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Telework, Psychological Contracts and Burnout

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Abstract

Telework, which has increased with the lockdown related to the Covid-19 crisis, has resulted in an improvement in the quality of life of employees and an increase in their productivity, but also in burnout cases. This article uses psychological game to study the risk of burnout from the feelings of guilt associated with the improvement of telework conditions, and disappointment and reciprocity associated with the psychological contract and the effort-reward model of Siegrist. It shows that for active women the risk of burnout is increased by a similar psychological contract existing in the family setting. Using an information design approach, it considers the employer intervention to limit the risk of burnout of his employees.

Keywords

Burnout, Telework, Effort-Reward Model, Psychological Contract, Psychological Game, Information Design

1. Introduction

The use of telework, which was intended, during the first oil shock, to "reduce the costs and time lost in travel in large urban areas" (Ollivier, 2017) and was also justified by climate and ecological arguments (Taskin, 2021), has been promoted since the 1970s by the development of information technologies and perpetuated by successive lockdown periods put in place by the governments to stem the Covid-19 epidemic. In theory, this method appears to be mutually advantageous for the employer and the employee, insofar as it can lead to productivity gains by reducing fatigue and loss of time, as well as greater flexibility in work organization and therefore a better work-life balance, staff retention (Ollivier, 2017) and reduced absenteeism (Taskin, 2021).

In practice, improving the quality of life of employees has indeed been ac-

companied by an increase in their productivity (Tremblay, 2020), but negative effects have also appeared due to isolation (Taskin, 2021) and interpenetration of professional and family time (Tremblay, 2014) related to the difficult separation between private and professional life (Ollivier, 2017; Taskin, 2021), as was highlighted during the lockdowns. Flexibility in the organization of work can indeed result in a significant overflow of working time over personal time, already common especially among lawyers (Tremblay, 2014) and executives (Genin, 2017) and reinforced by communication and information processing tools (Cléach & Metzger, 2004). Thus, "under the pressure of a kind of internalized 'guilt' (guilt of being able to work in good conditions, escaping certain superfluous constraints such as transport time, noise generated by office life, etc.), the remote worker is tempted to do too much, to add, in a word, to work without limits" (Cléach & Metzger, 2004).

Telework can thus be the cause of burnout with the employee, because of the phenomena of disappointment and reciprocity associated with the *psychological contract* linking the employee to her employer, as defined by Rousseau (1989): "When an individual perceives that contributions he or she makes obligate the organization to reciprocity (or vice versa), a psychological contract emerges. Belief that reciprocity *will* occur can be a precursor to the development of a psychological contract. However, it is the individual's belief in an *obligation of reciprocity* that constitutes the contract." In his *effort-reward imbalance* model (Siegrist, 1996, 2017), Siegrist highlights "stressful features of the work contract" related to "social reciprocity in costly transactions". In his analysis, the employee provides an effort in response to an *extrinsic demand* as well as a *subjective motivation*, where she can demonstrate excessive overcommitment, and can receive three types of rewards: "salary or wage (financial reward), career promotion or job security (status-related reward), and esteem or recognition (socio-emotional reward)" (2017). He shows that "The experience of an imbalance between high effort spent and low reward received at work is assumed to be particularly stressful as this imbalance violates core expectations about reciprocity and adequate exchange in a crucial area of social life… [H]igh-cost/low-gain conditions are likely to elicit recurrent feelings of threat, anger, and depression or demoralization, which in turn evoke sustained autonomic arousal." (1996).

The purpose of this article is to analyze the risk of burnout generated by telework through an approach in terms of *psychological game* based on these phenomena of *guilt*, *disappointment* and *reciprocity*. The observation showing the prevalence of burnout risk among women working on-site or teleworking (McKinsey & Company, 2021; Boston Consulting Group Study, 2021), we will see that it can be explained by the existence of a similar psychological contract in the family setting. We will then focus, through an *information design* approach, on the employer's decision on prevention measures to limit the risk of burnout of his employees. The contribution of this research lies in the formalization of the behaviors of the employee and the employer, where the latter may be guided by the advice of a regulator, and in the identification of leverages to reduce the

psychosocial risks associated with telework.

Section 2 considers the employee-employer relationship where the employee chooses between low or high effort, with the employer then deciding whether to reward her effort if it is high. It presents the trust game favorable to burnout and introduces the psychological game integrating the feelings of guilt of the employee if she does not provide a sufficient effort, disappointment if she is sensitive to the absence of remuneration of her effort, and reciprocity of the employer concerned to pay for this effort. It then considers the case where, in accordance with the effort-reward imbalance model, the breach of the psychological contract by the employer not very sensitive to reciprocity can lead an employee sensitive to disappointment to develop a burnout. It finally integrates the psychological contract present in the family as soon as the woman in activity expects support and recognition in return for the effort she makes to carry out her professional activity and her family life. Section 3 then adopts an information design approach in which the employer asks a regulator to advise him in his choice between the status quo and the implementation of prevention measures to limit the risk of burnout of his employees. Section 4 concludes.

2. The Employee-Employer Game and the Risk of Burnout

An employee working from home makes an effort associated with a greater or lesser intensity of work and transfer of her personal time to her working time. The employer's recognition of this effort may be more or less important: he may neglect it, give a few compliments, name the employee "employee of the month", reward her with a gift certificate, a bonus or the financing of training, give her a salary increase or allow her to move up or change positions. Following a game theory approach, the employee and the employer participate in a sequential non-cooperative game where the employee first chooses her effort, the employer then decides on the reward.

Consider the case where the employee chooses between a low effort ($e = 0$), which does not give rise to remuneration, and a high effort, $\bar{e} > 0$, where she shows an overcommitment. The employer may in this case offer a reduced reward ($r(\bar{e}) = 0$) or express sufficient recognition in relation to the employee's expectations, $\bar{r}(\bar{e})$. This is a *trust game* configuration (Kreps, 1990), following the criteria introduced by Bacharach et al. (2007), if for the employee, to trust the employer by producing a high effort is preferable to a reduced effort when the employer shows recognition, but at the risk that the employer betrays that trust by choosing not to reward her, and the employer is indeed encouraged to betray that trust.

If $G_S(e, r(e))$ and $G_E(e, r(e))$ indicate the gains of the employee and the employer, then $G_S(\bar{e}, \bar{r}(\bar{e})) > G_S(0,0) > G_S(\bar{e}, 0)$ and $G_E(\bar{e}, 0) > G_E(\bar{e}, \bar{r}(\bar{e}))$. It will be assumed that $G_E(\bar{e}, \bar{r}(\bar{e})) > G_E(0,0) = 0$ and $G_S(0,0) = 0$. This basic game and its equilibrium are presented in **Figure 1**.

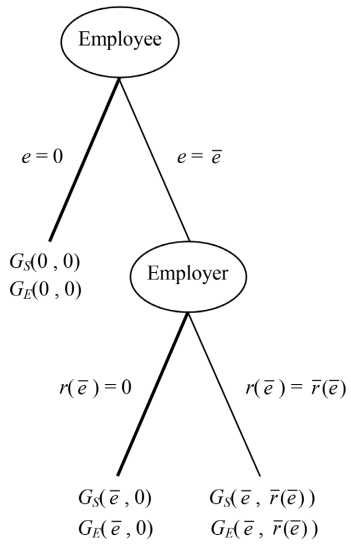

Figure 1. The basic game and its equilibrium.

In this classic game, if the employee anticipates that the employer will not reward a high effort, she has no interest in making an effort. Her choice to make a high effort comes from psychological phenomena, namely the guilt she feels if she thinks the employer expects a high effort, and her belief in reciprocity from the employer. These phenomena appear in beliefs in the psychological game (Geanakoplos et al., 1989; Battigalli & Dufwenberg, 2022) associated with the trust game.

- If the employee makes a limited effort ($e = 0$), she feels a guilt that reduces her gain according to the difference between the gain that her choice leads the employer to obtain and that which the employer expected. Let α_E be the employer's belief in the provision of high effort and $\Theta_S^g \geq 0$ the employee's sensitivity to guilt, her psychological gain is written as follows (Battigalli & Dufwenberg, 2022):

$$U_S\left(0,0,\alpha_E = 1\right) = G_S\left(0,0\right) - \Theta_S^g\left[G_E\left(\bar{e},\bar{r}\left(\bar{e}\right)\right) - G_E\left(0,0\right)\right]$$

- An employee who has made a high effort expects reciprocity, in the form of sufficient recognition by her employer, in accordance with the psychological contract (Rousseau, 1989). If she receives a low reward, she experiences a disappointment that reduces her gain based on the difference between the reward she expected and the one she obtains.

Let α_S be her belief in the probability of receiving the reward $\bar{r}\left(\bar{e}\right)$ she expects and $\Theta_S^d \geq 0$ her sensitivity to disappointment, her psychological gain is (Battigalli & Dufwenberg, 2022):

$$U_S\left(\bar{e},0,\alpha_S = 1\right) = G_S\left(\bar{e},0\right) - \Theta_S^d\left[G_S\left(\bar{e},\bar{r}\left(\bar{e}\right)\right) - \left(G_S\left(\bar{e},0\right) + k\right)\right]^+$$

where $k \geq 0$ limits the influence of disappointment when it is low.

- If the employer is sensitive to reciprocity, he improves his gain if he respects the psychological contract and shows sufficient recognition to the employee

for the effort she has made. He assesses the employee's *dedication* (κ_{SE}) to him based on the difference between the gain that the employee believes he will obtain and the average gain she believes he can obtain. His *benevolence* (κ_{ES}) towards the employee is indicated by the difference between the reward obtained by the employee and the average gain that she can expect. Reciprocity increases the employer's gain if this difference measuring his benevolence is positive in response to a positive gain reflecting the employee's dedication (Battigalli & Dufwenberg, 2022).

Let α_E be the belief of the employer on the probability p with which the employee thinks that he chooses to pay a high effort and $\Theta_E \geq 0$ his sensitivity to reciprocity, his psychological gain if he rewards by $\bar{r}(\bar{e})$ the effort $\bar{e}$ is written as follows (calculations are given in **Appendix 1**):

$$U_E\left(\bar{e},\bar{r}(\bar{e}),\alpha_E\right)=G_E\left(\bar{e},\bar{r}(\bar{e})\right)+\Theta_E\kappa_{ES}\left(\bar{r}(\bar{e})\right)\kappa_{SE}\left(\bar{e},\alpha_E\right),$$

with

$$\kappa_{ES}\left(\bar{r}(\bar{e})\right)=\frac{1}{2}\left[G_S\left(\bar{e},\bar{r}(\bar{e})\right)-G_S\left(\bar{e},0\right)\right]$$

$$\kappa_{SE}\left(\bar{e},p\right)=\frac{1}{2}\left[pG_E\left(\bar{e},0\right)+(1-p)G_E\left(\bar{e},\bar{r}(\bar{e})\right)\right]$$

then

$$U_E\left(\bar{e},\bar{r}(\bar{e}),p\right)>G_E\left(\bar{e},0\right)$$

if:

$$\Theta_E\times\left[p+\frac{G_E\left(\bar{e},\bar{r}(\bar{e})\right)}{G_E\left(\bar{e},0\right)-G_E\left(\bar{e},\bar{r}(\bar{e})\right)}\right]>\frac{4}{G_S\left(\bar{e},\bar{r}(\bar{e})\right)-G_S\left(\bar{e},0\right)}$$

Thus, in this psychological game, in order for the employer to reward the employee's effort according to her expectations ($\bar{r}(\bar{e})$), his sensitivity to reciprocity, Θ_E, must be all the greater as the probability with which he thinks the employee expects to be rewarded is important (p low).

- The breach of the psychological contract by the employer if he does not sufficiently recognize the effort of the employee results in an effort-reward imbalance (Siegrist, 1996, 2017) which places her in the conditions of burnout: "The model of effort-reward imbalance at work asserts that experiencing lack of reciprocity in terms of high cost spent and low gain received in turn elicits negative emotions of anger and frustration and associated bodily stress reactions, with adverse long-term consequences for health and well-being." (Siegrist, 2017).

The respective gains of the employee and the employer in case of burnout are $b < 0$ and $c < 0$. An employee does not systematically develop burnout in the event of a breach of the psychological contract: ρ is the probability of burnout. **Figure 2** shows the set of subgames where psychological phenomena occur and alter gains such that the employee may be placed in the conditions of burnout. The gain of the employee who minimizes her effort is reduced by guilt, that of the employer

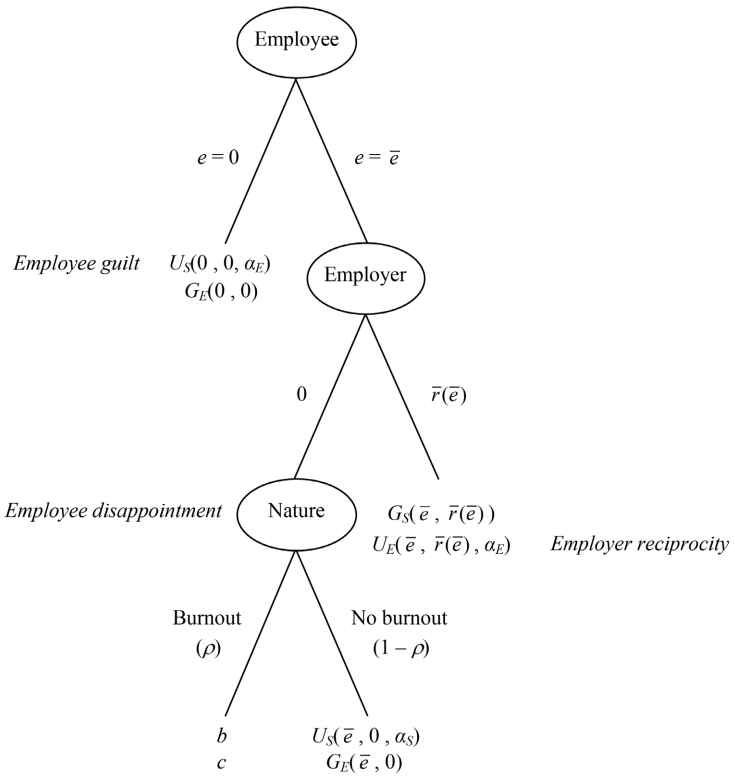

Figure 2. The psychological game with risk of burnout.

who rewards a significant effort is increased by reciprocity, the gain of the employee whose effort is not recognized is reduced by disappointment and Nature finally decides whether this disappointment leads her to burnout.

The condition for the employer to sufficiently remunerate the employee's effort becomes (the calculations are given in **Appendix 2**):

$$\Theta_E \times \frac{pG_E(\bar{e},0)+(1-p)G_E(\bar{e},\bar{r}(\bar{e}))}{G_E(\bar{e},0)-G_E(\bar{e},\bar{r}(\bar{e}))-\rho(G_E(\bar{e},0)-c)} > \frac{4}{G_S(\bar{e},\bar{r}(\bar{e}))-G_S(\bar{e},0)}$$

Therefore, for the employer to reward the employee's effort according to her expectations ($\bar{r}(\bar{e})$), this probability ρ must be greater if the employer's sensitivity Θ_E to reciprocity is lower.

- The probability of employee burnout depends on her expected reward and the reward obtained, her sensitivity Θ_S^d to disappointment, and exogenous factors such as extreme tiredness. A psychological contract also exists in the family context because a working woman expects support (job sharing at home) and recognition ("Mom of the year") in return for the effort she makes to carry out her professional activity and family life simultaneously. She may feel an imbalance effort-reward if she is criticized for her work-life sharing, her lack of availability, or if she is insufficiently supported in daily tasks or in accompanying children in their extra-curricular activities and in their education. The combination of a break in this psychological family contract and the one linked to professional activity, with an interaction be-

tween the sensitivities to disappointment occurring in these contracts, can increase the risk that she develops a burnout.

3. Information Design

The employer who is not sensitive to reciprocity ($\Theta_E = 0$) and who rewards in a limited way the high effort of his employees ($r(\bar{e}) = 0$) may consider taking measures to avoid their burnout. He can reduce the length of telework to curb overcommitment or force employees to take time off, to limit their guilt about the effort (BBC Worklife, 2022). He can also give them advice to avoid overwork by learning to manage their time and disconnect, thanks to workshops and companies specializing in coaching. Finally, he can set up internal communication on the pay scale according to the effort made, in order to limit the feeling of insufficient recognition and reduce the impression of having reached a *career plateau* (Kwon (2022) highlights the lack of social comparison due to the relative isolation when working from home in the context of the COVID-19 lockdown). Dias-Oliveira et al. (2022) verify during the Covid crisis that "the strategies implemented by leaders to manage their teams contributed to reduce employees' sense of professional isolation which, in turn, is associated with lower feelings of burnout and higher perceptions of performance."

Let m indicate the measure(s) chosen, K the corresponding cost and ρ_m the resulting burnout risk. In the absence of measure (choice indicated by 0), the risk of burnout, ρ, is higher. The state of the world (θ) is unfavorable (D) or favorable (F) depending on whether or not the employee may develop burnout, the two states being a priori equally likely. The employer's gains are presented in **Table 1**.

- In the absence of information on the state θ, the employer may instruct a regulator to advise him (Bergemann & Morris, 2016, 2019) on his choice: this regulator chooses, before being informed about the existence or not of a risk, a rule indicating to the employer the decision to be made.

If the employer does not have the possibility of obtaining additional information on the employee, the regulator indicates to him a rule recommending not to take any measure with a probability p_D or p_F according to whether the state is D or F, the measure m being chosen with the additional probability $1 - p_D$ or $1 - p_F$. The rules at equilibrium are characterized by *obedient constraints*, which ensure that the employer prefers to follow the regulator's recommendations (Bergemann & Morris, 2016, 2019). They amount to the following inequality (the calculations are given in **Appendix 3**):

$$p_D \leq \mu_E p_F + \min\{0; 1-\mu_E\}, \text{ with}$$

$$\mu_E = \frac{K}{(\rho-\rho_m)(G(\bar{e},0)-c)-K}.$$

We will consider the case where the cost of the measures is affordable, $K < (\rho-\rho_m)(G_E(\bar{e},0)-c)$, so that $\mu_E > 0$.

Table 1. The employer's gains.

Measure \ θ	D	F
0	$\rho c+(1-\rho)G_E(\bar{e},0)$	$G_E(\bar{e},0)$
m	$\rho_m c+(1-\rho_m)G_E(\bar{e},0)-K$	$G_E(\bar{e},0)-K$

The regulator has the possibility to behave as an information designer. If his objective is not to put in place accompanying measures, he will recommend to the employer to choose it with the probability $p_F = 1$ when there is no risk of burnout and, when there is a risk, with the probability $p_D = 1$ if $\mu_E \geq 1$ and $p_D = \mu_E$ if $\mu_E < 1$.

μ_E varies in the opposite direction of the cost $|c|$ incurred in case of burnout and in the same direction as the probability ρ_m resulting from the action, and its cost K (as shown in **Appendix 4**). Thus, the employer is encouraged to take action if the regulations deem him liable of burnout, or if the probability of remaining burnout is reduced. More specifically, this is the case if, using a comparative cost approach, the cost of burnout compared to the cost of implementing the measure, $\frac{|c|}{K}$, is high, or if, following a cost-advantage approach, the advantage in terms of the resulting probability relative to the cost of the intervention, $\frac{\rho-\rho_m}{K}$, is high. Figure 3 shows the evolution of the probability of inaction as a function of $\frac{|c|}{K}$ and $\frac{\rho-\rho_m}{K}$, from $\mu_E > 1$.

- If the employer has the opportunity to have additional information, by receiving a signal (t) indicating whether the situation is unfavorable (d) or favorable (f), with a probability $q > 1/2$ that this signal is correct, the rule that the regulator indicates to the employer recommends a type of action depending on t and θ. The constraints of obedience in this case are summarized as follows (the calculations are given in **Appendix 5**):

$$p_D \leq \mu_E p_F + \min\{0; q-(1-q)\mu_E\} + \min\{0; (1-q)-q\mu_E\}$$

Figure 4 shows the case $\mu_E = 1$ according to the accuracy of the signal received by the employer.

The designer's influence is thus reduced if the accuracy q of the signal increases (Bergemann & Morris, 2016, 2019). Once the employer knows θ with certainty ($q = 1$), he chooses to implement a measure only if he knows that he is in the unfavorable case, $p_F = 1$ and $p_D = 0$. The type of employer structure can therefore play a role: if it is small, more family-friendly, the employer will have more easily information on the living conditions of his employees and the risks involved.

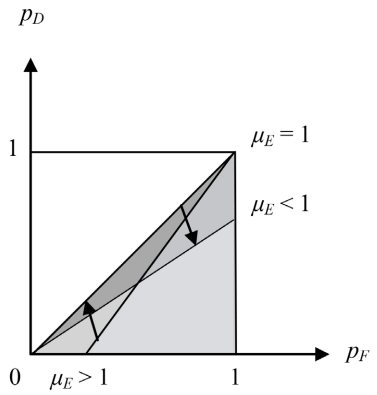

Figure 3. Probability of inaction from $\mu_E > 1$ when $\frac{\rho - \rho_m}{K}$ or $\frac{|c|}{K}$ increases.

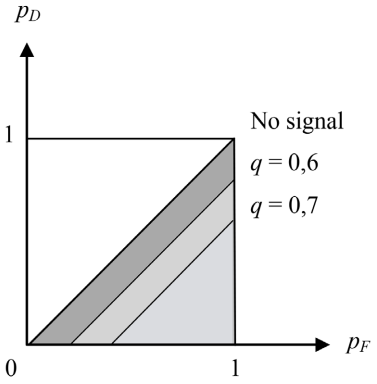

Figure 4. Probability of no measure based on information for $\mu_E = 1$.

4. Conclusion

An employee in telework may be led to burnout by her overcommitment to work, in terms of work intensity or transfer of personal time to working time, especially because of the guilt she would feel otherwise. The Siegrist effort-reward imbalance model explains that insufficient recognition by the employer of the effort provided by the employee may be the trigger. It is thus a breach, by the employer, of the psychological contract that binds him to his employee.

The use of psychological games makes it possible to integrate the employee's beliefs about the employer's expectations and recognition, based on her feelings of guilt and disappointment, and to study the influence of her sensitivity to these feelings, and that of the employer to reciprocity, on the risk of burnout. It shows that for the employer to sufficiently reward the employee's effort, his sensitivity to reciprocity must be all the greater as the probability with which he thinks the employee expects to be rewarded is important and the risk of burnout must be greater if he is less sensitive to reciprocity. As a similar psychological contract exists in the family domain, the interaction between sensitivities to disappointment increases the risk of women burnout.

In the absence of significant and systematic recognition of the effort of his

employees, to avoid cases of burnout the employer may choose to take measures based on communication to reduce the feeling of insufficient recognition, on telework limitation and on coaching. In the absence of precise information on the presence of a risk of burnout, he can instruct a regulator to advise him in his choice between letting go and implementing a measure to avoid the burnout of an employee-type. He is encouraged to take action if the cost of burnout compared to the cost of implementing the measure or the gain in terms of risk relative to the cost of implementing the measure is high. He benefits from limiting the influence of this regulator by acquiring external information on the living conditions of his employees and the risks involved, what is favored by a small family structure.

This study considers theoretically the psychological conditions of burnout and the choice of accompanying measures to limit the risks. It would be interesting to conduct an empirical study within employee and employer populations to assess the relative influence of different psychological factors on behavior, and the interference between the family and professional contracts. We should also see to what extent the accompanying measures work and compare the respective efficiencies. In related areas, empirical studies have been conducted by Katsiana et al. (2021) on symptoms of burnout and personal resilience, and by Torrès et al. (2021, 2022) on burnout during the Covid-19 crisis.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Appendix 1

If the employer thinks that the employee is making the effort $\bar{e}$ by expecting not to be rewarded with the probability p, he believes that the employee expects to allow him to obtain the gain $pG_E(\bar{e},0)+(1-p)G_E(\bar{e},\bar{r}(\bar{e}))$ so that his expected average gain is $\frac{1}{2}\left[G_E(0,0)+pG_E(\bar{e},0)+(1-p)G_E(\bar{e},\bar{r}(\bar{e}))\right]=\frac{1}{2}\left[pG_E(\bar{e},0)+(1-p)G_E(\bar{e},\bar{r}(\bar{e}))\right]$, and the employee's dedication, indicated by the difference between these gains, is then

$$\begin{aligned}\kappa_{SE}(\bar{e},p) &= pG_E(\bar{e},0)+(1-p)G_E(\bar{e},\bar{r}(\bar{e}))\\ &\quad -\frac{1}{2}\left[pG_E(\bar{e},0)+(1-p)G_E(\bar{e},\bar{r}(\bar{e}))\right]\\ &= \frac{1}{2}\left[pG_E(\bar{e},0)+(1-p)G_E(\bar{e},\bar{r}(\bar{e}))\right]\end{aligned}$$

When the employer shows a recognition $\bar{r}(\bar{e})$ to the effort $\bar{e}$, his benevolence is reflected by the difference between the employee's reward and the average reward she can expect:

$$\begin{aligned}\kappa_{ES}(\bar{r}(\bar{e})) &= G_S(\bar{e},\bar{r}(\bar{e}))-\frac{1}{2}\left[G_S(\bar{e},0)+G_S(\bar{e},\bar{r}(\bar{e}))\right]\\ &= \frac{1}{2}\left[G_S(\bar{e},\bar{r}(\bar{e}))-G_S(\bar{e},0)\right]\end{aligned}$$

If he is sensitive to reciprocity (with Θ_E his sensitivity), the employer increases his gain by rewarding the employee's effort $\bar{e}$, his benevolence being of the same sign as the employee's dedication:

$$\begin{aligned}U_E(\bar{e},\bar{r}(\bar{e}),\alpha_E) &= G_E(\bar{e},\bar{r}(\bar{e}))+\Theta_E\kappa_{ES}(\bar{r}(\bar{e}))\kappa_{SE}(\bar{e},\alpha_E)\\ &= G_E(\bar{e},\bar{r}(\bar{e}))+\Theta_E\times\frac{1}{2}\left[G_S(\bar{e},\bar{r}(\bar{e}))-G_S(\bar{e},0)\right]\\ &\quad\times\frac{1}{2}\left[pG_E(\bar{e},0)+(1-p)G_E(\bar{e},\bar{r}(\bar{e}))\right]\end{aligned}$$

He will therefore reward the employee sufficiently for her effort $\bar{e}$ if $U_E(\bar{e},\bar{r}(\bar{e}),p)>G_E(\bar{e},0)$, which gives the condition

$$\Theta_E\times\frac{pG_E(\bar{e},0)+(1-p)G_E(\bar{e},\bar{r}(\bar{e}))}{G_E(\bar{e},0)-G_E(\bar{e},\bar{r}(\bar{e}))}>\frac{4}{G_S(\bar{e},\bar{r}(\bar{e}))-G_S(\bar{e},0)},$$

or

$$\Theta_E\times\left[p+\frac{G_E(\bar{e},\bar{r}(\bar{e}))}{G_E(\bar{e},0)-G_E(\bar{e},\bar{r}(\bar{e}))}\right]>\frac{4}{G_S(\bar{e},\bar{r}(\bar{e}))-G_S(\bar{e},0)},$$

where the term on the left is a growing function of p.

Appendix 2

The expected gain of the employer if he chooses not to pay the employee is $\rho c+(1-\rho)G_E(\bar{e},0)$. It is thus in his interest to reward the employee for her ef-

fort if it is weaker than $U_E\left(\bar{e},\bar{r}\left(\bar{e}\right),p\right)$, or

$$\rho c+\left(1-\rho\right)G_E\left(\bar{e},0\right)<G_E\left(\bar{e},\bar{r}\left(\bar{e}\right)\right)+\Theta_E\times\frac{1}{2}\left[G_S\left(\bar{e},\bar{r}\left(\bar{e}\right)\right)-G_S\left(\bar{e},0\right)\right]$$
$$\times\frac{1}{2}\left[pG_E\left(\bar{e},0\right)+\left(1-p\right)G_E\left(\bar{e},\bar{r}\left(\bar{e}\right)\right)\right],$$

which gives the condition

$$\Theta_E\times\frac{pG_E\left(\bar{e},0\right)+\left(1-p\right)G_E\left(\bar{e},\bar{r}\left(\bar{e}\right)\right)}{G_E\left(\bar{e},0\right)-G_E\left(\bar{e},\bar{r}\left(\bar{e}\right)\right)-\rho\left(G_E\left(\bar{e},0\right)-c\right)}>\frac{4}{G_S\left(\bar{e},\bar{r}\left(\bar{e}\right)\right)-G_S\left(\bar{e},0\right)},$$

where the term on the left is a growing function of ρ.

Appendix 3

The regulator indicates to the employer a rule $\sigma\left(m|\theta\right)$ specifying the probability with which he should choose m according to the state θ. Noting $p_D=\sigma\left(0|D\right)$ and $p_F=\sigma\left(0|F\right)$, the condition for the employer to follow the recommendation not to take action is (after simplification):

$$\left[\rho c+\left(1-\rho\right)G_E\left(\bar{e},0\right)\right]p_D+G_E\left(\bar{e},0\right)p_F$$
$$\geq\left[\rho_m c+\left(1-\rho_m\right)G_E\left(\bar{e},0\right)-K\right]p_D+\left[G_E\left(\bar{e},0\right)-K\right]p_F$$, hence

$p_D\leq\mu_E p_F$, where $\mu_E=\frac{K}{\left(\rho-\rho_m\right)\left(G\left(\bar{e},0\right)-c\right)-K}$, with $\mu_E>0$ if $K<\left(\rho-\rho_m\right)\left(G\left(\bar{e},0\right)-c\right)$.

Conversely, it is in his interest to follow the recommendation to choose m if

$$\left[\rho_m c+\left(1-\rho_m\right)G_E\left(\bar{e},0\right)-K\right]\left(1-p_D\right)+\left[G_E\left(\bar{e},0\right)-K\right]\left(1-p_F\right)$$
$$\geq\left[\rho c+\left(1-\rho\right)G_E\left(\bar{e},0\right)\right]\left(1-p_D\right)+\left[G_E\left(\bar{e},0\right)\right]\left(1-p_F\right)$$, hence

$$p_D\leq\mu_E p_F+\left(1-\mu_E\right).$$

These two conditions amount to inequality $p_D\leq\mu_E p_F+\min\left\{0;1-\mu_E\right\}$.

Appendix 4

Writing $\mu_E=\frac{1}{\frac{\left(\rho-\rho_m\right)\left(G\left(\bar{e},0\right)-c\right)}{K}-1}$ shows that it is an increasing function of ρ_m, K and c, and a decreasing function of $\frac{\rho-\rho_m}{K}$ and $\frac{-c}{K}$.

Let us assume for example that $\mu_E>1$, from which $\min\left\{0;1-\mu_E\right\}=1-\mu_E$, the condition thus writing

$$p_D\leq\mu_E p_F+\left(1-\mu_E\right).$$

If $\frac{\rho-\rho_m}{K}$ or $\frac{|c|}{K}$ increase, the slope μ_E of the obedience constraint decreases and the term $1-\mu_E$ increases, so that from a certain point, $\min\left\{0;1-\mu_E\right\}=0$ and the condition is written $p_D\leq\mu_E p_F$.

Appendix 5

If the employer independently receives a signal on the state θ, the designer indicates a rule specifying the probability $\sigma(0|t,\theta)$ with which he can choose not to take measures according to the signal t and the state θ: note $\sigma(0|t,\theta)=p_\theta^t$. Let $q>1/2$ be the accuracy of the signal, the obedience constraints are as follows (after simplification):

- If the regulator recommends that the employer do nothing when he has received a negative signal, he will comply if

$$\begin{aligned}&\left[\rho c+(1-\rho)G_E(\bar{e},0)\right]qp_D^d+G_E(\bar{e},0)(1-q)p_F^d\\&\geq\left[\rho_m c+(1-\rho_m)G_E(\bar{e},0)-K\right]qp_D^d+\left[G_E(\bar{e},0)-K\right](1-q)p_F^d\end{aligned},$$

so

$$p_D^d\leq\frac{1-q}{q}\mu_E p_F^d.$$

If the employer must instead implement measure m when the signal indicates that the situation is unfavorable, the condition is written

$$\begin{aligned}&\left[\rho_m c+(1-\rho_m)G_E(\bar{e},0)-K\right]q\left(1-p_D^d\right)+\left[G_E(\bar{e},0)-K\right](1-q)\left(1-p_F^d\right)\\&\geq\left[\rho c+(1-\rho)G_E(\bar{e},0)\right]q\left(1-p_D^d\right)+G_E(\bar{e},0)(1-q)\left(1-p_F^d\right)\end{aligned},$$

so

$$p_D^d\leq\frac{1-q}{q}\mu_E p_F^d+\left[1-\frac{1-q}{q}\mu_E\right].$$

- Symmetrically, when the signal is favorable, the condition gives

$$\begin{aligned}&\left[\rho c+(1-\rho)G_E(\bar{e},0)\right](1-q)p_D^f+G_E(\bar{e},0)qp_F^f\\&\geq\left[\rho_m c+(1-\rho_m)G_E(\bar{e},0)-K\right](1-q)p_D^f+\left[G_E(\bar{e},0)-K\right]qp_F^f\end{aligned},$$

so

$$p_D^f\leq\frac{q}{1-q}\mu_E p_F^f,$$

if the employer must not act, and finally, if the employer must choose measure m,

$$\begin{aligned}&\left[\rho_m c+(1-\rho_m)G_E(\bar{e},0)-K\right](1-q)\left(1-p_D^f\right)+\left[G_E(\bar{e},0)-K\right]q\left(1-p_F^f\right)\\&\geq\left[\rho c+(1-\rho)G_E(\bar{e},0)\right](1-q)\left(1-p_D^f\right)+G_E(\bar{e},0)q\left(1-p_F^f\right)\end{aligned},$$

so

$$p_D^f\leq\frac{q}{1-q}\mu_E p_F^f+\left[1-\frac{q}{1-q}\mu_E\right].$$

The constraints of obedience are summarized as follows:

$$p_D^d\leq\frac{1-q}{q}\mu_E p_F^d+\min\left\{0;1-\frac{1-q}{q}\mu_E\right\}$$

and

$$p_D^f \le \frac{q}{1-q}\mu_E p_F^f + \min\left\{0;1-\frac{q}{1-q}\mu_E\right\}.$$

The joint distribution of the actions of the employer and the states, obtained using the relations

$$p_D = qp_D^d + (1-q)p_D^f$$

and

$$p_D = (1-q)p_F^d + qp_F^f,$$

then gives

$$p_D \le \mu_E p_F + \min\{0;q-(1-q)\mu_E\} + \min\{0;(1-q)-q\mu_E\}.$$

If for example μ_E = 1, this constraint is written $p_D \le p_F + (1-2q)$ since $q-(1-q) > 0 > (1-q)-q$.