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# Optimizing ad hoc trade in a commercial barter trade exchange

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## Abstract

In this paper, we describe the operation of barter trade exchanges by identifying key techniques used by trade brokers to stimulate trade and satisfy member needs, and present algorithms to automate some of these techniques. In particular, we develop algorithms that emulate the practice of trade brokers by matching buyers and sellers in such a way that trade volume is maximized while the balance of trade is maintained as much as possible.

We model the trade balance problem as a minimum cost circulation problem (MCC) on a network. When the products have uniform cost or when the products can be traded in fractional units, we solve the problem exactly. Otherwise, we present a novel stochastic rounding algorithm that takes the fractional optimal solution to the trade balance problem and produces a valid integer solution. We then make use of a greedy heuristic that attempts to match buyers and sellers so that the average number of suppliers that a buyer must use to satisfy a given product need is minimized. We present results of empirical evaluation of our algorithms on test problems and on simulations built using data from an operating trade exchange.

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## 1. Introduction

With the movement of business to the Internet, one of the most popular e-commerce models to emerge has been that of the B2B e-marketplace. B2B e-marketplaces are Internet based business sys-

tems that support all activities related to transactions and interactions between various companies [10]. These support services have traditionally consisted of such things as e-catalogs, search capabilities, and transaction support. More recently, researchers have sought to exploit the electronic infrastructure of e-marketplaces and the wealth of information that can be gathered in e-marketplaces to provide sophisticated methods of matching

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buyers and sellers, using agent-based, auction-based, and broker-based techniques. Of the work in this area that has addressed profitability of the e-marketplace, the overriding concern has been for maximization of single-period revenues [6,20,15], with less attention paid to how the techniques fit within a more strategic business model. But as the dramatic down-turn in the e-commerce sector demonstrated, e-business initiatives require solid business models that clearly relate the services provided to the overall profitability of the company [17]. In this paper, we take a particular but quite general e-marketplace business model as our point of departure and use that model to motivate the development of algorithms to support management of trade among buyers and sellers.

The model used in this paper is that of the barter trade exchange, also called retail or commercial barter. A barter trade exchange is a collection of businesses that trade their goods and services, managed by an intermediary. We call the collection of businesses the *barter pool* and call the intermediary the *trade exchange*. In modern barter trade exchanges, businesses do not exchange goods directly in the bilateral fashion of traditional barter. Rather, modern barter is multilateral, using a form of private label currency. The trade exchange issues trade dollars to the member businesses and acts as a neutral third party record keeper. When a company sells a good, they receive credit in trade dollars, which they can then use to purchase goods from other members. The value of the trade dollar is tied to the US dollar by not permitting businesses to charge more for their goods in terms of trade dollars than they do in US dollars in the open market, thus preventing devaluation of the currency.

The barter industry is interesting as a test bed for market design because a barter pool is a relatively closed economy about which we have very detailed information due to the book keeping function of the trade exchange. The trade exchange maintains a general profile for every member business, as well as complete records of all transactions between members. A barter pool has many similarities with a traditional economy, with the trade exchange playing a role analogous to that of the federal government in regulating the economy. The exchange controls such variables as monetary supply, interest

rate, rate of commission (analogous to revenue tax), and even supply and demand through its ability to selectively recruit new member businesses. Interestingly, although it has control over all these parameters, the trade exchange works to stimulate the barter pool economy primarily by making referrals to member businesses through trade brokers.

The success and survivability of the barter business add to its attractiveness as a model to study. The barter trade exchange industry has existed for over forty years, surviving numerous changes in the economic landscape. The International Reciprocal Trade Association [12] estimated that the total value of products and services bartered by businesses through barter companies reached USD 7.87 billion in 2001. This number was an increase from USD 6.92 billion in 1999 and was the third consecutive year the industry saw over 12% growth. There were an estimated 719 trade companies active in North America in 1999 with some 471,000 client businesses [11]. Examples of active barter trade exchanges with a Web presence include [BizXchange.com](http://BizXchange.com), [ITEX.com](http://ITEX.com), [BarterCard.com](http://BarterCard.com), and Continental Trade Exchange ([ctebarter.com](http://ctebarter.com)).

The rest of this paper is organized as follows. In Section 2, we provide a description of the operation of barter trade exchanges, identifying key techniques used by trade brokers in order to stimulate trade and satisfy member needs. In this paper we focus on implementing techniques for maximizing single-period trade while maintaining balance of trade within the barter pool. We assume that trade is ad hoc, which means that there is no cost in switching between suppliers. In Sections 3 and 4, we present a formalization of this problem and novel efficient algorithms for its solution, using minimum cost circulations on networks and stochastic rounding techniques. In Section 5, we present empirical evaluation of our algorithms. In Section 6, we discuss related work and in Section 7, we present conclusions and directions for future work.

## 2. Barter trade exchange model

Given its important role in B2B commerce, there is a surprising lack of the literature on the

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