Partner Selection and Price Determination in Public Exchanges for Enhanced Supply Chain Profitability

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ABSTRACT
In this paper we develop a quadratic programming model for partner selection and planning in integrated supply chain networks embedded with both sell-side and buy-side electronic market places. Such a scenario arises in several practical applications. In particular, we consider a contract manufacturer that procures components from suppliers through a component marketplace and sells its manufactured sub-assemblies to original equipment manufacturers (OEMs), through a sub-assembly marketplace. In these web-enabled supply chains, embedded with upstream and downstream electronic marketplaces, we need methods for on-line supply chain partner selection based on pricing and delivery schedules. In this paper, we develop and present such a model that selects partners, synchronizes supply chain activities and optimizes the profit through optimal revenue pricing and cost minimization.

Keywords
Supply Chain Management, Dynamic Pricing, Partner Selection, Supply Chain Planning, Electronic Marketplaces.

1. INTRODUCTION

The Internet revolution of the recent past has completely transformed the nature of Business-to-Business interactions. Complicated, time-consuming and expensive paper-based interactions have now been replaced by virtual on-line interactions, communications and negotiations. The center-point of all these activities are Electronic marketplaces. Electronic marketplaces have revolutionized inter-enterprise business processes and interfaces, by smoothening out the transaction and information flows between companies, much like what Enterprise Resource Planning did for processes and interactions across departments within the same company. This has increased the overall efficiency of the supply chain. Also new business models such as direct-to-customer define the path to success. As a result, electronic marketplaces have emerged as invaluable intermediaries within supply chains. Their impact on businesses will be as much as the impact of distribution centers if not more.

Furthermore, a single company may do business in many different types of marketplaces, both up and down its supply chain, as shown in Figure 1. Increasingly the key to continued business success will lie in its ability to identify market opportunities in their downstream electronic markets and simultaneously procure the resources needed, to capture those opportunities, from the upstream markets. Businesses will continue to look towards electronic marketplaces to not only locate and forge profitably sustainable relationships with their customers and partners, but also to synchronize their activities with them. In this scenario, it is important that businesses develop tools and capabilities that allow them to optimally choose and harness opportunities offered by these digital marketplaces. Specifically, these tools should allow them to maximize revenues in the marketplaces they supply to and simultaneously minimize their costs in their procurement marketplaces. Decision-support tools need to be capable of reacting to pricing and supply-demand conditions in the marketplace, and should synchronize procurement and distribution activities of the company with other stakeholders in the marketplaces. This is especially critical since the transparency of the electronic marketplace fosters greater competition, requiring companies to adopt innovative dynamic pricing strategies, which are dependent on the supply and demand in the marketplace. In this paper, we address precisely these important issues.

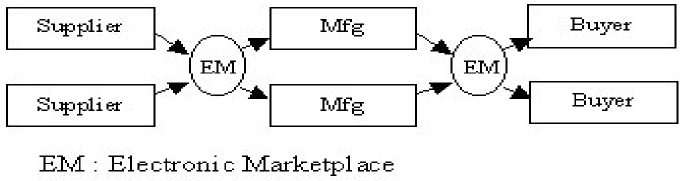

Figure 1: Supply Chains with Electronic Marketplaces

There is a significant amount of documented research in the area of operations research and management science that addresses some of these issues relating to dynamic pricing, partner selection and supply chain scheduling. We review the literature in these areas one-by-one. With regards to dynamic pricing, Biller et al [3] generalize some of the concepts in yield management for coordinating production and inventory decisions in supply chains. Bhattacharjee and Ramesh [2] develop a dynamic programming model for efficient management of the marketing/manufacturing interface in the supply chain, through the appropriate pricing strategies. McGill and Van Ryzin [11] review the research in transportation revenue management, with focus on airline pricing, and provide an extensive bibliography. In the field of partner selection, there have been a number of papers since the seminal work by Dickson in 1966. Weber and Current [13] discuss a multi-criteria analysis for vendor selection. They develop a model for minimizing total cost, late deliveries and supply rejection given the infrastructure constraints and constraints imposed by the company's policy. Chaudhary et al [6] provide a linear programming model for vendor selection with price breaks. De Boer et al [8] provide a comprehensive review of published decision methods for vendor selection and classify them under a framework that takes into account the diversity of purchasing scenarios and covers all phases of the vendor selection process. Degraeve et al [9] review and evaluate a number of vendor selection models, presented by various researchers, by employing total cost of ownership as a basis for comparison. By solving all the models for a single real life data set of a purchasing problem they obtain the relative efficiency of the models and show that mathematical programming models outperform rating models. Current and Weber [7] extend the extensive literature in facility location problems to the solution of vendor selection problems. In the industry environment, Arntzen et al [1] describe a global supply chain management model that was implemented at Digital Equipment Corporation. The model incorporates capacity constraints, import taxes, fixed charges, transportation constraints etc and recommends a production, distribution and supplier network. And finally, the arena of production and distribution scheduling and planning has been one of the most popular areas of research. More recently some of the research has focused on integrated production and distribution planning in supply chains. Erenguc et al [10] review and evaluates some of the relevant literature on production and distribution planning at each stage of the supply chain. Some other researchers have focused on the production scheduling aspects of the supply chain. Bretthauer and Cote [4] develop a non-linear programming model for multi-period capacity planning. In the related work on project scheduling, Brucker et al [5] present a comprehensive review on resource-constrained project scheduling and consider various issues in time-cost tradeoff and activities with stochastic lead times among other issues. Thus in the literature, most efforts have separately focused on dynamic pricing, supplier selection, or supply chain scheduling. But in electronic marketplaces, partners are selected on-line (strategic decision now becomes on-line decision) and hence the need for integrating all the above three issues in a single problem.

Our research here integrates the three aspects of planning in a single framework. We present a model for supply chain planning that harnesses the information within electronic marketplaces. Specifically, we determine the optimal price and quantities for sales and procurement within the marketplaces, select the supply chain configuration within the marketplaces that will allow us to meet the determined sales targets and provide manufacturing, assembly and transportation schedules for the selected supply chain configuration. This decision is based upon the demand of goods in the marketplaces downstream in the supply chain, supply of materials in the marketplaces upstream in the supply chain and the availability of transportation services in the logistics marketplaces. In particular, our analysis is in the context of the electronics manufacturing industry where marketplaces for components and sub-assemblies play an important role in the supply chain. Sub-assembly manufacturers procure chips and components from component exchanges, and use them to produce sub-assemblies that they sell to original equipment manufacturers (OEMs) on marketplaces for sub-assemblies. Similar examples can be found in the petrochemicals industry as well.

Our purpose in this paper is to develop a quadratic programming model for integrated supply chain planning for supply chains with electronic marketplaces, and in the process build a decision support tool for electronic marketplace participants. We begin in section 2, by describing the problem we wish to address. We also formulate a quadratic programming model for integrated partner selection, scheduling and pricing. We then proceed to present and discuss some of our computation results in section 3. And finally, we conclude in section 4 with some observations on e-supply chains and our research here.

2. PROBLEM FORMULATION

Problem Description

We assume a supply chain comprising a sub-assembly manufacturers and a number of component suppliers, OEMs and logistics service providers in different geographical locations, interacting through web-based electronic marketplaces. We assume an electronic marketplace for components through which the component suppliers sell a variety of components to the sub-assembly manufacturer. The sub-assembly manufacturer uses these components in the production of a variety of sub-assemblies. These sub-assemblies are then sold to OEMs through marketplaces for sub-assemblies. For the movement of goods between the various geographical locations the sub-assembly manufacturer can procure the services of warehousing, transportation and third party logistics companies through a logistics exchange. The supply chain configuration as seen by the sub-assembly manufacturer is shown in Figure 2.

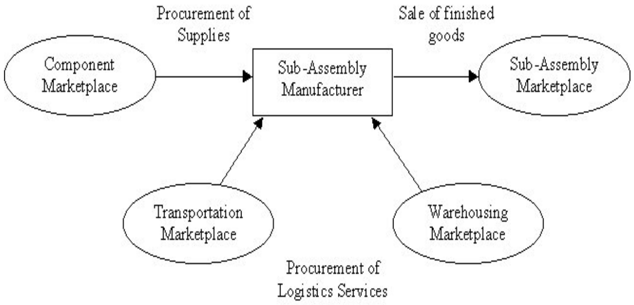

Fig 2: Connectivity between the manufacturer and the various electronic marketplaces

The marketplace participants discover information on each other's supply/demand functions and their capacities through negotiations prior to the transaction. They discover more and more about their partners during each of the many rounds of offers and counter-offers. We assume that the demand within the electronic marketplace for sub-assemblies is linearly related to the sales price per unit for the sub-assembly quoted by her, as shown in Figure 3 [3]. Demand will be very low for high prices and will pick-up if the prices are lowered.

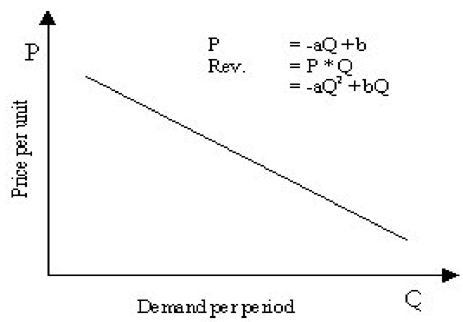

Fig 3: Linear demand curve as seen by the manufacturer

Similarly, the supply of resources within the components and the logistics marketplaces as seen by the sub-assembly manufacturer is also linearly dependent on the per unit price of the resource being traded. The supply of resources, will be greater if the per unit price offered by the sub-assembly manufacturer in these marketplaces is greater and will be lower for lower prices as shown in Figure 4.

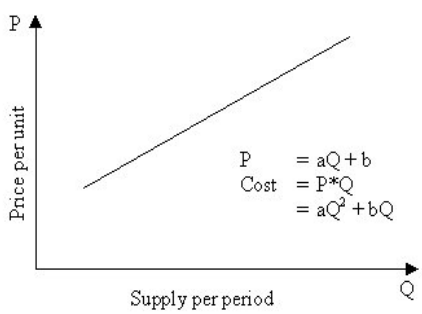

Fig 4: Linear supply curve seen by the manufacturer

The sub-assembly manufacturer is aware of the demand curves for each of the buyers in the sub-assembly marketplace. Within this electronic marketplace, the sub-assembly manufacturer needs to determine the optimal pricing strategy for a range of sub-assemblies and the corresponding demand that would maximize its revenue. The demand from the buyers in the market can be fulfilled from different manufacturing locations with the help of suppliers at different costs and in different lead times with the support of the transportation providers and warehousing companies. The logistics service providers have their own costs, capacity constraints and shipping schedules and so do the warehousing companies. The sub-assembly manufacturer can determine the supply functions for the component suppliers, warehousing companies and the transportation service providers by placing requests for quotations (RFQs) in the component, warehousing and transportation marketplaces. The sub-assembly manufacturer needs to determine the optimal quantity to procure from these exchanges and the corresponding price that it should pay in order to secure enough resources to fulfill its targeted demand. With access to all the market information and operational information on the marketplace participants the challenge for the sub-assembly manufacturer is, how best to meet the demands of the buyers, using a combination of suppliers and logistics providers with minimal operational cost. The sub-assembly manufacturer also needs to determine the optimal pricing for sub-assemblies within the sub-assembly marketplace so as to maximize its revenue.

In particular, a collaborative approach in supply chain management and coordination is required within the marketplace to enhance the efficiency of the supply chain. Apart from incorporating the pricing aspects and capacity constraints in the supply chain decisions, production activities need to be synchronized with the schedules of the logistics service providers, so that items can be ready for pickup in a just-in-time manner, instead of having to wait in inventory. There can be significant cost-savings in this exercise, through reduced inventory levels.

Notation

For development of a mathematical model for the above scenario, the following notations were used.

<u>Identifiers</u>

$i \in I$: Component type identifier.
$j \in J$: Component supplier identifier.
$l \in L$: Sub-assembly type identifier.
$k \in K$: Sub-assembly supplier identifier.
$m \in M$: Buyer Identifier.
$t \in T$: Time Period identifier.

Parameters

C_{abt} : Maximum availability of component *a* from Component Supplier *b* in time period *t*.

CI_{abt} : Capacity availability for storage space for item *a* at location *b* in period *t*.

CM_{abt} : Production capacity availability for sub-assembly *a* at manufacturing location *b* in period *t*.

T_{abdt} : Shipment capacity for component/sub-assembly type *a* from Supplier *b* to its customer *d* in time period *t*.

D_{ab} : Quantity of sub-assembly *a* required by Buyer *b*.

DD_{ab} : Time period by which required quantity of sub-assembly *a* is to be delivered to Buyer *b*.

L_{ab} : Service level negotiated with Buyer *b* for sub-assembly *a*.

R_{ab} : Units production of one unit of sub-assembly *a* will consume of component type *b*.

P_{ab} : Production cost for sub-assembly *a* at manufacturing location *b*.

L_{abd} : Transportation lead-time for transportation of product *a* from location *b* to location *d*.

SL_{ab} : Service level for product *a* for buyer *b*.

A : Slope of the supply/demand line for resource *a* procured from Supplier *b*. In case of transportation service there is an additional sub-script which refers to the destination as well. A is positive for supply graphs and negative for demand graphs.

B : Intercept of the supply/demand line for resource *a* procured from Component Supplier *b*. In case of transportation service there is an additional sub-script which refers to the destination as well.

Variables

Q_{abt} : Quantity procured for component *a* by sub-assembly manufacturer *b* in *t*.

M_{abt} : Quantity of sub-assembly *a* produced at manufacturing location *b* in *t*.

I_{abt} : Inventory of component *a* with supplier or customer *b* in time period *t*.

S_{abdt} : Quantity shipped of component *a* from supplier *b* to its customer *d* in time period *t*.

Quadratic Programming Model

We now develop a quadratic programming model for integrated supply chain planning in environments supported by electronic marketplaces. The objective of the model is to maximize the profit earned by the sub-assembly manufacturer subject to the various pricing, capacity, production and logistics schedules and flow balancing constraints as determined from the electronic marketplaces.

Objective Function

The profit can be calculated, as given in Equation. 1, as the sum of the revenue made from sales to the buyers, less the production costs and the costs incurred in the operation of the supply chain network, specifically transportation and inventory costs. The revenue and costs are dependent on both the choice of price and quantity for goods flowing the network. Additionally, the per unit price and quantity are linearly related.

The revenue is determined by the quantity sold in the sub-assembly marketplace and the costs include the costs of goods procured from the component marketplace, the transportation costs for transportation services and the cost of warehousing services procured from the logistics marketplace.

$$MaxPROFIT =$$

$$\sum_{l=1}^{L}\sum_{k=1}^{K}\sum_{m=1}^{M}\sum_{t=1}^{T} A_{lm} S_{lkmt}^2 + B_{lm} S_{lkmt}$$

$$-\left[\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{t=1}^{T} A_{ij} O_{ijt}^2 + B_{ij} O_{ijt} + \sum_{l=1}^{L}\sum_{K=1}^{K}\sum_{t=1}^{T} P_{lk} M_{lkt}\right]$$

$$-\left[\begin{array}{l}\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K}\sum_{t=1}^{T} A_{ijk} S_{ijkt}^2 + B_{ijk} S_{ijkt}\\ +\sum_{l=1}^{L}\sum_{k=1}^{K}\sum_{m=1}^{M}\sum_{t=1}^{T} A_{lkm} S_{lkmt}^2 + B_{lkm} S_{lkmt}\end{array}\right]$$

$$-\left[\begin{array}{l}\sum_{i=1}^{I}\sum_{k=1}^{K}\sum_{t=1}^{T} A_{ik} I_{ikt}^2 + B_{ik} I_{ikt}\\ +\sum_{l=1}^{L}\sum_{k=1}^{K}\sum_{t=1}^{T} A_{lk} I_{lkt}^2 + B_{lk} I_{lkt}\\ +\sum_{l=1}^{L}\sum_{m=1}^{M}\sum_{t=1}^{DD_{lm}} A_{lm} I_{lmt}^2 + B_{lm} I_{lmt}\end{array}\right] \quad \ldots (1)$$

There are various capacity constraints in the virtual supply chain that make the solution non-trivial.

Component Procurement Marketplace

The component suppliers would indicate a maximum amount that they can offer in a certain period of time based upon their production capacity limitations. The quantity that is procured from the component suppliers is less than the maximum they can offer.

$$O_{ijt} \le C_{ijt} \qquad forall \qquad i \in I, j \in J \,\&\, t \in T \quad \ldots (2)$$

The component suppliers would deliver their goods to various storage facilities managed by warehousing companies on behalf of the sub-assembly manufacturer. These storage facilities may be near the manufacturing plants or far away from them. The procurement of components from the marketplace would add to these inventories at the end of each time period and the shipment of components will reduce the quantity in these inventories. The cost of maintaining a warehouse would be zero for goods delivered by the supplier directly to the manufacturing facility.

$$I_{ij(t-1)} + O_{ijt} = \sum_{k=1}^{K} S_{ijkt} + I_{ijt} \quad forall \quad i \in I, j \in J, k \in K \,\&\, t \in T \quad \cdots (3)$$

The amount of inventory that can be managed is limited by the amount of warehousing space offered in the marketplace. Hence, the following constraint applies.

$$I_{ijt} \le CI_{ijt} \quad forall \quad i \in I,\, j \in J \,\&\, t \in T \quad \cdots (4)$$

The components in these inventories will be shipped out to the manufacturing facility. However, the quantity that can be transported in a single period is constrained by the maximum capacity that can be procured from the transportation marketplace. Hence, the amount that can be shipped is constrained.

$$S_{ijkt} \le T_{ijkt} \quad forall \quad i \in I, j \in J, k \in K \,\&\, t \in T \quad \cdots (5)$$

The components that are shipped will arrive at the manufacturing facility after a certain delay equivalent to the transportation lead-time. When the warehouses are far away from the manufacturing facility these lead-times will be significant, else they may be negligible. For items delivered directly to the manufacturing facility by the supplier the lead-time will be zero.

$$S_{ijk(t+L_{ijk})} = S'_{ijkt} \quad forall \quad i \in I, j \in J, k \in K \,\&\, t \in T \quad \cdots (6)$$

<u>Manufacturing facilities</u>

Once the components reach the manufacturer's facilities, they add to the on-site inventory there, which is then consumed by the manufacturing process. The amount of inventory maintained is constrained by the warehouse space that can be procured.

$$I_{ikt} \le CI_{ikt} \quad forall \quad i \in I, k \in K \,\&\, t \in T \quad \cdots (7)$$

However before the manufacturing process can start and the various component types can be consumed, the sub-assembly manufacturer will need to check adequate availability of all components that will be used in the sub-assembly production process. This imposes the following constraint on the component availability and the sub-assembly production.

$$I_{ik(t-1)} \ge \sum_{l=1}^{L} R_{li} M_{lkt} \quad forall \quad i \in I, l \in L, k \in K, t \in T \quad \cdots (8)$$

However once the production process begins the inventory of components drops and is replenished by incoming supplies. The inventory status for component types with the manufacturer can be determined as given below.

$$I_{ik(t-1)} + \sum_{j=1}^{J} S_{ijkt} = \sum_{l=1}^{L} R_{li} M_{lkt} + I_{ikt} \quad forall \quad i \in I, j \in J, k \in K, l \in L \,\&\, t \in T \quad \dots (9)$$

The production within the manufacturer's facility is constrained by the capacity of the manufacturing facility.

$$M_{lkt} \le CM_{lkt} \quad forall \quad l \in L, k \in K \,\&\, t \in T \quad \dots (10)$$

Subsequent to production the sub-assemblies are moved to an on-site storage facility, before they are shipped out to customers. The inventory balancing constraint for the sub-assembly inventory at the manufacturing locations applies.

$$I_{lk(t-1)} + M_{lkt} = \sum_{m=1}^{M} S_{lkmt} + I_{lkt} \quad forall \quad l \in L, k \in K \,\&\, t \in T \quad \dots (11)$$

Again, there is a limit on the amount of storage space that can be procured from the marketplace for storing sub-assemblies.

$$I_{lkt} \le CI_{lkt} \quad forall \quad i \in I, k \in K \,\&\, t \in T \quad \dots (12)$$

<u>Sales Marketplace</u>

Transportation service providers transport the sub-assemblies from the manufacturing facilities to the buyer's location. The amount that can be transported is limited by the maximum amount that is offered in the logistics marketplace.

$$S_{lkmt} \le T_{lkmt} \quad forall \quad l \in L, k \in K, m \in M \,\&\, t \in T \quad \dots (13)$$

The sub-assemblies reach the buyers after a certain transportation lead-time.

$$S_{lkm(t+L_{lkm})} = S_{lkmt} \quad forall \quad l \in L, k \in K, m \in M \,\&\, t \in T \quad \dots (14)$$

The sub-assemblies that reach the buyer add on to the amount supplied earlier.

$$I_{lm(t-1)} + \sum_{k=1}^{K} S_{lkmt} = I_{lmt} \quad forall \quad l \in L, k \in K, m \in M \,\&\, t \in T \quad \cdots (15)$$

The amount of storage space available for the sub-assemblies is constrained by the amount available in the marketplace.

$$I_{lmt} \le CI_{lmt} \quad forall \quad l \in L, m \in M \,\&\, t \in T \quad \dots (16)$$

The amount supplied to the buyers till their desired delivery date needs to be within the service levels quoted to them during the negotiation in the sub-assembly marketplace.

$$I_{lm(t+DD_{lm})} \geq SL_{lm} D_{lm} \quad forall \quad l \in L, m \in M \,\&\, t \in \lfloor 1, T - D_{lm} \rfloor \cdots (17)$$

The standard initial conditions with initial inventory, production and transportation equal to zero apply.

Te solution of this model determines the pricing strategy with the marketplaces, the selection of suitable suppliers in the supply chain and the synchronization of activities with them through integrated global scheduling.

For transportation and warehousing it has been assumed that there is no differentiation between the offerings of the various service providers and the cost for procuring these services is dependent only on the quantity required. As a result the supply curve for these services is the supply curve for the entire market. However the model can be extended for selection of transportation and warehousing service partners by defining the supply curves for each of the individual service providers in the marketplace. The additional decision that will have to be made is the allocation of transportation between the transportation companies on each individual link and between the warehousing companies at each sub-assembly facility location.

With the above mathematical model any of the available optimization toolkits might be used for decision making in supply chains supported by electronic marketplaces.

Solving the Model

The above linear model was developed in the AMPL modeling language and was solved using the quadratic solvers within CPLEX. The model was developed and solved for a scenario with 3 component suppliers, 2 sub-assembly manufacturing locations and 2 buyers. The manufacturing facilities make 2 different types of sub-assemblies from a combination of 3 different component types. The time horizon for the model was taken as 6 periods. Even for such a simple set-up the number of variables and constraints encountered are around 512 and 680 respectively. Hence, it can be expected that for real-life situations the problem can get too large. Fortunately, the widespread availability of good quadratic solvers will ease the solution process. In our stated example the solution time was less than 10 seconds.

3. COMPUTATIONAL RESULTS

Partner Selection in Public Exchanges

In order to give you a feel for the kind of results that the model generates the above scenario with 3 component suppliers, 2 sub-assembly manufacturing locations and 2 buyers was solved. The supply functions for the component suppliers, warehousing and transportation service providers were assumed. A representative data of the parameters for the supply function of the component suppliers is given below in Table 1.

Table 1: Parameters for the suppliers' supply functions

		A	B
Component Supplier 1	Comp 1	0.002	800
	Comp 2	0.003	700
	Comp 3	0.0016	850
Component Supplier 2	Comp 1	0.0023	900
	Comp 2	0.0022	800
	Comp 3	0.0017	750
Component Supplier 3	Comp 1	0.0015	850
	Comp 2	0.0019	900
	Comp 3	0.0021	950

On the sales side the sub-assembly manufacturer was faced with decisions relating to the demand curves of the various buyers as given in Table 2.

Table 2: Parameters for the buyers' demand functions

		A	B
Buyer 1	Brand 1	0.17	4000
	Brand 2	0.21	3700
Buyer 2	Brand 1	0.20	4500
	Brand 2	0.23	3500

The slopes for the demand functions are higher than the slopes for the supply functions of the component supplier, because it is argued that due to the fact that the finished goods have more value the difference in price with unit increase in quantity of the will be greater on the demand side as compared to the supply side. Similar the intercept is greater on the demand side representing the higher value of the sub-assemblies sold as compared to the cost of the components procured. Similar parameters were considered for the transportation and warehousing service providers. However, since the cost of warehousing and transportation was assumed to be much lower compared to the cost of the components and the prices of the sub-assemblies the values for their intercepts (B) were much lower than the value of the intercepts for the component supply and sub-assembly demand functions.

The buyers' demands were determined from the marketplace and service levels quoted to them as given in Table 3.

Table 3: Buyer demands and Service Levels quoted

		Demand	Service Level
Buyer 1	Brand 1	80	70 %
	Brand 2	90	80%
Buyer 2	Brand 1	125	75%
	Brand 2	80	65%

These demands were to be fulfilled through a dynamic manufacturing network supported by electronic marketplaces. Furthermore, the two brands are manufactured from a mix of components. Brand 1 requires 1 unit each of components 1, 2 and 3, whereas Brand 2 requires 2 units of component 1and 1 unit of component 2. In such a situation is it very much possible to gain from economies of scale in the collective ordering and transportation of materials, which are used in the manufacture of multiple models.

The optimal procurement and sales decision, consolidated over the entire time horizon, is obtained as given below in Figure 5. The profit earned from the operation of the supply chain in the optimal manner is expected to be $744295. Given the optimal quantity flows through the network it is possible to determine the associated pricing and procurement strategies within each of the marketplaces.

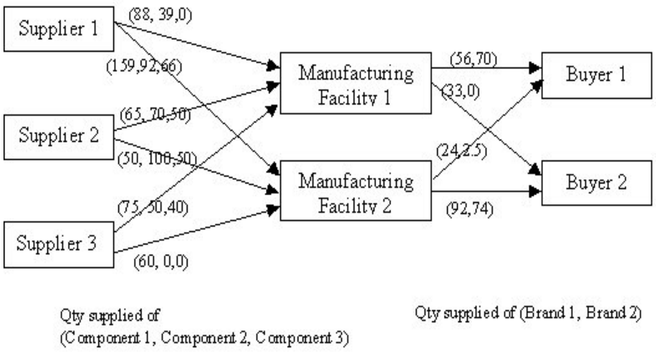

Figure 5: Optimal material flows through the supply chain supported by electronic marketplaces.

The negotiated prices, for consolidated procurement across all manufacturing facilities, associated with the above optimal quantities can be calculated by plugging in the quantities in the supply and demand functions. The optimal prices averaged over the time horizon are given in Table 4.

Table 4: Optimal prices negotiated in the marketplace

		Optimal Qty	Optimal Price
CS 1	Comp. 1	247	800.4740
	Comp. 2	131	700.3930
	Comp. 3	66	850.1056
CS 2	Comp. 1	115	900.2645
	Comp. 2	170	800.3740
	Comp. 3	100	750.1700
CS 3	Comp. 1	135	850.2025
	Comp. 2	50	900.0950
	Comp. 3	40	950.0840
Buyer 1	Brand 1	80	3986.4000
	Brand 2	73	3684.7750
Buyer 2	Brand 1	125	4475.0000
	Brand 2	74	3482.9800

Only partial demand, within the constraints of the service levels, is fulfilled for Brand 2 due to the limitations on the maximum amount of resources that can be procured from the marketplaces.

The model also generates the quantities flowing through the warehouses and the transportation links. These quantities can be used to determine the optimal prices for the warehousing and transportation services.

The solution of the model also provides the schedules for warehousing and transportation activities and production activities within the facilities of the sub-assembly manufacturer. Hence, the quadratic programming model provides an integrated strategic-level dynamic pricing and partner selection tool and a low level operational scheduling tool as well.

Influence of Supply Surpluses and Shortages on Partner Selection

The model was also employed to study the influence of dumping of surplus stocks and rationing of supplies by a single supplier on the supplier selection decision in public exchanges. Based on common microeconomic concepts [12], these scenarios were modeled by considering lateral shifts in the supply curve for the particular supplier. When a supplier dumps his excess stock in the marketplace, a given quantity of goods becomes available from him at a lower price, and corresponds to a shift of the supply curve to the right in our model. Similarly, a decrease in supply from the supplier corresponds to a shift to the left.

We consider three suppliers with similar production and transportation capacities for all three components. The slope of the supply curve for all three suppliers for all components is the same, taken to be equal to 1. The intercepts for two of the suppliers is taken as 800, and the intercept for the third supplier, who we refer to as the market mover is varied from 400 to 1200 for each component, representing its relative surpluses and shortages for the particular component with respect to the other two suppliers. These suppliers supply components to a single sub-assembly manufacturing location, which in turn supplies to 3 buyers. The shift in buying patterns and change in profits for the supply change network, with changing supply curves for the market mover is presented in Figures 6 and 7 respectively.

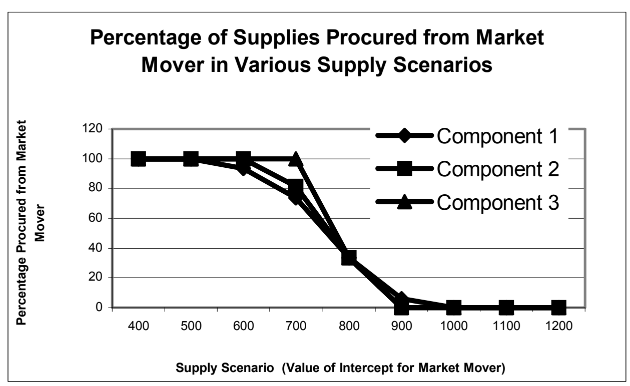

Figure 6: Percentage of supplies procured from the market mover for each variation in its supply curve.

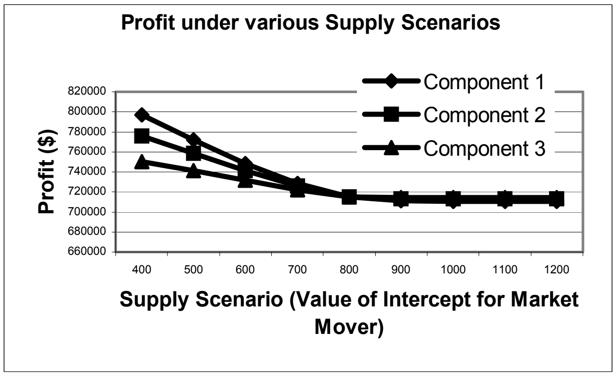

Figure 7: Profit from the supply chain network for different supply curves for the market mover.

We note that the effect of dumping or rationing on the supply chain network is more significant for components that are required in higher volumes. When the market mover dumps a lot of stock it is the preferred supplier due to its low cost. However, when the market mover faces a serious shortage of components and correspondingly its price is high, the market mover is not selected. Also, it is observed that the savings from procuring components, from a cheaper supplier, is balanced with the inventory cost of holding them until their consumption. Hence, if the components are required at a much later stage it might not be beneficial to procure components from cheaper suppliers, because of the high cost of holding inventory. Dumping by a supplier increases the profitability more significantly for components consumed in larger volumes. However, rationing of supplies has no effect on the profitability of the network, because the more expensive suppliers have no role to play in the supply chain network.

Influence of Demand Increases and Decreases on Selection of Partners

The influence of surges in demand and slumps in demand from a single buyer was also modeled and studied. An increase in demand corresponds to a lateral shift of the demand curve to the right (increase in intercept of the demand curve), and a decrease in demand corresponds to a lateral shift of the demand curve to the left (decrease in intercept of the demand curve).

To demonstrate the impact of increasing and decreasing demands, we consider three buyers with equivalent requirements for two sub-assemblies. The slope of the demand curve for all three buyers, for both sub-assemblies, is similar and set to be equal to 4. The intercept for two of the buyers is taken as 8000, and the intercept for the third buyer, who we refer to as the market mover is varied sequentially from 4000 to 12000 for each sub-assembly in order to study the impact of its action on the entire supply chain. Each new value of the intercept corresponds to an increase or decrease in demand from the market mover, with respect to the demand of the other two buyers. The requirement of all three buyers is fulfilled from one manufacturing location, which is supported by supply of components from three suppliers. The configuration of the supply chain network for increased and decreased demand from the market maker was studied, by changing the intercept of its demand curve. The results are presented in Figures 8 and 9 respectively.

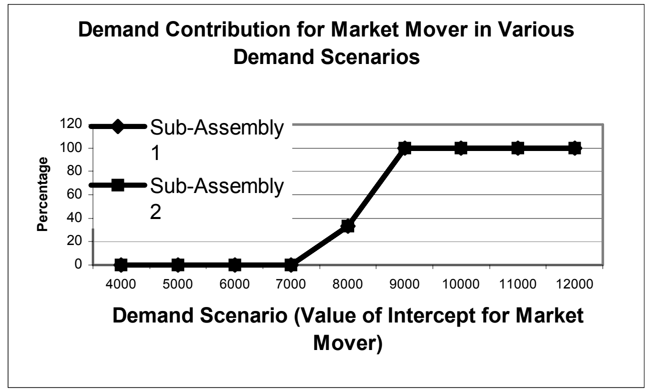

Figure 8: Percentage of sub-assemblies supplied to the market mover for each variation in its supply curve.

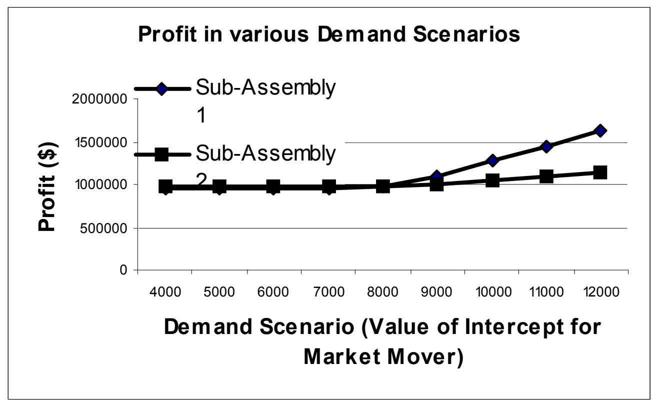

Figure 9: Profit from the supply chain network for different demand curves for the market mover.

When the demand from the market mover is low and the price it offers is lower compared to the other buyers, the quantity supplied to it is less. However, as it increases its offer price in line with its surge in demand, the sales made to the market mover increases. It was also noticed that the model tries to increase sales in more profitable sub-assemblies, subject to the constraints of the supply. The profitability of the network increases for increasing demand, whereas decreasing demand from the buyer has no effect, since the buyer is no longer involved in the network due to its relatively unattractive price.

4. CONCLUSIONS

In an electronic market environment, supply chain partners are selected online, based on negotiations regarding prices, quantities and delivery schedules. Hence, there arises a tremendous need for an integrated framework that incorporates partner selection, price fixation, and production and transportation scheduling. We formulate and solve this problem in this paper. We show how such problems might be solved by considering some simple scenarios for studying the impact of surges and shortages in supply and demand. We show that surges in supply and demand lead to higher profitability, whereas decreases in supply or demand do not have any affect on the profitability of the network.

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