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The Role of E-Marketplaces in Relationship-Based Supply Chains

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Abstract Despite the considerable excitement surrounding business-to-business (B2B) e-marketplaces around year 2000, many exchanges have since closed, citing their inability to generate sufficient revenue from thin transaction volume. Discussions with industry participants reveal that many firms are carefully watching developments, but are reluctant to commit serious trading volumes to online channels. Many firms continue to conduct the majority of their strategic transactions through traditional relationship-based contracting. Surviving e-marketplaces are trying hard to come up with compelling value propositions for participants. This paper explores the difficulties faced by e-marketplaces, and discusses potential sources of value that will encourage their adoption by preserving and complementing long-term B2B relationships. The focus is on the role of E-marketplaces in B2B transactions, where long-term relationships between buyers and sellers are important, as is the case in many supply chains. Our objective is to present an industry perspective, using real-world examples to demonstrate how firms can use e-marketplaces for their advantages.

(*E-marketplace, Relationship, Supply Chain Management, Information, Risk Management, E-commerce***)**

1. Introduction

Along with the Internet boom came high expectations for the role of e-marketplaces and their potential to enhance supply chain efficiency. Business-to-business (B2B) e-commerce was heralded as the next major innovation in business, and analysts projected that trillions of dollars would flow through B2B exchanges by 2004. Legions of exchanges sprang up virtually overnight, supported by a new industry of e-business software vendors providing tools for everything from dynamic pricing to collaborative commerce. In a two-year period, the number of e-marketplaces increased over seven-fold, reaching 1500 on August 2000. This brief but meteoric rise came to a sudden halt by the end of 2000. In a two-month period, 15 e-marketplaces failed or merged. Firms reevaluated their e-business strategies, and reduced their investments in B2B activities. Investors lost confidence in B2B-related stocks. Within a year, Ariba and Commerce One, two key B2B e-commerce solution providers, lost over 95% of their market value.

Early attention on e-marketplaces focused on their potential to lower the costs of doing business. By lowering search costs and making it easier to match buyers and sellers, E-marketplaces raised the possibility that firms could conduct large volumes of their B2B transactions using dynamic channels such as auctions and exchanges. More recently, e-marketplaces have sought to provide value by offering services to facilitate collaboration and information-sharing, rather than just online commerce. Proposed services include collaborative design, and systems to facilitate sharing supply chain information such as forecasts and inventory levels. E-marketplaces are also seeking to improve supply chain efficiency by automating business processes such as procurement, order management, and fulfillment.

This paper seeks to analyze potential sources of value provided by e-marketplaces in relationship-based supply chains. The focus is on dynamically priced business-to-business transactions in which long-term relationships between buyers and sellers are important, as is the case for strategic sourcing of most direct materials. We use the term dynamic pricing broadly to refer to short-term flexibility of prices to respond to changing supply and demand conditions. Prices may be *market-based,* as in exchanges, auctions, and reverse auctions. Dynamic prices may also be *seller-based* in response to real-time information about demand, required lead time, or remaining capacity or inventory levels.[1]

Our work complements two other papers in this issue that survey the literature on OR/MS models on E-business. Kleindorfer and Wu (2002) reviews the literature exploring the interconnection between long-term (through contracting) and short-term (through dynamic channel) markets for capital investment, capacity planning, and production scheduling. Swaminathan and Tayur (2002) provides a survey of OR models that have been proposed for solving problems in the context of electronic supply chains. This paper also builds on the work of Krishnan and Geoffrion (2001) in analyzing OR/MS opportunities enabled by the Internet. Our primary objective is to provide industrial motivation for work in this area by OR/MS scholars, highlighting real-world problems that should be the focus of future research.

The structure of the paper is as follows. Section 2 provides background material on the role of e-marketplaces in relationship-based supply chains. Section 3 describes potential sources of value for e-marketplaces, and Section 4 describes challenges facing e-marketplaces. Finally, Section 5 concludes with suggestions for areas of future OR/MS research.

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[1] We do not consider dynamic pricing for the purpose of price discrimination based on different willingness-to-pay for the same product. In our survey, price is a function of different circumstances, not individual customers.

2. Background

In a modern multi-echelon supply chain, business transactions can be extraordinarily complex. Multiple firms, each with unique and competing objectives, must coordinate production processes to respond to rapidly shifting patterns in customer demand. Decisions must be made quickly, and with imperfect knowledge about future supply and demand. Information sharing benefits overall supply chain performance, but in many cases the misaligned interests and incentives of supply chain partners prevent the unfettered flow of information. Firms can use a variety of mechanisms that have been widely discussed in the supply chain literature to align incentives, balance demand and supply, and facilitate information flows with their trading partners.

Business transactions involve an explicit or implicit agreement between buyers and sellers on many terms and conditions. We refer to the means by which transaction terms are determined as the coordination mechanism. For example, transaction prices may be announced, negotiated, or determined by a market mechanism. Transaction quantities may be stipulated contractually, or determined by demand and availability. Coordination mechanisms vary from industry to industry, depending on factors such as the importance of buyer-supplier relationships, the degree of buyer and supplier concentration, the uniqueness of the product or service, and the frequency of transactions.

2.1 The Role of Relationships in B2B Commerce

Despite the high visibility of anonymous, arm's length transactions in consumer and commodity markets, the majority of economic transactions involve long-term relationships. According to Blinder et al. (1998), the most common means of buyer-supplier coordination in B2B transactions is through long-term relationships and supply contracts. About 38 percent of private sector GDP is covered by explicit contracts[2], and about two-thirds of all U.S. companies have implicit contracts for prices, or implicit understandings with their customers that they will not "take advantage of the situation by raising prices when the market is tight."

Supply chain partners benefit from relationship-based contract coordination in several ways. These include reductions in transaction and agency costs, improved information sharing for production coordination, customized pricing, and price stickiness. Grey, Olavson and Shi (2001a, 2001b) discusses these sources of value in greater detail.

A concise way to articulate the advantages and disadvantages of different coordination mechanisms is through the economic framework of ***transaction costs***. In markets based on long-term relationships, the cost of doing business through contracts and relationships is presumably lower than the cost of using market transactions. Long-term relationships can be a more efficient way to maintain ongoing business relations, and by sharing information, firms can improve production planning, and reduce inventory and order fulfillment costs.

The economics literature on transaction costs (e.g., Williamson 1971, 1985) emphasizes the importance of ***agency costs***, suggesting that a concern for the future often provides incentives for cooperative long-term relationships that avoid the opportunistic behavior associated with short-term planning. Agency costs are particularly important when relationship-specific assets are involved, such as capital investments made on behalf of a specific customer, or jointly

[2] Furthermore, about three-quarters of these contracts set prices for a stated period of time.

developed intellectual property. Long-term partners are less likely to "hold up" one another for short-term gain. Short of vertical integration, developing long-term relationships is the best way to reduce agency costs. Other reasons for establishing long-term relationships include the presence of strategic synergies, like joint technological capabilities, reductions in product development cycle time through collaboration, and cross-organization learning effects.

The importance of relationships for ***information sharing*** has received considerable attention in the supply chain management (SCM) literature. Sharing sales information has been viewed as a major strategy to counter the bullwhip effect, in which the variability of orders is amplified as it moves upstream in the supply chain (Lee et al., 1997). This information distortion causes problems such as inaccurate forecasts, low capacity utilization, excessive inventory and poor customer service. Demand sharing between downstream operators and suppliers is the driving force behind collaborative relationships such as Vendor-Managed Inventory and Continuous Replenishment programs. The supply chain literature has also focused on creating the right incentives for efficient information and material flows and effective production planning. An emerging body of SCM research, reviewed by Tsay et al. (1999), evaluates supply contract design for channel coordination. Such contracts are designed to assign the true economic costs to fill an order, and to provide economic incentives to coordinate interactions between buyers and suppliers to increase supply chain value.

Customized pricing allows a supplier to set prices based on the true cost and benefit that a customer brings to the firm. Production and capacity planning are more efficient for regular customers with substantial purchasing volumes and predictable sales patterns. Such customers impose lower costs on the firm, which should be reflected in pricing. Similarly, different prices

may be justified based on the levels of technical support required, degree of effort required to generate and support sales, potential for future business, and benefits from strategic partnering.

Conducting business through explicit or implicit contracts also leads to ***price stickiness***, where price changes lag supply and demand shocks. Price stickiness increases customer loyalty, facilitates risk sharing, and reduces the cost of agreeing on "fair" prices.

2.2 Market Mechanisms in B2B Commerce

When search costs and the benefits from long-term relationships are low, buyers and sellers can interact with virtual anonymity. This can occur when there is a large pool of buyers, as is the case in highly liquid commodities markets. Anonymous transactions also occur when sales are one-time events, such as auctions for excess or obsolete inventory, used capital equipment, or one-of-a-kind items.

There are a number of different market-based pricing mechanisms, including exchanges, forward auctions, and reverse auctions. An ***exchange*** is a trading network for buying and selling goods and services in a market where prices are free to move in response to supply and demand. A classic example of an exchange is a commodities market, where prices are determined by a critical mass of buyers and sellers bidding for a fixed supply of standardized products.

Trading on exchanges need not be limited to traditional physical commodities. It can also involve products and services such as flexible production capacity, labor, transportation, and advertising. Exchanges can take the form of spot markets, where transactions are conducted for immediate delivery of goods or services, or forward or futures markets, where transactions are for delivery at a future date.

Exchanges are not particularly well suited for differentiated goods or services. Differentiated offerings often require customized design or manufacturing, and may need to be adapted along non-price dimensions to meet the needs of individual customers. Differentiated or customized goods can be traded on ***auctions***. Suppliers can offer items for sale to multiple bidders on ***forward auctions***, which are especially effective for liquidating one-off items, excess and obsolete capital equipment, and inventory. In a similar fashion, buyers can use ***reverse auctions*** to procure goods and services from multiple competing suppliers. Auctions can also serve as a complementary sales channel for suppliers already conducting business in relationship-based supply chains. Klemperer (1999) provides an extensive review of the auction literature.

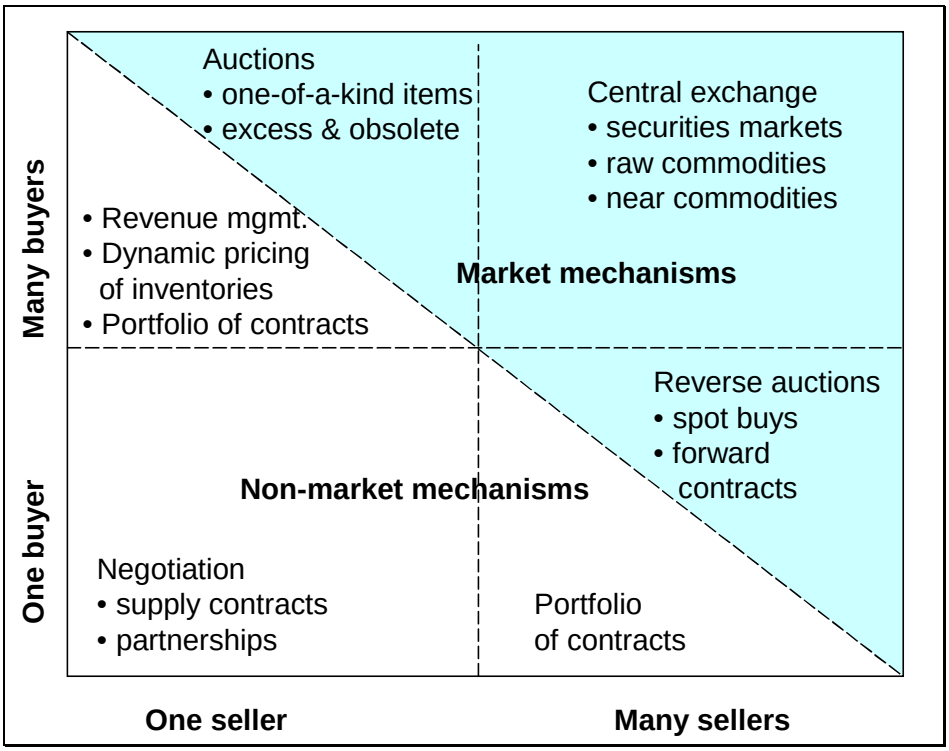

Figure 1. Market mechanisms characterized by buyer and seller concentration.

The choice of coordination mechanism depends greatly on the nature of the interaction between buyers and sellers. (See Figure 1.) When there are many buyers and many sellers (the upper right quadrant of the figure), market transactions predominate. Only commodities, near commodities or other highly standardized products are likely to attract adequate trading volumes to support such many-to-many interactions.

The opposite extreme is the one-to-one regime of negotiation and partnerships (the lower left quadrant of the figure), where it is virtually impossible to implement market-based coordination mechanisms. Prices in this regime often vary by customer, reflecting differences in product attributes, purchasing volumes, service requirements, and other non-price factors. Coordination is based on one-to-one negotiations that are influenced by the nature of the long-term relationship between the buyer and supplier.

In the other two quadrants, participants have more flexibility to select the most advantageous coordination mechanism. It is here that e-marketplaces hold the greatest promise for improving supply chain coordination. When a single buyer is interacting with multiple sellers (the lower right quadrant), the buyer can use either a portfolio of long-term contracts, or market-based approaches such as reverse auctions. When a single seller is interacting with multiple buyers (the upper left quadrant), the seller has a number of choices, including revenue management, auctions, dynamic pricing, and long-term contracting.

3. Potential Sources of Value for E-marketplaces

This section discusses potential sources of value for e-marketplaces, presenting examples of how e-marketplaces have been used to create value in relationship-based supply chains. We

structure these sources of value into three broad categories: efficient allocation of resources, improved information collection and aggregation, and risk management.

3.1 Efficient Resource Allocation

In theory, market mechanisms result in the most efficient means to produce and allocate goods, provide proper incentives, and convey information. When transacting in the marketplace, prices offered for goods and services by buyers convey information about their valuations, and prices asked by producers convey information about production costs. According to the "invisible hand" theory of perfectly efficient market allocation, the market-clearing price ensures that products are allocated to buyers with the highest willingness to pay, and production is allocated to suppliers with the lowest marginal cost of production.

While this "invisible hand" view of markets is elegant in theory, in practice it is rarely seen in relationship-based supply chains. Perfectly efficient markets can only be realized in many-to-many markets with perfect competition, and no externalities or transaction costs. Furthermore, for most B2B transactions the value of long-term relationships exceeds the incremental value from improving resource allocation through market pricing. Prices are negotiated rather than determined by the market, and efficient allocation is sacrificed in favor of the other benefits of relationship-based negotiations. When production volumes and purchase quantities are based on private negotiations and non-market-clearing prices, buyers may keep private information about their willingness to pay, and suppliers may keep private information about their marginal costs.

In relationship-based supply chains, supply and demand is often balanced by non-price mechanisms. In the case of undersupply, suppliers may ration output to strategic customers (e.g.,

Cachon & Lariviere, 1999a, 1999b), or dampen demand by degrading lead times or service levels (e.g., Carlton, 1983, 1991). Allocation then becomes a function of negotiation and relationship, and is not efficient in the economic sense of maximizing total surplus. In the case of oversupply, suppliers may negotiate special deals on forward buys or inventory buys to "borrow" demand from the future, or simply build up excess inventory.

In the absence of market-clearing prices, markets are often either in under or oversupply. Supply shocks or unanticipated demand increases can lead to shortages, since prices do not rise quickly enough to dampen demand or stimulate production. Weak demand or excess production can result in excess inventory, since prices do not fall quickly enough to equilibrate supply and demand. Furthermore, contract prices that lag true market-clearing prices can cause poor capacity investment decisions, leading to a vicious cycle of over and under supply.

In some industries, e-marketplaces can address these difficulties by providing a cost-effective means for creating spot markets that operate in parallel with existing supply chain relationships. This allows supply chain participants to simultaneously realize the benefits of both relationship-based and market-based coordination. By conducting the majority of their transactions through contracts with existing trading partners, participants can continue to reap the benefits of collaboration and long-term relationships. At the same time, spot markets serve as a channel for suppliers to offload excess inventory or capacity, and for buyers to address periodic shortages.

In the semiconductor industry, for example, e-marketplaces like Converge support an active spot market for computer memory devices (called DRAMs). Major buyers and suppliers conduct the majority of their transactions through negotiated contracts, using spot markets primarily to buffer supply and demand shocks. In addition, spot markets enable contract prices to

adjust more rapidly to shifts in supply and demand, since they serve as a benchmark during contract negotiations. They also improve resource allocation by serving as an important input for suppliers evaluating potential investments in new production capacity.

Dynamic pricing mechanisms such as auctions and exchanges may also play a valuable role in more efficiently allocating differentiated goods and services. In a B2B environment, transactions can be quite complex, and often require evaluation and negotiation along multiple dimensions. Differentiated offerings may have a broad array of potential attributes, and a number of different factors can affect the purchasing volumes between a given set of supply chain partners. Transactions may also involve bundles or combinations of possibly complementary goods and services. By using sophisticated decision support tools, supply chain participants can use auctions and exchanges to more efficiently consummate these complex, multi-dimensional transactions. (See, for example, Bichler et. al 2001, which describes a number of ways that both buyers and sellers can use optimization techniques in conjunction with dynamic pricing to better manage B2B transactions.)

3.2 Information Aggregation and Dissemination

The ability of markets to collect, aggregate, and broadcast information has been widely reported in the Economics and Finance literature. (See, for example, Plott, 2000.) Market information offers a number of potential benefits in relationship-based supply chains. Spot markets and auctions can serve as a vehicle for price discovery, making it easier to negotiate long-term contracts, and obtain real-time information about market demand. In markets with volatile prices, long-term supply contracts can be pegged to spot market prices, with contracts prices reset periodically based on a reference price index. This enables suppliers to offer strategic

customers volume discounts with respect to spot market prices, as well as preferred credit terms and higher service levels. At the same time, all parties benefit from contract prices that adjust more rapidly to changing market conditions. For example, computer manufacturers like IBM and Hewlett-Packard use reported DRAM spot market prices as a benchmarking tool during their negotiations with DRAM suppliers. This reduces the need for extensive negotiations to arrive at a market price, thus letting negotiations focus more on determining an equitable price based on the incremental value of the relationship, across dimensions such as purchasing volumes, quality, and service levels.

Futures and forwards markets play a particularly important role in generating information relevant to capacity and production planning, since they provide insight into market participants' expectations about future supply and demand conditions. In many markets, futures prices have been shown to provide unbiased forecasts of future prices. Market prices can be used to derive forward price curves, which show expected prices as a function of time. For example, forward price information about commodities like oil and grain can help suppliers develop production plans and determine product prices. Buyers in turn can use forward price information about key production inputs to help them plan their purchases, to estimate component costs when preparing quotes for future customer commitments, and to more effectively plan product pricing and promotions. Forward price curves are particularly valuable in industries with highly volatile prices. Examples include not only pure commodities markets like oil and grain but also high-tech markets characterized by highly unpredictable demand and inflexible supply capacity. If the forward price curve extends far enough forward in time to allow capacity changes, then suppliers can adjust capacity based on aggregated market information rather than private forecasts.

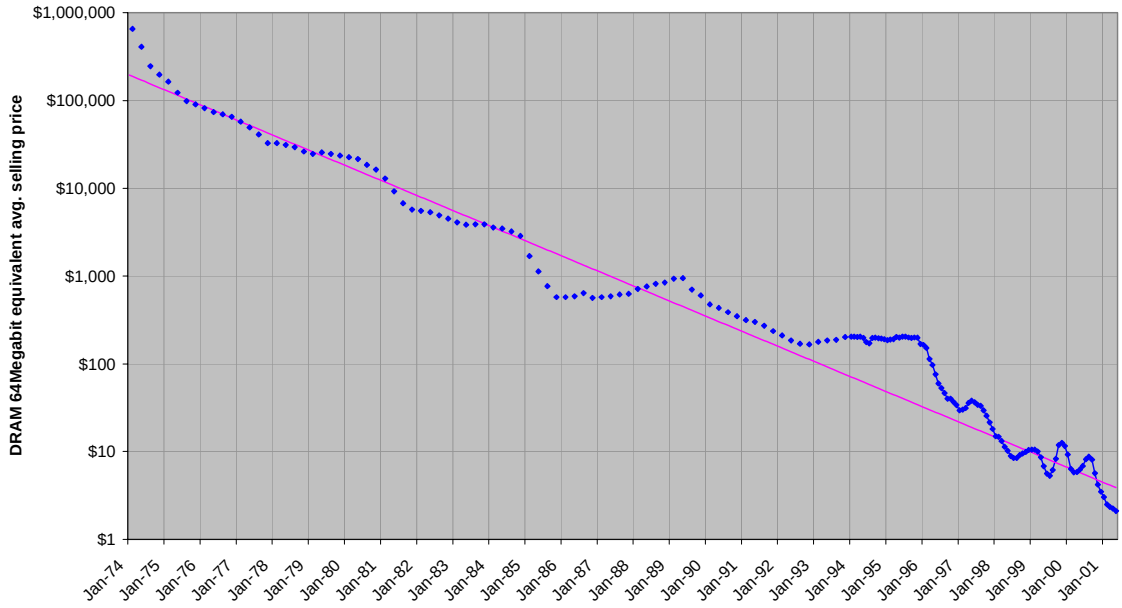

Figure 2. DRAM average selling price, 1974-2001. The long term trend is a 32% annual price decline, but boom and bust cycles cause oscillations around the trend. The first four cycles had an average duration of five years, whereas the last four cycles had an average duration of one year. Forward price curves could help suppliers plan production, and better anticipate market turns.

The DRAM market has historically experienced boom and bust cycles with drastic price volatility. There is evidence that forward markets could significantly dampen this volatility. In the past these cycles lasted about 5 years, but recently they have contracted and last only about a year on average. However, this has also made it more difficult to predict DRAM cycles, since instead of following a regular pattern, they now last from six to eighteen months (see Figure 2).[3] Chipmakers each develop their own forecast for market price and market size, and then build capacity based on aggressive projections for market share. The end result is a cycle of overcapacity followed by retrenchment and under-capacity (Richtmyer, 2002). If suppliers had

[3] One possible explanation for the cycle compression is that new technology has given suppliers more flexibility to ramp up capacity within a 6 month horizon. Increasing the density of chips can increase capacity, and it is now much easier to reach stable yield levels when introducing the next generation of chip density. With new fabrication plants taking approximately two years to build, suppliers now may have more short-term flexibility to make minor adjustments to capacity.

an unbiased forecast of future prices, they could use this aggregated information about market trends when making capacity investments. Moreover, the forward curve could provide information required for short-term capacity adjustment and ramp-up decisions, improving supply and demand matching in the short-term.

3.3 Risk Management

When transactions are conducted using market mechanisms, prices adjust rapidly to equilibrate supply and demand. This ensures that goods or services are efficiently allocated, but it also exposes market participants to ***price risk***, uncertainty about transaction prices. In B2B transactions, both buyers and sellers are equally exposed to price risk, assuming the market is competitive and fair.

Demand risk is caused by uncertainty in customer demand. Lower than expected demand can cause excess inventory for buyers and suppliers, and low capacity utilization for the supplier. Higher than expected demand imposes shortage costs on buyers and opportunity costs on suppliers.

Dynamic pricing can help manage both types of risks. Kleindorfer and Wu (2002) review the relevant literature on strategies for linking contracting and spot market, so we limit our discussion here to examples and applications of spot and forward markets for managing risk.

3.3.1 Managing Demand Risk Using Spot Markets

Market-based dynamic pricing ensures that supply and demand will always be in balance in spot markets. In contrast, supply and demand is rarely in perfect balance in relationship-based contract markets. In a buyer's market, suppliers hold excess stocks of inventory. In a seller's market, buyers face either long lead times for parts, or outright shortages in which their orders

will be rationed through an allocation mechanism of the supplier's choosing. By balancing supply and demand, market-based pricing helps buyers and sellers manage demand risk in several ways.

Spot markets help buyers manage demand risk primarily by providing a channel with continuous availability and short lead times. Spot purchases can then replace inventory buffers as a means for absorbing peak demand shocks. Buyers may pay a premium for spot purchases, but this may be offset by reductions in inventory overage and underage costs. Spot markets can also act as an effective means for allocating constrained capacity during supply shortages. [4] Furthermore, Buyers may be able to reduce inventory write-downs by reselling excess inventory in spot markets before it has significantly depreciated in value.

The Hewlett-Packard Customer Support (HPCS) group's approach to managing certain spare parts inventories illustrates how spot markets can help manage buyer's demand risk. HPCS is responsible for servicing -- and often replacing -- defective components in HP products. Since products under warranty generally have a 5-year guaranteed minimum support period, HPCS demand for components often extends well beyond the supplier's discontinuance of the component. In the past, when the manufacturer discontinued the product, HPCS did a "lifetime buy" – it purchased enough inventory to cover all expected future component requirements. Since demand over the remaining support period (typically 3-5 years) was uncertain, and since

[4]When demand is extremely unpredictable, and cannot be cost-effectively buffered using finished goods inventory or flexible capacity, demand risk may be compounded by "availability risk." Availability risk is the risk that supply will not be available to meet demand with an acceptable lead time. In this case, products are allocated based on rationing or longer lead times (degradation of service) rather than buyers' willingness-to-pay. In the most extreme case, chronic supply shortages prevent the desired quantity from being obtained at any price or any lead-time. Industries subject to availability risk include semiconductors and apparel. In the semiconductor industry, inflexible capacity sometimes forces suppliers to ration output. In the apparel industry, on the other hand, firms are forced to seasonally build inventories based on uncertain forecasts, and there is little flexibility to respond to market demand once the selling season starts.

the value of components continued to decline during this period, inventory write-downs were large.

To address this problem, HPCS has implemented a new strategy for procuring microprocessors directly from the high-tech exchange Converge. Under the new strategy, HPCS holds no microprocessors inventory. Converge provides the processors on a just in time basis, pulling from the spot market at market prices. This not only reduces inventory write-downs during the support period, but also lowers the average price paid for the parts.

Under the original inventory strategy, lead times were 30-45 days for microprocessors still under production. To meet the high service levels required for customer support, planners had to hold 3-4 months of inventory. Since microprocessor prices fell 60-80% per year, this was extremely costly. Furthermore, for discontinued microprocessors, HPCS would perform a lifetime buy, and the market value of its inventory would fall another 50-70% over the support period. HPCS was paying a high price for managing its demand risk, but it had no alternative. With Converge, HPCS has a liquid market for discontinued products. It also has a channel partner providing 1 day lead times, rather than the 30-45 day lead times provided by the microprocessor manufacturer. The savings have been so dramatic that HPCS now sources nearly all of its microprocessors through Converge, and plans to extend the approach to other components.

Spot markets can dramatically reduce the total inventory carried in the supply chain. By pooling demand across many buyers, spot markets can address demand risk far more efficiently than an individual buyer. This is in contrast to vendor managed inventory programs, in which buyer inventory is typically shifted to supplier hubs devoted to major customers, and the total inventory in the supply chain is not significantly reduced. Spot markets can improve efficiency

even in illiquid markets, by holding sufficient inventories to ensure supply for its customers by injecting liquidity into the market. Because of the benefits of demand pooling, spot markets can carry smaller stocks of inventory, without reducing service performance.

3.3.2 Managing Demand Risk Using Dynamic Pricing and Revenue Management

The advent of sophisticated IT systems first enabled airlines to practice dynamic pricing to manage demand for airline seats. In a similar fashion, increasingly sophisticated enterprise resource planning (ERP) systems and real-time pricing systems on e-marketplaces may lead to the diffusion of dynamic pricing techniques such as revenue management from service industries to markets for manufacturing capacity. Service industries in which dynamic pricing have successfully been applied share many characteristics with some direct materials markets for customized capacity. These include job shops, contract manufacturing, semiconductor foundries, and application specific integrated circuits (ASICs) manufacturing.[5]

In essence, revenue management systems allow sellers to make price a dynamic function of lead-time and available capacity. When capacity is highly perishable, and when customers each have a different willingness to pay for flexibility, dynamic pricing can better match supply and demand. For example, airlines monitor demand in real time and impose "booking limits" on economy class fares as the departure date approaches. Seats are reserved for business class travelers, who place a higher value on flexibility and short lead times. As a consequence, economy class passengers are shifted away from peak demand flights to flights with more available capacity. There are rarely "shortages", in the sense that seats are generally available if

[5] So far revenue management has found application mainly in airlines, hotels, car rental companies, and commercial shippers. RM requires three basic characteristics: (1) fixed or highly inflexible capacity, (2) a date at which the

a buyer is willing to pay a high enough price. The end result is better utilization of supplier capacity, and thus better management of both the supplier's demand risk as well as the capital risk associated with capital investments. Weatherford (1998) and McGill & van Ryzin (1999) provide overviews of RM problems and models. Dana (1999a, 1999b) provides evidence and models that suggest that revenue management is not dependent on price discrimination, but rather brings system-wide efficiency gains by shifting demand from peak times to off peak times.

3.3.3 Managing Price Risk Using Spot and Derivatives Markets

Information generated in spot markets plays an important role in enabling risk management. The derivatives instruments that serve as the basis for much risk management activity typically rely heavily on spot markets to provide reference prices for contract settlement and price determination. Traders also need reliable price benchmarks to provide inputs for analytical trading tools. "I wanted an all-digital free-market exchange", says Jeffrey Sprecher, CEO of Intercontinental Exchange (ICE), an electronic over-the-counter market for energy and metals contracts. "And to do this, I needed to find some index that could be a national or regional bellwether for the price" (Kaneshige and Costello 2001).

Buyers and sellers can use derivatives such as forward contracts, swaps, and options to actively manage price risk. Suppliers might seek to hedge against price decreases to ensure that any planned production can be sold above marginal cost. Similarly, buyers might seek to hedge against price increases on key components to ensure that any planned product sales or promotion commitments can be upheld while preserving positive gross margins.

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product or service becomes available after which it is either not available or ages, and (3) the ability to segment customers by price sensitivity (willingness to pay for flexibility).

Derivatives can play a particularly important role in markets where transactions are primarily conducted using supply contracts. One benefit of long-term supply contracts is that they smooth prices, thus reducing price risk for both buyers and suppliers. Unfortunately, this form of risk sharing may not be particularly efficient, since it is the result of bilateral contract negotiations between two parties who may have different appetites for risk, and divergent expectations about future market movements. By using spot market prices to more frequently adjust contract pricing, and then employing financial derivatives to manage risk, individual market participants can decide how much risk they are willing to bear, and manage their derivatives portfolios accordingly. Derivatives markets have the added advantage of bringing in new traders, such as investors and speculators, who can increase marketplace liquidity and facilitate price discovery. This in turn helps to ensure that risk is more fairly priced, and can be more efficiently transferred to parties with the greatest capacity or willingness to bear it.

Futures markets can be established for goods and services with either liquid exchanges, or active brokers with access to real time market information. For example, Enron began developing an over-the-counter market for financial swaps and forwards on DRAM memory chips. Though not a real-time exchange in the strict sense, Enron's DRAM derivatives trading operation is an example of dynamic pricing enabled by a high-speed information exchange network. Enron posted their forward curves on-line, gathered bids in real time, and instantaneously adjusted the forward curve based on new information from the market. Using that information, they could price forward, options, and swap contracts on DRAMs with major DRAM buyers and suppliers. When entering new markets like DRAMs, Enron's practice was to take physical positions to back their trades, and to help learn about market dynamics. Enron's long-term focus, though, was on purely financial trading of DRAM derivatives.

With the collapse of Enron, we will never know whether its venture into DRAM derivatives trading would have been successful. However, auctions and reverse auctions to price physical trades on forward and options contracts could be conducted on exchanges like Converge or e-marketplaces like e2open. It is also possible to negotiate prices on a one-to-one basis for options and forward contracts. However, the advantage of derivatives markets is that information is aggregated to determine a fair market price for an option premium or forward prices, thus establishing credible pricing benchmarks that can be used by other market participants.

4. Challenges to E-marketplaces in Relationship-based Supply Chains

In this section, we discuss several issues that must be addressed in order to use e-marketplaces to obtain the benefits of market-based price coordination. These include achieving liquidity, preserving the value associated with long-term supply chain relationships, and creating a win-win situation for both buyers and suppliers.

4.1 Developing Liquidity

For market-based coordination to be viable, e-marketplaces need to achieve adequate liquidity. In fact, the demise of many early e-marketplaces resulted from their failure to attract sufficient trading volumes. Ideally, exchanges should also have a large number of buyers and sellers. When a small number of traders control a substantial fraction of the transactions conducted on an exchange, there is the possibility of collusion or market manipulation.

Deregulated markets for electricity are a prime example of the difficulty of introducing market-based coordination in a highly concentrated industry. Even though electricity is a pure commodity, and thus an ideal candidate for market pricing, the future of spot markets for wholesale electricity is uncertain due to the potential for market manipulation (Smith and Fialka, 2000).

The type of good or service being bought and sold can have a significant influence on a marketplace's ability to establish liquidity. For exchanges, it is far easier to establish liquidity when the traded item is a commodity or near commodity. Commodities are typically highly standardized, and may be procured from a number of competing suppliers. Examples of strong candidates for exchanges include traditional commodities such as grains, metals, and petroleum products, as well as standardized parts, and maintenance, repair, and operating (MRO) items. Differentiated goods, on the other hand, differ from competing products along a number of non-price dimensions, including performance, quality, features, and service level. This lack of standardization makes it difficult to establish liquid markets.

4.2 Preserving the Benefits of Long-Term Relationships

One of the greatest challenges associated with the introduction of e-marketplaces is finding a way to reap the benefits of market-based coordination, while still preserving the value associated with long-term supply chain relationships. Since major buyers and sellers have the most to lose, they will probably be the most resistant to change.

Several characteristics of market-based price coordination mechanisms make them a particularly poor match for many strategic B2B purchases. Strategic customers expect -- and generally receive -- volume discounts, supply flexibility, preferred credit terms, and higher

service levels. In a pure exchange, all participants are treated as equals: large buyers and sellers pay the same price as their smaller, less strategic counterparts. In fact, when trading on exchanges, large buyers and sellers may actually face higher transaction costs than their smaller counterparts. As is frequently seen in the financial markets, a large purchase or sale has a significant market impact, increasing or decreasing the market price because of the large additional demand or supply introduced into the market (Sharpe et. al. 1995).

Major buyers may also resist price transparency, since they may view information about their procurement costs and practices as a source of competitive advantage that they would not want revealed to competitors. Both buyers and sellers may also be reluctant to give up control over pricing. In industries where supply chain participants benefit from price stickiness, the price transparency introduced by spot markets can make it difficult to maintain price stability using long-term contracts, since fluctuations in spot market prices begin to influence negotiated contract prices. This can lead to a shift from the stable environment of implicit and explicit supply contracts, to a regime of greater price uncertainty. The introduction of market-based pricing mechanisms can also undermine long-term supply chain relationships in more subtle ways. For example, if buyers feel that spot market prices may be lower than contract prices, they have less incentive to commit to the advance orders that suppliers require for production and capacity planning.

In the previous section, we discussed opportunities to manage demand risk using dynamic pricing and revenue management of direct materials or capacity. Although revenue management offers the potential to improve system-wide profits through improved allocation and capacity utilization, it will face challenges gaining acceptance by buyers in relationship-based supply chains. Revenue management has traditionally taken a seller profit maximization

perspective. It has been successfully applied in consumer environments with anonymous transactions, but not yet in B2B environments where relationships are important. It may be difficult to convince buyers that they benefit from revenue management through lower everyday prices or improved availability, since the relevant value measure is seller profit. Nevertheless, adapting revenue management so that it offers a clear win-win proposition to buyers and sellers and preserves the value of relationships could bring the efficiency of price-based allocation into relationship-based supply chains.

4.3 Creating a Win-win for both buyers and suppliers

In practice, e-marketplaces will only succeed if both buyers and suppliers believe that it is in their interest to participate. Dynamic pricing must clearly represent an improvement over traditional relationship-based negotiations for both buyers and suppliers. Otherwise, some participants would have to be coerced into accepting the new paradigm.

In many cases e-marketplaces lead to improvements in overall efficiency, but only one party benefits. In reverse auctions, for example, the lower cost of reaching a wider pool of potential bidders primarily benefits buyers, whose procurement costs fall. However, much of these gains come at the expense of suppliers, whose revenues decline because of increased competition.

Creating a win-win will be critical if new market-based pricing mechanisms are to replace relationship-based coordinating mechanisms. Indicative are the comments of an unnamed supplier who was quoted in a white paper on b2b exchanges:

> Let's see, you want me to put all my products and prices online so my customers can beat me about the head and shoulders. Then I can commoditize myself even more to take my razor-thin margins down to microscopic levels. Finally, I get to pay transactions fees for this privilege... What am I missing? (Meeker & Philips, 2000)

5. Conclusion and Suggestion for OR/MS Research

The focus of this paper is on how e-marketplaces can add value to supply chains in which long-term buyer-supplier relationships are important. We identified three sources of value: efficient allocation of resources, information aggregation and dissemination, and risk management. A number of challenges must be addressed for these sources of value to be realized, and it is unlikely that market-based coordination will completely replace the use of explicit and implicit contracts in relationship-based supply chains.

Fortunately, however, e-marketplaces can add value even if only a small minority of market transactions is conducted through spot or forward markets. Many-to-many exchanges, even with relatively small transaction volumes, can help balance industry supply and demand and improve allocation by finding market-clearing prices, as well as generate and aggregate market information through price signals for improved planning. They can also serve the role of inventory buffers for managing demand risk, and provide an efficient means for hedging price risk. Furthermore, much of the value of exchanges can also be captured through one-to-many auctions. Auctions can be important mechanisms for finding market-clearing spot and forward prices, and for hedging price risk. Thus, many of the benefits of market-based coordination can be realized in markets for non-commodity goods and services that are not suited to trading on a pure exchange.

We believe the greatest promise of e-marketplaces lies in facilitating the formation of spot and forward markets without replacing or displacing relationship-based transactions. The Internet makes the creation of such small-scale exchanges and auction platforms economically viable. With e-marketplaces, it is not necessary for an exchange to be the central focal point of all market transactions. E-marketplaces and relationship-based contracting can peacefully co-exist.

The advent of electronic commerce has made the co-existence of spot markets and relationship-based more economically feasible. This introduces many exciting research opportunities on the role of e-marketplaces in relationship-based supply chains. The most interesting research questions concern the value of information generation and risk management, and optimal buyer and seller strategies for exploiting this value.

With regard to the value of information generation, there are a number of important research questions. What impact would information from spot and futures markets have on supply chain planning? How could buyers benefit in sales and promotion planning by having improved information about the distribution of component costs? How could suppliers benefit in production and product mix planning by having improved information about the distribution of product prices? How would manufacturing strategies and inventory policies be affected?

There are also macro level issues to consider, such as the longer-term benefit of complementing sticky contract prices with spot market pricing that reflects the true "market-clearing" price. This line of research would consider the implications of eliminating the lag between supply-demand shocks and price movements. For example, signals sent through spot and forward prices could improve capacity planning decisions, perhaps reducing the duration or severity of industry supply-demand cycles.

With regard to the value of e-marketplaces for risk management, a number of research issues are inspired by the possibility of more widespread development of spot markets. For buyers, spot markets can add value through improved availability and lead time reduction. If this benefit comes at the added cost of a spot market premium (i.e. the expected spot price is above the contract price), what should be the buyer's optimal inventory policy? How should the buyer determine the optimal mix between contract and spot market purchases, and what tradeoffs should be considered? (E.g., Kleindorfer and Wu, 2001; Wu et. al, 2001a, 2001b; Kleinknecht et. al, 2001.) How can buyers allocate and prioritize purchases across multiple dynamic channels such as reverse auctions, RFQs, and electronic negotiation? (E.g., Bichler et. al., 2001.) Swaminathan and Tayur (2002) survey the use of existing OR models in the context of electronic supply chains.

Questions from a supplier policy perspective are similar. How much capacity should a supplier sell through forward contracts instead of reserving for spot market sales? How can revenue management mechanisms be adapted to relationship-based supply chains, so that price can be a function of lead-time, capacity, and demand in real time? (e.g., Harris & Pinder, 1995; Gilbert & Ballou, 1999l; Olavson, 2001) One challenge is creating win-win price mechanisms that are simple and realistic enough for the average supplier to implement, while still preserving the benefits of relationship-based contracting. Also, how can capacity be priced through mechanisms similar to revenue management if inventory is storable? Finally, from a supply chain efficiency perspective, what is the effect of a spot market broker holding supply chain inventory and pooling demand risk across buyers?

There are also a number of potential research topics associated with using e-marketplaces to more efficiently allocate resources. These include the development of new decision-support

techniques and market mechanisms for transactions involving multiple attributes, multiple items, and bundles or combinations of goods and services.

In considering what new research may be motivated by e-marketplaces, it is our opinion that the guiding principle should be to identify and exploit dynamic networks of information exchange to enhance and complement long-term supply chain relationships. We believe that e-marketplaces, even if they are not the primary channel for B2B transactions, can be leveraged to significantly enhance allocation efficiency, improve planning decisions and enable new approaches for managing risk.

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