



# A non-cooperative bargaining theory with incomplete information: Verifiable types

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## Abstract

We consider a non-cooperative sequential bargaining game with incomplete information where two players negotiate for mechanisms with ex post verifiable types at the interim stage. We prove the existence of a stationary sequential equilibrium of the bargaining game where the ex post Nash bargaining solution with no delay is asymptotically implemented with probability one. Further, the ex post Nash bargaining solution is a unique outcome of a stationary equilibrium under the property of Independence of Irrelevant Types (IIT), whereby the response of every type of a player is independent of allocations proposed to his other types, and under a self-selection property of their belief.

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## 1. Introduction

We consider a two-person bargaining problem with incomplete information in which each player has private information about his type. Knowing their own types, players negotiate for

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a contract (or a mechanism) that is a contingency plan that prescribes a joint action for every possible type profile of players. Players' private information may affect their preferences over agreements. To reach a preferable agreement, players may want to reveal or conceal their types. Private information may leak through actions in negotiations. A bargaining situation is called a case of *verifiable types* if players' types become publicly known and verifiable when an agreement is implemented. In the other case of *unverifiable types*, a contract should satisfy the Bayesian incentive compatibility so that players have incentives to disclose their types truthfully at the time of implementation.<sup>1</sup> To focus on the analysis of bargaining behavior with incomplete information, we assume the condition of verifiable types in this paper.

As an example, consider an insurance contract between an insurer (seller) and an insured (buyer). An insurance prescribes not only an insurance price but how much an insured should be covered for contingencies. Formally, an insurance contract is a contingency plan of allocations between the two parties. At the time of trading, both parties have only imperfect and private information about which event may happen. They negotiate for contracts based on their private information about contingencies. In negotiations, their private information may be revealed through bargaining actions such as offers and responses. In a certain case, when a contract is implemented, the insurer has a sufficient ability to verify realized damages to the insured. For example, a travel insurance company may obtain the information on damages to a customer by inspecting it, or from the third party such as a hospital and a police. In this case, the company needs not worry about a possibility of false reports by insureds. If the damage is unverifiable, then the insurer has to take into account the insured's incentive of false reports. Thus, an insurance game becomes much more complicated, and is formally modeled as a two-stage process. A sequential bargaining process is followed by a communication process where the insured reports her damages to the insurer. An insurance contract will be implemented based on reports. Our assumption of verifiable types renders the game analytically tractable.<sup>2</sup>

In this paper, we consider a [Rubinstein \(1982\)](#)-type sequential bargaining process under incomplete information. Knowing his own type, a randomly selected player proposes a contract. The other player either accepts or rejects it. If he accepts it, then the contract is agreed upon. Thereafter, a process of verification is conducted, and an action prescribed by the contract for both players' types is jointly taken. If the proposal is rejected, then there is the risk that negotiations may fail with a positive probability. In this case, a predetermined outcome results. In the example of insurance contracts, no trading prevails. If negotiations may not fail (with the remaining probability), then the game goes to the next round, and the same process is repeated until an agreement is made.

Unlike the literature on sequential bargaining with incomplete information, our approach has two special elements: mechanism (contract) bargaining and verifiable types. Players negotiate for a contract (a contingent plan) of allocations, not for a single allocation. In other words, they negotiate for allocations "type by type" under incomplete information. Together with a property on responders' behavior called Independence of Irrelevant Types (IIT), the contract bargaining can exclude equilibrium delay of agreements commonly observed in the literature. IIT means that the response of every type of a player depends only on a proposal made to himself, independent of allocations proposed to his other (irrelevant) types. The property of verifiable types simplifies

<sup>1</sup> When players' types represent their internal states such as satisfaction, risk attitudes and psychological characters, it is appropriate for us to model them as unverifiable types.

<sup>2</sup> Two classic works by [Harsanyi and Selten \(1972\)](#) and [Wilson \(1978\)](#) on mechanism bargaining with incomplete information also employ this assumption.

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