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Human resource management and productivity in the "trust game corporation"

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Abstract Contemporary production activity is crucially determined by the performance of complex tasks with the characteristics of corporate trust games. In this paper, we outline a productivity paradox showing that, under reasonable conditions, the noncooperative solution, which yields a suboptimal firm output, is the equilibrium of corporate trust games when relational preferences are not sufficiently high. We show that tournaments and steeper pay for performance schemes may crowd out cooperation in the presence of players preferences for relational goods. These findings help to explain firm investment in workers' relationships and the puzzle on the less than expected use of such schemes.

Keywords Trust game · Work incentives · Folk theorem

JEL Classification C79 · L29 · Z13

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1 Introduction

This paper provides an explanation of two apparent puzzles: why contemporary firms invest money to increase the quality of relationships among workers, inside and outside the workplace,[1] and why pay for performance (team compensation) schemes are relatively less (more) widespread than expected (Baker et al. 1998, 2002).

We introduce some changes in the way firms are conceived, and we argue that (1) corporate activity crucially depends on the realization of complex tasks; (2) these tasks possess the intrinsic characteristics of trust games with super-additivity and require the combination of nonoverlapping skills of different workers; (3) workers have relational preferences (i.e., a taste for the quality of relationships) with colleagues. By introducing these elements, we show that lower quality of relational goods, individual pay for performance schemes and (single winner) tournament incentive structures significantly widen the parametric space of "non-cooperative"[2] equilibria which, in turn, reduce the sharing of knowledge and the interaction of different competencies, yielding suboptimal output for the firm. In this paper, we refer to the concept of relational goods (Ash 2000), slightly different from that of reciprocity (Fehr and Falk 2002), as a crucial missing element required to shed light on the interaction between incentive rules and productivity. According to Uhlaner (1989) and Gui (2000), relational goods are local public goods that need (1) to be jointly coproduced and (2) to be simultaneously co-consumed to be enjoyed. While a sufficient condition for reciprocity is the feeling of the obligation to reciprocate a positive or negative action from the counterpart, relational values are more related to the pleasure that individuals have in spending time with the others.[3] Frey (1997) argues that more personal relationships imply recognition, trust and loyalty which, in turn, support intrinsic motivation. Relational goods are, therefore, at the root of the widely analyzed phenomena of trust, reciprocity and intrinsic motivation (Fehr et al. 1997; Fehr and Gächter 2000; Bewley 1995). Despite the controversial issues on the nature of relational goods, there is a general consensus that such goods cannot be defined using the standard properties of rivalry and excludability. Randon et al. (2008) suggest three new characteristics: simultaneity, motivation and identity (Gui 2002; Sugden 2005 and Uhlaner 1989) commonly agree with them. In our

[1] To quote just some of the innumerable examples of corporate "teambuilding" practices, one of the biggest Italian banks, Mediobanca, finances weekend skying holidays, and the Italian telecom company sailing holidays, to its management and white collars with the goal of increasing their group working attitudes.

[2] Note that we define as *cooperative solution* the equilibrium given by the (share, not abuse) pair of strategies (see Fig. 1) and as *noncooperative solutions* the (do not share, abuse) and (share, abuse) equilibria which do not imply the joint work of the two players. Hence, the term cooperative is not referred to the structure of the game (or to the coordination/noncoordination of players decisions) but to the characteristics of its equilibrium.

[3] Bruni and Stanca (2008) document how relational goods impact positively on life satisfaction. Frey et al. (2007) provide theoretical explanations for the underinvestment in relationship. Other theoretical models highlighting important elements of the relational good approach such as the conditionality of the enjoyment of leisure invested in relational goods to the investment choice of partners are those of Corneo (2005), Jenkins and Osberg (2003), Antoci et al. (2007) and Bruni et al. (2008).

model, the relational goods enjoyed by two workmates before the game experience is a stock that depends on the "set of intangibles ranging from companionship, sympathy and intimacy" based on past experiences. Successful cooperation adds to the existing stock, while the decision to abuse destroys such stock. This is how relationships work in the reality. Given these characteristics, more standard concepts such as those of reciprocity[4] and guilt aversion[5] would be inadequate for our model. If the positive effect generated from cooperation that we model in the game may arise from coherence with an internalized norm of reciprocity (and therefore, reciprocity and relational goods may produce observationally equivalent predictions in the case of the share, not abuse equilibrium), reciprocity fails to grasp that the cost of abusing implies the loss of the ex ante level of friendship with the workmate. With reciprocity, the cost of abusing would be the same whatever the counterpart. A similar reasoning applies for guilt aversion. In both cases, a disutility is attached to the subject not corresponding with a cooperative behavior to a cooperative behavior of the counterpart, but the disutility is impersonal, that is, it is related to a disposition of the subject and not depending on the (story of the) relationship between the individual and the counterpart. On the contrary, with relational goods, the cost depends on the ex ante stock of relational goods, that is, on the story of the relationship. This example brings into light that the concept of relational goods is able to capture the specificity of the relationship, that is, the history of the intercourse between two individuals and to deal with it objectively. With reciprocity, the others are all equal, and my kindness in response to an act of kindness is just an act of coherence with my own internal norms. With relational goods, we acknowledge the "otherness" of our counterpart and of the relationship created with her. This implies that the cost of abusing is not always the same but varies in proportion to the quality and history of my relationship with the counterpart. Note as well that in the concept of relational goods we develop there is a symmetry in its value for both counterparts. For simplicity, we assume in the model that all individuals have the same metric on the stock of relational goods, and therefore, its value gives the same utility to both. Hence, a noncooperative behavior does not produce only a loss for the noncooperating individual but also for her counterpart. This is not the case if we use the concept or reciprocity or guilt aversion since, in this case, the loss arises only for the noncorresponding individual. Given what considered above, relational goods have, therefore, with respect to guilt aversion and reciprocity, two important properties that make such concept more consistent with what happens in real-life relationships.

[4] Following Greig and Bohnet (2008, p. 2) "Reciprocity is an internalized norm, inducing people to respond to kindness with kindness and to unkindness with unkindness, even if it is not in a person's material self-interest to do so. It differs fundamentally from cooperation in repeated games where reputational concerns can enforce 'cooperation'" (e.g., Kreps et al. 1982; Fudenberg and Maskin 1986).

[5] An individual is guilt averse when she suffers a disutility from guilt where, according to Baumeister et al. (1994), guilt is intended as …"an unpleasant emotional state … that is caused by the infliction of harm, loss, or distress on a relationship partner (p. 245)". Corazzini et al. (2007, p. 2) add that "If subjects feel guilty because of (believing that they are) letting others down, they shoulder psychological costs of lying. These costs increase with the perceived harm of deceiving others (see Baumeister et al. 1994 and Dufwenberg 2002)".

We identify a positive nexus that goes from the quality of workers' relationships to the willingness to share information and cooperate and, from the latter, to firm productivity.

The paper applies the standard trust game approach to the literature of the firm's organization, and to our knowledge, it represents the first study on the consequences of trust games among coworkers. The specific characteristics which make our trust game different from the standard one are that (1) the payoff is not continuous and depends on the relative performance of the two players; (2) a clear rationale for the increase in the payoff in the case of cooperation is provided; (3) the trustee can not arbitrarily decide how much output he has to give back to the trustor, and (4) in the extension of the model with pay for performance schemes, the trustee decision of not abusing implies an additional specific penalty (loss of part of his pay for performance fee).

The decision to model the firm activity as a corporate trust game is due to the fact that, departing from the assembly line perspective and moving toward a modern firm in which workers skills are central to create value and innovate products and processes, corporate activity becomes more complex and requires the sharing and interaction of different nonoverlapping competencies and information. Regarding this point, Thompson and Wallace (1996) argue that, with the development of lean production and other forms of work organization under advanced manufacturing, team-working has emerged as a central focus of redesigning production. Katz and Rosemberg (2004) argue that "the productivity of an organization crucially depends on cooperation among workers" and highlight the importance of altruistic and cooperative attributes in workers emphasized by the organizational theory (see among others, Smith et al. 1983; Organ 1988; Organ and Ryan 1995; McNeely and Meglino 1994; Penner et al. 1997 and Podsakoff and Mackenzie 1993). With our novel approach, we also aim to reconcile theoretical models with the empirical evidence on the lower than expected diffusion of individual pay for performance schemes and the higher than expected spread of profit sharing or team compensation schemes, especially among workers who perform some kind of intellectual activities (Frey 1997; Baker et al. 1998, 2002). This evidence seems to be consistent with the standard theory of the firm and with the traditional argument advanced in the literature on tournament schemes and their positive effects on performance when the disciplining effect is larger than the crowding-out effect of intrinsic motivation (Lazear and Rosen 1981). To explain this paradox, Fehr and Falk (2002) argue that peer pressure on high performers may reduce the positive impact of tournaments on corporate productivity.[6] Other potential explanations for the puzzle are horizontal equity concerns and imperfect performance measurement. As pointed out by Kosfeld and von Siemens (2007), firms often develop remarkably different corporate cultures characterized by differences in the level of cooperation and team work. In the airline industry, for example, Southwest Airlines has become the prototype of a strong cooperative corporate culture since team spirit and good

[6] The crowding-out hypothesis relies on the assumption that if workers are already intrinsically motivated, an extrinsic reward over motivates them leading the latter to react by reducing the motivation which is under their control (i.e., the intrinsic motivation).

relationship between different work units play a key role (Gittell 2000, 2003). In contrast to Southwest, most of the other US airlines have been unable to achieve cooperation between workers and have been often characterized by a culture of conflict rather than cooperation (Gittell et al. 2004). Ichniowsky et al. (1997) report similar differences for the steel industry, documenting a strong heterogeneity in human resource management practices (including team work, training, hiring, supervision, etc.) in a sample of 36 US production lines all of which operate in the same steel finishing business. Other empirical contributions show that firms that enjoy high level of team work tend to be more productive than firms without or with low levels of team work. Ichniowsky, Shaw and Prennushi (1997) find that production lines using innovative work practices, which include high levels of team work, are significantly more productive than lines with the traditional approach where team work does not play an important role. Hamilton et al. (2003) analyze the effect of a "cultural change" from individual to team production in a US garment plan and find a positive impact of team work on productivity. Finally, high levels of cooperation seem to be associated with weak individual incentives or viceversa. Encinosa et al. (2007), for example, show in a US random sample of medical group practices that incentive pay reduces aid activities among physicians such as mutual consultations about cases. Moreover, the relationship between cooperative attitudes and incentive schemes may be affected by selection bias. Burks et al. (2006) show in a sample of Swiss and US bicycle messenger companies that firms that pay for performance employ significantly less cooperative workers than those that pay hourly wages or are organized as cooperatives.

Exploring the links between workers' relational attitudes, incentive schemes and performance, our paper provides a broad and simple framework which is consistent with the previously mentioned findings. The paper proceeds as follows. Section 2 examines the one shot and the infinitely repeated full information games (with and without the presence of relational goods) when the two players own the company. Section 3 illustrates the equilibria for the corporate trust game when players do not own the company and pay for performance and tournament schemes are introduced. Section 4 briefly illustrates the optimal personnel policy for "trust game corporations". Finally, Sect. 5 draws some conclusions.

2 The basic trust game when the players own the company

We assume that the firm activity originates from the performance of complex tasks[7] that require the contribution of knowledge, inventive skills and ideas of workers with nonoverlapping human capital endowments. We assume that each complex task consists in a trust game between two workers who own the firm, player A and B. Nature chooses the personal skills (stand alone contributions to final output) of

[7] Consider for instance a blueprint in which different skills are production inputs related by some forms of complementarity, or to the definition of a corporate strategy which requires participants from different firm divisions to share knowledge and skills. The same scheme could be applied in different fields of activity such as, for instance, a coauthored academic working paper to which different researchers contribute with their specialized skills.

the two players, $h_a \in R^+$ and $h_b \in R^+$, respectively, and skill types are immediately revealed to players. One of the two players (player A, the trustor) may decide whether sharing or not his skills with the other player. In the second stage of the game, the second player (player B, the trustee) may decide to cooperate or abuse. We assume that sharing ideas, projects or intuitions create a positive externality, introduced in the model as a super-additive component, $(e \in [0, \infty])$, generated by the dialogic process of jointly performing the task. Interaction and information sharing are necessary to improve production knowledge. In particular, we argue that (1) part of the skills may be acquired only by integrating experiences of different people; (2) learning is a process that can be enhanced by explaining and comparing one's own knowledge with the others.

Summing up the set of available strategies, player A (the trustor) may decide to share (*s* strategy) or not share (*ns* strategy) his initial ideas with the trustee who, in turn, may decide to abuse (*a* strategy) or not (*na* strategy). If the trustee decides to abuse, he will join his ideas with those of the trustor and present everything as his own work, while if he decides to share, the two players will interact and produce, as additional contribution to the output, the super-additive component e. We assume in this case that the final output is divided in equal parts between the two players. Under these assumptions, the set of payoffs (respectively, for player A, player B and firm) are[8]

$$\{(0|h_a < h_b, h_a|h_a > h_b), (0|h_a > h_b, h_b|h_a < h_b), Max(h_a, h_b)\}$$

if player A does not share;[9]

$$\{0, h_a + h_b, h_a + h_b\}$$

if player A does share but player B does abuse;

$$\{(h_a + h_b + e)/2, (h_a + h_b + e)/2, h_a + h_b + e\},$$

if player A does share and player B does not abuse.

The game is represented in extensive form in Fig. 1 in the "Appendix".

The analysis of the uniperiodal trust game leads us to formulate the following proposition.

Proposition 1 *The non sharing solution yielding a "third best" suboptimal firm output is the SPNE of the uniperiodal full information game when* (1) *the trustor has noninferior stand alone contribution to output with respect to the trustee's one and* (2) *the super-additive component is inferior to the sum of trustee and trustor stand alone contributions.*

[8] The implicit assumption here is that an authority external to the two players will pick up the best individual "blueprint" (in the case of equal value, any individual project will have a 50% chance of winning).

[9] The implicit assumption here is that the two players' competencies and skills do not overlap. If they do, the total output of player B in the (*s, a*) solution and the one shared by the two players in the (*s, na*) solution should be interpreted as the nonoverlapping part of the sum of the two stand alone contributions. A second assumption implied by our complete information framework is that the trustee has sufficient skills to be able to understand the contribution provided by the trustor and to abuse of it.

Proof When $h_a > h_b$, player A payoff is h_a if he does not share and 0 if he decides to share but player B abuses, as he will do when $h_a + h_b > (h_a + h_b + e)/2$, or, $e < h_a + h_b$ (abuse condition). Hence, if $h_a > h_b$[10] and $e < h_a + h_b$, the nonsharing solution is the SPNE of the uniperiodal full information game. The SPNE yields a firm output – *Max* (h_a, h_b)—which is lower than the one achievable under cooperation $(h_a + h_b + e)$, and even lower than the "second best" output obtainable under the share, abuse pair of strategies $(h_a + h_b)$.[11] □

Two consequences of the SPNE of the game which are intuitively reasonable were the following: (1) the trustor's decision to share crucially depends on the knowledge of the relative value of his stand alone contribution to output versus that of the trustee; (2) the likelihood of the occurrence of the (share, not abuse) solution is higher when the two players' stand alone contributions are small with respect to the output they can generate by applying together to the problem (i.e., the task has complex rules that can be interpreted only by combining players skills). Furthermore, the loss of social surplus in the nonsharing solution is $h_a + h_b + e - Max\ (h_a, h_b)$.[12]

If we explore the solution of the game when the ranking of stand alone contributions is inverted, we find that, if $h_a < h_b$ and $e < h_a + h_b$, player A is indifferent between the two available strategies (*share* and *not share*), since the payoff he will receive is the same in both cases. In such case, we have two sub-game perfect Nash equilibria represented by the following strategy pairs, (*ns, a*) or (*s, a*), yielding again a suboptimal firm output with a social loss equal to $h_a + h_b + e - Max\ (h_a, h_b)$ or e, respectively. To sum up, the full information uniperiodal game shows that when the trustor stand alone contribution is higher, and under reasonable parametric conditions on the super-additive component (lower than the sum of the stand alone contributions of the two players), the sub-game perfect equilibrium is a *noninformation sharing* solution and the firm output is not maximized. Under the alternative assumption on the relative human capital endowments of the two players, we have two possible solutions. Both of them do not imply information sharing and still yield a suboptimal firm output.

2.1 The infinitely repeated game

The analysis of the infinitely repeated version of the game leads us to formulate the following proposition.

Proposition 2 *In the full information infinitely repeated trust game, the (share, not abuse) strategy is an equilibrium of the game for reasonable discount rates.*

[10] With $h_a = h_b$ the trustor will still have a 50% chance of winning and, therefore, a relatively higher payoff when choosing the nonsharing strategy.

[11] We reasonably assume that when player B abuses, he exploits player A information for his own project before starting the cooperative process of jointly performing the task and, therefore, $e = 0$.

[12] Note that the trustor would, in principle, decide not to share also if $e > h_a + h_b$, but his payoff from the information sharing equilibrium is lower than the opportunity cost (the payoff occuring when the decision is to not share), that is, if $e > h_a + h_b$. However, as it easy to check, these two conditions cannot be jointly met.

Proof If there exists a $\delta \in [0, 1]$[13] such that the (*share*, *not abuse*) equilibrium is enforceable, the Folk theorem applies. By applying it, we get $(1-\tilde{\delta})(h_a+h_b) = (h_a+h_b+e)/2$ if $h_a > h_b$ and $(1-\tilde{\delta})(h_a+h_b)+\tilde{\delta}h_b = (h_a+h_b+e)/2$ if $h_a < h_b$. If $h_a > h_b, \tilde{\delta} = 1/2 - e/[2(h_a+h_b)]$, which is below 1 for reasonable parametric values. On the other hand, if $h_b > h_a, \tilde{\delta} = 1/2 + (1/2)\,(h_b/h_a) - (1/2)(e/h_a)$. Note that in this case, the satisfaction of the $[(h_b - h_a)] > e$ condition implies also discount rates above the admissible range $(\tilde{\delta} > 1)$. In this case, the no-abuse condition is not met and the cooperative equilibrium may not be enforced. □

The renegotiation argument applies here. Consider that the punishment strategy represents a cost for the trustor, equal to $(h_a + h_b + e)/2 - h_a$, if $h_a > h_b$ and to $(h_a + h_b + e)/2$, if $h_a < h_b$. On the other hand, if player B is punished, he gets 0 if $h_a > h_b$ and h_b if $h_a < h_b$. Therefore, after abusing in the first period, both players may be better off if they shift to cooperative equilibrium. Renegotiation will take place whenever the continuation payoffs of the *(s, na)* equilibrium strictly dominate the continuation payoffs of the (*ns*, ·) equilibrium.[14] Hence:

Proposition 3 *Even though the (share, not abuse) equilibrium applies, it is based on a trustor threat which is never renegotiation proof if the superadditivity component is positive and above the difference in absolute value between trustor's and trustee's stand alone contribution.*

Proof The continuation payoffs in the cooperative solution are $(h_a + h_b + e)/2$ and $(h_a + h_b + e)/2$, while in the *(ns, ·)* equilibrium are $(h_a, 0)$ if $h_a > h_b$ and $(0, h_b)$ if $h_b > h_a$; $(h_a + h_b + e)/2 > h_a$ when $e > h_a - h_b$; $(h_a + h_b + e)/2 > h_b$ when $e > h_b - h_a$. □

Notice that if player A's stand alone contribution is higher than player B's, renegotiation will take place only if player A's sharing solution is met; for very low values of e ($e < h_a - h_b$), sharing can never be a solution. When player B's contribution is higher, renegotiation will take place if player B's abuse condition is met which would prevail when player A does not share, as not sharing would be player A's strategy under punishment.[15]

Note as well that "softer " (i.e., tit for tat) punishment strategies, which allow for instance to meet renegotiation proofness in simultaneous games such as the standard Prisoners' Dilemma (Van Damme 1989), cannot apply in our case because (1) the game is sequential and the punishment of the trustor interrupts the game (hence making impossible to observe the "intention to repent" of the punished), and (2)

13 δ is the inverse of the subjective discount rate or the standard measure of players' "patience". Higher values of δ can also be viewed as a measure of the reduced distance between two consecutive stages of the game.

14 Farrell and Maskin (1989).

15 In the static game, if player B abuses, player A would be indifferent whether sharing or not sharing because his payoff would always be 0. However, the payoff for B would change following A's choice: if A does not share, B can only get h_b by abusing, while if A shares, B gets $h_a + h_b$. In the latter case, B would abuse even with higher values of e ($e \le h_a + h_b$).

(differently from the Prisoner's dilemma) punishing is costly for the punisher even if the punished is willing to revert to cooperation in the same round.

The Folk theorem condition implies that the trustee "patience" required to have a cooperation equilibrium is negatively related to the super-additive component in both cases. The intuition is that the super-additive component is what players lose when they decide not to cooperate; if the loss is high, a cooperative equilibrium can be enforced also when the trustee has limited patience. Moreover, if $h_a > h_b, \tilde{\delta}$ is higher and positively related to the sum of both players' stand alone contributions, while if $h_a < h_b$, the effect of h_a on the minimum trustee patience is more ambiguous as in this case it enters in the trustee's side payment, thus lessening the benefits from abusing.

2.2 The one-shot trust game with relational goods when players own the company

In this section, we take into account the role of relational goods. We assume that the two players have a stock of accumulated relational goods (F), depending on their current level of friendship, and may jointly produce a relational good (f) with their decision to cooperate; the accumulated stock of relational goods between the two players is enjoyed in every period and may be lost only when one of the two players decides to abuse and not when he decides not to share. The solution of the uniperiodal game with relational goods leads us to formulate the following proposition.

Proposition 4 *In the uniperiodal full information game, when* $(h_a + h_b - e)/2 > F$ and $f > (h_a - h_b - e)/2$, *there exists a threshold value of the relational good* (f*) *in the trustee's utility function which triggers the switch from the non cooperative to the cooperative* (*share, not abuse*) *equilibrium.*

Proof In the presence of relational goods, the payoff set (player A and player B payoffs and firm output) becomes

$$\{(F|h_a < h_b, F + h_a|h_a > h_b), (F|h_a > h_b, F + h_b|h_a < h_b), Max(h_a, h_b)\}$$

if player A does not share;

$$\{0, h_a + h_b, h_a + h_b\},$$

if player A does share but player B does abuse;

$$\{(h_a + h_b + e)/2 + F + f, (h_a + h_b + e)/2 + F + f, h_a + h_b + e\},$$

if player A does share and player B does not abuse (see Fig. 2 in the "Appendix"). In this case, the abuse condition turns out to be $h_a + h_b > e + 2(F + f)$. However, the trustor would decide not to share even if the abuse condition is not met ($e > (h_a + h_b) - 2(F + f)$) if his payoff from cooperation is inferior to the opportunity cost, or $f + (h_a + h_b + e)/2 < h_a$. Standing these two conditions, there exist a threshold (f*) in the value of the relational goods for the trustee above which the (share, not abuse) couple of strategies becomes the SPNE of the single period full information game, which is equal to $f^* = Max[(h_a + h_b - e)/2 - F, \ (h_a - h_b - e)/2]$. □

Notice that if the not abuse condition is not met, in the presence of relational goods the trustor will not be indifferent anymore between sharing or not when $h_a < h_b$ since, by sharing, he will "induce into temptation" the other player with the risk of losing the accumulated stock of relational goods. Hence, if $F > 0$ and $h_a < h_b$, the (*ns*, .) strategy is strictly preferred if the not abuse condition is not met. Under this case, the firm output is always suboptimal but may be lower than that obtainable in the model without relational goods if in that model the (*s*, *a*) equilibrium is selected. However, if the super-additive component is not high enough to violate the not abuse condition, the sub-game perfect equilibrium of the full information uniperiodal game is (*ns*, *a*) whatever is the relationship between the two players stand alone contributions. Again, the noncooperative solution yields a "third best" firm output, $Max(h_a, h_b)$, which is lower than $h_a + h_b + e$ (firm output under the (*s*, *na*) equilibrium) and lower than the "second best" output obtained under the (*s*, *a*) solution.

Finally, in the presence of relational goods, the not abuse condition may be respected also for small super-additive components and the payoff from cooperation for the trustee falls below its opportunity cost, when he has superior stand alone contribution. In this case, a noncooperative equilibrium is avoided only for high levels of the flow of relational goods stemming from the decision to cooperate. Also, the incentive to abuse is reduced because of the potential loss of the stock of relational goods and the missed production of new relational goods in the case of noncooperation. The introduction of relational goods, therefore, identifies a virtuous circle among quality of workers' relationship, decision to cooperate (which further increases the quality of relationships) and firm productivity, or among relational goods, social capital (under the form of trust and trustworthiness) and output.

In the proposition which follows, we show that, by setting reasonable laws of motion for the stock of relational goods conditional to different outcomes of the game, the one-shot equilibria described previously are also stationary equilibria[16] in the infinitely repeated version of the corporate trust game with relational goods.

Proposition 5 *Given the following three rules of the law of motion of relational goods*:

a. $F_t = F_0 + f_t | (s, na)$ *SPNE of the game in t;*
b. $F_t = F_0 | (ns, a)$ *SPNE of the game in t and*
c. $F_t = 0 | (s, a)$ *SPNE of the game in t,*

where F_0 *is the stock of relational goods at time 0*

(*s*, *na*) *is a stationary equilibrium of the game if:* (1a) $e > (h_a + h_b)/2 - (F_0 + f_t)$ *and* (1b) $f_t > (h_a - h_b - e)/2$ *when* $h_a > h_b$ *or* $h_a = h_b$; (2) *if* $e > (h_a + h_b)/2 - (F_0 + f_t)$ when $h_a < h_b$. *Conversely, if* $e < (h_a + h_b)/2 - (F_0 + f_t)$, *(ns,a) is a stationary equilibrium of the game.*

[16] We use the concept of stationary equilibrium as a "pair of strategies that prescribe to play the stage-game Nash equilibrium at every stage" (Burkov and Chaib-draa 2010) or, equivalently, as "the equilibrium of the corresponding one-round game, repeated in every round" (Myerson 1991).

Proof If the parametric condition (1a) is met for player B, it is better not to abuse and for player A is better to share under $h_a < h_b$. Under $h_a > h_b$, we need to add also condition (1b) since this makes more profitable for player A to share than not to share. If these conditions are met and the (s, na) equilbrium enforced, this raises the value of F due to the rule (a) of the law of motion of relational goods. Hence, in the following round, the conditions of the (s, na) equilibrium are reinforced and this occurs progressively round after round. On the contrary, if parametric condition (2) is met, player A decides not to share. This does not change the level of F due to rule (b) and again the equilibrium does not change over game rounds. □

Our results are robust to two small reasonable departures from our hypotheses on the law of motion of relational goods. First, the situation does not change even if we modify assumption (b) in the sense that the decision to share alters negatively the stock of preexisting relational value (we may assume that the decision not to share is not neutral but "offends" player B). If F falls, this will reinforce the decision not to share in the rounds which follow. Second, imagine as well that the consequences of abuse are not so drastic as those imagined under assumption (c), that is, F falls but not to zero. Whatever the magnitude of the reduction of F again the incentive to abuse will be reinforced and player A will persist in her decision not to share.

Setting the following laws of motion for the stock of relational goods conditional to different outcomes of the game, the one-shot equilibria described earlier are also stationary equilibria in the infinitely repeated version of the corporate trust game with relational goods : (1) $F_t = F_0 + f_t \mid (s, na)$ SPNE of the game in t; (2) $F_t = F_0 \mid (ns, a)$ SPNE of the game in t; and (3) $F_t = 0 \mid (s, a)$ SPNE of the game in t.

Given this law of motion, it results that (s, na) is a stationary equilibrium of the game if: (i) $e > (h_a + h_b)/2 - (F_0 + f_t)$ and $f_t > (h_a - h_b - e)/2$ when $h_a > h_b$ or $h_a = h_b$; (2) if $e > (h_a + h_b)/2 - (F_0 + f_t)$ when $h_a < h_b$. Conversely, if $e < (h_a + h_b)/2 - (F_0 + f_t)$ (ns, a) is a stationary equilibrium of the game. The intuition behind these results is that when parametric conditions for cooperation do not exist (exist), the initial stock of relational goods falls to zero (grows period by period in proportion of the flow f_t), and therefore, cooperative (noncooperative) equilibria of the one-shot game persist across time.

3 Basic trust game when the players do not own the company

This section examines how equilibria change when we remove the assumption that the two players own the company. We show that under reasonable assumptions, single winner tournaments or pay for performance schemes are not optimal in the presence of workers taste for relational goods. This result holds without considering the crowding-out effect on intrinsic motivations and, therefore, is purely based on extrinsic motivation grounds. More specifically, we show that (1) a steeper pay for performance scheme increases the probability of noncooperative equilibria in the presence of relational goods; (2) the cooperative equilibrium can never be attained with the introduction of a single winner tournament scheme, even in the absence of relational goods.

3.1 Pay for performance schemes

Let us consider a simple pay for performance structure that consists of a fixed remuneration (w_a for player A, and w_b for player B) plus an additional share $s \in [0, 1]$ of the employee performance when the latter contributes to firm output. The analysis of the uniperiodal game under the new framework leads us to formulate the following proposition.

Proposition 6 *Individual pay for performance schemes are neutral in corporate trust games in which players do not own the firm, as they do not provide incentives to widen the parametric space of the cooperative equilibrium. In presence of relational goods they raise the opportunity cost of the trustee's not abuse strategy and may crowd out cooperation since a steeper pay for performance scheme may induce the switch from a cooperative (productively optimal) to a non cooperative (productively suboptimal) equilibrium.*

Proof Under the pay for performance scheme framework, the set of payoffs is

$$\{w_a + s(h_a|h_a > h_b, 0|h_a < h_b), w_b + s(h_b|h_a < h_b, 0|h_a > h_b), \\ (1 - s)[Max(h_a, h_b] - (w_a + w_b)\}$$

under the (*ns, a*) pair of strategies, while it is

$$\{w_a, w_b + s(h_a + h_b), (1 - s)(h_a + h_b) - (w_a + w_b)\}$$

and

$$\{w_a + s(h_a + h_b + e)/2,\ w_b + s(h_a + h_b + e)/2, \\ (1 - s)(h_a + h_b + e) - (w_a + w_b)\}$$

under the (*s, a*) and (*s, na*) strategy pairs, respectively (see Fig. 3 in the "Appendix").

Hence, in this case the not abuse condition ($e > h_a + h_b$) corresponds to the not abuse condition of the full information game when players own the company. When relational goods are considered, the payoff set under the (*ns, a*), (*s, a*) and (*s, na*) strategy pairs becomes, respectively,

$$\{F + w_a + s(h_a|h_a > h_b, 0|h_a < h_b), F + w_b + s(h_b|h_b > h_a, 0|h_b < h_a), \\ (1 - s)[Max(h_a, h_b)] - (w_a + w_b)\}$$

and

$$\{F + f + w_a + s(h_a + h_b + e)/2, F + f + w_b + s(h_a + h_b + e)/2, \\ (1 - s)(h_a + h_b + e) - (w_a + w_b)\}$$

(see Fig. 4 in the "Appendix").

The not abuse condition in this case is $e > h_a + h_b - 2(F + f)/s$. □[17]

[17] It is easy to check that the pay for performance incentive, which is compatible with nonnegative profits, is $s < 1 - [2w/(h_a + h_b + e)]$ under the (*s, na*) strategy; $s < 1 - (2w/h_i)$, where $h_i = Max[Max(h_a, h_b)]$, under the (*ns,a*) strategy and $s < 1 - [2w/(h_a + h_b)]$ under the (*s, a*) strategy.

This result shows that pay for performance schemes crowd out quality of relationships and trust and provide a simple rationale to the puzzle evidenced, among others, by Baker et al. (1998) on the relatively low use of individual pay for performance schemes in personnel management. Our finding implies that a steeper reward scheme (s) may induce the switch from the cooperative (s, na) to the noncooperative solutions of the game. The intuition is that (s) becomes the relative price of the relational goods in terms of missed output performance arising from the abuse strategy.

Note that, given the model characteristics, if $s = 0$, $F = f = 0$ and the wage is fixed at w, player B is indifferent between sharing and abusing. As a consequence, proposition 6 implies that, if the pay for performance scheme is introduced, it re-creates the same parametric space as in the base model in which players own the firm and do not have a fixed wage, that is, a situation in which the decision to share depends on the no-abuse condition ($e > h_a + h_b$). Note that this means that, even in the absence of relational goods ($F = f = 0$), the introduction of pay for performance schemes has nontrivial effects that may vary according to the assumption crucial parameters: more specifically, if $e > h_a + h_b$, it shifts players from indifference to cooperation, while if $e < h_a + h_b$, it moves them from indifference to noncooperation. This implies that with a relationally poor environment and high super-additivity (no-abuse condition met), a move from fixed wage to pay for performance schemes may indeed generate positive productivity effects. The same move generates negative effects if super-additivity is low (no-abuse condition not met) or if s is high and more than compensates the positive effect of relational goods.

3.2 Firms with a vertical hierarchical structure

Remuneration schemes in firms with hierarchical structure also depend on the job positions, and changes in employees compensation may be obtained through a promotion. As pointed out by Baker et al. (1998), promotions have two different purposes: (1) they are a way to match individuals to the job for which they are best suited, and (2) they provide incentives for lower level employees who evaluate the opportunity to increase their wage and job position obtaining a better one. Disadvantages and advantages of promotion-based incentive schemes are widely debated. Baker et al. (1998) underline how incentives generated by promotion opportunities depend on the probability of promotions and, in turn, on the identity and expected horizon of the incumbent superior. Moreover, promotion incentives (1) do not work after promotion of a young employee with a long expected horizon in the job since such event decreases the probability of promotion and the incentive to work hard for coworkers, (2) are reduced for employees who already obtained it and (3) generate problems in slowly growing or shrinking firms.

This section examines a tournament promotion system in which the best performer is promoted to a higher career level. At the beginning of the game, both player A and player B work at the same hierarchical level. We assume that if the *(s,na)* equilibrium applies, the winner is randomly selected and both players have a

50% chance of getting the promotion. The introduction of this reward system leads us to formulate the following proposition.

Proposition 7 *With an individual winner tournament structure the not abuse condition never applies.*

Proof If the trustor (player A) decides in favor of sharing his information, the payoff set is $\{w_a + (PR|h_a > h_b, 0|h_a < h_b), w_b + (PR|h_a < h_b, 0|h_a > h_b), Max(h_a, h_b) - (w_a + w_b + PR)\}$ where PR is the promotion wage premium. In this framework, the strategies *(s, a)* and *(s, na)* are the following: in the first case, the payoff set is

$$\{w_a, w_b + PR, h_a + h_b - (w_a + w_b + PR)\}$$

while in the second case, the payoff set is

$$\{w_a + PR/2, w_b + PR/2, h_a + h_b + e - (w_a + w_b + PR)\}.$$

Hence, the not abuse condition is $w_b + PR/2 > w_b + PR$ and can never hold. □

The consequence of this result is that the trustor never shares his information when $h_a > h_b$, while he is indifferent between doing it or not when $h_a < h_b$; however, in this case, B will abuse. Hence, we can conclude that, with a promotion-based incentive system and an uniperiodal game, the cooperative solution can never be reached. Consider that the presence of relational goods may mitigate this result. In this case, the trustee's taste for relational goods creates some room for the cooperative solution and may offset his propensity to abuse. If the trustor decides in favor of not sharing the payoff set will be (respectively for the trustor, the trustee and for the firm):

$$\{(F + w_a + PR|h_a > h_b, 0|h_b > h_a), (F + w_b + PR|h_b > h_a, 0|h_a > h_b), Max(h_a, h_b) - (w_a + w_b + PR)\}.$$

If the trustor decides to share the idea, the payoff set is

$$\{w_a, w_b + PR, h_a + h_b - (w_a + w_b + PR)\}$$

or

$$\{w_a + PR/2 + F + f, w_b + PR/2 + F + f, h_a + h_b + e - (w_a + w_b + PR)\}$$

under the (s, a) and (s, na) pairs of strategies, respectively. Hence, the not abuse condition is $F + f > PR/2$ and may, therefore, be respected in the presence of strong player tastes for relational goods.

4 Optimal human resource policies in the trust game corporation

In the light of the results presented above, this section identifies the optimal policy for a "'trust game corporation" that aims at maximising its output. When players do not own the firm, and under reasonable parametric conditions, the preferred option for the firm consists in investing in relational goods. Let us consider a single period full information game with relational goods and assume the following parametric conditions ($h_a > h_b$, $f = F = 0$ and $e < h_a + h_b$) under which the SPNE of the game is the (ns, a) equilibrium and the firm output loss gap is $h_a + h_b + e - Max(h_a, h_b)$. In such framework (under the conditions stated in proposition 4 [$(h_a + h_b - e)/2 > F$ and $f > (h_a - h_b - e)/2$], the firm will find optimal to invest in relational goods if there exists a production technology of relational goods yielding the following cost function $C(f^* + \varepsilon) = c^*$ such that $c^* < h_a + h_b + e - Max(h_a, h_b)$, with $f^* = Max[(h_a + h_b - e)/2 - F, (h_a - h_b - e)/2]$ being the threshold that induces the switch from the noncooperative to the cooperative (s, na) equilibrium in the game illustrated in Sect. 2.2

5 Conclusions

In this paper, we model firm activity as a sequence of complex tasks having the basic features of trust games and requiring the contribution of different workers with nonoverlapping competencies. We shed light on two puzzles that standard firm theories cannot explain, the lower than expected use of individual pay for performance schemes and single winner tournament schemes, and the existence of corporate expenditures aimed at strengthening relational links among coworkers. The corporate trust game model presented provides several insights. First, it identifies a microeconomic nexus between relational goods and productivity at firm level. Second, it explains why individual pay for performance schemes may, under reasonable parametric assumptions, crowd out relational goods and cooperation justifying their lower than expected application in the reality. Third, it provides an explanation on why single winner tournament schemes are rarely implemented by corporations by showing how they crowd out information sharing and lead to suboptimal output, even without taking into account their potential effect on workers' intrinsic motivations. Fourth, it shows how the taste for relational goods significantly affects workers cooperation which, in turn, positively affects firm productivity. As expected, our results are much stronger in single period than in repeated games but, also in the latter, our conclusions hold for relevant parametric spaces. Moreover, in those cases in which cooperative equilibria may be attained on the basis of the Folk theorem, we show that such equilibria are not renegotiation proof.

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Appendix

See Figs. 1, 2, 3 and 4.

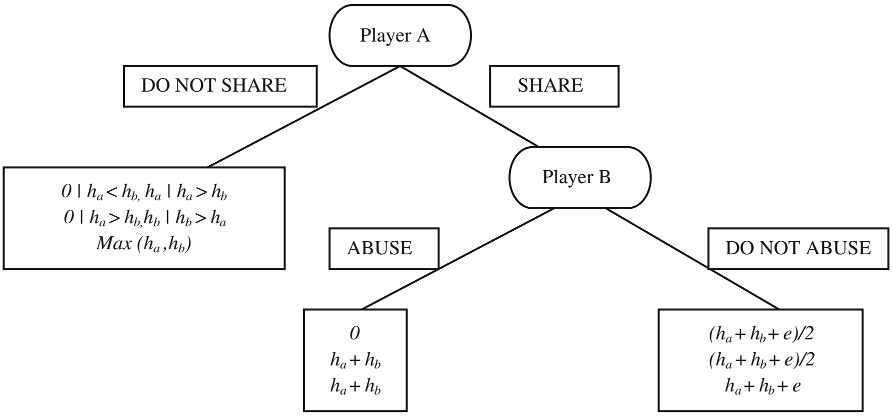

Fig. 1 The uniperiodal full information game

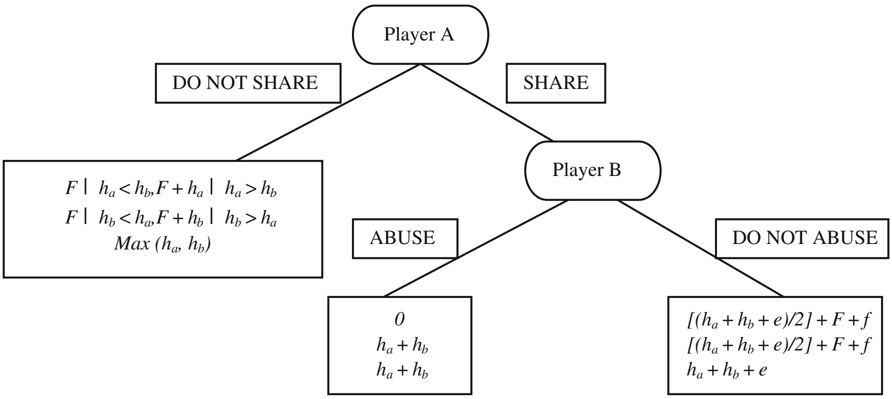

Fig. 2 The uniperiodal full information game with relational goods

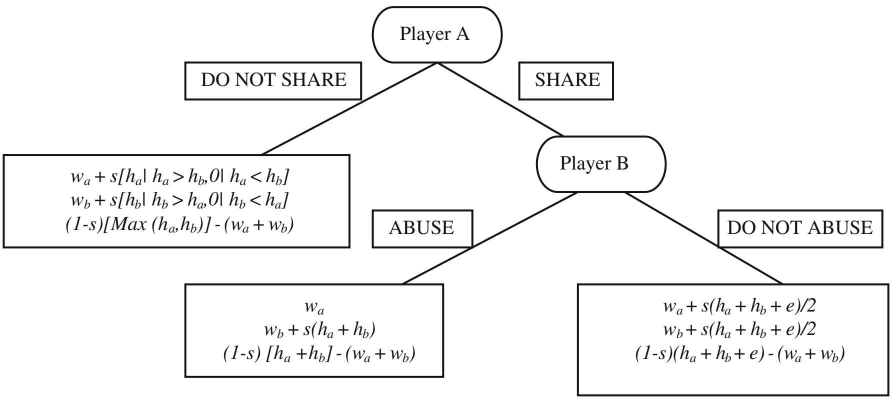

Fig. 3 The uniperiodal full information game with pay for performance schemes

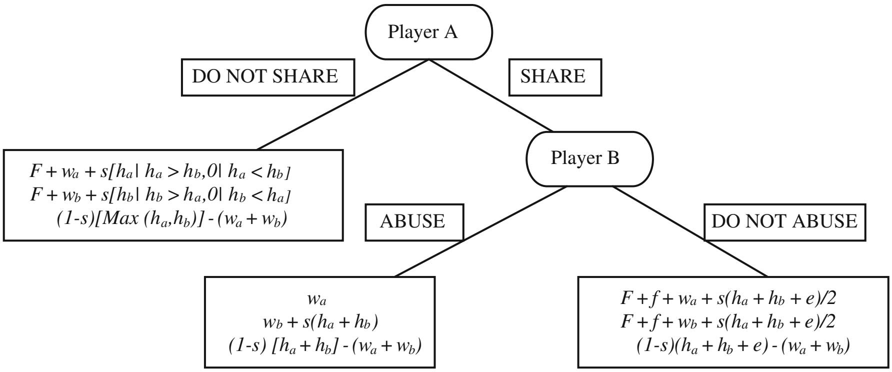

Fig. 4 The uniperiodal full information game with relational goods and pay for performance schemes

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