Relational Incentive Contracts with Hidden Action and Unequal Discounting*

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Abstract

We analyze relational incentive contracts with hidden action when the principal and the agent have different discount factors. We show that there is a new trade-off between rent extraction and incentive provision, and the optimal contract may be non-stationary, even without private information or limited liability constraint. We characterize the condition under which the trade-off exists, as well as the condition for the optimality of non-stationary contracts, and then analyze the relationship between the rent captured by the agent and exogenous parameters.

1 Introduction

The purpose of this paper is to extend the theory of relational incentive contracts with hidden action to cases where the transacting parties have different discount factors. We consider an infinitely repeated principal-agent model in which the agent's binary effort level is unobservable to the principal, and the principal offers an incentive contract in a take-it-or-leave-it fashion to motivate the agent to exert effort in every period. Both the principal and the agent are risk-neutral. The performance measure is non-verifiable, and hence the contract has to be dynamically enforceable, that is, it must satisfy self-enforcing constraints that require any

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bonus and penalty specified to be bounded above by the principal and the agent's discounted continuation payoffs (net of their reservation utilities), respectively.

The first contribution of the paper is methodological: We introduce unequal discount factors into the otherwise standard model of relational contracting with hidden action, and derive an optimal incentive contract in a way distinct from existing literature where the principal and the agent are equally patient. The other contribution is to elucidate whether and how the standard results on relational contracts under the assumption of equal discounting, such as the optimality of stationary contracts and no rent left for the agent (Levin, 2003), change with the introduction of unequal discount factors.

Furthermore, considering unequal discount factors in the ongoing principal-agent relationship has its practical motivation—they usually have different time preferences such that one of them is more patient, expecting their relationship to be longer-lived, or facing a higher cost of capital (such as internal rate of return in capital budgeting). Our analysis, hence, can link characteristics of the contracting parties, such as their size, tenure, access to financial markets, and so on, to the optimal contracts between them and the resulting division of surplus.

We allow the principal's discount factor to be either higher or lower than that of the agent. Since patience is one source of bargaining power, one might think that the principal who makes a take-it-or-leave-it offer be more patient than the agent. We however think that situations where the impatient principal can make a take-it-or-leave-it offer are not unreasonable. As Lyon and Rasmusen (2004) argue, an "advantage of economic theory over looser thinking about bargaining is that this definition of bargaining power distinguishes strong bargaining power from a strong bargaining position. (p.151)" For example, the regulator and the CEO facing elections and other turnover possibilities near future may be more interested in short-term outcomes than the regulated firm and the lower-level manager, respectively. Furthermore, our analysis of the less patient principal applies with minor modifications to the case in which the less patient agent makes a take-it-or-leave-it offer such as the relationship between an entrepreneur and investors, the former of which has scarce and valuable business ideas but can raise money only at a higher interest rate. In financial contracting literature, the entrepreneur is often assumed to be relatively impatient than the financiers but has all the bargaining power at the initial date (see, e.g., Biais et al. (2013) for an overview).

We first confine our attention to stationary contracts, and derive the optimal stationary contract that maximizes the principal's expected payoff. When the principal's discount factor is at least as high as a threshold, the optimal contract simply consists of a bonus to provide effort incentives and a fixed salary (or,

equivalently, an up-front payment) such that the agent's individual rationality constraint is binding and hence no rent is left to him every period. The principal will not renege on the bonus because she is so patient that the future payoff matters more than the benefit from reneging. While the optimal stationary contract is the same as the standard one under equal discount factors, the way we derive the optimal contract is distinct from that in existing literature because adding up the relevant constraints does *not* eliminate the monetary transfer parts when the discount factors are unequal.

When the principal's discount factor is lower than the threshold, bonuses alone are not enough to provide effort incentives because the principal's continuation payoff is too low for her not to renege on the payment of the bonus needed for effort provision. In this case, however, if instead the agent's discount factor is at least as high as the threshold (and hence the agent is more patient than the principal), it becomes worthwhile to use some penalty to supplement incentives, even though it requires leaving the agent some rents for him not to renege on the payment of the penalty. The trade-off between rent extraction and incentive provision arises even though the agent neither faces the *ex post* limited-liability constraint nor has private information at the beginning of each period. Intuitively, when the principal is less patient than the agent, transferring payoff to the agent can *increase* the joint continuation payoff and making the implementation easier by relaxing the bound on penalty more than tightening the bound on bonus. Hence, when the principal is impatient enough (so that effort cannot be implemented without giving rent to the agent) and the agent is patient enough, it becomes optimal for the principal to leave some rent to the agent by using penalty to make up the effort incentive that the bonus is not enough to provide by itself.

Finally, if both parties' discount factors are lower than the threshold, the agent reneges on the payment of the penalty even under the contract that consists of the penalty and a fixed salary only and hence leaves all the rent to the agent.[1]

Stationary contracts are in general suboptimal, however, when the principal and the agent have unequal discount factors. There are two reasons for this. First, the principal and the agent benefit from engaging in intertemporal payoff trading via non-stationary contracts. The optimal intertemporal trading expands the Pareto frontier, so that it is no longer a straight line with slope -1. Along the Pareto-optimal path, the stage payoff to the more patient party is increasing and that to the less patient party is decreasing over periods. This implies that while

[1]Note that our analysis clearly distinguishes between bonuses and penalties as incentive devices, that are often pointed out as algebraically equivalent if no behavioral effect unless some psychological elements are taken into account (see, for example, Lazear, 1995). However, in this paper we do not intend to offer any explanation concerning under what conditions these contracts are used in practice.

the stage payoff to the less patient player cannot drop below his/her reservation payoff, that to the more patient player *can* be lower than his/her reservation payoff for some periods.

If the principal is more patient than the agent, allowing non-stationary contracts does not alter the optimality of a stationary bonus contract because the principal must guarantee the less patient agent at least his reservation payoff every period, and she can attain the maximum stage payoff by a stationary bonus contract. If the principal is less patient, however, intertemporal payoff trading via a non-stationary contract benefits her. The optimal "semi-dynamic" contract, that explores intertemporal payoff trading but provides the agent with effort incentives only by current payments (bonus and penalty), entails a decreasing bonus plan, accompanied with an increasing penalty schedule, in order to ensure the agent's effort incentives. The fixed salary is an increasing, "seniority-based" plan in order to compensate the diminishing payment due to the decreasing bonuses and increasing penalties, as well as to backload payoffs to the agent and guarantee him larger stage payoffs in later periods.

The second reason why stationary contracts are suboptimal is that the less patient principal may be able to extract more rent from the agent by making his continuation payoffs contingent on the current output, although they then have to deviate from the optimal intertemporal trading and hence their payoff vector is short of the Pareto frontier. We show that if the optimal semi-dynamic contract has to leave some rent to the agent, the optimal "dynamic" contract is a "promotion contract" under which his average payoff does not decrease with low output and one-time success (high output) moves his payoff to the one prescribed by the optimal semi-dynamic contract. And termination never occurs on the equilibrium path.

We also obtain several comparative statics results about the agent's rent. The rent is decreasing in the surplus of the relationship, and is increasing in the reservation utilities of both parties. An increase in the surplus of the relationship makes it easier to satisfy the self-enforcing constraints, and hence shifts the optimal contract toward more use of bonuses, thereby reducing the rent to the agent. An increase in the reservation utility of either party makes it harder to satisfy the self-enforcing constraints, and hence increases the rent to the agent via a change of the optimal contract toward more use of penalties. The agent weakly prefers less advanced contracting technology because his rent decreases as the optimal contracting form improves from stationary to semi-dynamic, and from semi-dynamic to dynamic contracts.

In the literature on repeated games, Lehrer and Pauzner (1999) study two-player repeated game with unequal discount factors to show how intertemporal

payoff trading expands the Pareto frontier and prove a folk theorem result that outcomes on the frontier can be achieved as equilibria as discount factors converge to one with the relative patience between players fixed. Their folk theorem result is extended to n-player games (Chan and Takahashi, 2012) and to imperfect public monitoring (Sugaya, 2015). We also follow Lehrer and Pauzner (1999) to expand the Pareto frontier, but non-stationary contracts are used for intertemporal payoff transfer in our paper. Fong and Surti (2009) confine their attention to repeated prisoners' dilemma with unequal discounting, but instead extend Lehrer and Pauzner (1999) by introducing the possibility of voluntary side payments at the beginning of each period. Side payments are used to provide incentives to cooperate as well as to trade payoffs across periods. They show that providing incentives for the impatient player and intertemporal payoff trading may conflict with each other, and full cooperation may be Pareto dominated by partial cooperation in which only the patient player chooses cooperation.

Most literature on relational contracts assumes equal discounting: For example, a recent survey chapter Malcomson (2013) contains no discussion of unequal discounting. Some of the recent papers on dynamic principal-agent relationships assume that the principal and the agent have different discount factors (Biais et al., 2007, 2013; Hoffmann et al.,2017; Krasikov et al., 2017; and Opp and Zhu, 2015). However, they exclusively focus on the case where the principal is more patient than the agent, and hence the principal benefits from *frontloading* rewards to the agent. In these papers, backloading of the agent's payoffs arises from the features other than unequal discounting, such as no hidden action (Opp and Zhu, 2015), limited liability ((Biais et al., 2007, 2013), persistent private information (Krasikov et al., 2017), and persistent hidden action (Hoffmann et al., 2017). And they do not consider the dynamic enforcement issue that the principal and the agent may renege on payments contingent on unverifiable performance measures. In contrast to them, in our model there is no reason to either frontload or backload the payoffs to the agent if his discount factor is the same as that of the principal. We then highlight how the optimal incentive contract is affected when unequal discounting and the dynamic enforcement condition for incentive contracts interact.

In relational contracting literature, the agent may enjoy a positive information rent when the agent's type is his private information (Yang, 2013; Ishihara, 2016; Malcomson, 2016) or a positive limited-liability rent when the agent is protected by the ex post limited liability (Fong and Li, 2017). The agent's rent in our model is clearly different from the information rent because there is no adverse selection in our model. Our agent's rent is also different from the limited-liability rent. The latter exists because a bound is imposed on penalty exogenously, and, because

there need to be enough difference between bonus and penalty to induce effort, bonus is push up to the point that the agent obtains more than his reservation utility in expectation. In contrast, there is no exogenous bound for penalty in our model.[2] The agent still enjoys a rent if the principal is so impatient that giving all the surplus to the principal is not enough to ensure her paying the bonus needed, and the agent is patient enough so that giving him all the surplus is enough to guarantee him paying the penalty needed. The key observation is that when the agent is more patient than the principal, raising the agent's pay increases the continuation payoff to the agent (the room for using penalty) *more* than it decreases the continuation payoff to the principal (the room for using bonus). This is why substituting some bonus with a penalty can restore the incentive in relational contracts given that using bonus alone cannot provide enough incentive.

Although there no limited-liability constraint in our model, Fong and Li (2017) is still closely related to ours because in their model with equal discounting, the principal, facing the dynamic enforcement constraint, wants to defer rewards to the agent as our impatient principal does. This feature generates dynamics similar to theirs in our analysis of dynamic contracts. In their online appendix they also study the extension that the principal is more patient than the agent. In contrast to our result that a stationary contract is optimal in such a case, they show that the optimal contract can be non-stationary because of their limited-liability assumption. Importantly, while there will never be termination in our model, inefficient termination occurs with a positive probability in Fong and Li (2017). In our model, inefficiency takes the form of deviation from the efficient intertemporal payoff trading that expands the Pareto frontier.

The rest of the paper is organized as follows. Section 2 introduces the baseline model. Section 3 contains the analysis of the benchmark case when the discount factors are the same. Stationary contracts and non-stationary contracts are analyzed in Sections 4 and 5, respectively. Section 7 discusses some potential applications and concludes.

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[2]We impose a lower bound on the *expected* total payment to the agent in order to make the optimization problem well-defined when we analyze non-stationary contracts. This assumption does not generate a positive rent in the equal discounting case.

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