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# Renegotiation-proof relational contracts

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ABSTRACT

We study infinitely repeated two-player games with perfect monitoring and assume that each period consists of two stages: one in which the players simultaneously choose an action and one in which they can transfer money to each other. In the first part of the paper, we derive simple conditions that allow a constructive characterization of all Pareto-optimal subgame perfect payoffs for all discount factors. In the second part, we examine different concepts of renegotiation-proofness and extend the characterization to renegotiation-proof payoffs.



## 1. Introduction

Relational contracts are self-enforcing informal agreements that arise in many long-term relationships, often in response to obstacles to write endogenously enforceable contracts. Examples include the non-contractible aspects of employment relations, illegal cartel agreements, or buyer–seller relations in which complete formal contracts are too costly to write. Agreements between countries also often have the nature of a relational contract, when there is no institution that is able or willing to enforce compliance with the agreed terms. In these examples, monetary transfers play a role in the relationships, be it in form of prices, bonuses, or other compensation schemes, and could thus also be used to sustain the relational contract. Moreover, the relational contracts are drafted and negotiated, and meetings continue to take place as the relationship unfolds. In this paper, we analyze relational contracts under these circumstances: with renegotiation and the possibility to make monetary transfers.

As an illustration how side payments can be used in a relational contract, consider the case of collusive agreements. Cartels sometimes use compensation schemes to make sure that each firm in the cartel stays with the target (see Harrington, 2006, for details[1]). A cartel member that violates the agreement is required to buy a certain quantity from a competitor, or to transfer a valuable customer to a competitor. Such compensation schemes seem more robust to renegotiation than threatening with an immediate price war after a violation of the agreement. Price wars are costly for all firms, and therefore cartel members will be tempted to agree to ignore the violation. In contrast, if a deviating firm must pay a fine, competitors gain from the punishment and have therefore no incentive to renegotiate the agreement. However, to induce a firm to pay

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[1] For a list of cartels in which such compensation schemes have been used see the introduction of Harrington and Skrzypacz (2007), who offer a theoretical analysis of collusion with imperfect monitoring.

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the compensation there must be the threat of a real punishment in case no payment is made, i.e., a punishment that does not require the voluntary participation of the punished firm. Renegotiation can then again play a role.

The present paper investigates these issues and provides a characterization of feasible payoffs given arbitrary discount factors. We study infinitely repeated two-player games with perfect information in which players can make monetary transfers before they play a simultaneous move stage game. We translate Abreu's (1988) optimal penal codes to this set-up and show that every Pareto-optimal subgame perfect payoff can be achieved using a class of simple strategy profiles, which we call *stationary contracts*. In a stationary contract, the same action profile is played in every period. A player who deviates from an action is required to pay a fine to the other player, and after payment equilibrium play is resumed. If a player does not make a required payment, a punishment action profile is played once and then a lower fine is imposed on the player. Afterwards play continues as on the equilibrium path. Monetary transfers are useful not only because of the possibility to punish with fines, but also because any feasible distribution of the surplus can be achieved by incentive compatible up-front payments. In addition, equilibrium path payments in later periods can be used to balance incentive constraints between the two players.[2]

In the second part of the paper, we analyze different concepts of renegotiation-proofness and show that one can typically restrict the analysis to the simple class of stationary contracts to find payoffs that survive these renegotiation-proofness refinements. All considered concepts share the idea that renegotiation is deterred if players cannot achieve a Pareto improvement by renegotiating to an alternative continuation equilibrium chosen from an appropriate set.[3] Since a period consists of two stages, a crucial question is at what times renegotiation is possible. In the existing literature, different assumptions have (often implicitly) been made. For example, Fong and Surti (2009) assume in their study of repeated prisoner's dilemma games with side payments that renegotiation is possible before both the payment and the play stage, while Levin (2003) assumes in his study of repeated principal-agent relationships that renegotiation is only possible before the payment stage.

Levin observes that the possibility of renegotiation before the payment stage does not alter the Pareto frontier of implementable payoffs. This observation easily extends to our set-up in which both players can take actions. The reason is that punishment at the payment stage takes the form of the deviator paying a fine to the other player immediately followed by a return to equilibrium play. Hence, in a Pareto efficient stationary contract, all continuation equilibria that start at the payment stage achieve the highest feasible joint continuation payoff. This means that if renegotiation is allowed only before payments can be made, the threat of inefficient continuation play (which is necessary to induce payment of the fine) is never subject to renegotiation.

For the main part of the analysis we also allow renegotiation before the play stage. Even having fixed the timing of renegotiation, there exist several concepts of renegotiation-proofness.

We first adapt strong perfection (see Rubinstein, 1980) to our setting. A subgame perfect equilibrium is strong perfect if all its continuation payoffs lie on the Pareto frontier of subgame perfect continuation payoffs. In general, the set of strong perfect equilibrium payoffs is a subset of the Pareto frontier of subgame perfect payoffs, but it may well be empty. We show that every strong perfect payoff can be achieved by a stationary contract and derive simple conditions that allow to check for strong perfection. These conditions are used to show that in a simple principal-agent game strong perfect stationary contracts always exist, while in other games they fail to exist.

We then analyze the concepts of weak renegotiation-proofness (WRP) and strong renegotiation-proofness (SRP) introduced by Farrell and Maskin (1989). An equilibrium is WRP if none of its continuation equilibria Pareto-dominate each other. This captures the idea that a necessary condition for renegotiation-proofness is that players never want to renegotiate to an alternative continuation equilibrium of the original contract.[4] Strong renegotiation-proofness requires that all continuation equilibria lie on the Pareto frontier of weakly renegotiation-proof payoffs. We show that if the discount factor is not below $\frac{1}{2}$, every Pareto-optimal WRP and every SRP payoff can be achieved by a stationary contract. The set of SRP equilibria may be empty for intermediate discount factors, but we provide simple sufficient conditions to check for existence. For discount factors below $\frac{1}{2}$, stationary contracts cannot always be used; instead the implementation of Pareto-optimal WRP payoffs can sometimes require alternation between different action profiles or money burning on the equilibrium path, as we illustrate for a prisoner's dilemma game.

Our analysis is most closely related to the work of Baliga and Evans (2000), who study asymptotic behavior of SRP equilibria in a setting in which payments and actions are chosen simultaneously. They establish that the set of SRP payoffs converges to the Pareto frontier of individually rational stage game payoffs when players become infinitely patient. Since under simultaneous choice of actions and payments inefficient action profiles are subject to renegotiation, their set-up is more closely related to our analysis where renegotiation before play stage is possible than to the case where only renegotiation before payment stages is considered. Our approach differs because we allow arbitrary discount factors and a sequential

[2] In Goldlücke and Kranz (2012), we show how the subgame perfection results naturally extend to $n$ players. In this companion paper, we analyze games with imperfect public monitoring, and addresses the case of perfect monitoring as a special case. It also contains a detailed discussion of how monetary transfers facilitate the computation of equilibrium payoffs and a comparison with computation procedures if no transfers are allowed.

[3] That Pareto improvements are necessary for successful renegotiation can be motivated by the idea that the original continuation equilibrium provides the fall back option (or disagreement point) if renegotiations should fail. See Miller and Watson (2012) for an alternative approach to model renegotiation and disagreement points in a repeated games with transfers.

[4] Weak renegotiation-proofness is the terminology of Farrell and Maskin (1989). Bernheim and Ray (1989) introduce an essentially identical concept and call it *internal consistency*.