



Notes

# One-to-many bargaining when pairwise agreements are non-renegotiable

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## Abstract

We study a model where a central player (the principal) bargains bilaterally with each of several players (the agents) to create and share the surplus of a coalitional game. It is known that, if the payments that were previously agreed (with each of the remaining agents) are renegotiated in case any bilateral negotiation permanently breaks down, then the Shapley value is the unique efficient and individual rational outcome consistent with bilateral Nash bargaining. Here we show that when instead the agreed payments cannot be renegotiated the outcome is also unique but it now coincides with the Nucleolus of an associated bankruptcy problem. We provide a strategic foundation for this outcome. Then we study how such renegotiation affects the principal's payoff according to the properties of the surplus function. We find, for example, that renegotiation benefits the principal when agents are complements and it hurts him when they are substitutes (situations with, respectively, increasing and decreasing marginal contributions).

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## 1. Introduction

In many situations, a central player (the principal) bargains bilaterally with each of the remaining players (the agents) to create and share a surplus which varies with the set of agents

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reaching an agreement—a structure that allows for “partial” cooperation if an agreement is not reached with every agent. Examples of these situations include a firm bargaining over wages with each of several workers, a drug developer acquiring rights to use multiple patents, or a consumer buying different products from multiple sellers.

Stole and Zwiebel [28] studied how the surplus is shared in these situations when the payment agreed by the principal with each agent in a bilateral negotiation divides evenly the gains from this pairwise agreement relative to their respective disagreement payoffs—as in bilateral Nash bargaining. To determine those disagreement payoffs they assumed that if any pairwise agreement fails to be reached then the agreements with all remaining agents must be *renegotiated*. They showed that in that case the Shapley value is the unique *stable outcome*, i.e., the unique individual rational and efficient payoff vector consistent with bilateral Nash bargaining. That outcome is also a subgame perfect equilibrium of an alternating-offers bargaining game where all pairwise agreements must be negotiated anew once any bilateral negotiation breaks down.

However in practice it is not always simple or feasible to bargain agreements anew. There may be, for example, significant legal costs or some time during which agreements simply cannot be terminated. The question is whether the absence of such renegotiations will hurt or benefit the principal. The answer would, for example, help us understand why sometimes the principal prefers long-term agreements and other times a succession of short-term pairwise agreements—which usually rollover but could all be renegotiated almost immediately if any other bilateral negotiation permanently breaks down.

To address these issues we here study a situation where payments, once agreed, are *non-renegotiable*. In this case we determine the disagreement payoffs assuming that, if any pairwise agreement is not reached, the payments agreed with all remaining agents must still be paid in full from the surplus of partial cooperation. Thus, the principal becomes the residual claimant of that surplus. This captures the fact that in practice, if a firm is unable to honour its obligations, a court will typically make use of any available surplus to serve as much as possible those obligations.

We show that in this situation a *stable outcome* also exists and is unique, but it now coincides with the Nucleolus of an associated bankruptcy problem where each player’s marginal contribution to the total surplus forms a claim—bankruptcy problems were formalized by Aumann and Maschler [2]. Accordingly in equilibrium each agent is paid the minimum of half his marginal contribution and what the principal receives—being the latter determined endogenously.

This stable outcome can easily be visualized by a system of communicating vessels where each player  $i$  is represented by a vessel with a height equal to his marginal contribution ( $\Delta_i$ ) (see Fig. 1 below). The vessel of each agent is sealed at half its height while the principal’s (player 0) vessel is left unsealed. Once we introduce in the system an amount of liquid equal to the total cooperative surplus  $v(M)$ , it becomes distributed in the vessels according to the unique stable outcome when agreements are non-renegotiable.

Moreover we show that, when this stable outcome lies in the strict Core, it is also a subgame perfect equilibrium of an alternating-offers bargaining game where the payments once agreed cannot be renegotiated. Situations where this outcome lies in the strict Core include, for example, both those cases where agents are substitutes and cases with strong complementarities—such as when only cooperation by all players has a positive worth. In the former case each agent receives half his marginal contribution, and in the latter an equal share of the surplus—and therefore less

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