Evolution of B2B Marketplaces

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INTRODUCTION

For the past several years we have witnessed the emergence of various business models, successful or unsuccessful, which created a lot of excitement about the technology underlying electronic business. As systems and businesses matured, firms within and across industries started to use the Internet in places where they believed efficiency gains would be maximal. One particular area in which we have seen exponential increase is business-to-business (B2B) electronic commerce (EC). Several analysts forecast B2B EC to reach a level of billions of dollars by 2005. Jupiter Research reports that B2B Net Market infrastructure spending in the US will grow from $2.1 billion in 2000 to $80.9 billion by 2005. In spite of this and similar forecasts, over the past couple of years, we saw a dramatic revision of the numbers. For example, while Gartner Group forecasts worldwide B2B Internet commerce to swell to $5.9 trillion by 2004, that is down from the $7.3 trillion Gartner forecast a couple of years ago.

A conclusion one can clearly deduce from these observations and forecasts is that B2B EC is in a constant flux. In the initial stages of B2B EC, independent exchanges were forecasted by a majority of the analysts to be the most successful B2B model. Today, we are witnessing the move towards privately owned, exchange-based B2B networks (e.g., Walmart’s private exchange) or consortia backed exchanges (e.g., Covisint), although there are independent exchanges that are relatively successful (e.g., RetailExchange.com). EDI is still widely used by large corporations and Web-EDI is taking its place among small- and medium-scale enterprises.

Most of these transactions are currently handled over private or neutral third-party exchanges and traditional value added networks and EDI systems integrated with the Internet. Recently, several authors suggested peer-to-peer (P2P) networks for B2B solutions (e.g., McAfee 2000; Parameswaran et al. 2001) due to their decentralized information management potential. The compelling reason behind such an application of P2P technology is the decentralized structure that will help companies everywhere to locate trading partners on the fly and complete transactions swiftly, securely and efficiently without the need for any central aggregator or facilitator.

In this paper we provide answers to the following research questions:

• How do trading networks form in electronic B2B environments?
• What network types can be expected to form in the long run?

We start by discussing the value proposition of electronic marketplaces. We
then provide an economic modelling approach that may advance our understanding of which electronic structures constitute potential convergence points and hence sustainable business models for B2B marketplaces.

VALUE PROPOSITION OF ELECTRONIC MARKETPlACES

B2B trade is extremely complex involving countless transactions along the supply chain. Demand triggered by a customer may generate hundreds of B2B transactions that occur before the purchase is completed. Furthermore, each transaction typically involves multiple parties beyond the buyer and the seller including providers of insurance, inspection, escrow, credit, warehousing and transportation. The main goal of business automation is not only to give an electronic form to existing business processes and relationships but also, more importantly, to help firms lay a foundation for establishing new relationships much more efficiently.

There are several distinctive economic characteristics of electronic markets (Bakos 1991). If we regard both a purchasing firm and an individual customer as the consumer, electronic markets can reduce the costs of obtaining information about the prices and product offerings of alternative suppliers as well as suppliers’ costs of communicating information about their prices and product characteristics to additional customers. Benefits of participating in an electronic market increase as the number of individual member firms increases, commonly known as the network externality effect (Katz and Shapiro 1985). If being a member of an electronic market requires a significant investment from their participants and hence becomes a strategic relationship, resulting switching costs may be too high.

Beyond these characteristics shared by both the consumer and business-oriented electronic markets, there are features specific to B2B transactions that distinguish B2B from B2C markets. One such characteristic is **asset specificity**. It refers to the relative lack of transferability of assets intended for use in a given transaction to other uses. Highly specific assets represent sunk costs that have relatively little value beyond their use in the context of a specific transaction. High asset specificity requires strong contracts or internalization to protect the company from the threat of rivalry. This has a fundamental impact on the form of the electronic marketplace that is sustainable in the long run. One would expect, for example, that a company purchasing highly specific assets for production will not trade over a third party owned (neutral) marketplace. A recent study by Kauffman and Mohtadi (2002), addresses the problem of incentive alignment for B2B e-procurement technology investments that permit inventory coordination and operating cost control. They find that larger firms tend to adopt costlier, but more certain procurement technologies such as proprietary EDI. Smaller firms, on the other hand, tend to adopt less-costly procurement solutions that entail greater supply uncertainties, such as open B2B procurement platforms like exchange-based B2B networks. In a related paper, Tomak (2000) describes conditions under which firms may choose to join a B2B marketplace.

There is little empirical work in the area of B2B marketplaces on the Internet. One reason for this may be the limited availability of the data pertaining to the inner workings of such digital platforms. Most of the firms operating such marketplaces keep the data confidential due to the nature of the relationships among the trading parties.

Garicano and Kaplan (2000) posit that the key impact of B2B EC is to change the costs of transaction via changing/improving processes, the nature of the marketplace, decisions, the degree of information incompleteness and the ability to commit. They find little evidence that informational asymmetries are more important in the electronic marketplace they study than the existing physical ones. However, generalization of their conclusions to all types of B2B marketplaces is questionable due to the characteristics and size of the sample used in the study.

We approach the B2B structures as networks of relationships among participating companies. Due to the nature of trade along the supply chain, each participating member actually establishes a close relationship with the rest and makes complementary EC investments. Although not presented in this paper, our approach establishes a framework in which one can test the sensitivity of the network forms to the existence of informational asymmetries. There is research under way by the authors of this paper which looks at the impact of information asymmetry on the incentives to join exchange-based B2B networks.

### Intermediated vs. Peer-to-peer networks

Exchange-based B2B models are in essence a collection of centrally managed client–server networks which are highly integrated in order to make the transactions among them as flawless and fast as possible. As McAfee (2000) also points out, these exchanges have two main roles: aggregation and facilitation. Their aggregation role is fulfilled by bringing a group of dispersed trading partners under the umbrella of a virtual marketplace. They also facilitate transactions by providing the necessary software tools and protocols. Hence, an exchange-based B2B network can be imagined as a star-like structure as in Figure 1.

In P2P networks, however, the client–server relationship is partially if not completely abandoned. Napster’s technology still centrally manages the directory and user information but the actual files reside on separate locations. Gnutella further decentralizes the network structure by treating users as independent nodes among which the information needs to be transacted. P2P networking is a way of sharing of computer resources and services by direct exchange between systems. These resources and services include the exchange of information, CPU time, data storage, and file transfer. Peer-to-peer computing takes
A MODEL OF B2B RELATIONSHIPS

Aside from the operations management literature, there is a limited number of papers in the IS literature addressing economic problems related to B2B marketplaces. An excellent survey in the B2B as well as the B2C area listing a large body of literature in the economics of IS area can be found in Kaufman and Walden (2001). Dai and Kaufman (2001) also explore several online business models and the adoption of purchasing firms. They posit that private aggregating and negotiating mechanisms are being adopted for large quantity business supply purchases and public market mechanisms are more often adopted when firms face uncertain and high variance demand. Their study provides support to our assessment of the linkage between asset specificity and the B2B network structure.

Nault and Dexter (2000) look at the investments to integrate electronic marketplaces in the buying and selling infrastructure of firms from a strategic point of view and suggest that a pure strategy Nash equilibrium in investments is not assured in such environments. Based on their models of information sharing, Seidmann and Sundararajan (1997) classify different forms of relationships between independent – yet virtually integrated – companies. Four primary types of such relationships include EDI, vendor managed inventory, continuous replenishment, and category management. They also show how retailers and other buyers can successfully contract to end up with more value through sharing information.

In a related paper, Yu and Chaturvedi (2001) study the problem of what the structure of the B2B marketplace will be. They base their model on Gehrig’s (1996) paper, which takes the number of participants in a particular network structure set exogenously, similar to the existing research in this area. Furthermore, marketplaces in an industry are treated as islands that consist of a number of firms set ex-ante. A major difference between our work and theirs is that we take the network type as a side result of the equilibrium of a game that is played among the participants in a market rather than assume it to be set already, exogenously.

In this paper, we use game theory as our main tool for modelling. There are mainly two branches of game theory that study strategic interactions among individuals or groups. Cooperative game theory, unlike its non-cooperative counterpart, allows for the existence of enforceable binding agreements and also for side payments. Hence, fair allocation of costs or revenues becomes the main problem. In the context of our problem setting, this approach can be used to address questions such as ‘How can profits from a consortia-backed B2B marketplace be shared among the participants? What is a fair and envy-free allocation to all the participants so that proper incentives for membership to the B2B marketplace can be given to all the suppliers and manufacturers in the industry?’ One approach in the cooperative framework concentrates on the costs of forming social and economic relationships (Haller and Sarangi 2000). An excellent survey of this literature can be found in Borm et al. (1994).

A large portion of the papers in the intersection of OM and IS literature, including this paper, use non-cooperative game theory. Unlike the cooperative version, enforceable binding agreements are assumed not to be possible. Individual incentives and strategic interactions become the centre of attention. Non-cooperative games take players as individual decision makers who base their decisions on opportunistic strategies that lead to desired outcomes. This approach is more suitable for the type of problems that involve individual firm decision making under uncertain B2B liquidity and potential for opportunistic use of the trade platform. Several trade structures may also result from the relationships between suppliers and manufacturers. Examples include vertical integration, markets and network forms. Kranton and Minehart (2000) apply the model proposed by Jackson and Wolinsky (1996) to a buyer–seller network structure and compare economic welfare of such a network with vertical integration. They find that networks can yield greater social welfare than vertically integrated
firms when there are large idiosyncratic shocks in demand. They also show that individual firms have the incentive to form the network structure. An application of their findings to B2B networks suggest that formation of industrial networks are to the benefit of all parties involved especially when the industry operates under high uncertainty, but third party ownership may curtail this activity. Figure 2 shows an example of a graph that represents a supply chain structure.

The direction on an arrow implies that there is a link in that direction to the node it points to from the node it originates. Furthermore, the direction indicates the path of information flow. Most of the communication that takes place on B2B networks is bi-directional. However, there are examples, such as electronic catalogues that suppliers or manufacturers use to inform their customers about their product offerings and prices, in which the direction of information on the B2B platform is one-way. By two-way communication, we mean that data is transferred from an origin to a destination and back as in a proprietary network setup like an EDI system.

In our example, suppliers 1, 2 and 3 do not have any connections with the rest of the network structure as there is no arrow pointing outwards from them to the next node they are connected to while it is possible for the rest of the network to link to them. This situation may arise if a supplier is small and the only way it can attract customers is by putting ads on specialized catalogues and expecting customers to visit it. Hence these suppliers can be envisioned to lack technology-based links to the subcontractor or simply have chosen not to link to the subcontractor since it may be too costly to them. The burden of maintaining the link is on the subcontractor. On the other hand, Suppliers 4 and 8 have at least an EDI connection with their trading partners to allow for two-way communication between them. In order to keep the exposition simple, we assume that the links are bi-directional. All notation used in this article is shown in Table 1.

We let \( N = \{1, \ldots, n\} \) \( n \geq 3 \) represent the set of players with locations at the nodes of a graph before the graph is formed. We assume that the reason why the links are formed is the gains from information sharing by doing so. A typical supply chain information flow is a good example for this setup. A strategy of a player \( i \in N \) is a vector \( s_i = \{s_{i,1}, s_{i,2}, \ldots, s_{i,n+1}, \ldots, s_{i,n}\} \) where \( s_{i,j} = 0 \) if \( i \) does not have a link with \( j \) and \( s_{i,j} = 1 \) otherwise. The set of all strategies of player \( i \) is given by \( S_i \). In this setting, a link \( s_{i,j} \) is represented by an edge starting at \( j \) with the arrowhead pointing at \( i \). For example, in Figure 2, \( s_{3,4} = s_{2,4} = s_{1,4} = 1 \).

Literature on non-cooperative strategic network formation, such as the one we have just depicted, deals with the flow of information from one agent to another and looks at

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**Figure 2.** A supply chain network structure and its graph form. Any supply chain relationship can be reduced to its graph form and represented as a stage in a finite horizon dynamic network game.
Table 1. Notation Used in the Paper

<table>
<thead>
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<th>Notation</th>
<th>Description</th>
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<tr>
<td>(N = {1, \ldots, n})</td>
<td>set of players with locations at the nodes of a graph.</td>
</tr>
<tr>
<td>(s_i = {s_{i,1}, s_{i,2}, \ldots, s_{i,i-1}, s_{i,i+1}, \ldots, s_{i,n}})</td>
<td>Strategy of player (i) where (s_{i,j} = 0) if (i) does not have a link with (j) and (s_{i,j} = 1) otherwise.</td>
</tr>
<tr>
<td>(S_i)</td>
<td>Set of all strategies of player (i).</td>
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<tr>
<td>(L_i)</td>
<td>Set of players with whom (i) maintains a link.</td>
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<tr>
<td>(\bar{L}_i)</td>
<td>Set of all players whose information (i) has access to either through a link or through a sequence of links via an intermediary.</td>
</tr>
<tr>
<td>(c &gt; 0)</td>
<td>The cost to each player of forming the link.</td>
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<td>(</td>
<td>L^A_i</td>
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<tr>
<td>(</td>
<td>L^B_i</td>
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<tr>
<td>(c_s)</td>
<td>Cost to the supplier firms for forming a link with the buyers.</td>
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<tr>
<td>(c_b)</td>
<td>Cost to the buyer firms for forming a link with the suppliers.</td>
</tr>
<tr>
<td>(c_m)</td>
<td>Cost of a link with a marketplace.</td>
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issues such as information transmission with unreliable links.

We now define \(L_i = \{k \in N | s_{i,k} = 1\}\) as the set of players with whom \(i\) maintains a link. It is also important to find out all players whose information \(i\) accesses either through a link or through a sequence of links with an intermediary in between. Let such a set be given by

\[ \bar{L}_i = \{k \in N | \text{either } s_{i,k} = 1 \text{ or there exists } j_l \in N(l = 1, \ldots, m) \text{ such that } s_{i,j_1} = s_{j_1,j_2} = \ldots = s_{j_{m-1},k} = 1\} \]

Finally, the payoff to each player is given by \(\Pi_i = |L_i| - |L_i|\varepsilon\) where \(|L_i|\) measures the benefit that a player \(i\) receives from his/her links and \(|L_i|\varepsilon\) measures the cost associated with maintaining them with \(c > 0\) being the cost to each player of forming the link. This particular setup of the profit function implies that the benefit to the player increases by the number of links he/she forms with other firms. Using this approach, we are able to account for the network externality effect that is inherent in most of the network forms, especially in B2B relationships (see for example, Dai and Kauffman (2001)). However this benefit is weighed by the cost of actually maintaining the links. Hence the more the number of links, the better; including the indirect ones, net of costs of establishing the direct links. Finally, we assume that \(\Pi_i\) is strictly increasing in \(|L_i|\) and strictly decreasing in \(|L_i|\varepsilon\). This assumption implies that increasing the number of links to other firms adds to the profits of the firm. It also implies that increasing the number of links that needs to be maintained by the firm himself/herself adds to the cost and hence decreases the profits.

Given this formulation, these links can be approached in two ways. One can take the links as one of EDI or B2B marketplace link types with their associated costs or take them as the aggregate cost of establishing a relationship between a buyer and a supplier. In this paper, we take the latter approach. Furthermore, there may be several forms of network structures. The most common ones are star or wheel networks given in Figure 1. Star networks can be interpreted as public or private networks with the centre formed by either a firm, a third party or a consortium. Wheel network structures can be interpreted as peer-to-peer (P2P) networks. A network structure is Nash if no individual link owner benefits by deviating from the existing network structure he/she belongs to by severing his/her link or by adding another link. The uniqueness of this approach comes from the treatment of the evolution of network forms in the B2B context. We let the B2B relationships form endogenously as opposed to the previous approaches in the IS literature, which assume that networks are formed a priori or investment in networks is considered to be over a pre-designed network structure (Nault and Dexter, 2000).

If all the players in the game described above try to maximize their individual payoffs, the resulting equilibrium is described by the following proposition:

**Proposition 1**: Starting with a random network structure between buyers and sellers, let them decide on whether to maintain or sever a link from their set of links. If this process converges to a state where none of the parties involved would rather change their existing links, the resulting exchange-based B2B (private or public) network will take the form of a star-like Nash network.

This Proposition implies that if the firms act selfishly and form their links with each other on the basis of increasing their information sharing capabilities, an exchange-based B2B network structure can be supported in steady state. Once it is formed, no firm would have any incentives to deviate to other networks or connect to each other directly. One can easily envision such conglomerate exchanges emerging in every industry which values sharing information along different supply chain architectures. eBay is an excellent example in the value chain side. With 100,000 trading partners and one billion transactions processed annually, GE Global eXchange Services (GXS) is a good example of such a conglomerate in the B2B side.
The cost to the seller and buyer are different when they form links with each other or through a marketplace due to the asset specificity of the processes each gets involved in. Let $c_b$ be the cost to the buyer firms for forming a link with the suppliers. For both the buyer and the seller, cost of a link with a marketplace is given by $c_m$. For the suppliers, direct link cost is assumed to be $c_s$. We rewrite the payoff function to incorporate these changes as follows

$$\Pi_b = |L_b| - |L_D|c_b - c_m|L^M_s|$$

$$\Pi_s = |L_s| - |L_D|c_s - c_m|L^M_i|$$

Here, $|L^M_i|$ corresponds to the number of marketplaces that the buyer (supplier) firm establishes a link with and $|L_D|$ is the number of direct links to the buyers (suppliers). In order to understand how asset specificity plays an important role, let the cost of the link be directly proportional to the cost of acquiring the product. The more asset-specific the production process is, the more the cost of the link to the marketplace for the buyer. This is because of the fact that the risk a buyer incurs by going to the marketplace for highly asset-specific processes is quite high. Assumption on the payoff function implies that as $|L_D|$ increases, profit falls. Hence, we expect that $|L_D|$ decreases and $|L^M_i|$ tends to zero for highly asset-specific processes of the buyer. Similar observation holds for the suppliers.

**Proposition 2**: High asset specificity leads to a wheel-like Nash network at the steady state whereas low asset specificity results in a star-like Nash network.

This is a rather insightful result since it suggests that peer-to-peer networks have a higher chance of succeeding in establishing connections among trading partners for highly asset-specific processes, whereas exchange-based B2B networks play more of a role in facilitating transactions for low asset-specific tasks.

**CONCLUSION**

Motivated by the recent business model transformations in exchange-based B2B network structures, our research focused on the endogenous formation of B2B relationships. In particular, we studied the strategic choice of a buyer or seller, of linking to a marketplace or participating in a peer-to-peer network. Although our model is representative of the establishment of actual B2B exchanges, we recognize that the results are limited to the setting we consider. In our model, links are formed because of the gains from information sharing. Although this assumption is necessary to provide focus to our study, in reality, there may be many reasons why links are formed. A link to a marketplace for procuring indirect materials such as office supplies does not have any strategic context other than cutting costs of such an activity. Another restriction comes from the homogeneity of costs among the buyers and sellers. Obviously, costs of establishing B2B links vary for different suppliers of heterogeneous sizes. The assumption of a two-way communication channel does not play a significant role in our model although assuming one instead of two-directional links would change the nature of the equilibrium network structure (see Bala and Goyal (2000)).

Our results show the significance of letting the B2B network relationships form endogenously as opposed to exogenously. Previous literature has predominantly assumed the network structure given, which limited our understanding of how exchanges and trade networks form. We contribute to the existing literature by introducing a complementary view of B2B exchanges and networks. In the context of non-cooperative relationships, it is important to look at a similar game with either heterogeneous players and/or informational asymmetries among them. This extension will make the model more realistic and lead to testable hypotheses if relevant data can be found in the future. In order to study consortia-backed exchanges, one needs to look at cooperative rather than non-cooperative settings. This route would help us understand and devise revenue sharing models for B2B exchanges as well as link the network forms in equilibrium with concepts such as fairness and governance. Another promising extension is the study of the impact of upstream cooperation and downstream competition – such as the case of Covisint exchange – on the sustainability of exchange based B2B network form.

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**REFERENCES**


To show that this implies the equilibrium network structure is a star-like Nash network, we start by assuming that the initial random network is such that every pair in the network is connected either directly or indirectly to each other in at most one way and that it is Nash. This implies that there is only one path between every pair in the network and deleting a link would isolate at least one player in the network. Furthermore, there is a unique path for each pair in the network. Multiple paths are not allowed. Now, let i and j be firms such that si,j = 1. We claim that max{s_i,j, s_j,i} = 0 for any j’ ∈ {i, j}. If this did not hold, then i can delete his/her link with j and form one with j’ and receive the same payoff, which contradicts the Nash assumption of the initial network. Hence, any agent with whom i is directly linked, cannot have any other links. Since, by assumption, every player is linked to each other in a unique way, i must be the centre of a star.

To show the convergence, let each player move sequentially and decide on whether to keep an existing link, build one or sever it. Note that if the resulting network is not empty, it must be that each player is uniquely linked to each other. As identity (1) holds, a firm’s best response is to form links with all the others and hence a star-network is formed.

Proposition 2

High asset specificity leads to a wheel-like Nash network at the steady state whereas low asset specificity results in a star-like Nash network.

Proof

As | L_i^k | tends to zero for highly asset specific processes by the argument given prior to the Proposition, the payoff function for the buyer reduces to

$$\Pi_i = |L_i| - |L_i^k| e_i.$$  

Let e_i > e_s and \( f(k) = |L_n|, g(k) = |L_o| \). Then for the buyer, due to high asset specificity,
\[ f'(n) - g(1)c_2 > f'(n) - g(n)c_2. \]

But since \( f'(n) - g(1)c_2 > f'(n) - g(1)c_2 \) it is also beneficial for the seller to establish a unique direct link with the buyer. Since each firm values linking to as many firms as possible but prefers only direct links with his/her immediate neighbour, a wheel type network arises in equilibrium.

If the process has low asset specificity, \( c_b = c_s \) and the pay-off function for the buyer is

\[ \Pi_{i,b} = |L_i| - |L^D_i|c_b - |L^M_i|c_m. \]

If \( c_b = c_s \), by Proposition 1, the equilibrium network is of star type. If \( c_m \neq c_b \), then either \( |L^M_i| \) or \( |L^D_i| \) tend to 0 and again, by Proposition 1, we have a star-like Nash network as the equilibrium of the game.