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Working Paper

Delegation in long-term relationships

SOEPPapers on Multidisciplinary Panel Data Research, No. 480

Provided in Cooperation with:

German Institute for Economic Research (DIW Berlin)

Suggested Citation: Schütte, Miriam; Wichardt, Philipp C. (2012) : Delegation in long-term relationships, SOEPPapers on Multidisciplinary Panel Data Research, No. 480, Deutsches Institut für Wirtschaftsforschung (DIW), Berlin

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480-2012

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Miriam Schütte and Philipp C. Wichardt

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ISSN: 1864-6689 (online)

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Delegation in Long-Term Relationships*

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This Version: April 24, 2012

Abstract This paper considers the effects of a two-period interaction on the decision of a principal to delegate authority to a potentially biased but better informed agent. Compared to the (repeated) one-period case, the agent's first period actions may also signal his type which in turn impacts wages in Period 2. As a result, biased agents have an incentive not to follow their own preferences in Period 1, thereby inducing the principal to delegate more often. Moreover, we find that, depending on the players' relative utilities and the wage schedule, long term relationships will increase aggregate welfare. Finally, to empirically support our findings, we analyse data from the German Socio-Economic Panel (SOEP) which show that temporary workers indeed experience less autonomy in their decisions.

Keywords: Delegation, Signalling, Reputation

JEL code: C72, C73, D82, D86, L22, M54

*Acknowledgements: We are grateful to Florian Englmaier, Sandra Ludwig, Niko Matouschek, Andrea Prat, Klaus Schmidt and Peter Norman Sørensen as well as to the participants of the Munich Micro Workshop for helpful comments and discussions. Financial support of the German Research Foundation (DFG), GRK 801, is gratefully acknowledged.

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1 Introduction

A central question in the design of organisations, which has been much discussed in the literature over the last decades, is how to allocate decision rights to subordinate agents (e.g. Holmström, 1977, 1984, Aghion and Tirole, 1997, Alonso and Matouschek, 2008). The general problem is that while agents often may have better information about the profitability of certain projects – or at least be able to obtain such information – this does not necessarily imply that they will always opt for the projects which are most preferred by the principal. A possible reason for this, which we will focus on in the sequel, is that agents may be biased and therefore disagree with the principal on what project to choose.¹

An immediate direct effect of such biases, if unknown to the principal, is that the expected profit from delegation decreases due to too frequent choices of suboptimal projects (for a discussion of such instances see, for example, Jensen and Meckling, 1992, Alonso and Matouschek, 2007, 2008). A more indirect but related effect, which arises in repeated interactions, derives from reputation concerns of the agents. In particular, agents may have an incentive to be perceived as unbiased and therefore strategically distort their information; in such cases, eliciting information from the agent via communication (Crawford and Sobel, 1982) may be problematic (see, for example, Benabou and Laroque, 1992, Morris, 2001, or Sobel, 1985).²

In the present paper, we combine both of the above mentioned aspects and analyse the consequences of delegation by an uninformed principal in a repeated interaction. In particular, we introduce asymmetric information about the agent's type and assume that the agent's decisions are also subject to reputation concerns. Thus, different from most previous studies, we do not consider a situation where both parties are equally uninformed about the type of the agent (e.g. Blanes i Vidal, 2007, Englmaier et al., 2010) but instead assume that agents know their type. In our view, this assumption is reasonable as agents often receive a variety of private signals about their preferences and/or ability during their education.³

¹Alternatively, agents may differ in their ability to interpret incoming signals about the state of the world so that delegation will become very costly if the probability of unable agents letting opportunities pass (or choosing the wrong projects) is too high (e.g. Levy, 2005).

²Similar concerns about reputation in an organisational context, which have been studied in the literature, are career concerns when agents care about the perception of their productivity (e.g. Holmström, 1999) or asymmetric information about the agent's a priori uncertain ability to learn the state (e.g. Ottaviani and Sørensen, 2006a and 2006b, Blanes i Vidal, 2007, Englmaier et al., 2010, or Prat, 2005).

³An interesting paper which also considers a delegation problem with private information about the agent's type is the paper by Aghion, Rey and Dewatripont (2004), where the allocation of control

For the purposes of our argument, we assume that there are two types of agents: a) agents who are unbiased or loyal and b) agents who are biased with regard to the principal’s preferences.⁴ That is, while the loyal agent agrees with the principal in his project choice, the biased agent always prefers to implement a different project. In the one-shot interaction where the principal can either delegate or take an uninformed decision himself, the optimal delegation decision therefore depends on the principal’s prior belief about the type of the agent and the principal’s relative payoff of taking an uninformed decision.

In a repeated interaction, however, things change as the agent’s project choice in the first interaction may also signal information about his type. Accordingly, the principal’s delegation decision now is not only driven by the agent’s informational advantage but also by an incentive to learn about the agent’s type. In particular, if the principal delegates to the agent in the first period, this results in a signalling game where the agent first chooses a project (thereby potentially revealing his type) and the principal then decides whether or not to delegate again in the second period. Thus, being ex post informed about the agent’s project choice, the principal can condition his delegation decision in Period 2 on this choice.

The foreseen reaction of the principal in Period 2, in turn, induces additional reputation concerns for the agent. Regarding these incentives, we assume that second period wages are determined endogenously depending on the agent’s reputation, i.e. the principal’s belief about the agent’s type (his bias) at the beginning of Period 2 conditional on the agent’s project choice in Period 1. In particular, we assume that the agent’s wage is an increasing function of his reputation. As a motivation, one can, for example, think of project choices as being (partly) observable for the market which then determines an “outside-option” wage the principal has to match.

Although the assumption about endogenous wages slightly complicates the analysis, the resulting overall two-period game is amenable to a common backward induction argument. Relying on standard equilibrium selection arguments (Cho and Kreps, 1987), we characterise the equilibria of the resulting signalling game and report the results of comparative statics based on changes in the prior probability that the agent is biased and the agent’s relative loss from choosing the disliked project if he is biased. The analysis shows that the principal delegates more often in the first period of the

rights (contingent on announcing a type) is analysed. Different from the present setting, however, Aghion et al. consider a two stage – but one-shot – interaction where the principal benefits from learning the agent’s type but where there are no incentives for pooling derived from later periods.

⁴Note that being biased may also be interpreted in terms of ability, with more (less) able agents incurring a low (high) cost when trying to optimally match the state of the world.

repeated interaction than in the one-shot game. At first sight, this may seem surprising as the principal pays for the agent's gain in reputation (through an increased wage in Period 2) which will render delegation less attractive in comparison to standard models of reputation. However, the cost of inefficient delegation in the first period and higher wages in Period 2 is off-set by the expected benefit from being able to discriminate between types in combination with the induced reputation incentives for the biased agent to align his Period 1 choice with the principal's preference.

More specifically, in the analysis, we find multiple equilibria for the signalling game depending on the prior belief about the agent being loyal and the specific relation between wages and utilities. In particular, if wages are low compared to the biased agent's utility gain from implementing his preferred project in Period 1, we obtain a separating equilibrium, where the agent's type is perfectly revealed. In this case, the principal expands the agent's initial discretion in comparison to a one-shot interaction in order to be able to sort between types. This at least allows him to avoid the undesired decision of the biased agent in Period 2. By contrast, if the biased agent's benefit from choosing his preferred project is relatively low, both types choose the project which is preferred by the principal in Period 1 (pooling equilibrium). In this case, the principal strictly prefers delegation to centralisation in order to exploit the biased agent's incentive to align his project choice with that of the loyal one in Period 1.⁵ Thus, taken together, we find two reasons for increased delegation in the two-period interaction: a possible revelation of the agent's type (separating equilibrium) and an alignment of the biased agent's behaviour in Period 1 with the preferences of the principal (pooling equilibrium).

Interestingly, the different equilibria imply different effects on aggregate welfare compared to the repeated one-period interaction. In particular, the pooling equilibrium, in which the biased agent opts for an opportunistic choice in Period 1, is always welfare enhancing if the principal's stakes in the decision are at least as high as those of the biased agent. For the mixed and the separating equilibrium, welfare effects depend on prior beliefs and on whether delegation to a biased agent in a one-shot setting would be efficient, i.e. give rise to higher aggregate payoffs, or not. In particular, for high prior beliefs, welfare is increased in both types of equilibrium if centralisation is efficient when facing a biased agent, while for low prior beliefs, welfare is increased if delegation to a biased agent is efficient.

⁵In intermediate cases, we get mixed equilibria in the signalling game, with the biased agent (and the principal) randomising between the two possible options, and higher levels of delegation than in the one-period case.

What is more, while wages have no direct impact on aggregate welfare, as they affect only the redistribution of payoffs, they still matter, namely through their (indirect) influence on equilibria. In particular, transferring all benefits to the agent (as is the case if the market for agents is perfectly competitive) weakly reduces the range of less desirable separating equilibria and weakly increases the range of the more desirable pooling equilibria. Thus, in the present setting with high priors, giving all bargaining power to the agents maximises aggregate welfare.

Finally, we want to emphasise that, from an applied point of view, the results suggest that the delegation of authority to agents, while potentially inefficient from a one-shot perspective, offers a reasonable way to separate the wheat from the chaff in long term relations (or to push the biased agents to align their project choices with the principal's preferences). In fact, an empirical analysis of data from the German Socio-Economic Panel (SOEP) shows that, in accordance with our theoretical results, workers in a temporary status experience less autonomy in their decisions than workers in a regular employment relationship; see Section 3 for details.

The rest of the paper is structured as follows: In Section 2, we introduce and analyse the model. In Section 3, we briefly discuss the results and present data which empirically support our main theoretical predictions. Section 4 concludes. All proofs are gathered in the appendix.

2 Model and Results

In the sequel, we first briefly describe the underlying delegation problem (Section 2.1). Having done so, we proceed to contrast the optimal delegation decision of the principal in a one-shot interaction (described in Section 2.2) with the case of a repeated interaction, here captured by a simplified two-period game (Section 2.3). The section concludes with a discussion of welfare effects (Section 2.4).

2.1 The Underlying Delegation Problem

Consider the following standard delegation problem: A firm has to implement a project where the principal has the formal authority to decide what project is chosen, but he needs an agent to implement it.

Setup.

The set of possible projects, X , is given by a subset of the real line, i.e. $X \subseteq \mathbb{R}$. Both the principal and the agent enjoy a personal benefit from a project choice $x \in X$.

However, by assumption, the principal himself is unable to implement his preferred project, e.g. because he lacks some important information about local conditions which only the agent can acquire. Thus, in order to circumvent his lack of information, the principal can delegate the project decision to the agent.⁶ However, the agent can be either of two types, $\tau \in T := \{b, l\}$. If the agent is loyal, $\tau = l$, his preferences are aligned with those of the principal. If the agent is biased, $\tau = b$, the preferences of the principal and the agent do not match.

Remark 1 *For the purposes of the present discussion, we think of biases as reflecting differences in preferences. However, as should become clear from the subsequent argument, it is also possible to think of the agent's and the principal's preferences as being generally aligned. In that case, being biased would reflect a high cost when trying to satisfy these preferences for a given state of the world (and being unbiased would reflect a low cost of doing so). While some details of the modelling will of course change, the general thrust of the argument does not hinge on the interpretation.*

Utility

The players' utility is given by $u_i(x)$, $i \in \{P, b, l\}$. For the sake of argument, we assume that there always exists a unique optimal project x_i , $i \in \{P, b, l\}$, which maximises utility for player i , $i \in \{P, b, l\}$,⁷ i.e.

$$x_i := \arg \max_{x \in X} u_i(x).$$

Note that, as the preferences of the biased agent differ from those of the principal, we have $x_b \neq x_P$, while the loyal agent prefers the same project, i.e. $x_l = x_P$.

The corresponding utility of each player $i \in \{P, b, l\}$, is then referred to as u_i^+ , i.e.

$$u_i^+ := u_i(x_i).$$

⁶In line with the delegation literature, this lack of information can be modelled by the realisation of some state of nature, θ , which is observed only by the agent. For the present purposes, we omit an explicit reference to θ as focus of the argument lies primarily on the agent's signalling motive (and not on the effects of different realisations of θ).

⁷Here and in the following, we slightly abuse notation by sometimes referring to the agent's different types as player b and player l .

Similarly, utilities in case an undesired project is implemented are defined as follows:

$$\begin{aligned} u_b^- &:= u_b(x_P) \\ u_P^- &:= u_P(x_b) \\ u_l^- &:= u_l(x_b). \end{aligned}$$

Furthermore, if the principal retains authority, he chooses a default project x_P^0 , which can be interpreted as the best choice according to the principal's knowledge. The *default utilities* realised in this case are denoted by

$$u_i^0 := u_i(x_P^0), \text{ for all } i \in \{P, b, l\} .$$

In order to make the problem interesting, we assume that delegating to a loyal agent is profitable for the principal while delegating to a biased agent is harmful. Thus, we have

$$u_P^- < u_P^0 < u_P^+ .$$

The biased (loyal) agent's default utility u_b^0 (u_l^0), in turn, is always smaller than his optimal choice, i.e. $u_b^0 < u_b^+$ ($u_l^0 < u_l^+$); whether u_b^0 (u_l^0) is smaller or larger than u_b^- (u_l^-) is not specified.

Contracts and Wages.

As usual, the principal allocates authority, i.e. he determines whether he or the agent decides on the project x . The actual choice of x is not contractible, though, only the allocation of authority can be contractually fixed. In either case, the principal pays a wage $w(\mu)$ to the agent, which depends on the principal's belief about the agent being loyal, μ . While not restricting attention to common competitive wages, we still assume that the wage is competitive in that it reflects the principal's (correct) perception of the competitiveness of the market, i.e. wages correctly match the agent's expected outside option.⁸

Moreover, although the project choice is observable to the principal and the market, we assume that it is not verifiable to the court. Thus, the principal cannot reward the agent for a loyal decision, but instead pays a flat wage every period.

A priori, the principal and the market share a common prior that the agent is loyal with probability $p \in (0, 1)$, i.e. $p = \text{Prob}(\tau = l)$. Accordingly, without any further

⁸As mentioned before, we assume that the agent is needed for the implementation of the project and, hence, needs to get payed even if the project choice is not delegated.

information about the agent (e.g. in the one-shot setting), the common market wage for the agent is $w(p) \geq 0$. We normalise $w(0) = 0$ and assume that w is (weakly) increasing in the belief that the agent is loyal, μ .

Finally, it is important to note that, if the principal is sure about the agent being loyal, the maximal profit he expects to earn, net of what he is able to generate himself, is given by $u_P^+ - u_P^0$. In the following, we therefore assume that the wage cannot exceed this threshold, i.e.

$$w(\mu) < u_P^+ - u_P^0 \quad \forall \mu \in (0, 1)$$

and $w(1) \leq u_P^+ - u_P^0$.⁹

Summing up, with the above specifications, total per period payoffs for the principal can be specified by

$$U_P(x, \mu) = u_P(x) - w(\mu) .$$

The corresponding expression for the agent is given by

$$U_\tau(x, \mu) = u_\tau(x) + w(\mu) .$$

2.2 The One-Period Game

To begin with, consider the case where the decision of the principal is isolated so that the agent does not care about his reputation.

In this case, the principal has to decide whether or not to delegate the decision. As in the one-period game the agent's wage is determined ex ante depending on the prior p , the agent always chooses his preferred project x_τ if the decision is delegated to him. Thus, the principal's expected benefit from project choice in case of delegation is

$$E[u_P(x_\tau)] = pu_P^+ + (1 - p)u_P^- .$$

This immediately leads to Proposition 1.

Proposition 1 *In the one-shot interaction, the principal prefers delegation to centralisation if*

$$p \geq \eta := \frac{u_P^0 - u_P^-}{u_P^+ - u_P^-} .$$

⁹Here we implicitly assume that all principals face the same constraints so that this threshold will not exclude any of them from the market.

2.3 The Two-Period Game

As a next step, consider the case where the principal commits to employing the agent for two periods. By assumption, neither the project choice nor the allocation of authority in either period can be contractually fixed *ex ante*. The resulting two-period interaction can be modelled as follows.

In the first period, the principal decides whether or not to delegate the decision to the agent. The action space of the principal, thus, is given by $A_P = \{D, C\}$, consisting of delegation, D, and centralisation, C. If the principal retains his decision authority, C, he always takes the default decision and the market belief about the agent's loyalty is not updated. If the principal delegates his decision authority to the agent, D, the agent decides which project to implement. At the end of Period 1, the principal's profit is realised and the principal is informed about the agent's project choice.

In the second period, the principal faces essentially the same delegation problem as in the first except that he now can utilise the agent's observed behaviour from Period 1 to update his belief about the type of the agent. The updated beliefs are denoted as follows:

$$\begin{aligned}\mu_+ &:= \text{prob}(\tau = l | x = x_l) \\ \mu_- &:= \text{prob}(\tau = l | x = x_b).\end{aligned}$$

The resulting signalling game that arises after delegation in Period 1 is illustrated in Figure 1.

In the sequel, we analyse the subgame that arises after delegation by the principal in Period 1 and neglecting wages in Period 1 (as these have no strategic impact). For this, we denote the action the principal chooses in Period 2 upon observing x by $a_P(x)$. A strategy of the principal in the subgame, thus, consists of a pair $s_P = (a_P(x_l), a_P(x_b))$. A strategy for the agent in the resulting subgame, in turn, comprises the choice of an action both in case of delegation in Period 1 (which has occurred by assumption) and in Period 2. As it is strictly dominant for the agent to choose his preferred action whenever the decision is delegated in Period 2, we focus the analysis on the agent's strategy in Period 1, denoted by s_τ , which is given by specifying $x \in \{x_b, x_l\}$.

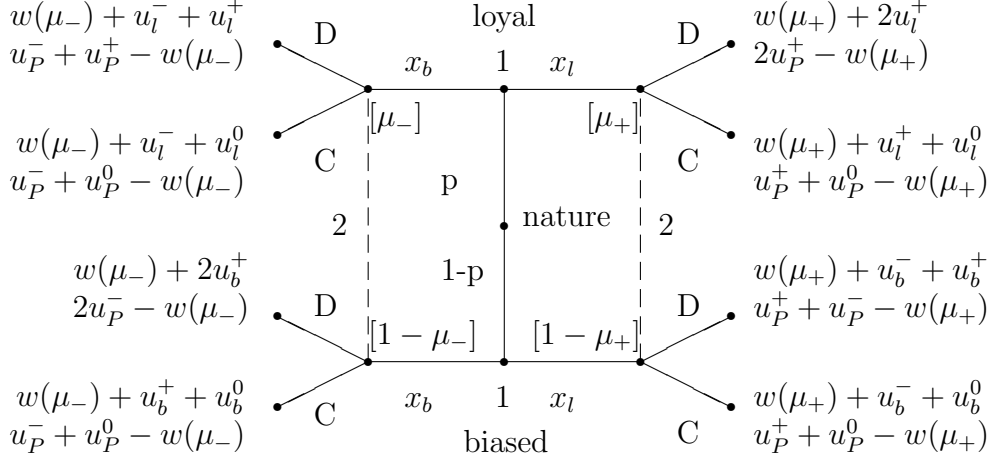


Figure 1: Graphical illustration of the strategic situation after a delegation decision of the principal in Period 1. Player 1, the sender, is the agent and player 2 is the principal. First period wages are neglected as they have no strategic impact.

Noting that it is dominant for the principal to choose D upon observing x_l (x_b resp.) if $\mu_+ \geq \eta$ ($\mu_- \leq \eta$),¹⁰ we obtain the following equilibria,¹¹ here and in the following, the biased agent's *utility differential* is denoted by Δ_b , i.e.

$$\Delta_b := u_b^+ - u_b^-.$$

Lemma 1 *If $p \geq \eta$, the signalling game depicted in Figure 1 exhibits the following three types of equilibria:*

- *If $\Delta_b \leq w(p) + u_b^+ - u_b^0$:*
Pooling: (pool (D,C)) $s_P = (D,C)$, $s_l = s_b = x_l$
- *If $w(p) + u_b^+ - u_b^0 < \Delta_b < w(1) + u_b^+ - u_b^0$:*
Biased agent randomises (mix1 (D,C)): $s_P = (D,C)$, $s_l = x_l$, $s_b = \lambda x_l + (1-\lambda)x_b$
- *If $\Delta_b \geq w(1) + u_b^+ - u_b^0$:*
Separating (sep (D,C)): $s_P = (D,C)$, $s_l = x_l$, $s_b = x_b$

¹⁰If $\mu = \eta$, the principal is indifferent which is why the dominance is not strict.

¹¹The structure of these equilibria is robust to introducing some noise into the principal's observation of the agent's project choice.

Lemma 2 *If $p \leq \eta$, the signalling game depicted in Figure 1 exhibits the following five types of equilibria:*

- *If $\Delta_b \leq w(p)$:*
Pooling (pool (C,C)): $s_P = (C, C)$, $s_l = x_l$, $s_b = x_b$
- *If $w(\eta) + u_b^+ - u_b^0 \leq \Delta_b < w(p)$:*
Biased agent randomises (mix1 (D,C)): $s_P = (D, C)$, $s_l = x_l$, $s_b = \lambda x_l + (1-\lambda)x_b$
- *If $w(\eta) < \Delta_b < w(\eta) + u_b^+ - u_b^0$:*
Principal and biased agent randomise (mix2 (λ_P, C)):
 $s_P = \lambda_P D + (1 - \lambda_P)C$, $s_l = x_l$, $s_b = \lambda x_l + (1 - \lambda)x_b$
- *If $w(\eta) + u_b^+ - u_b^0 \leq \Delta_b < w(1) + u_b^+ - u_b^0$:*
Biased agent randomises (mix1 (D,C)): $s_P = (D, C)$, $s_l = x_l$, $s_b = \lambda x_l + (1-\lambda)x_b$
- *If $\Delta_b \geq w(1) + u_b^+ - u_b^0$:*
Separating (sep (D,C)): $s_P = (D, C)$, $s_l = x_l$, $s_b = x_b$

Figure 2 illustrates the resulting equilibria and their relation to the underlying wage schedule.

In case the principal retains authority in the first period, the belief about the agent's loyalty cannot be updated and the principal delegates in Period 2 if $p \geq \eta$. Thus, the overall payoff of the principal in case of centralisation in Period 1, depending on his delegation decision in Period 2, is given by

$$E[U_P|C] = \begin{cases} 2u_P^0 - w(p) & \text{if } p < \eta, \\ u_P^0 + pu_P^+ + (1-p)u_P^- - w(p) & \text{else,} \end{cases}$$

where the first-period wage $w(p)$ is again left out.

Comparing the principal's payoff when delegating in the first period and in case of retaining authority, we obtain the following result for the principal's delegation decision in Period 1.

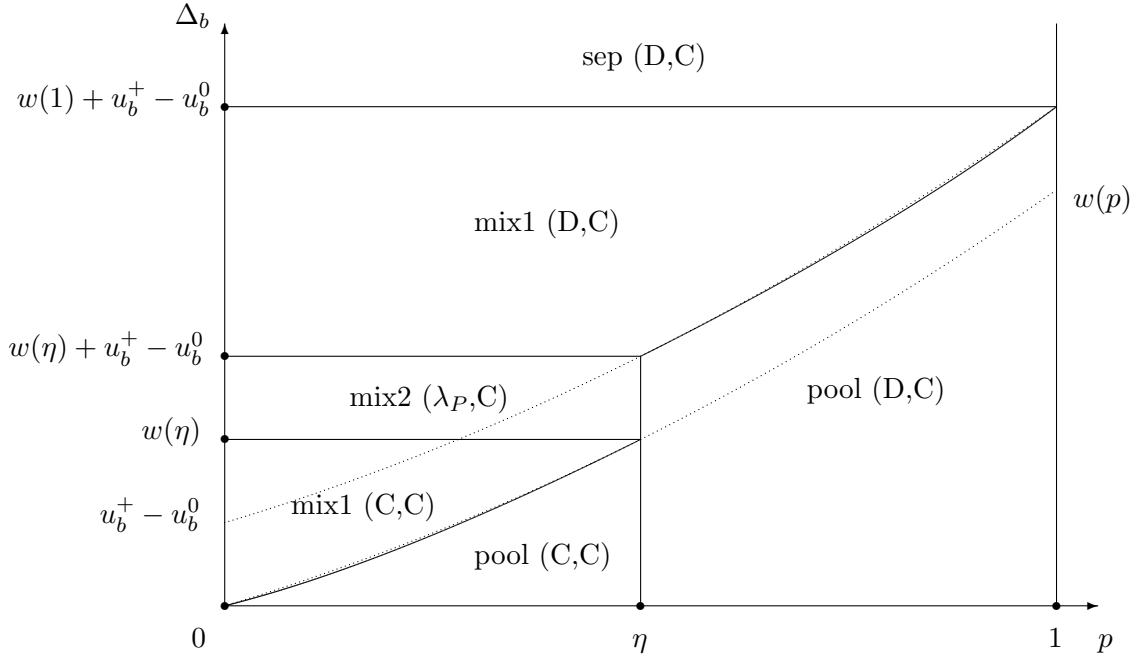


Figure 2: Equilibria of the signalling game depending on prior belief p and the biased agent's utility differential, Δ_b – for a given wage schedule (indicated by the lower curve). The upper curve depicts the wage schedule increased by $u_b^+ - u_b^0$. Solid lines determine the borders of the respective equilibrium.

Proposition 2 *In the first period of the two-period game, the principal delegates more often than in the one-period game. In particular, he always delegates if $p \geq \eta$ and if $p \leq \eta$, the following holds:*

- If $\Delta_b \leq w(p)$, the principal centralises in Period 2 independent of the agent's action and he delegates in Period 1 for all $p \geq 0$.
- If $\Delta_b \geq w(p)$, the principal delegates if $p \geq \delta(p)$ with

$$\delta(p) = \frac{[u_P^0 - u_P^- - w(p)]\mu_+}{(u_P^+ - u_P^-) \max\{\mu_+, \eta\} + (u_P^+ - u_P^0) - w(\mu_+)}.$$

In particular, $\delta(p) \leq \eta$ such that the principal delegates more often than in the one-period case, where he delegates the decision only for $p \geq \eta$.

The main point to note here is that, if the relationship is repeated, the biased agent has an incentive to deviate from his preferred option in Period 1 in order to

signal loyalty.¹² In exchange for this, he receives a higher wage in Period 2 and is more likely to decide over the project in the next period. In combination, this is enough to induce more aligned decisions in Period 1 and, hence, more delegation.

Moreover, aligning the biased agent's preferences is more beneficial to the principal than learning his type and paying him less in Period 2. Therefore, the principal is more likely to delegate in the pooling equilibrium than in the separating equilibrium.

Proposition 3 *All other things equal, the principal delegates more the lower the biased agent's concerns about the decision are, i.e. the delegation threshold p^* fulfilling $p^* = \delta(p^*)$ increases in Δ_b .*

Note that this result is also rather intuitive. In particular, if the biased agent's concerns regarding the project choice are weaker (lower Δ_b), he is more likely to align his preferences with the principal in Period 1 if this promises a higher wage in Period 2.

2.4 Welfare

In the following, we consider the players' welfare obtained in the two-period interaction and compare the results to the (twice) repeated one-period interaction. As the results differ depending on whether delegation occurs in the one-period interaction, we split the subsequent discussion in two parts: to begin with, we analyse the case $p \geq \eta$, where we see delegation in the one-period interaction, and then move on to the case $p \leq \eta$, where there is no delegation in the short term interaction.

2.4.1 The Case $p \geq \eta$

First, we focus on the rent effects for the principal. The main point to note here is that a separation of agents as well as an alignment of the agents' behaviour (in Period 1), which only occur in the two-period interaction, can be beneficial for the principal. In a second step, we then move on to the agent for whom we have to consider rents depending on the type. As we will see, the loyal agent always profits from the long-run interaction; his preferences are aligned with the principal in any case but the repeated interaction may increase his wage in Period 2. The biased agent, by contrast, will lose one opportunity to choose his preferred action and therefore be worse off than in the repeated one-period interaction. Finally, we proceed to analyse aggregate effects and

¹²Cast in the ability interpretation indicated in Remark 1, the biased agent would invest a high effort/cost in Period 1, which is individually suboptimal in the one-shot setting, in order to imitate the more able agent.

perform comparative statics of welfare with regard to the expected default utilities and the wage schedule.

The Principal.

For the principal, a repeated interaction can be profitable either because he learns the agent's type or because the biased agent imitates the loyal one by choosing the principal's preferred project in the first period. The overall effect, however, depends on which equilibrium played in each case.

In particular, the biased agent imitates the loyal one and chooses the principal's preferred project in Period 1 (pooling equilibrium), if his expected loss from the opportunistic choice in Period 1 is low compared to the wage he earns in Period 2, i.e. if $u_b^0 - u_b^- \leq w(p)$. In this case, the two-period interaction results in higher expected project returns for the principal. More specifically, the principal's expected total profits in the two-period interaction net of the profits in the repeated one-period game are given by

$$E[\Pi_2 - \Pi_1] = (1 - p)(u_P^+ - u_P^-) ,$$

which is always positive; all derivations are deferred to the appendix.

By contrast, if Period 2 wages never suffice to reimburse the biased agent for making an opportunistic choice in Period 1, i.e. if $u_b^0 - u_b^- \geq w(1)$, a separating equilibrium is played. While not profiting from an alignment of choices in Period 1 in this case, the principal still benefits from avoiding delegation to the biased agent in Period 2. Also accounting for wage effects, the principal's profit, then, is given by

$$E[\Pi_2 - \Pi_1] = (1 - p)(u_P^0 - u_P^-) - (pw(1) - w(p)) .$$

Thus, the principal is better off in the two-period interaction if

$$pw(1) - w(p) \leq (1 - p)(u_P^0 - u_P^-) .$$

Furthermore, if the expected benefits from centralisation for the biased agent are intermediate, i.e. $w(p) < u_b^0 - u_b^- < w(1)$, a mixed equilibrium is played. In this case, the principal's expected benefit derives from a mixture of the above two effects net of wage payments. In particular, the principal's expected net profit is given by

$$E[\Pi_2 - \Pi_1] = (1 - p)\lambda [(u_P^+ - u_P^0) - w(\mu^+)] + (1 - p)(u_P^0 - u_P^-) + w(p) - pw(\mu^+) ,$$

which again is non-negative if

$$pw(1) - w(p) \leq (1 - p)(u_P^0 - u_P^-).$$

To wrap up, the principal always profits from a two-period interaction if the wage schedule does not deviate too much from linearity.

The Agent.

Next, we turn to the agent for whom we have to consider both types separately. As we will see, both types have completely opposed preferences with regard to the one-period or the two-period interaction.

Regarding the loyal agent, he always chooses the principal's preferred project in Period 1 and, thus, subsequently gains discretion in Period 2. Yet, compared to the one-period interaction, the wage in Period 2 may increase (and does except a pooling equilibrium is played). In particular, while the loyal agent always earns $w(p)$ in the one-period interaction, his wage in the two-period interaction ranges from $w(p)$ in the pooling equilibrium up to $w(1)$ in the separating equilibrium. Hence, regardless of the biased type's strategy, the loyal agent (weakly) prefers the two-period interaction over the repeated one-period interaction.

The biased agent, in turn, is always (weakly) better off in the repeated one-period interaction as in this case the decision is always delegated so that he can choose his preferred project.

Aggregate Welfare.

Having taken a closer look at single players, we now turn to the analysis of aggregate effects. As we have already seen in the argument given above, all effects on individual welfare essentially depend on the players' gains and losses incurred in case a default project is implemented (instead of the preferred one) as well as on the wage schedule.

Accounting for both players and both types of the agent, expected aggregate welfare in the two-period interaction net of expected aggregate welfare in the repeated one-period interaction is given by

$$E[W_2 - W_1] = (1 - p)\lambda[(u_P^+ - u_P^0) - (u_b^0 - u_b^-)] - (1 - p)[(u_b^+ - u_b^0) - (u_P^0 - u_P^-)],$$

with $\lambda = 0$ if $u_b^0 - u_b^- \geq w(1)$ (separating equilibrium) and $\lambda = 1$ if $u_b^0 - u_b^- \leq w(p)$ (pooling equilibrium).

Thus, assuming that the principal's benefits from an optimal project decision

outweigh the respective benefits of the biased agent, i.e. assuming

$$u_P^+ - u_P^- \geq u_b^+ - u_b^- ,$$

the following proposition is straightforward.

Proposition 4 *If $p \geq \eta$, the comparison of expected welfare effect in the two-period interaction and the repeated one-period interaction yields the following results:*

- *In the separating equilibrium, i.e. $\lambda = 0$ and $u_b^0 - u_b^- \geq w(1)$, welfare is increased if centralisation is efficient in case the agent is biased, i.e.*

$$u_P^0 - u_P^- \geq u_b^+ - u_b^0.$$

- *In the mixed equilibrium, i.e. $w(p) \leq u_b^0 - u_b^- \leq w(1)$, welfare is increased if*

$$\lambda \geq \frac{(u_b^+ - u_b^0) - (u_P^0 - u_P^-)}{(u_P^+ - u_P^0) - (u_b^0 - u_b^-)}.$$

- *In the pooling equilibrium, i.e. $\lambda = 1$ and $u_b^0 - u_b^- \leq w(p)$, welfare is increased if the principal has higher concerns about the decision than the biased agent, i.e.*

$$u_P^+ - u_P^- \geq u_b^+ - u_b^- .$$

In particular, in the mixed equilibrium, we always have $u_b^0 - u_b^- \leq w(1) \leq u_P^+ - u_P^0$, so that the denominator in the threshold for λ is non-negative. Thus, if we also require

$$u_P^0 - u_P^- \geq u_b^+ - u_b^0,$$

the lower threshold for λ becomes non-positive, i.e.

$$\frac{(u_b^+ - u_b^0) - (u_P^0 - u_P^-)}{(u_P^+ - u_P^0) - (u_b^0 - u_b^-)} \leq 0.$$

Hence, welfare is always increased in the mixed equilibrium under the above assumption. Together with the results on the separating and the pooling equilibrium, we can therefore conclude that welfare is always increased if the principal's profit from centralisation compared to a biased project choice is higher than the biased agent's gain from deciding over the project, i.e. $u_P^0 - u_P^- \geq u_b^+ - u_b^0$.

Corollary 1 *If $u_P^0 - u_P^- \geq u_b^+ - u_b^0$, we have $E[W_2 - W_1] \geq 0$.*

The intuition for this result is straightforward. In the two-period interaction, the principal has the opportunity to centralise in the second period when observing an inappropriate project choice whereas in the one-period interaction the decision is always delegated if the prior is high. As this opportunity to centralise is more valuable to the principal than it harms the biased agent aggregate welfare is increased in the two-period interaction.

Welfare Effects of the Wage Schedule.

Another determinant of aggregate welfare is the wage schedule. Of course, total welfare never changes under a simple redistribution of payoffs. Thus, in a usual context, the wage schedule does not influence total welfare. In the present setting, however, the wage schedule, together with $u_b^0 - u_b^-$, determines the equilibrium played in the signalling game which, in turn, influences total welfare. In particular, high wages (weakly) increase the area where a pooling equilibrium is played and (weakly) decrease the area where a separating equilibrium is played, which has a positive effect on aggregate welfare. Thus, focusing on the effect of the wage schedule, paying competitive wages weakly increases welfare in the two-period interaction if prior beliefs are high.

Proposition 5 *If $p \geq \eta$, expected net aggregate welfare increases in λ . Thus, welfare in the two-period game is maximised if $w(\mu)$ is maximal within the principal's budget constraints for $\mu \in [p, 1]$.*

Intuitively, increasing wages for a given belief μ strengthens the incentive for the biased agent to mirror the behaviour of the loyal agent in Period 1 (so as to obtain the high wage and the discretion to choose in Period 2). In particular, the higher the wages, the more likely is the biased agent to choose the project which is aligned with the principal's preferences. Thus, for higher wages, the region where a pooling equilibrium is played is increased (while the region for a separating equilibrium is reduced). As the pooling equilibrium is welfare enhancing if $u_b^+ - u_b^- \leq u_P^+ - u_P^-$, this improves aggregate welfare.

2.4.2 The Case $p \leq \eta$.

Finally, we briefly turn to the case where the prior belief is such that the principal would not delegate in the one-period setting, i.e. $p \leq \eta$.

Unfortunately, for such small priors, it is difficult to determine clear-cut welfare results in general. However, more can be said if we focus on cases where the principal’s benefit from his preferred choice is at least as high as the biased agent’s benefit when choosing the project, i.e. $u_P^+ \geq u_b^+$, which appears to be rather plausible from an applied point of view. In this case, if the principal’s benefit from centralisation compared to letting the biased agent decide about the project, $u_P^0 - u_P^-$, is smaller than the biased agent’s respective gain when choosing the project, $u_b^+ - u_b^0$, welfare is always enhanced in the two-period interaction (as opposed to the case $p \geq \eta$).

Proposition 6 *If $u_P^+ \geq u_b^+$ and $p \leq \eta$ but p large enough such that the principal delegates in the two-period game, total expected welfare is increased in the two-period game if*

$$u_b^+ - u_b^0 \geq u_P^0 - u_P^-.$$

Note that the intuition for this result is in line with the interpretation in case $p \geq \eta$. If the prior is low, the principal centralises in the one-period interaction. By contrast, in the two-period interaction, he delegates in the first period and thereby induces a benefit of u_b^+ for the biased agent – instead of u_b^0 in the one-period interaction. If this relative gain of the biased agent is larger than the principal’s benefit from centralising compared to letting the biased agent decide, aggregate welfare is increased.

3 Empirical evidence

From an applied point of view, the theoretical analysis provided in the previous section essentially suggests that that long-term relationships lead to higher job discretion than temporary employment and that, under certain conditions, this may even have a positive impact on aggregate welfare. While the welfare result very much depends on exact specifications of the model, which makes it hard to test empirically, the prediction on increased discretion under long-term relationships between a firm and its employees is more amenable to empirical scrutiny.

In order put this implication to the test, we analyse the German Socio-Economic Panel data (SOEP), which collects information on a wide range of personal and household characteristics such as wages, job satisfaction, work experience and occupation. Moreover, the 2001 wave of the survey includes a question about the perceived level of job discretion: “Do you decide yourself how to complete the tasks involved in your work?,” which we use as an indicator for “autonomy level,” our dependent variable.

The possible answers to the question range from 1 (does not apply at all) to 3 (applies completely).

For our analysis, we use a sample containing all individuals who were fully or part-time employed at the time of the survey and earned at least 200 Euros per month. We excluded apprentices, military/civil servants, handicapped and self-employed as well as all individuals who did not answer to one of the relevant questions.

Based on this sample, we use an OLS-regression analysis to test whether temporary employment – being an agency worker – impacts the perceived level of autonomy. The results are summarised in Table 1.

As expected, we find a significant negative relationship between temporary work status and autonomy level. In particular, agency workers perceive an autonomy level which is about 0.3 standard deviations lower than what regular workers report. This effect is significant at the 1%-level for all three specifications we considered.

Moreover, the results are in line with earlier findings. For example, Hall (2006) presents evidence that agency workers in Austria experience less discretion in their job than permanent workers. And, in a similar vein, Parker et al. (2002) show a temporary work status decreases the perception of participative decision making on the job.

While certainly not an empirical proof of our results, these empirical findings are very much in line with the implications of our analysis.

Autonomy level	(1)	(2)	(3)
Temporary work	-.323*** (.003)	-.315*** (.003)	-.297*** (.006)
Gross wage	.0001*** (.000)	.0001*** (.000)	.0001*** (.000)
Full time	-.185*** (.000)	-.185** (.015)	-.146** (.025)
Higher education		.105** (.471)	.125** (.394)
Tenure		-.003* (.571)	-.003* (.609)
Male		-.090** (.029)	-.083** (.044)
Firm size 5 - 19			-.140* (.062)
Firm size 20 - 99			-.211*** (.006)
Firm size 100 - 199			-.204** (.024)
Firm size 200 - 1999			-.171** (.028)
Firm size > 2000			-.219*** (.005)
Constant	1.945*** (.000)	1.937*** (.000)	2.092*** (.000)
<i>N</i>	1463	1463	1463
Adjusted R^2	.073	.077	.083

Table 1: OLS estimates with robust standard errors. Standard errors in parentheses; ***, **, * indicates significance at the 1%, 5% and 10% level, respectively. Full time is a dummy variable indicating full-time employment; part-time employment serves as a baseline. Tenure indicates years with current employer. Higher education is a dummy variable for university degree. Firm size is controlled by 5 dummy variables; firms with less than 5 employees serve as a baseline.

4 Concluding Remarks

In this paper, we have analysed a model of delegation between an uninformed principal and an informed but potentially biased agent. In particular, assuming generic utilities and discrete choice options, we have compared the effects of a long-run (two-period) interaction with those of a repeated one-shot interaction.

As we have shown, in the long-run relationship, concerns for reputation may lead the biased agent to misrepresent his preferences and choose the project which is preferred by the principal at an early stage of the interaction, thereby inducing increased levels of delegation by the principal in the first period.

Moreover, we have argued that, from a welfare perspective, increased levels of delegation may even lead to an increase in aggregate welfare compared to the repeated one-period interaction. Focusing on the effects of the wage schedule, we have shown that, if delegation occurs both in the short- and the long-term interaction, paying competitive wages (the highest possible) is best from a welfare perspective. This is due to the fact that increases in welfare are essentially achieved at the expense of the biased agent, and high wages provide the strongest incentives for this type to align his first period behaviour with the principal's preferences.

In addition to the theoretical analysis, we have also analysed a data set from the German Socio-Economic Panel (SOEP) in order to test whether long-run employment indeed is positively correlated with an increased autonomy in decision making on the workplace. As we have seen, the data are indeed compatible with this prediction of our model, thereby providing some empirical support for our analysis.

Unfortunately, the second main implication of the argument – regarding welfare – is less clear cut and, in the direction of its effect, strongly correlated with the specifications of the model. Thus, while the prediction of increased autonomy under long-run firm-employee relationships already receives some empirical support, the implications for aggregate welfare would require a more profound empirical analysis, which is left for future research.

Appendix

Equilibrium refinement

In this paper, we use the Intuitive Criterion (Cho and Kreps, 1987) as a refinement for equilibria in the signalling game.

In short, the Intuitive Criterion rules out all equilibria which are sustained by unreasonable beliefs off the equilibrium path. In particular, in a pooling equilibrium where both types choose x_b , the loyal agent is the first one to switch to x_l when payoffs are gradually changed. Thus, reasonable off-equilibrium beliefs have to satisfy $\mu_+ = 1$ in this case. But if $\mu_+ = 1$, the principal delegates after observing x_l and the agent's wage after choosing x_l is maximal. Therefore, choosing x_l is strictly dominant for the loyal agent if $\mu_+ = 1$. This leads us to the following Lemma.

Lemma 3 *All pooling equilibria of the signalling game where both types choose x_b are ruled out by the intuitive criterion.*

Accordingly, for a pooling equilibrium where both types choose x_l , the Intuitive Criterion requires $\mu_- = 0$. This requirement is not restrictive for the considered equilibria. See Cho and Kreps (1987) or Mas-Colell et al. (1995, pp. 467ff.) for further details on the Intuitive Criterion .

Proofs

Proof of Proposition 1. The principal prefers delegation to centralisation in the one-shot interaction if

$$\begin{aligned} pu_P^+ + (1-p)u_P^- &\geq u_P^0 \\ \Leftrightarrow p &\geq \frac{u_P^0 - u_P^-}{u_P^+ - u_P^-} \end{aligned}$$

■

Proof of Lemma 1 and Lemma 2. In order to analyse the equilibria of the signalling game (Lemma 1 and 2), we consider all possible strategies of the principal separately. The pure strategies are analysed in cases 1 to 4, while case 5 includes all possible mixed strategies by the principal. Throughout the proof, we omit the analysis of pooling equilibria where both types choose x_b because of Lemma 3.

Case 1: $s_P = (D, C) \Rightarrow \mu_- \leq \eta, \mu_+ \geq \eta$

In this case, we have $\mu_- \leq \eta$ and $\mu_+ \geq \eta$. Moreover, the loyal agent chooses x_l if $s_P = (D, C)$ and $\mu_+ \geq \mu_-$ irrespective of the biased agent's strategy.

In a separating equilibrium, we have $s_b = x_b, \mu_- = 0$ and $\mu_+ = 1$. Thus, $s_b = x_b$ is a best reply for the biased agent if

$$\begin{aligned} w(0) + u_b^+ + u_b^0 &\geq w(1) + u_b^- + u_b^+ \\ \Leftrightarrow u_b^0 - u_b^- &\geq w(1). \end{aligned}$$

In a pooling equilibrium, we have $s_b = x_l$ and $\mu_+ = p$. As $\mu_+ \geq \eta$ is needed for the principal to choose $s_P = (D, C)$, this equilibrium can only exist if $p \geq \eta$. Furthermore, this equilibrium can only be sustained if

$$\begin{aligned} w(p) + u_b^- + u_b^+ &\geq w(\mu_-) + u_b^+ + u_b^0 \\ \Leftrightarrow u_b^0 - u_b^- &\leq w(p) - w(\mu_-). \end{aligned}$$

Restricting the analysis to rational beliefs yields $\mu_- = 0$ and, thus, the above expression is equivalent to

$$u_b^0 - u_b^- \leq w(p).$$

In an equilibrium where the biased agent mixes between x_l and x_b with probability $\lambda, 1 - \lambda$, respectively, we have $\mu_- = 0$ as the loyal agent always chooses x_l . The biased agent's indifference condition is given by

$$\begin{aligned} w(\mu_+) + u_b^- + u_b^+ &= w(\mu_-) + u_b^+ + u_b^0 \\ \Leftrightarrow u_b^0 - u_b^- &= w(\mu_+). \end{aligned}$$

The randomisation parameter λ is then implicitly given by $\mu_+ = \frac{p}{p+(1-p)\lambda}$. Furthermore, if $p \leq \eta$, we always have $\mu_+ \in [\eta, 1]$ or, equivalently, $\lambda \in [0, \frac{p(1-\eta)}{\eta(1-p)}]$. If instead $p \geq \eta$, $\mu_+ \in [p, 1]$ or, equivalently, $\lambda \in [0, 1]$. Thus, there exists some mixed strategy $(\lambda, 1 - \lambda)$ by the biased agent fulfilling his indifference condition whenever

- $w(\eta) \leq u_b^0 - u_b^- \leq w(1)$ if $p \leq \eta$ or
- $w(p) \leq u_b^0 - u_b^- \leq w(1)$ if $p \geq \eta$.

Hence, if $s_P = (D, C)$, there are three types of equilibria depending on $u_b^0 - u_b^-$ and the wage schedule: separating, pooling on x_l and one where the biased agent randomises.

Case 2: $s_P = (D, D) \Rightarrow \mu_- \geq \eta, \mu_+ \geq \eta$

In this case, we have $\mu_- \geq \eta$ and $\mu_+ \geq \eta$, so there cannot be a separating equilibrium.

In a pooling equilibrium with $s_l = s_b = x_l$, rational beliefs are given if $\mu_- = 0$. But this contradicts $\mu_- \geq \eta$, so there is no pooling equilibrium in this case.

Finally, an equilibrium where one of the types mixes and the other type plays a pure strategy can only occur if the loyal agent mixes (in which case either $\mu_+ = 1$ or $\mu_- = 1$), which occurs if and only if $u_l^+ - u_l^- = w(\mu_-) - w(\mu_+)$ and thus $\mu_- \geq \mu_+$. But in this case the biased agent chooses x_b , which yields $\mu_+ = 1$ and $\mu_- < 1$. Thus, there is no equilibrium where *one* of the types mixes.

Accordingly, the only possible mixed equilibrium in this case is the one where both types mix between their pure strategies. This equilibrium requires

$$u_b^+ - u_b^- = -(u_l^+ - u_l^-) = w(\mu_+) - w(\mu_-),$$

which is not possible as we assumed uniqueness of the preferred project and thus $u_i^+ > u_i^-$ for $i \in \{l, b\}$.

Hence, there is no equilibrium with $s_P = (D, D)$.

Case 3: $s_P = (C, C) \Rightarrow \mu_- \leq \eta, \mu_+ \leq \eta$

In this case, $\mu_- \leq \eta$ and $\mu_+ \leq \eta$ so there is no separating equilibrium.

Moreover, in any pooling equilibrium with $s_l = s_b = x_l$, we conclude $\mu_+ = p$ and thus $p \leq \eta$ is required. Then, the biased agent chooses x_l if

$$\begin{aligned} w(p) + u_b^- + u_b^0 &\geq w(\mu_-) + u_b^+ + u_b^0 \\ \Leftrightarrow u_b^+ - u_b^- &\leq w(p), \end{aligned}$$

assuming rational beliefs, i.e. $\mu_- = 0$. The loyal type also prefers x_l in this case.

Furthermore, an equilibrium where one of the types mixes and the other type plays a pure strategy can only occur if the biased agent mixes (in which case either $\mu_+ = 0$ or $\mu_- = 0$). The biased agent is indifferent in this case if and only if

$$u_b^+ - u_b^- = w(\mu_+) - w(\mu_-).$$

Thus, $\mu_+ > \mu_-$, $\mu_- = 0$ and $s_l = x_l$. As $\lambda \leq 1$, we have that $\mu_+ \geq p$. On the other hand, $\mu_+ \leq \eta$ such that the principal centralises when observing x_l . Thus, this mixed equilibrium is only possible if $p \leq \eta$, in which case we find a randomisation λ

whenever

$$w(p) \leq u_b^+ - u_b^- \leq w(\eta)$$

Finally, an equilibrium where both types play mixed strategies requires

$$u_b^+ - u_b^- = -(u_l^+ - u_l^-) = w(\mu_+) - w(\mu_-),$$

which is again not possible.

Hence, if $p \leq \eta$, there are two types of equilibria in this case: A pooling equilibrium if $u_b^+ - u_b^- \leq w(p)$ and a mixed equilibrium if $w(p) \leq u_b^+ - u_b^- \leq w(\eta)$.

Case 4: $s_P = (C, D) \Rightarrow \mu_- \geq \eta, \mu_+ \leq \eta$

In this case, $\mu_- \geq \eta$ and $\mu_+ \leq \eta$. Thus, the only possible separating equilibrium is one in which $s_l = x_b$ and $s_b = x_l$ is played. However, with $\mu_- = 1$ and $\mu_+ = 0$, the biased agent strictly prefers x_b . So there is no separating equilibrium in this case.

In any pooling equilibrium with $s_l = s_b = x_l$ and rational beliefs, we have $\mu_- = 0$, which is not possible if the principal delegates upon observing x_b . So, there is no pooling equilibrium in this case.

Furthermore, an equilibrium where the biased agent mixes is only possible if he is indifferent, i.e.

$$\begin{aligned} w(\mu_-) + 2u_b^+ &= w(\mu_+) + u_b^- + u_b^0 \\ \Leftrightarrow w(\mu_-) - w(\mu_+) &= u_b^- + u_b^0 - 2u_b^+ < 0, \end{aligned}$$

which is not possible if $\mu_- \geq \mu_+$. Thus, we can exclude such an equilibrium where the biased agent randomises.

On the other hand, if only the loyal agent mixes, the requirement $\mu_- \geq \eta$ can only be achieved if the biased agent chooses x_l and thus, $\mu_- = 1$. But if $\mu_- = 1$, the biased agent strictly prefers x_b . Hence, there is no equilibrium in case $s_P = (C, D)$ where one of the types mixes.

Finally, an equilibrium where both types mix is only possible if $u_i^+ = u_i^-$ for $i \in \{l, b\}$, which is ruled out by assumption.

Thus, there is no equilibrium if $s_P = (C, D)$.

Case 5: $s_P = \lambda_P D + (1 - \lambda_P)C$

The principal randomises between D and C with probabilities $(\lambda_P, 1 - \lambda_P)$ after observing x_l if and only if $\eta = \mu_+$.

Consider the case where the biased agent plays x_l with probability λ and x_b with probability $1 - \lambda$ and the loyal agent chooses x_l . Then, $\mu_- = 0$ and $s_P(x_b) = C$. The principal randomises in order to make the biased agent indifferent, which occurs if

$$\begin{aligned} w(\mu_-) + u_b^+ + u_b^0 &= w(\mu_+) + \lambda_P(u_b^- + u_b^+) + (1 - \lambda_P)(u_b^- + u_b^0) \\ \Leftrightarrow \lambda_P &= \frac{u_b^+ - u_b^- - w(\eta)}{u_b^+ - u_b^0}, \end{aligned}$$

using $\eta = \mu_+$ and $\mu_- = 0$. Then, $\lambda_P \in [0, 1]$ if and only if $u_b^0 - u_b^- \leq w(\eta) \leq u_b^+ - u_b^-$. By contrast, the principal is indifferent between C and D if and only if $\mu_+ = \eta$. However, if the biased agent randomises with probabilities $(\lambda, 1 - \lambda)$, μ_+ is given by $\mu_+ = \frac{p}{p+(1-p)\lambda}$, which is equivalent to

$$\lambda = \frac{p(1 - \eta)}{\eta(1 - p)}.$$

Thus, $\lambda \leq 1$ if and only if $p \leq \eta$ and there is no equilibrium for $p > \eta$.

If the loyal agent mixes, $\mu_+ = \eta$ can only be achieved if the biased agent chooses x_l . But in this case, $\mu_- = 1$ and the biased agent strictly prefers x_b . So there is no equilibrium in this case.

Now we consider the case where the principal randomises in x_b , i.e. $\mu_- = \eta$. If the loyal agent randomises as well, $\mu_- = \eta$ can only be achieved if the biased agent chooses x_b . Then, $\mu_+ = 1$ and $s_P(x_l) = D$. But in this case, the loyal agent is never indifferent because $w(1) + 2u_l^+ > w(\eta) + \lambda_P(u_l^- + u_l^+) + (1 - \lambda_P)(u_l^- + u_l^0)$. Hence, there is no equilibrium in this case.

If the biased agent randomises, the loyal agent has to choose x_b in order to satisfy $\mu_- = \eta$. Then, we have $\mu_+ = 0$ and $s_P(x_l) = C$. But in this case, the biased agent is never indifferent because $w(0) + u_b^- + u_b^0 < w(\eta) + \lambda_P(2u_b^+) + (1 - \lambda_P)(u_b^+ + u_b^0)$.

Hence, in an equilibrium where the principal randomises between C and D , the loyal agent chooses x_l , while the biased agent randomises between x_l and x_b . This equilibrium is possible only if $p \leq \eta$.

Rewriting all conditions with respect to $\Delta_b = u_b^+ - u_b^-$ yields the Proposition. ■

Proof of Proposition 2. If $p \geq \eta$ and the principal delegates in Period 1, he delegates in Period 2 upon observing x_l and centralises otherwise. In turn, if he centralises in Period 1, he does not update his belief and delegates in Period 2 as $p \geq \eta$. Thus, delegation in Period 1 is preferred by the principal if

$$\begin{aligned} & p[2u_P^+ - w(\mu_+)] + (1-p)[\lambda(2u_P^+ - w(\mu_+)) + (1-\lambda)(u_P^- + u_P^0)] \\ \geq & u_P^0 + pu_P^+ + (1-p)u_P^- - w(p) \\ \Leftrightarrow & w(p) + [p + (1-p)\lambda][u_P^+ - u_P^0 - w(\mu_+)] + (1-p)\lambda(u_P^+ - u_P^-) \geq 0, \end{aligned}$$

which holds for all $\lambda \in [0, 1]$ as $w(\mu_+) \leq u_P^+ - u_P^0$. Thus, the principal delegates at least for all $p \geq \eta$, as in the one-period case.

If $p \leq \eta$ and the principal centralises in Period 1, he does not update his prior belief and centralises again in Period 2 as $p \leq \eta$. Now we consider all possible equilibria of the signalling game for the case $p \leq \eta$ and determine the delegation decision of the principal in Period 1.

Case 1: $\Delta_b \leq w(p)$

In this case, a pooling equilibrium is played with the principal centralising in Period 2 no matter which action the agent chooses. Thus, the principal delegates in this case if

$$u_P^+ + u_P^0 - w(p) \geq 2u_P^0 - w(p),$$

which is always the case.

Case 2: $w(p) \leq \Delta_b \leq w(\eta)$

In this case, the biased agent chooses a mixed strategy, while the principal centralises in any case. Thus, the principal delegates in this case if

$$\begin{aligned} & p[u_P^+ + u_P^0 - w(\mu_+)] + (1-p)[\lambda(u_P^+ + u_P^0 - w(\mu_+)) + (1-\lambda)(u_P^- + u_P^0)] \\ \geq & 2u_P^0 - w(p) \\ \Leftrightarrow & \frac{p}{\mu_+}[u_P^+ - u_P^- - w(\mu_+)] \geq u_P^0 - u_P^- - w(p), \end{aligned}$$

where we used

$$\lambda = \frac{p}{1-p} \frac{1-\mu_+}{\mu_+}.$$

As $u_P^+ - u_P^- \geq w(\mu_+)$, it follows that the principal delegates if

$$p \geq \frac{[u_P^0 - u_P^- - w(p)]\mu_+}{u_P^+ - u_P^- - w(\mu_+)} = \frac{[u_P^0 - u_P^- - w(p)]\mu_+}{(u_P^+ - u_P^-)\eta + (u_P^+ - u_P^0) - w(\mu_+)}.$$

The latter equals $\delta(p)$ because $\max\{\mu_+, \eta\} = \eta$.

Case 3: $\Delta_b \geq w(\eta)$

In this case, three equilibria are possible: sep (D,C), mix1 (D,C) or mix2 (λ_P, C). In general, the principal delegates if

$$\begin{aligned} & p[\lambda_P(2u_P^+ - w(\mu_+)) + (1 - \lambda_P)(u_P^+ + u_P^0 - w(\mu_+))] + (1 - p)(1 - \lambda)(u_P^- + u_P^0) \\ & + (1 - p)\lambda[\lambda_P(u_P^- + u_P^+ - w(\mu_+)) + (1 - \lambda_P)(u_P^+ + u_P^0 - w(\mu_+))] \\ & \geq 2u_P^0 - w(p) \\ \Leftrightarrow & p[u_P^+ - u_P^- - w(\mu_+)] + p\lambda_P[\mu_+(u_P^+ - u_P^-) - (u_P^0 - u_P^-)] \geq [u_P^0 - u_P^- - w(p)]\mu_+, \end{aligned}$$

where we used $\lambda = \frac{p}{1-p} \frac{1-\mu_+}{\mu_+}$.

If $\lambda_P \neq 1$, i.e. in the mix2 equilibrium, it has to hold that $\mu_+ = \eta$ in order to make the principal indifferent between his choices. Thus, in this case, $\mu_+(u_P^+ - u_P^-) - (u_P^0 - u_P^-) = 0$ and the principal delegates if

$$p \geq \frac{[u_P^0 - u_P^- - w(p)]\mu_+}{u_P^+ - u_P^- - w(\mu_+)} = \frac{[u_P^0 - u_P^- - w(p)]\mu_+}{(u_P^+ - u_P^-)\eta + (u_P^+ - u_P^0) - w(\mu_+)} = \delta(p)$$

because $\mu_+ = \eta$.

In all other cases, $\lambda_P = 1$ and the principal delegates if

$$p \geq \frac{[u_P^0 - u_P^- - w(p)]\mu_+}{(u_P^+ - u_P^-)\mu_+ + (u_P^+ - u_P^0) - w(\mu_+)} = \delta(p)$$

because $\mu_+ \geq \eta$ in these cases.

Again, it is worth noting that μ_+ does not depend on p . It is given by $w(\mu_+) = u_b^0 - u_b^-$ in the mix1 (D,C) equilibrium, and we have $\mu_+ = 1$ ($\mu_+ = \eta$) in the separating (in the mix2) equilibrium, respectively.

Furthermore, as $w(\mu_+) \leq u_P^+ - u_P^0$, we have

$$\begin{aligned}\delta(p) &\leq \frac{[u_P^0 - u_P^- - w(p)]\mu_+}{(u_P^+ - u_P^-) \max\{\mu_+, \eta\}} \\ &\leq \frac{[u_P^0 - u_P^- - w(p)]\mu_+}{(u_P^+ - u_P^-)\mu_+} = \frac{u_P^0 - u_P^- - w(p)}{u_P^+ - u_P^-} \leq \eta.\end{aligned}$$

Thus, we have shown that the principal delegates more often in the two-period case than in the one-period case. \blacksquare

Proof of Proposition 3. We define

$$f(\mu, p) := \delta(\mu, p) - p.$$

Then, f is continuously differentiable in $p \in [0, 1]$ and piecewise continuously differentiable on $\{\mu < \eta\}$ and $\{\mu > \eta\}$. Furthermore, $f(\mu, 0) = \delta(\mu, 0) > 0$ and f is strictly decreasing in p :

$$\frac{\partial f}{\partial p}(\mu, p) = -\frac{\mu w'(p)}{(u_P^+ - u_P^-) \max\{\mu, \eta\} + (u_P^+ - u_P^0) - w(\mu)} - 1 < 0$$

Thus, for every $\mu \geq 0$ there exists a unique $p^*(\mu) > 0$ with

$$f(\mu, p^*(\mu)) = 0.$$

In fact, we know that $\delta(\mu, p) \leq \eta$ for all μ, p , so the intersection of $\eta(\mu, p)$ and p is in fact a point $p^* \leq \eta$.

Fix such a point (μ^*, p^*) . Then we know that $\frac{\partial f}{\partial p}(\mu^*, p^*) \neq 0$ for all (μ^*, p^*) . Hence, by the Implicit Function Theorem, $p^*(\mu)$ can be locally represented by a continuously differentiable function. Accordingly, there exists a continuously differentiable function

$$g : U \rightarrow V$$

from an environment U of μ^* to an environment V of p^* such that

$$g(\mu) = p^*(\mu) \quad \forall \mu \in U.$$

Furthermore,

$$\frac{\partial g}{\partial \mu}(\mu^*) = -\left(\frac{\partial f}{\partial p}(\mu^*, p^*)\right)^{-1} \frac{\partial f}{\partial \mu}(\mu^*, p^*).$$

As we have seen, $\frac{\partial f}{\partial p}(\mu^*, p^*) < 0$ for all (μ^*, p^*) , and so the sign of the derivative depends on $\frac{\partial f}{\partial \mu}(\mu^*, p^*)$.

Let $\mu^* < \eta$. Then, $p^* = p(\mu^*)$ is given by

$$[u_P^0 - u_P^- - w(p^*)]\mu^* = p^*[u_P^+ - u_P^- - w(\mu^*)].$$

As the right-hand side is strictly positive for $p^* > 0$, we have $u_P^0 - u_P^- - w(p^*) > 0$ for all $p^* > 0$ in this case.

If $\mu^* > \eta$, $p^* = p(\mu^*)$ is given by

$$[u_P^0 - u_P^- - w(p^*)]\mu^* = p^*[(u_P^+ - u_P^-)\mu^* + (u_P^+ - u_P^0) - w(\mu^*)].$$

Applying the same reasoning as before, we conclude $u_P^0 - u_P^- - w(p^*) > 0$ for all $p^* > 0$.

Thus, for $\mu^* < \eta$ we have

$$\frac{\partial f}{\partial \mu}(\mu^*, p^*) = \frac{[u_P^0 - u_P^- - w(p^*)][u_P^+ - u_P^0 - w(\mu^*) + \mu^*w'(\mu^*)]}{[(u_P^+ - u_P^-)\mu^* + (u_P^+ - u_P^0) - w(\mu^*)]^2}$$

and for $\mu^* > \eta$

$$\frac{\partial f}{\partial \mu}(\mu^*, p^*) = \frac{[u_P^0 - u_P^- - w(p^*)][u_P^+ - u_P^- - w(\mu^*) + \mu^*w'(\mu^*)]}{[u_P^+ - u_P^- - w(\mu^*)]^2}.$$

In both cases, the derivative is non-negative and thus

$$\frac{\partial g}{\partial \mu}(\mu^*) > 0$$

for all $\mu^* \neq \eta$. As μ_+ is (weakly) increasing in Δ_b , we conclude that the delegation threshold weakly increases in Δ_b . ■

Welfare for the principal in case $p \geq \eta$.

If $p \geq \eta$, the principal delegates in the one-period game. In this case, his expected payoff in the one-period game (played twice) is given by

$$\Pi_1 = 2pu_P^+ + 2(1-p)u_P^- - w(p),$$

where we omit the first-period wage $w(p)$ in all cases.

In the two-period interaction, when a pooling equilibrium is played, the principal's

payoff net of the payoff in the one-period game is then given by

$$\begin{aligned}\Pi_2 - \Pi_1 &= [2pu_P^+ + (1-p)(u_P^+ + u_P^-) - w(p)] - [2pu_P^+ + 2(1-p)u_P^- - w(p)] \\ &= (1-p)(u_P^+ - u_P^-),\end{aligned}$$

which is non-negative.

In the separating equilibrium, the principal's net expected payoff is given by

$$\begin{aligned}E[\Pi_2 - \Pi_1] &= [p(2u_P^+ - w(1)) + (1-p)(u_P^- + u_P^0)] - [2pu_P^+ + 2(1-p)u_P^- - w(p)] \\ &= (1-p)(u_P^0 - u_P^-) - pw(1) + w(p),\end{aligned}$$

which is non-negative if $pw(1) - w(p) \leq (1-p)(u_P^0 - u_P^-)$.

In the mixed equilibrium, net expected payoffs are given by

$$\begin{aligned}E[\Pi_2 - \Pi_1] &= [p(2u_P^+ - w(\mu_+)) + (1-p)\lambda(u_P^+ + u_P^- - w(\mu_+)) \\ &\quad + (1-p)(1-\lambda)(u_P^- + u_P^0)] \\ &\quad - [2pu_P^+ + 2(1-p)u_P^- - w(p)] \\ &= (1-p)\lambda(u_P^+ - u_P^0 - w(\mu_+)) + (1-p)(u_P^0 - u_P^-) - (pw(\mu_+) - w(p)).\end{aligned}$$

As $w(\mu_+) \leq w(1)$, we conclude

$$E[\Pi_2 - \Pi_1] \geq [(1-p)\lambda(u_P^+ - u_P^0 - w(\mu_+))] + [(1-p)(u_P^0 - u_P^-) - (pw(1) - w(p))]$$

and, thus,

$$E[\Pi_2 - \Pi_1] \geq 0$$

if

$$pw(1) - w(p) \leq (1-p)(u_P^0 - u_P^-).$$

Accordingly, the principal is better off in the two-period interaction if

$$pw(1) - w(p) \leq (1-p)(u_P^0 - u_P^-).$$

Proof of Proposition 4. If $p \geq \eta$, aggregate welfare in the one-period game is given by

$$W_1 = 4pu_P^+ + 2(1-p)(u_b^+ + u_P^-).$$

In the two-period interaction with $p \geq \eta$, the principal's strategy is $s_P = (D, C)$ in

all equilibria and the loyal agent always chooses $s_l = x_l$. The biased agent's strategy is given by $(\lambda, 1 - \lambda)$ with $\lambda \in [0, 1]$. Thus, we can calculate the aggregate welfare

$$W_2 = 4pu_P^+ + (1 - p)\lambda[(u_P^+ + u_P^-) + (u_b^+ + u_b^-)] + (1 - p)(1 - \lambda)[(u_P^0 + u_P^-) + (u_b^+ + u_b^0)].$$

Accordingly, expected net aggregate welfare is given by

$$E[W_2 - W_1] = (1 - p)\lambda[(u_P^+ - u_P^0) - (u_b^0 - u_b^-)] + (1 - p)[(u_P^0 - u_P^-) - (u_b^+ - u_b^0)].$$

In a separating equilibrium, we have $\lambda = 0$ and $E[W_2] \geq E[W_1]$ if and only if

$$u_b^+ - u_b^0 \leq u_P^0 - u_P^-.$$

If a pooling equilibrium is played ($\lambda = 1$), expected welfare is increased if and only if

$$u_b^+ - u_b^- \leq u_P^+ - u_P^-,$$

which holds by assumption.

Finally, in a mixed equilibrium, $E[W_2 - W_1] \geq 0$ if and only if the probability of the biased agent choosing the principal's preferred project is high enough, i.e.

$$\lambda \geq \frac{(u_b^+ - u_b^0) - (u_P^0 - u_P^-)}{(u_P^+ - u_P^0) - (u_b^0 - u_b^-)}.$$

■

Proof of Proposition 5.

From Proposition 4, we conclude

$$\frac{\partial E[W_2 - W_1]}{\partial \lambda} = (1 - p)[(u_P^+ - u_P^0) - (u_b^0 - u_b^-)].$$

Accordingly, if a mixed equilibrium is played ($\lambda > 0$), we have $u_b^0 - u_b^- \leq w(1) \leq u_P^+ - u_P^0$ and, thus, $E[W_2 - W_1]$ increases in λ for $\lambda > 0$.

As the wage schedule influences the played equilibrium, increasing $w(p)$ increases the region for values of $u_b^0 - u_b^-$ where a pooling equilibrium is played. In turn, rising $w(1)$ reduces the region for values of $u_b^0 - u_b^-$ where a separating equilibrium is played. Furthermore, if $w(p) < u_b^0 - u_b^- < w(1)$, expected welfare decreases in $w^{-1}(u_b^0 - u_b^-)$. Thus, for a given $u_b^0 - u_b^- \in (p, 1)$, $w(\mu)$ should be maximal for the μ fulfilling $w(\mu) = u_b^0 - u_b^-$.

Hence, high wages for $\mu \in [p, 1]$ (weakly) increase expected welfare in the two-period interaction. \blacksquare

Proof of Proposition 6. If $p \leq \eta$, expected aggregate welfare in the one-period game is given by

$$E[W_1] = 2(u_P^0 + u_b^0).$$

We first consider the case $u_b^+ - u_b^- \geq w(\eta)$. In this case, the principal centralises in equilibrium if he observes x_b and plays the mixed strategy $(\lambda_P, 1 - \lambda_P)$ in case x_l , with $\lambda_P = 1$ in the mix 1-equilibrium and in the separating one. The loyal type always chooses $s_l = x_l$. The biased agent's strategy is given by $(\lambda, 1 - \lambda)$ with $\lambda = 0$ in the separating equilibrium. Thus, we can calculate the aggregate welfare in the general case:

$$\begin{aligned} E[W_2] &= p[4\lambda_P u_P^+ + 2(1 - \lambda_P)(u_P^+ + u_P^0)] \\ &+ (1 - p)\lambda[\lambda_P(u_P^+ + u_P^- + u_b^+ + u_b^-) + (1 - \lambda_P)(u_P^+ + u_P^0 + u_b^0 + u_b^-)] \\ &+ (1 - p)(1 - \lambda)(u_P^0 + u_P^- + u_b^+ + u_b^0). \end{aligned}$$

In the separating equilibrium, i.e. $\lambda = 0$ and $\lambda_P = 1$, the expected aggregate welfare in the two-period interaction net of the one-period aggregate welfare, then, is given by

$$\begin{aligned} E[W_2 - W_1 | \lambda = 0, \lambda_P = 1] &= [(u_b^+ - u_b^0) - (u_P^0 - u_P^-)] \\ &+ p[(u_P^+ - u_P^0) + (u_P^+ - u_P^-) + (u_P^+ - u_b^+) + (u_P^+ - u_b^0)]. \end{aligned}$$

If we assume $u_P^+ \geq u_b^+$ and $u_b^+ - u_b^0 \geq u_P^0 - u_P^-$, this term is non-negative.

In the mix1 equilibrium, we have $\lambda_P = 1$. In this case,

$$\frac{\partial E[W_2 - W_1 | \lambda_P = 1]}{\partial \lambda} = (1 - p)[(u_P^+ - u_P^0) - (u_b^0 - u_b^-)],$$

which is non-negative as $u_b^0 - u_b^- \leq w(1)$ in the mix1 equilibrium and wages are bounded above by $u_P^+ - u_P^0$. Thus, with expected net aggregate welfare being non-negative if $\lambda = 0$, we conclude that welfare is increased in the mix1 equilibrium (assuming $u_P^+ \geq u_b^+$ and $u_b^+ - u_b^0 \geq u_P^0 - u_P^-$).

In the mix2 equilibrium, we first consider the case $\lambda_P = 0$ for an arbitrary λ . This

yields

$$\begin{aligned}
E[W_2 - W_1 | \lambda_P = 0] &= [(u_b^+ - u_b^0) - (u_P^0 - u_P^-)] \\
&+ p[(u_b^+ - u_b^0) + 2(u_P^+ - u_b^+) + (u_P^0 - u_P^-)] \\
&+ (1 - p)\lambda[(u_P^+ - u_P^-) - (u_b^+ - u_b^-)].
\end{aligned}$$

By assumption, all of the above terms are positive.

If $\lambda_P = 1$, we have

$$\begin{aligned}
E[W_2 - W_1 | \lambda_P = 1] &= [(u_b^+ - u_b^0) - (u_P^0 - u_P^-)] \\
&+ p[(u_P^+ - u_P^-) + 2(u_P^+ - u_b^+) + (u_P^+ - u_P^0) + (u_b^+ - u_b^0)] \\
&+ (1 - p)\lambda[(u_P^+ - u_P^-) - (u_b^0 - u_b^-)].
\end{aligned}$$

Again, all of the above terms are positive by assumption. The last term is positive because $u_b^0 - u_b^- \leq w(\eta)$ in the mix2 equilibrium and wages are bounded above by $u_P^+ - u_P^-$.

Finally, we have

$$\frac{\partial E[W_2 - W_1]}{\partial \lambda_P} = (1 - p)\lambda[(u_b^+ - u_b^0) - (u_P^0 - u_P^-)] + 2p(u_P^+ - u_P^0) \geq 0.$$

Now, we consider the case $u_b^+ - u_b^- \leq w(\eta)$. In this case, the principal centralises no matter what he observes. The loyal agent always chooses x_l and the biased agent chooses x_l or randomises between strategies.

In the general case where the biased agent randomises with probabilities $(\lambda, 1 - \lambda)$, the expected net aggregate welfare is given by

$$\begin{aligned}
E[W_2 - W_1] &= [(u_b^+ - u_b^0) - (u_P^0 - u_P^-)] \\
&+ p[(u_P^0 - u_P^-) + 2(u_P^+ - u_b^+) + (u_b^+ - u_b^0)] \\
&+ (1 - p)\lambda[(u_P^+ - u_P^-) - (u_b^+ - u_b^-)].
\end{aligned}$$

By assumption, all the above terms are non-negative independent of λ .

Thus, expected aggregate welfare is increased if $u_P^+ \geq u_b^+$ and $u_b^+ - u_b^0 \geq u_P^0 - u_P^-$. ■

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