w}_t, v_t) + \sum_{k=t+1}^{T} \delta^{k-t} \mathbb{E}\left[\pi_k(\bar{w}_k, V_k) | V_t = v_t\right] \\
&= n_t \int^{w_t^{-1}(\bar{w}_t)} v_t - w_t(r)\, dF_{r_t}(r) \\
&\quad + \sum_{k=t+1}^{T} \delta^{k-t} \mathbb{E}\left[n_k \int^{\tilde{w}_k^{-1}(\bar{w}_k)} V_k - \tilde{w}_k(r)\, dF_{r_k}(r) \,\middle|\, V_t = v_t \right].
\end{aligned} \tag{22}$$

The following Proposition 9 characterizes the equilibrium in case of three periods.

Proposition 9. *Let $T = 3$. Suppose the period-t workers observe an indicator about all previous periods. Then, in equilibrium, the workers' period-1 wage demand w_1 and the firm's first-period cutoff $\bar{w}_1$ satisfy the respective first-order conditions*

$$\begin{aligned}
&(w_1(r_{i1}) - r_{i1})\, f_{\bar{w}_1}(w_1(r_{i1})) \\
&\qquad = 1 - F_{\bar{w}_1}(w_1(r_{i1})) \quad \textit{and} \\
&n_1\left(v_1 - \bar{w}_1(v_1)\right) f_{w_1}(\bar{w}_1(v_1)) \\
&\qquad = -\delta n_2 \int \frac{\partial w_2^{-1}}{\partial \tilde{v}_1}(\bar{w}_2) \tilde{v}_1'(\bar{w}_1)\bigg|_{\tilde{v}_1 = v_1} \left(v_1 + \lambda_2\theta_2 - \bar{w}_2\right) f_{r_2}(w_2^{-1}(\bar{w}_2))\, dF_\Theta(\theta_2) \\
&\qquad + \delta n_2 \int\int^{w_2^{-1}(\bar{w}_2)} \frac{\partial w_2}{\partial \tilde{v}_1}(r) \tilde{v}_1'(\bar{w}_1)\bigg|_{\tilde{v}_1 = v_1} f_{r_2}(r) dr\, dF_\Theta(\theta_2) \\
&\qquad + \delta^2 n_3 \int\int\int^{w_3^{-1}(v_1 + \lambda_2\theta_2 + \lambda_3\theta_3)} \frac{\partial w_3}{\partial \tilde{v}_2}(r) \tilde{v}_2'(\bar{w}_1)\bigg|_{\tilde{v}_1 = v_1} f_{r_3}(r) dr\, dF_\Theta(\theta_2)\, dF_\Theta(\theta_3).
\end{aligned} \tag{23}$$

In the second period, the workers' wage demand w_2 and the firm's cutoff $\bar{w}_2$ fulfill

$$\begin{aligned}
&(w_2(r_{i2}) - r_{i2})\, f_{\bar{w}_2}(w_2(r_{i2})) = 1 - F_{\bar{w}_2}(w_2(r_{i2})) \quad \textit{and} \\
&n_2\left(v_2 - \bar{w}_2(v_2)\right) f_{w_2}(\bar{w}_2(v_2)) = \delta n_3 \int\int^{w_3^{-1}(v_2 + \lambda_3\theta_3)} \frac{\partial w_3}{\partial \tilde{v}_2} \tilde{v}_2'(\bar{w}_2)\bigg|_{\tilde{v}_2 = v_2} (r) dF_{r_3}(r) dF_\Theta(\theta_3).
\end{aligned} \tag{24}$$

In the third period, the workers' wage demand w_3 and the firm's cutoff $\bar{w}_3$ fulfill

$$(w_3(r_{i3}) - r_{i3})\, f_\Theta\left(\frac{w_3(r_{i3}) - v_2}{\lambda_3}\right) = \lambda_3\left(1 - F_\Theta\left(\frac{w_3(r_{i3}) - v_2}{\lambda_3}\right)\right) \quad \textit{and}$$
$$\bar{w}_3(v_3) = v_3. \tag{25}$$

We focus on period 2 and note that the equilibrium conditions for that period have the exact same form as those for the first period in the two-period model (as specified in Proposition 3). This means that the strategic effect on the workers' payoff in the second period of the three-period model acts in the same way as that in the first period of the two-period model, allowing us to apply our previous results on this effect in the three-period model.

Furthermore, the second-period workers learn the true first-period productivity v_1, just as they did in the two-period model. This means that the learning effect that we identified in the two-period model continues to hold in the second period, again allowing us to apply our preceding results. Summing up, the payoff of the second-period workers is now impacted on by both the strategic and the learning effect. It follows that, if Θ_3 has a decreasing hazard rate, then the two effects act into the same direction and workers are clearly better off after the introduction of the transparency rule. In contrast, if Θ_3 has an increasing hazard rate, then the effects are countervailing, and whether or not workers benefit from the introduction of the transparency rule depends on which effect dominates. One may conjecture that, as the λ_t's get large, the relative importance of the learning effect declines since the correlation of productivity across time becomes weaker. At the same time, however, the firm's incentive to manipulate the information that the workers receive declines as well, diminishing the importance of the strategic effect. Accordingly, a ranking of the two effects is likely to depend on the specifics of the model (even if we fix the λ_t's at certain values).

6. Conclusion

The goal of the current paper has been to study the effects of transparency rules on the wage-setting in firms and the payoffs of workers. To this end, we have started by developing a model of wage negotiations, in which workers are uncertain about their contribution to the firm value when making wage demands to the firm. We have introduced a transparency rule into this model, and we have identified a class of equivalent rules that lead to an identical equilibrium outcome. Furthermore, we have found that the introduction of a transparency rule induces the firm to behave strategically with the aim of manipulating the information workers receive. We have shown that the effect of the rule on payoffs crucially depends on the hazard rate of the productivity distribution. For distributions with a decreasing hazard rate, transparency rules increase the workers' payoffs, while for distributions with an increasing hazard rate, the opposite could happen.

In practice, wage transparency rules are often introduced with the aim of reducing wage gaps between different groups of workers. While we have focused on a single group of workers in our model, it would be easy to extend the model to allow for distinct worker groups.[17] If one assumes that the worker groups have different distributions of reservation values, a wage gap between groups results.[18] It is, however, difficult to make general statements about the effect of wage transparency rules on the wage gap. We believe that the effect again depends on the hazard rate of the productivity distribution and we think that the wage gap tends to become lower (greater) in the case of an increasing (decreasing) hazard rate. This means that, for some productivity distributions, something akin to an equity-efficiency trade-off could be observed, where greater equity between groups comes at the cost of lower payoff. Our conjecture can be confirmed for an example with the uniform distribution, where transparency rules indeed lead to lower wage gaps, but also lower payoffs.

Throughout the model, we have imposed the assumption that productivity is the same

[17]We have made such a distinction in an earlier version of our paper; see Gürtler and Struth (2021).

[18]Support for the assumption that reservation values tend to differ across worker groups is provided by, e.g., Brown et al. (2011), Caliendo et al. (2017), and Khan and Majid (2020).

for all workers, and a next possible step in the analysis would be to consider workers with different productivity. While a detailed analysis of such a model is beyond the scope of this paper, our conjecture is that the qualitative results would not change strongly, while the firm's strategic behavior would be muted. The reason is that the additional worker heterogeneity would dilute the signal that workers observe about the firm's productivity (e.g., since a high wage could now be paid either because of the firm's high productivity or because of a worker's outstanding ability), reducing the firm's incentive to manipulate the information that workers receive.

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7. Appendix

7.1. Omitted proofs

Proof of Proposition 2. Denote the (strictly increasing) second-period workers' belief about w_1 and $\bar{w}_1$ by $\tilde{w}_1$ and $\hat{w}_1$, respectively. Then, the second-period workers' belief $\tilde{V}_1$ about the first-period productivity v_1 is formed via the condition

$$X_{F_{w_1}}(\bar{w}_1) = X_{F_{\tilde{w}_1}}(\hat{w}_1(\tilde{V}_1))$$

or, equivalently, $X_{F_{w_1}}(\bar{w}_1) - X_{F_{\tilde{w}_1}}(\hat{w}_1(\tilde{V}_1)) = 0$. Since $\hat{w}_1$ is strictly increasing and $X_{F_{\tilde{w}_1}}$ is strictly monotone, $\tilde{V}_1 = \tilde{v}_1$ is a deterministic function of $\bar{w}_1$, and we obtain

$$\tilde{v}_1'(\bar{w}_1) = \frac{\partial X_{F_{w_1}}(\bar{w}_1)/\partial \bar{w}_1}{\partial X_{F_{\tilde{w}_1}}(\hat{w}_1(\tilde{v}_1))/\partial \hat{w}_1 \cdot \hat{w}_1'(\tilde{v}_1)}.$$

In equilibrium, beliefs are correct, that is, $\tilde{w}_1 = w_1$ and $\hat{w}_1 = \bar{w}_1$. Hence, we obtain $X_{F_{w_1}}(\bar{w}_1(v_1)) = X_{F_{w_1}}(\bar{w}_1(\tilde{v}_1))$, and therefore $\tilde{v}_1 = v_1$ and $\tilde{v}_1'(\bar{w}_1) = 1/\bar{w}_1'(v_1)$. □

Proof of Proposition 3. First, consider the second period. Since the second period is the last period, the firm has no incentive to shade its productivity and accepts all workers with a wage demand not greater than their value to the firm. Thus, the firm sets $\bar{w}_2(v_2) = v_2 = \lambda_1 v_1 + \lambda_2 \theta$.

Second-period workers maximize, given their belief $\hat{w}_2$ about the period-2 cutoff, the expected payoff $(1 - F_{\hat{w}_2}(w_{i2}))\, w_{i2} + F_{\hat{w}_2}(w_{i2}) r_{i2}$. Hence, the first-order condition with respect to w_{i2} is given by

$$0 = -f_{\hat{w}_2}(w_{i2}) w_{i2} + 1 - F_{\hat{w}_2}(w_{i2}) + f_{\hat{w}_2}(w_{i2}) r_{i2}$$

which is equivalent to $(w_{i2} - r_{i2})\, f_{\hat{w}_2}(w_{i2}) = 1 - F_{\hat{w}_2}(w_{i2})$. It holds that $F_{\hat{w}_2} = F_{\tilde{V}_2} \circ \hat{w}_2^{-1}$ and $\tilde{V}_2 = \lambda_1 \tilde{v}_1 + \lambda_2 \Theta$. Hence, we obtain $F_{\hat{w}_2}(x) = F_\Theta\left(\frac{\hat{w}_2^{-1}(x) - \lambda_1 \tilde{v}_1}{\lambda_2}\right)$ and $f_{\hat{w}_2}(x) =$

$f_\Theta\left(\frac{\hat{w}_2^{-1}(x)-\lambda_1\tilde{v}_1}{\lambda_2}\right)\frac{1}{\lambda_2\hat{w}_2'(\hat{w}_2^{-1}(x))}$. The first-order condition is then given by

$$(w_{i2}-r_{i2})\, f_\Theta\left(\frac{\hat{w}_2^{-1}(w_{i2})-\lambda_1\tilde{v}_1}{\lambda_2}\right)\frac{1}{\lambda_2\hat{w}_2'(\hat{w}_2^{-1}(w_{i2}))}=1-F_\Theta\left(\frac{\hat{w}_2^{-1}(w_{i2})-\lambda_1\tilde{v}_1}{\lambda_2}\right).$$

In the first period, the firm chooses the cutoff $\bar{w}_1$ to maximize its total (expected) profit Π across both periods. Hence, its objective function is

$$\begin{aligned}
\Pi(\bar{w}_1,v_1)&=\pi_1(\bar{w}_1,v_1)+\delta\mathbb{E}[\pi_2(\bar{w}_2,\lambda_1v_1+\lambda_2\Theta)]\\
&=n_1\int^{w_1^{-1}(\bar{w}_1)}v_1-w_1(r)\,dF_{r_1}(r)+\delta\mathbb{E}\left[n_2\int^{\tilde{w}_2^{-1}(\bar{w}_2)}\lambda_1v_1+\lambda_2\Theta-\tilde{w}_2(r)\,dF_{r_2}(r)\right]\\
&=n_1\int^{w_1^{-1}(\bar{w}_1)}v_1-w_1(r)\,dF_{r_1}(r)\\
&\qquad+\delta\int n_2\int^{\tilde{w}_2^{-1}(\bar{w}_2)}\lambda_1v_1+\lambda_2\theta-\tilde{w}_2(r)\,dF_{r_2}(r)\,dF_\Theta(\theta).
\end{aligned}$$

Note that, since π_2 depends on the firm's belief about $\tilde{w}_2$, the second-period workers' wage demand, it also implicitly depends on those workers' beliefs $\tilde{v}_1$ about the first-period productivity which is influenced by the firm's choice of $\bar{w}_1$. Hence, the first-order condition with respect to $\bar{w}_1$ is given by

$$\begin{aligned}
0&=n_1\frac{d}{d\bar{w}_1}w_1^{-1}(\bar{w}_1)\left(v_1-w_1(w_1^{-1}(\bar{w}_1)\right)f_{r_1}(w_1^{-1}(\bar{w}_1))\\
&\quad+\delta n_2\int\frac{d}{d\bar{w}_1}\tilde{w}_2^{-1}(\bar{w}_2)\left(\lambda_1v_1+\lambda_2\theta-\tilde{w}_2(\tilde{w}_2^{-1}(\bar{w}_2))\right)f_{r_2}(\tilde{w}_2^{-1}(\bar{w}_2))\,dF_\Theta(\theta)\\
&\quad+\delta n_2\int\int^{\tilde{w}_2^{-1}(\bar{w}_2)}-\frac{d}{d\bar{w}_1}\tilde{w}_2(r)f_{r_2}(r)dr\,dF_\Theta(\theta)\\
&=\frac{n_1}{w_1'(w_1^{-1}(\bar{w}_1))}\left(v_1-\bar{w}_1\right)f_{r_1}(w_1^{-1}(\bar{w}_1))\\
&\quad+\delta n_2\int\frac{\partial}{\partial\tilde{v}_1}\tilde{w}_2^{-1}(\bar{w}_2)\tilde{v}_1'(\bar{w}_1)\left(\lambda_1v_1+\lambda_2\theta-\bar{w}_2\right)f_{r_2}(\tilde{w}_2^{-1}(\bar{w}_2))\,dF_\Theta(\theta)\\
&\quad-\delta n_2\int\int^{\tilde{w}_2^{-1}(\bar{w}_2)}\frac{\partial\tilde{w}_2}{\partial\tilde{v}_1}(r)\tilde{v}_1'(\bar{w}_1)f_{r_2}(r)dr\,dF_\Theta(\theta).
\end{aligned}$$

Observe that, since $\bar{w}_2(v_2)=v_2=\lambda_1v_1+\lambda_2\theta$, the second term vanishes, and thus, after some rearrangement, the first-order condition reduces to

$$n_1\left(v_1-\bar{w}_1\right)\frac{f_{r_1}(w_1^{-1}(\bar{w}_1))}{w_1'(w_1^{-1}(\bar{w}_1))}=\delta n_2\tilde{v}_1'(\bar{w}_1)\int\int^{\tilde{w}_2^{-1}(\bar{w}_2)}\frac{\partial\tilde{w}_2}{\partial\tilde{v}_1}(r)f_{r_2}(r)dr\,dF_\Theta(\theta).$$

Since $f_{w_1}(x)=F_{w_1}'(x)=f_{r_1}(w_1^{-1}(x))/w_1'(w_1^{-1}(x))$, this can be rewritten as

$$n_1\left(v_1-\bar{w}_1\right)f_{w_1}(\bar{w}_1)=\delta n_2\tilde{v}_1'(\bar{w}_1)\int\int^{\tilde{w}_2^{-1}(\bar{w}_2)}\frac{\partial\tilde{w}_2}{\partial\tilde{v}_1}(r)f_{r_2}(r)dr\,dF_\Theta(\theta).$$

First-period workers maximize their expected payoff $\left(1-F_{\hat{w}_1}(w_{i1})\right)w_{i1}+F_{\hat{w}_1}(w_{i1})r_{i1}$. Hence, the first-order condition with respect to w_{i1} is given by

$$0=-f_{\hat{w}_1}(w_{i1})w_{i1}+1-F_{\hat{w}_1}(w_{i1})+f_{\hat{w}_1}(w_{i1})r_{i1}$$

which is equivalent to $\left(w_{i1}-r_{i1}\right)f_{\hat{w}_1}(w_{i1})=1-F_{\hat{w}_1}(w_{i1})$.

In equilibrium, beliefs are correct. Thus, for all $t\in\{1,2\}$, it holds $\hat{w}_t=\bar{w}_t$ and $\tilde{w}_t=w_t$. The result then follows by invoking Proposition 2. □

Proof of Proposition 4. In Proposition 3, we have shown that for any equilibrium cutoff $\bar{w}_1$ it holds that

$$n_1\left(v_1-\bar{w}_1(v_1)\right)f_{w_1}(\bar{w}_1(v_1))=\frac{\delta n_2}{\bar{w}_1'(v_1)}\int\int^{w_2^{-1}(\lambda_1 v_1+\lambda_2\theta)}\left.\frac{\partial w_2}{\partial\tilde{v}_1}\right|_{\tilde{v}_1=v_1}(r)dF_{r_2}(r)dF_\Theta(\theta).\quad(26)$$

By Lemma 1, since the hazard rate h_Θ is non-constant, the right-hand side of equation (26) is non-zero if the area of integration is of positive (Lebesgue) measure. This is ensured by noting that

$$w_2(\underline{r}_2)=w_2^{\min}<\lambda_1 v_1+\lambda_2\theta$$

is equivalent to $\underline{r}_2<w_2^{-1}(\lambda_1 v_1+\lambda_2\theta)$. Furthermore, by the assumption that the second-period workers observe an indicator, it holds that $f_{w_1}\circ\bar{w}_1>0$, and thus the left-hand side is non-zero if and only if $\bar{w}_1(v_1)\neq v_1$. The result follows by the observation that the right-hand side of equation (26) is continuous in the first-period productivity. $\square$

Proof of Lemma 1. In period 2, workers form a belief regarding v_1, denoted by $\tilde{v}_1$. Hence, their belief about V_2 is given by $\tilde{V}_2 = \lambda_1\tilde{v}_1 + \lambda_2\Theta$. As shown in the proof of Proposition 3, the first-order condition to the second-period workers' maximization problem can be stated as

$$w_{i2} = r_{i2} + \lambda_2 \frac{1 - F_\Theta\left(\frac{w_{i2}-\lambda_1\tilde{v}_1}{\lambda_2}\right)}{f_\Theta\left(\frac{w_{i2}-\lambda_1\tilde{v}_1}{\lambda_2}\right)} = r_{i2} + \frac{\lambda_2}{h_\Theta\left(\frac{w_{i2}-\lambda_1\tilde{v}_1}{\lambda_2}\right)},$$

where h_Θ denotes the hazard rate corresponding to Θ. Applying the implicit function theorem yields

$$\frac{\partial w_{i2}}{\partial \tilde{v}_1} = -\frac{\frac{\lambda_2 h'_\Theta\left(\frac{w_{i2}-\lambda_1\tilde{v}_1}{\lambda_2}\right)\left(-\frac{\lambda_1}{\lambda_2}\right)}{\left(h_\Theta\left(\frac{w_{i2}-\lambda_1\tilde{v}_1}{\lambda_2}\right)\right)^2}}{1 + \frac{\lambda_2 h'_\Theta\left(\frac{w_{i2}-\lambda_1\tilde{v}_1}{\lambda_2}\right)\frac{1}{\lambda_2}}{\left(h_\Theta\left(\frac{w_{i2}-\lambda_1\tilde{v}_1}{\lambda_2}\right)\right)^2}} = \frac{\lambda_1 h'_\Theta\left(\frac{w_{i2}-\lambda_1\tilde{v}_1}{\lambda_2}\right)}{\left(h_\Theta\left(\frac{w_{i2}-\lambda_1\tilde{v}_1}{\lambda_2}\right)\right)^2 + h'_\Theta\left(\frac{w_{i2}-\lambda_1\tilde{v}_1}{\lambda_2}\right)}.$$

Since, by assumption, $\left(h_\Theta\left(\frac{w_{i2}-\lambda_1\tilde{v}_1}{\lambda_2}\right)\right)^2 + h'_\Theta\left(\frac{w_{i2}-\lambda_1\tilde{v}_1}{\lambda_2}\right) > 0$, the sign of $\frac{dw_{i2}}{d\tilde{v}_1}$ thus equals the sign of the numerator $\lambda_1 h'_\Theta\left(\frac{w_{i2}-\lambda_1\tilde{v}_1}{\lambda_2}\right)$. $\square$

Proof of Proposition 5. The proof goes by similar arguments to the proof of Proposition 4. Again, note that in Proposition 3 we have shown that for any equilibrium cutoff $\bar{w}_1$ it holds that

$$n_1\left(v_1 - \bar{w}_1(v_1)\right) f_{w_1}(\bar{w}_1(v_1)) = \frac{\delta n_2}{\bar{w}_1'(v_1)} \int \int^{w_2^{-1}(\lambda_1 v_1 + \lambda_2\theta)} \left.\frac{\partial w_2}{\partial \tilde{v}_1}\right|_{\tilde{v}_1 = v_1} (r) dF_{r_2}(r) dF_\Theta(\theta). \quad (27)$$

If the hazard rate h_Θ is increasing (decreasing), by Lemma 1, the right-hand side of equation (27) then is positive (negative) if the area of integration is of positive (Lebesgue) measure. This is ensured by noting that

$$w_2(\underline{r}_2) = w_2^{\min} < \lambda_1 v_1 + \lambda_2\theta$$

is equivalent to $\underline{r}_2 < w_2^{-1}(\lambda_1 v_1 + \lambda_2\theta)$. Furthermore, by the assumption that the second-period workers observe an indicator, it holds that $f_{w_1} \circ \bar{w}_1 > 0$, and thus the left-hand-side of equation (27) is positive (negative) if and only if $\bar{w}_1(v_1) < (>) v_1$. If the hazard rate h_Θ is constant, by Lemma 1, the right-hand side of equation (27) vanishes, and since $f_{w_1} \circ \bar{w}_1 > 0$, almost everywhere we obtain $\bar{w}_1(v_1) = v_1$. □

Proof of Proposition 6. Recall that the expected equilibrium payoff of worker i_t is given by

$$\begin{aligned} U_{it}(w_{it}, r_{it}) &= \mathbb{P}[w_{it} \leq \bar{w}_t(V_t)]w_{it} + \mathbb{P}[w_{it} > \bar{w}_t(V_t)]r_{it} \\ &= \left(1 - F_{\bar{w}_t}(w_{it})\right) w_{it} + F_{\bar{w}_t}(w_{it}) r_{it}. \end{aligned}$$

Denote the expected payoff in the model with and without the indicator by U_{it}^{tr} and U_{it}, respectively. By Proposition 1, in the baseline model it holds that $\bar{w}_1(v_1) = v_1$, and therefore

$$\begin{aligned} & U_{i1}^{tr}(w_{i1}, r_{i1}) - U_{i1}(w_{i1}, r_{i1}) \\ &= \left(1 - F_{\bar{w}_1}(w_{i1})\right) w_{i1} + F_{\bar{w}_1}(w_{i1}) r_{i1} - \left(\left(1 - F_{V_1}(w_{i1})\right) w_{i1} + F_{V_1}(w_{i1}) r_{i1}\right) \\ &= \left(F_{V_1}(w_{i1}) - F_{\bar{w}_1}(w_{i1})\right)(w_{i1} - r_{i1}) \end{aligned}$$

is negative (positive) for all $w_{i1} > r_{i1}$ if and only if $F_{V_1}(w_{i1}) - F_{\bar{w}_1}(w_{i1})$ is negative (positive). By Proposition 5, we have $\bar{w}_1(v_1) \leq v_1$ and $\bar{w}_1(v_1) \geq v_1$ for all v_1 with strict inequality for some v_1 if the hazard rate h_Θ is increasing and decreasing, respectively. By Theorem 1.A.17 in Shaked and Shanthikumar (2007), it follows that V_1 dominates (is dominated by) $\bar{w}_1(V_1)$ in the usual stochastic order, and therefore $F_{V_1}(w_{i1}) - F_{\bar{w}_1}(w_{i1})$ is negative (positive) for all $w_{i1} > r_{i1}$ if h_Θ is increasing (decreasing).

For some r_{i1} denote by w_{i1} and w_{i1}^{tr} the optimal wage demand in the baseline model and the model with a transparency rule, respectively. Then, it must hold that $U_{i1}(w_{i1}, r_{i1}) \geq U_{i1}(w_{i1}^{tr}, r_{i1})$ and $U_{i1}^{tr}(w_{i1}^{tr}, r_{i1}) \geq U_{i1}^{tr}(w_{i1}, r_{i1})$. If $w_{i1}, w_{i1}^{tr} > r_{i1}$ and the hazard rate h_Θ is increasing, we thus obtain $U_{i1}(w_{i1}, r_{i1}) \geq U_{i1}(w_{i1}^{tr}, r_{i1}) \geq U_{i1}^{tr}(w_{i1}^{tr}, r_{i1})$ and, if the hazard rate is decreasing, we obtain $U_{i1}^{tr}(w_{i1}^{tr}, r_{i1}) \geq U_{i1}^{tr}(w_{i1}, r_{i1}) \geq U_{i1}(w_{i1}, r_{i1})$. This concludes the proof. $\square$

Proof of Proposition 7. Denote the second-period workers' belief about the period-2 productivity by $\tilde{V}_2$ and $\tilde{V}_2^{tr}$ in case of the baseline model and the model with a transparency rule, respectively. Further, denote the corresponding equilibrium wage demands by w_{i2} and w_{i2}^{tr}. Then, since in equilibrium $\bar{w}_2(v_2) = v_2$, for all r_{i2} it holds that

$$\begin{aligned} w_{i2} &\in \text{argmax}_{w_{i2}} \left\{ \mathbb{P}[w_{i2} \leq \tilde{V}_2] w_{i2} + \mathbb{P}[w_{i2} > \tilde{V}_2] r_{i2} \right\} \\ w_{i2}^{tr} &\in \text{argmax}_{w_{i2}^{tr}} \left\{ \mathbb{P}[w_{i2}^{tr} \leq \tilde{V}_2^{tr}] w_{i2}^{tr} + \mathbb{P}[w_{i2}^{tr} > \tilde{V}_2^{tr}] r_{i2} \right\}. \end{aligned} \tag{28}$$

Suppose now that $V_1 = v_1$. Then the second-period workers' payoff in the baseline model is given by

$$U_2(w_{i2}, r_{i2}, v_1) = \left(1 - F_{V_2|V_1=v_1}(w_{i2})\right) w_{i2} + F_{V_2|V_1=v_1}(w_{i2}) r_{i2},$$

while in the model with transparency it is given by

$$U_2(w_{i2}^{tr}, r_{i2}, v_1) = \left(1 - F_{V_2|V_1=v_1}(w_{i2}^{tr})\right) w_{i2}^{tr} + F_{V_2|V_1=v_1}(w_{i2}^{tr}) r_{i2}.$$

Since in the model with a transparency rule second-period workers learn the first-period productivity perfectly, it holds that $\tilde{V}_2 = V_2 = \lambda_1 V_1 + \lambda_2 \Theta \sim F_{V_2}$ and $\tilde{V}_2^{tr} = (V_2 | V_1 = v_1) = \lambda_1 v_1 + \lambda_2 \Theta \sim F_{V_2|V_1=v_1}$. By (28), it therefore follows that $U_2(w_{i2}, r_{i2}, v_1) \leq U_2(w_{i2}^{tr}, r_{i2}, v_1)$ for all $r_{i1} \in \mathit{supp}(f_{r_{i1}})$. Hence, for all $v_1 \in \mathit{supp}(f_{V_1})$, the expected payoff of every second-period worker increases due to the transparency rule.

Furthermore, it can immediately be seen that the average expected payoff (across all types of firms) also increases due to the transparency rule, that is, it holds that

$$\int U_2(w_{i2}, r_{i2}, v_1) dF_{V_1}(v_1) \leq \int U_2(w_{i2}^{tr}, r_{i2}, v_1) dF_{V_1}(v_1).$$

This concludes the proof. $\square$

Proof of Proposition 9. First, consider the third period. Since the third period is the last period, the firm has no incentive to shade its productivity and accepts all workers with a wage demand not greater than their value to the firm. Thus, the firm sets $\bar{w}_3(v_3) = v_3 = v_2 + \lambda_3\theta_3$.

Period-3 workers maximize, given their belief $\hat{w}_3$ about the period-3 cutoff, the expected payoff $(1 - F_{\hat{w}_3}(w_{i3}))\, w_{i3} + F_{\hat{w}_3}(w_{i3}) r_{i3}$. Hence, the first-order condition with respect to w_{i3} is given by

$$0 = -f_{\hat{w}_3}(w_{i3}) w_{i3} + 1 - F_{\hat{w}_3}(w_{i3}) + f_{\hat{w}_3}(w_{i3}) r_{i3}$$

which is equivalent to $(w_{i3} - r_{i3})\, f_{\hat{w}_3}(w_{i3}) = 1 - F_{\hat{w}_3}(w_{i3})$. It holds that $F_{\hat{w}_3} = F_{\tilde{V}_3} \circ \hat{w}_3^{-1}$ and $\tilde{V}_3 = \tilde{v}_2 + \lambda_3\Theta_3$. Hence, we obtain

$$F_{\hat{w}_3}(x) = F_\Theta\left(\frac{\hat{w}_3^{-1}(x) - \tilde{v}_2}{\lambda_3}\right)$$

and

$$f_{\hat{w}_3}(x) = f_\Theta\left(\frac{\hat{w}_3^{-1}(x) - \tilde{v}_2}{\lambda_3}\right)\frac{1}{\lambda_3 \hat{w}_3'(\hat{w}_3^{-1}(x))}.$$

The first-order condition is then given by

$$(w_{i3} - r_{i3})\, f_\Theta\left(\frac{\hat{w}_3^{-1}(w_{i3}) - \tilde{v}_2}{\lambda_3}\right)\frac{1}{\lambda_3 \hat{w}_3'(\hat{w}_3^{-1}(w_{i3}))} = 1 - F_\Theta\left(\frac{\hat{w}_3^{-1}(w_{i3}) - \tilde{v}_2}{\lambda_3}\right).$$

In the second period, the firm chooses the cutoff $\bar{w}_2$ to maximize its total (expected) profit Π_2 across the current and all future periods, that is, across periods 2 and 3. Hence, its objective function is

$$\begin{aligned}
\Pi_2(\bar{w}_2, v_2) &= \pi_2(\bar{w}_2, v_2) + \delta\mathbb{E}[\pi_3(\bar{w}_3, v_2 + \lambda_3\Theta_3)] \\
&= n_2 \int^{w_2^{-1}(\bar{w}_2)} v_2 - w_2(r)\, dF_{r_2}(r) + \delta\mathbb{E}\left[n_3 \int^{\tilde{w}_3^{-1}(\bar{w}_3)} v_2 + \lambda_3\Theta_3 - \tilde{w}_3(r)\, dF_{r_3}(r)\right] \\
&= n_2 \int^{w_2^{-1}(\bar{w}_2)} v_2 - w_2(r)\, dF_{r_2}(r) \\
&\quad + \delta \int n_3 \int^{\tilde{w}_3^{-1}(\bar{w}_3)} v_2 + \lambda_3\theta_3 - \tilde{w}_3(r)\, dF_{r_3}(r)\, dF_\Theta(\theta_3).
\end{aligned}$$

Note that, since π_3 depends on the firm's belief about w_3, the third-period workers' wage demand, it also implicitly depends on those workers' beliefs $\tilde{v}_2$ about the second-period productivity which is influenced by the firm's choice of $\bar{w}_2$. Hence, the first-order condition with respect to $\bar{w}_2$ is given by

$$\begin{aligned}
0 &= n_2 \frac{d}{d\bar{w}_2} w_2^{-1}(\bar{w}_2) \left(v_2 - w_2(w_2^{-1}(\bar{w}_2)\right) f_{r_2}(w_2^{-1}(\bar{w}_2)) \\
&\quad + \delta n_3 \int \frac{d}{d\bar{w}_2} \tilde{w}_3^{-1}(\bar{w}_3) \left(v_2 + \lambda_3\theta_3 - \tilde{w}_3(\tilde{w}_3^{-1}(\bar{w}_3))\right) f_{r_3}(\tilde{w}_3^{-1}(\bar{w}_3))\, dF_\Theta(\theta_3) \\
&\quad + \delta \int n_3 \int^{\tilde{w}_3^{-1}(\bar{w}_3)} -\frac{d}{d\bar{w}_2} \tilde{w}_3(r) f_{r_3}(r) dr\, dF_\Theta(\theta_3) \\
&= \frac{n_2}{w_2'(w_2^{-1}(\bar{w}_2))} (v_2 - \bar{w}_2)\, f_{r_2}(w_2^{-1}(\bar{w}_2)) \\
&\quad + \delta n_3 \int \frac{\partial \tilde{w}_3^{-1}}{\partial \tilde{v}_2}(\bar{w}_3) \tilde{v}_2'(\bar{w}_2) \left(v_2 + \lambda_3\theta_3 - \bar{w}_3\right) f_{r_3}(\tilde{w}_3^{-1}(\bar{w}_3))\, dF_\Theta(\theta_3) \\
&\quad - \delta \int n_3 \int^{\tilde{w}_3^{-1}(\bar{w}_3)} \frac{\partial \tilde{w}_3}{\partial \tilde{v}_2}(r) \tilde{v}_2'(\bar{w}_2) f_{r_3}(r) dr\, dF_\Theta(\theta_3).
\end{aligned}$$

Observe that, since $\bar{w}_3(v_3) = v_3 = v_2 + \lambda_3\theta_3$, the second term vanishes, and thus, after some rearrangement, the first-order condition reduces to

$$n_2 (v_2 - \bar{w}_2) \frac{f_{r_2}(w_2^{-1}(\bar{w}_2))}{w_2'(w_2^{-1}(\bar{w}_2))} = \delta n_3 \tilde{v}_2'(\bar{w}_2) \int \int^{\tilde{w}_3^{-1}(\bar{w}_3)} \frac{\partial \tilde{w}_3}{\partial \tilde{v}_2}(r) f_{r_3}(r) dr\, dF_\Theta(\theta_3).$$

Since $f_{w_2}(x) = F'_{w_2}(x) = f_{r_2}(w_2^{-1}(x))/w_2'(w_2^{-1}(x))$, this can be rewritten as

$$n_2 (v_2 - \bar{w}_2) f_{w_2}(\bar{w}_2) = \delta n_3 \tilde{v}_2'(\bar{w}_2) \int \int^{\tilde{w}_3^{-1}(\bar{w}_3)} \frac{\partial \tilde{w}_3}{\partial \tilde{v}_2}(r) f_{r_3}(r) dr\, dF_\Theta(\theta_3).$$

Second-period workers maximize their expected payoff $(1 - F_{\hat{w}_2}(w_{i2}))\, w_{i2} + F_{\hat{w}_2}(w_{i2}) r_{i2}$. Hence, the first-order condition with respect to w_{i2} is given by

$$0 = -f_{\hat{w}_2}(w_{i2}) w_{i2} + 1 - F_{\hat{w}_2}(w_{i2}) + f_{\hat{w}_2}(w_{i2}) r_{i2}$$

which is equivalent to $(w_{i2} - r_{i2})\, f_{\hat{w}_2}(w_{i2}) = 1 - F_{\hat{w}_2}(w_{i2})$.

In the first period, the firm chooses the cutoff $\bar{w}_1$ to maximize its total (expected) profit Π_1 across the current and all future periods, that is, across periods 1, 2, and 3. Hence, its objective function is

$$\begin{aligned}
\Pi_1(\bar{w}_1, v_1) &= \pi_1(\bar{w}_1, v_1) + \delta\mathbb{E}[\pi_2(\bar{w}_2, v_1 + \lambda_2\Theta_2)] + \delta^2\mathbb{E}[\pi_3(\bar{w}_3, V_2 + \lambda_3\Theta_3)|V_1 = v_1] \\
&= n_1 \int^{w_1^{-1}(\bar{w}_1)} v_1 - w_1(r)\, dF_{r_1}(r) \\
&\quad + \delta\mathbb{E}\left[n_2 \int^{\tilde{w}_2^{-1}(\bar{w}_2)} v_1 + \lambda_2\Theta_2 - \tilde{w}_2(r)\, dF_{r_2}(r)\right] \\
&\quad + \delta^2\mathbb{E}\left[n_3 \int^{\tilde{w}_3^{-1}(\bar{w}_3)} V_2 + \lambda_3\Theta_3 - \tilde{w}_3(r)\, dF_{r_3}(r) \,\middle|\, V_1 = v_1\right] \\
&= n_1 \int^{w_1^{-1}(\bar{w}_1)} v_1 - w_1(r)\, dF_{r_1}(r) \\
&\quad + \delta \int n_2 \int^{\tilde{w}_2^{-1}(\bar{w}_2)} v_1 + \lambda_2\theta_2 - \tilde{w}_2(r)\, dF_{r_2}(r)\, dF_\Theta(\theta_2) \\
&\quad + \delta^2 \int\int n_3 \int^{\tilde{w}_3^{-1}(\bar{w}_3)} (v_1 + \lambda_2\theta_2 + \lambda_3\theta_3 - \tilde{w}_3(r))\, dF_{r_3}(r)\, dF_\Theta(\theta_2)\, dF_\Theta(\theta_3).
\end{aligned}$$

Again, since π_2 depends on the firm's belief about w_2, the second-period workers' wage demand, it also implicitly depends on those workers' belief $\tilde{v}_1$ about the first-period productivity which is influenced by the firm's choice of $\bar{w}_1$. Additionally, π_3 depends on the firm's belief about w_3 and therefore also on the period-3 workers' belief $\tilde{v}_1$ about the first-period productivity. Hence, the first-order condition with respect to $\bar{w}_1$ is given by

$$
\begin{aligned}
0 = {} & n_1 \frac{d}{d\bar{w}_1} w_1^{-1}(\bar{w}_1) \left(v_1 - w_1(w_1^{-1}(\bar{w}_1)\right) f_{r_1}(w_1^{-1}(\bar{w}_1)) \\
& + \delta n_2 \int \frac{d}{d\bar{w}_1} \tilde{w}_2^{-1}(\bar{w}_2) \left(v_1 + \lambda_2\theta_2 - \tilde{w}_2(\tilde{w}_2^{-1}(\bar{w}_2))\right) f_{r_2}(\tilde{w}_2^{-1}(\bar{w}_2))\, dF_\Theta(\theta_2) \\
& + \delta n_2 \int \int^{\tilde{w}_2^{-1}(\bar{w}_2)} -\frac{d}{d\bar{w}_1} \tilde{w}_2(r) f_{r_2}(r) dr\, dF_\Theta(\theta_2) \\
& + \delta^2 n_3 \int \int \frac{d}{d\bar{w}_1} \tilde{w}_3^{-1}(\bar{w}_3) \left(v_1 + \lambda_2\theta_2 + \lambda_3\theta_3 - \tilde{w}_3(\tilde{w}_3^{-1}(\bar{w}_3))\right) f_{r_3}(\tilde{w}_3^{-1}(\bar{w}_3))\, dF_\Theta(\theta_2)\, dF_\Theta(\theta_3) \\
& + \delta^2 n_3 \int \int \int^{\tilde{w}_3^{-1}(\bar{w}_3)} -\frac{d}{d\bar{w}_1} \tilde{w}_3(r) f_{r_3}(r) dr\, dF_\Theta(\theta_2)\, dF_\Theta(\theta_3) \\
= {} & \frac{n_1}{w_1'(w_1^{-1}(\bar{w}_1))} (v_1 - \bar{w}_1)\, f_{r_1}(w_1^{-1}(\bar{w}_1)) \\
& + \delta n_2 \int \frac{\partial \tilde{w}_2^{-1}}{\partial \tilde{v}_1}(\bar{w}_2) \tilde{v}_1'(\bar{w}_1)\, (v_1 + \lambda_2\theta_2 - \bar{w}_2)\, f_{r_2}(\tilde{w}_2^{-1}(\bar{w}_2))\, dF_\Theta(\theta_2) \\
& - \delta n_2 \int \int^{\tilde{w}_2^{-1}(\bar{w}_2)} \frac{\partial \tilde{w}_2}{\partial \tilde{v}_1}(r) \tilde{v}_1'(\bar{w}_1) f_{r_2}(r) dr\, dF_\Theta(\theta_2) \\
& + \delta^2 n_3 \int \int \frac{\partial \tilde{w}_3^{-1}}{\partial \tilde{v}_2}(\bar{w}_3) \tilde{v}_2'(\bar{w}_1)\, (v_1 + \lambda_2\theta_2 + \lambda_3\theta_3 - \bar{w}_3))\, f_{r_3}(\tilde{w}_3^{-1}(\bar{w}_3))\, dF_\Theta(\theta_2)\, dF_\Theta(\theta_3) \\
& - \delta^2 n_3 \int \int \int^{\tilde{w}_3^{-1}(\bar{w}_3)} \frac{\partial \tilde{w}_3}{\partial \tilde{v}_2}(r) \tilde{v}_2'(\bar{w}_1) f_{r_3}(r) dr\, dF_\Theta(\theta_2)\, dF_\Theta(\theta_3).
\end{aligned}
$$

Note that, since $\bar{w}_3(v_3) = v_3 = v_2 + \lambda_3\theta_3$, the second-to-last term vanishes, and thus, after some rearrangement, the first-order condition becomes

$$
\begin{aligned}
& n_1 (\bar{w}_1 - v_1) \frac{f_{r_1}(w_1^{-1}(\bar{w}_1))}{w_1'(w_1^{-1}(\bar{w}_1))} \\
& \quad = \delta n_2 \int \frac{\partial \tilde{w}_2^{-1}}{\partial \tilde{v}_1}(\bar{w}_2) \tilde{v}_1'(\bar{w}_1)\, (v_1 + \lambda_2\theta_2 - \bar{w}_2)\, f_{r_2}(\tilde{w}_2^{-1}(\bar{w}_2))\, dF_\Theta(\theta_2) \\
& \qquad - \delta n_2 \int \int^{\tilde{w}_2^{-1}(\bar{w}_2)} \frac{\partial \tilde{w}_2}{\partial \tilde{v}_1}(r) \tilde{v}_1'(\bar{w}_1) f_{r_2}(r) dr\, dF_\Theta(\theta_2) \\
& \qquad - \delta^2 n_3 \int \int \int^{\tilde{w}_3^{-1}(\bar{w}_3)} \frac{\partial \tilde{w}_3}{\partial \tilde{v}_2}(r) \tilde{v}_2'(\bar{w}_1) f_{r_3}(r) dr\, dF_\Theta(\theta_2)\, dF_\Theta(\theta_3).
\end{aligned}
$$

Analogously to the second period, it holds that $f_{w_1}(x) = F_{w_1}'(x) = f_{r_1}(w_1^{-1}(x))/w_1'(w_1^{-1}(x))$.

First-period workers maximize their expected payoff $(1 - F_{\hat{w}_1}(w_{i1}))\, w_{i1} + F_{\hat{w}_1}(w_{i1}) r_{i1}$.

Hence, the first-order condition with respect to w_{i1} is given by

$$0 = -f_{\hat{w}_1}(w_{i1})w_{i1} + 1 - F_{\hat{w}_1}(w_{i1}) + f_{\hat{w}_1}(w_{i1})r_{i1},$$

which is equivalent to $(w_{i1} - r_{i1})\, f_{\hat{w}_1}(w_{i1}) = 1 - F_{\hat{w}_1}(w_{i1})$.

In equilibrium, beliefs are correct. Thus, for all $t \in \{1, 2, 3\}$, it holds that $\hat{w}_t = \bar{w}_t$ and $\tilde{w}_t = w_t$. □

7.2. Examples of indicators

7.2.1. Transparency rules regarding wages

First, suppose that, at the beginning of the second period, the workers observe the mean wage

$$\mu_{w_1}(\bar{w}_1) = \frac{1}{F_{w_1}(\bar{w}_1)} \int_{w_1^{\min}}^{\bar{w}_1} x \, dF_{w_1}(x)$$

of all workers who are accepted by the firm in the first period. If $\bar{w}_1 \in (w_1^{\min}, w_1^{\max})$, it holds that

$$\mu'_{w_1}(\bar{w}_1) = -\frac{f_{w_1}(\bar{w}_1)}{F^2_{w_1}(\bar{w}_1)} \int_{w_1^{\min}}^{\bar{w}_1} x \, dF_{w_1}(x) + \frac{f_{w_1}(\bar{w}_1)}{F_{w_1}(\bar{w}_1)} \bar{w}_1 = \frac{f_{w_1}(\bar{w}_1)}{F_{w_1}(\bar{w}_1)} \left(\bar{w}_1 - \mu_{w_1}\right) > 0.$$

Hence, $X_{F_{w_1}} = \mu_{w_1}$ is strictly increasing and therefore an indicator in the sense of Proposition 2.

Second, suppose that, at the beginning of the second period, workers observe the median wage m_{w_1} of all workers who are accepted by the firm in the first period, which is given by the equation

$$\int_{w_1^{\min}}^{\mathrm{m}_{w_1}} dF_{w_1}(x) = \int_{\mathrm{m}_{w_1}}^{\bar{w}_1} dF_{w_1}(x).$$

If $\bar{w}_1 \in (w_1^{\min}, w_1^{\max})$, it holds that

$$\mathrm{m}'_{w_1}(\bar{w}_1) = \frac{f_{w_1}(\bar{w}_1)}{2 f_{w_1}(m_{w_1})}.$$

Hence, $X_{F_{w_1}} = \mathrm{m}_{w_1}$ is strictly increasing and therefore an indicator in the sense of Proposition 2.

Third, suppose that, at the beginning of the second period, the workers observe the maximum wage that is paid by the firm in the first period, which, if $\bar{w}_1 \in (w_1^{\min}, w_1^{\max})$ is simply given by the cutoff $\bar{w}_1$ and therefore $X_{F_{w_1}} = \mathrm{id}$ which is strictly increasing.

7.2.2. Transparency rules regarding firm size

Suppose that, at the beginning of the second period, the workers observe the measure m_1 of the workers who are accepted by the firm in the first period, that is, the indicator is given by $X_{F_{w_1}}(\bar{w}_1) = m_1 = n_1 \cdot F_{w_1}(\bar{w}_1)$. Since by assumption F_{r_1} and w_1 are strictly increasing, $F_{w_1} = F_{r_1} \circ w_1^{-1}$ is also strictly increasing. It is then immediate that $X_{F_{w_1}}(\bar{w}_1) = m_1$ is an indicator in the sense of Proposition 2. In case the second-period workers observe the measure of rejected workers in the first period, the result is obtained by analogous arguments.