Barter Double Auction as Model for Bilateral Social Cooperations

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August 4, 2009

Abstract

The idea of this paper is an advanced game concept. This concept is expected to model non-monetary bilateral co-operations between self-interested agents. Such non-monetary cases are social co-operations, for example, allocation of high level jobs or finding a suitable partner to marry. In a barter double auction, there is a set of agents. Every agent has a vector of parameters which specifies his demand and a vector which specifies his offer. Two agents can achieve an agreement through a barter exchange. The level of satisfaction (a number between 0% and 100%) of an agent is as high as small is the distance between his demand and the accepted offer. This paper introduces some facets of this complex game concept.

1 Introduction

In artificial intelligence, an agent can be designed to be humanlike or rational [8, p.2]. Rationality means that an agent maximizes his payoff or the chance to achieve his goal considering what he knows and perceives. Rational and humanlike is by far not the same. It is this (seeming) absence of rationality in human behavior. "British people argue that it is worth spending billions of pounds to improve the safety of the rail system. However, the same people habitually travel by car rather than by train, even though travelling by car is approximately 30 times more dangerous than by train!"[4, p.527–530]. Nevertheless, economists model business interactions as interactions between rational self-interested agents. For instance, a loyal manager is expected to choose the action which maximizes the profit of his firm.

Achieving a goal makes an agent 'happy'. "Because 'happy' does not sound very scientific, the customary terminology is to say that if one world state is preferred to another, then it has higher utility for the agent" [8, p.51]. For (small group) strategic interactions, economists use game theory. In the game theory the utility is also called the payoff. Game theory models rational behavior in strategic interactions. One can say that an agent will be twice as 'happy', if he gets a doubled payoff. The experimenters, who try to explain the difference between the human behavior and the game theoretic predictions, accept the previous sentence at face value and pay their subjects according to their performance [5]. But the money is not a measure for the happiness [3]. The safety is also not a measure for the happiness, as it has been mentioned in the rail system example. Payoff is not bounded, happiness is - one can be fully happy or unhappy. For non-monetary interactions, happiness can be quantified by a satisfaction level which is a number between 0% and 100% [2].

This work addresses the question of how to reason strategically if one wants to maximize his level of satisfaction in a non-monetary domain. Strategic reasoning means taking into account the reasoning of other agents [6]. Participants of a non-monetary strategic interaction are interested in achieving the highest satisfaction level and their success, in part, depends on decisions of other participants. These issues can be studied using game theory. "When the chips are down, the payoff is not five dollars but a successful career, and people have time to understand the situation-the predictions of game theory fare quite well."[Robert Aumann[1]]. Bilateral co-operations are chosen as a specific example for a non-monetary strategic interaction. How can an agent become as much 'happy' as possible in a non-monetary bilateral interaction, where agents not always behave rationally? To answer this question a new game concept is introduced, namely, the barter double auction.

Outline In section 'previous work', we describe different types of auctions. The section after introduces a mathematical concept of a barter double auction. Section 4 contains a preliminary summary of extreme cases for the barter double auction and explains possible solutions to them. Section 5 concludes the work.

[1] Laureate of Nobel Memorial Prize in Economics

2 Previous Work

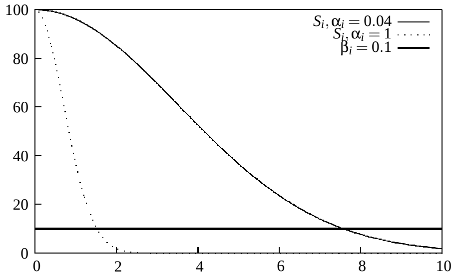

Figure 1: Satisfaction level in % (y-axis). The x-axis is the distance between demand and offer.

From the game theoretic point of view, an auction is a mechanism for structured negotiation of terms for a co-operation. For instance, if Alice wants to sell an item L and get as much money as possible for it, she announces it on eBay[1]. Bob is highly interested in L and bids the highest value. Alice is interested in money, while Bob is interested in L offered by Alice. The cooperation is the exchange and the terms of this cooperation is the price of L. There are many types of auctions, such as English auctions, Dutch auction, and double auction. In general, every item can be acquired only in exchange to money, but not other items.

At the same time, there are markets, such as the car market for example, where participants do not limit there relationships to selling or buying for money only. [7] introduces a concept of 'differential auction-barter' (DAB) for such cases. DAB is the hybrid between a money-based auction and barter. In DAB, participants exchange their items under the condition that they pay the difference of their personal values. This example shows that there are cases of co-operations in modern markets, which require advanced auction models. The following section introduces a novel model for regulating barter relationships among trading partners.

3 Barter Double Auction

Let N be the number of agents participating in a barter double auction. Each agent i in this set has an offer O_i and a demand D_i. The offer is defined as a vector in a multi-dimensional space. Every dimension embodies one certain characteristic of the offer. The demand is defined in the same way. If two agents i and j cooperate, the agent i gets the offer O_j and the agent j gets the offer O_i. The cooperation is a barter exchange. If an agent i gets an offer which is equal to his demand, he gets what he needs. This means that his satisfaction level S_i is 100%. In general, one can approximate mathematically the relation between the satisfaction level and the mismatch of the offer by using the Euclidean distance $\text{dist}(D_i, O_j)$ between

Alice\Bob	Allure/Accept	Ignore
Allure/Accept	S_{Bob} S_{Alice}	β_{Bob} $\beta_{Alice} * \gamma$
Ignore	$\beta_{Bob} * \gamma$ β_{Alice}	β_{Bob} β_{Alice}

Table 1: Satisfaction matrix for a bilateral non-monetary cooperation.

the demand D_i and the offer O_j:

$$S_i = e^{-\alpha_i * \text{dist}(D_i, O_j)^2}$$

$\alpha_i > 0$ is a constant value which defines the sensitivity of the agent's satisfaction level to the mismatch of the offer. $0 < \beta_i < 1$ will be the default satisfaction level, if the agent does not cooperate. Fig.1 shows the plots of the satisfaction level for different α. It shows also the plot of β. As can be seen from the figure, if the mismatch of the offer achieves a certain level, an agent will not accept it. Two agents Alice and Bob will cooperate assuming rationality, if the satisfaction levels of both agents exceed the non-cooperative case. Tab.1 shows the satisfaction matrix. The lower left corners of this matrix contain outcomes of Alice and the upper right corners contain the outcomes of Bob. Alice can choose between rows and Bob can choose between columns. Each agent can either allure(accept) or ignore a cooperation with the other agent. Alluring an ignoring agent diminishes the non-cooperative satisfaction level. This value $0 < \gamma_i < 1$ is called the frustration factor of an agent. In the context of game theory, there are two equilibrium in pure strategies at most - mutual alluring(accepting) or ignoring. If an agent i allures m different agents and gets no results, he achieves the satisfaction level $\beta_i * {\gamma_i}^m$.

In the double auction case, every agent allures agents with the best matching offer and is allured by other agents in its turn. The protocol for an agent in the barter double auction is following:

1. Allure a subset of agents.
2. Accept one or none of the alluring agents. Ignore the rest.
3. Confirm one of the accepts. Defect the rest.

To understand the barter double auction, one needs a graphical representation. The number of dimensions is reduced to two. A demand is a circle and an offer is

Figure 2: Graphical representation of an agent's type & the special seesaw type.

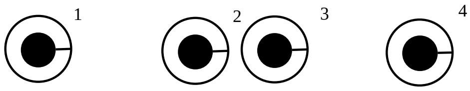

Figure 3: A set of seesaw types.

a point on a surface. If a couple of agents have a certain demand O_h and a certain offer D_h, they are considered to be of the same type $T_h = (O_h, D_h)$. An agent's type is represented through a connection between a circle and a point. Fig.2 (left) shows a type of a couple of agents.

4 Case Study

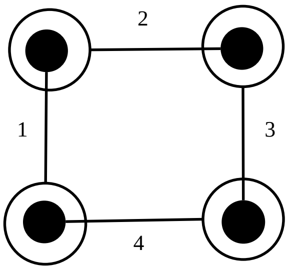

Figure 4: Cycling demand.

Let us consider the simplest example of the barter double auction. A number of children want to play with seesaws. A seesaw is a toy; only two persons of approximately the same weight can play with it. This means that each player needs a partner of approximately the same weight. The partner is interested in the same. In this scenario, the demand of an agent is equal to his offer. Fig.2 (right) shows this type. If the children are all of the same weight, they will have to coordinate. Due to the fact that there is no difference between partners, an agent would randomly choose a partner. In this case, every agent allures only one agent and he will allure none of them, if he is already allured. If the number of agents is not even, then there will be one agent who has nobody to cooperate with. If there are many children with different weights, every agent will cooperate with the best matching agent. Fig.3 shows such an example. If there is only one agent for each

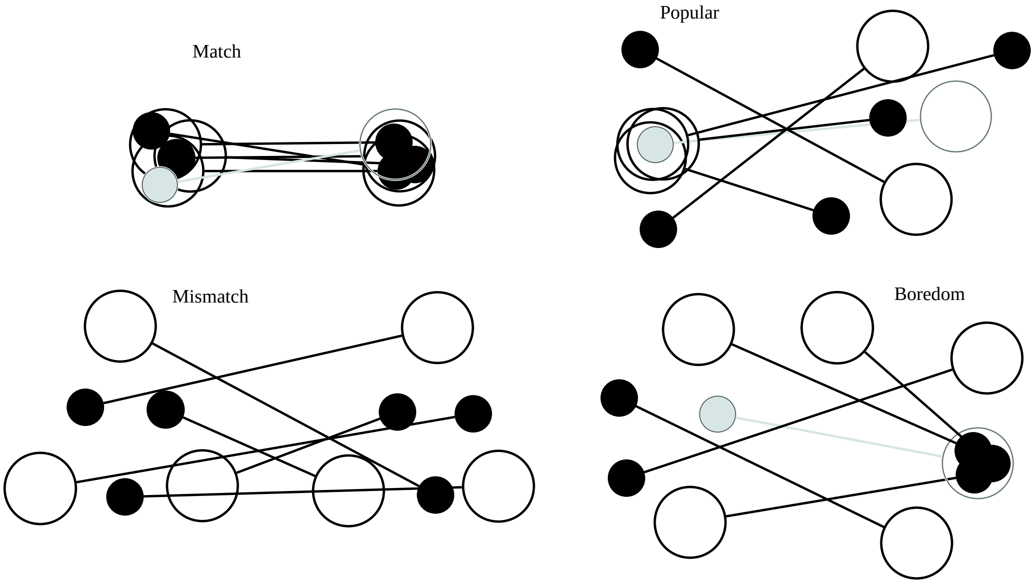

Figure 5: Cases for bipartite agent types.

type, there will be two agents (of type 1 and 4) which will get a very low satisfaction level, if they cooperate.

Let us consider a more advanced case. Fig.4 shows a system of four types. For simplicity, there is one agent per each type - agent A for type 1, agent B for type 2 and so on. Agent A can get three different offers. Best matching is the offer of agent D. The worst matching is the offer of agent B. If each agent allures agents with the best and the average matching offer, then each agent will be allured by agents with the average and the worst matching offer. If each agent accepts the better one, agent A will cooperate with agent C and agent B will cooperate with agent D. This means that in this cycling offer example, each agent achieves the average satisfaction level.

The real world examples for the barter double auction are allocations of high level jobs or sexual relationships among humans. The value of a job offer can not be reduced to the money one can earn there. For a job offer like the position of a lecturer, one also considers the climate, country, language, scientific level and so on. The same would be if one is searching for a marriage partner. Both examples are bipartite (in heterosexual case) systems of agents' types. This means that there are two categories of offers and two categories of demands. If an agent has an offer of the one category, he will have a demand of another category. There can be 4 different cases (Fig.5). In the case of 'match', the agents must only coordinate as in the seesaw example. In the case of 'mismatch', the agents can not achieve any valuable satisfaction level. Most would not cooperate at all. In the case 'popular', there is an agent who is wooed by agents with an offer of another category and can choose the best offer. In the case of 'boredom', there is an agent whose demand is exactly the average offer. This agent considers a lot of agents who can provide him with a high satisfaction level. The only problem of this agent is to find an agent who is interested in his offer. These four cases can be also combined. For instance, if an agent's demand is the average offer and his offer is the average demand, he will have the chance to find the best matching cooperation partner.

5 Conclusions

In this paper, a new game concept is introduced. This concept is the barter double auction. The concept is introduced in a very preliminary way. Nevertheless, it can be used to model non-monetary strategic interactions.

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