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Exogenous coalition formation in the e-marketplace based on geographical proximity

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ABSTRACT

This paper considers a model for exogenous coalition formation in e-marketplaces. Using its informational advantage, an e-retailer creates coalitions of customers based on geographical proximity. Most of the literature regards this process as endogenous: a coalition leader among the buyers bundles eventual purchases together in order to obtain a better bargaining position. In contrast – and in response to what is typically observed in business practice – we analyse a situation in which an existing e-retailer exogenously forms customers' coalitions. Results of this study are highly encouraging. Namely, we demonstrate that even under highly imperfect warehouse management schemes leading to contagion effects, the proposed combined delivery service may offer significant efficiency gains as well as opportunities for Pareto improvement.

1. Introduction

Over the last decade, electronic marketplaces have witnessed considerable growth and development in terms both of volume and value. However, in spite of the very diverse contributions from the scientific world for the obvious opportunities of virtual marketplaces, the methods used in practice are still usually very simple (cfr. Tsvetovat et al., 2000). Although the efficiency and low costs of electronic communication offer numerous possibilities for economic agents to meet and cooperate (*i.e.*, to form coalitions), it is still rare for companies to facilitate or provide such collaboration. Among the few current examples include Ag Guild from Chicago,[1] US Iowa-based e-markets[2] or Accompany.com and Mercata.dcom[3] as well as Aerogistics.com.[4] A related theoretical literature has focused mainly on the opportunities for volume discount, essentially proving that in terms of business practice there is room for an additional intermediary. The Internet has turned this intermediary into a virtual marketplace, where contributors are possibly able (depending on the design of the market mechanism) to appropriate all the benefits.

In this paper, we consider coalition formation in e-marketplaces from a different perspective. We study whether the purchase orders of different customers from the same geographical location could be pooled together (thus, forming coalitions of customers) in order to generate savings on shipment costs.[5] Our approach is based on an informational advantage that a seller has over the buyers. In particular, a seller knows the locations and purchase details of all the buyers whereas buyers only know, in principle, their own information. Consequently, the seller may easily form coalitions of orders (which process is referred to as coalition formation being *exogenous* to the buyers), creating opportunity for shipment cost reductions. We demonstrate that, even under highly demanding assumptions of an imperfect warehouse management system as well as contagion effects due to delivery defaults, combining orders can

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[1] Ag Guild is a corporation founded by 35 farmers, with an average of 150 acres of land each. Every producer pledges 10% of his or her output to the management of the guild, which specializes in organizing production and marketing of corn and soybean crops. The guild buys production inputs and sells final products. Companies which buy and process agriculture find it easier to negotiate with one large seller than with 35 smaller farmers. Similarly, the guild, as a buyer of production inputs, has the power to negotiate better prices by aggregating demand. Farmers can pool orders *via* the Internet. The first farmer specifies the type of product he wants to buy, *e.g.*, seed, and how long the order may be open. Then other farmers can add their names to the list (cfr. Robinson, 2000).

[2] A leader in agricultural-based e-commerce, serving more than 14,000 agrifood companies, grain elevators, and producers (cfr. Robinson, 2000).

[3] These companies allow potential purchasers to form buying coalitions, and offer volume discounts based on the size of the group.

[4] This company allows manufacturers of diverse aerospace components to form consortia to bid for larger contracts.

[5] Note that we are not in this paper considering the problem of routing of deliveries within or between geographic areas. We assume that delivery is undertaken by some exogenous courier service provider and our focus is only on the e-retailer's perspective.

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be beneficial to e-retailers. This benefit also occurs even when potential savings are redistributed to customers, because such a strategy leads to a general Pareto improvement. The proposed mechanism is not only able to increase profits in the long-run but contributes to other strategic seller objectives (*e.g.*, price comparative advantage, enlargement of the potential customer base, and increased customer loyalty).

Our setting differs considerably from those analyzed in the literature.[6] The key idea behind our approach is to allow the seller to use the informational advantage it has over its dispersed customers, in order to partially or fully control the coalition formation process. This contrasts with, say, the case of Ag Guild, where orders are created spontaneously. Moreover, the benefits from coalition formation in our setting will come solely from shipment cost reductions (combined shipment discount); while we do not neglect potential volume discounts, they are not modeled in the paper.

The motivation for this choice is that the literature has convincingly demonstrated that volume discounts are a mechanism fostering coalition formation. Nonetheless, taking a longer term perspective, a forum that allows buyers to pool their orders and profit from volume discounts is essentially an intermediary; such an intermediary will develop into a retailer itself over time. With repeated activities and the emergence of some operation costs (as well as taxes!) it becomes, in effect, a regular shop. In other words, the existing literature demonstrates that there is room for one more intermediary in the purchasing process by using the informational advantages to obtain a volume discount. Conversely, this paper attempts to demonstrate that even without volume discounts, the combining of shipments guarantees Pareto improvements even under quite demanding assumptions.

Receiving purchase orders from customers in different locations, an e-retailer is in possession of a unique advantage vis-a-vis potential coalition members, namely, he already knows what purchase orders have already been placed. In principle, this allows him to offer a combined delivery service to buyers whose purchase orders arrive later, thus overcoming the informational cost. However, an important coordination issue arises here. Notably, some of the potential coalition members may have delivery times considerably shorter than some others, thus threatening the stability of a coalition. Therefore, optimal stock levels are affected adversely by the introduction of a combined delivery shipment (CDS) service; for a retailer with lower stock levels, coalitions can be formed less frequently than for those with higher availability of items, *ceteris paribus*.

This paper demonstrates that a combined delivery service can constitute an exogenous coalition formation mechanism, while the profitability of this solution depends on the preferences of the consumers as well as – crucially – on the relationship between shipment costs and the price of goods purchased. The main findings of this paper are that shipment costs can be reduced by as much as 10–20% (under the assumed parametrization). Even the application of simple combined delivery shipment (CDS) algorithms can thus significantly boost the rentability in the e-marketplace as well as induce customers to resort to this form of shopping. Consequently, value can be created economy-wide because resources are released from inefficient uses, with Pareto improvements.

From a theoretical perspective, the main contribution of this work is a new conceptualization of the issue of coalition formation, which allows a seller to create *ad hoc* and temporary coalitions of buyers with the purposes of combining the delivery of purchases. This conceptualization leads to a proposed method for sellers to undertake this activity, a method we test under various assumptions. Our results suggest – according to a shorthand intuition – that, in a perfect world without delivery defaults, introducing a combined delivery service brings nothing but a Pareto improvement. However, the results are somewhat stronger than this, demonstrating also that, in an imperfect world with delivery defaults, introducing a modified combined delivery service (called CDS II below) can actually help to overcome these imperfections at an aggregate level. Thus, these findings are not susceptible to possible weaknesses of the warehouse management systems. With combined deliveries, any delay may spread to other customers, thus decreasing their satisfaction from e-purchasing. Simulations show that despite this contagion effect, a CDS is still mutually beneficial. However, in this case, CDS does not immediately lead to a Pareto improvement, because some clients are worse off due to the contagion effect. Nonetheless, introducing an incentive to the e-retailer to incorporate longer term objectives into his optimization task, *i.e.*, going beyond short term profit maximization, guarantees that, on the aggregate scale, consumers benefit from a combined delivery service and so does the e-retailer.

The remainder of this paper is structured as follows. Section 2 presents a brief literature review focusing on contributions to coalition formation in e-marketplaces. In Section 3, we present the design of the model, including both the buyer decision and exogenous coalition formation mechanisms. Based on this framework, Section 4 presents the simulation setting and parameterization assumptions. Section 5 presents simulation results and Section 6 offers a discussion of model sensitivity to parameterization. Finally, in Section 8, we conclude with a summary and some insights into future research directions.

2. Brief literature review and motivation

Coalition formation has been a subject of extensive game theoretic research for some years (*e.g.*, Moulin, 1988; Osborne and Rubinstein, 1999 and Bloch, 1996).[7] The topic has also become of interest to the emerging multi-agent system (MAS) literature with the works of Shehory and Kraus (1996) and Yamamoto and Sycara (2001). However, only a small number of papers have been published on coalition formation in e-marketplaces.[8]

Yamamoto and Sycara (2001) propose a buyer coalition formation scheme, GroupBuyAuction, which enables a large number of buyers who want to buy a certain good or a type of a good to form coalitions. In this setting, each buyer specifies a set of (substitutable) goods, one of which he would be willing to purchase, together with their reservation prices. Based on this information the leader of the auction group divides all buyers into coalitions in such a way that each coalition purchases a desired quantity of a particular good profiting from any volume discounts; the resulting surplus is distributed in a stable way between participating buyers. In reality it seems unlikely that such a mechanism could grow in popularity, mainly due to the costs incurred by the leader of the group and the issue of trust.

Li et al. (2003) extend this work, discussing the desired mechanism properties of coalition formation in an e-marketplace from the perspective of cooperative and non-cooperative game theory. These desirable properties include stability (being in the core) and incentive compatibility with good efficiency. Li and Sycara (2002) discuss algorithms for coalition formation in combinatorial auctions analyzing a setting where each buyer places a bid on a

[6] See Section 2 for details.

[7] See Moulin (1995) for review of the coalition formation literature.

[8] He and Ioerger (2000) provides an excellent but general survey and analysis of the state-of-the-art agent-mediated e-commerce.