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A New Approach for Evaluating the Order Fulfillment Process Options of B2C Horizontal Portals Using DEA (Data Envelopment Analysis)

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ABSTRACT

By using the traditional statistical or operations research methods for deciding the product-delivery logistics, the portal companies are not using their competitive advantages on being more e-enabled, informed and computationally able than their traditional counterparts. In this paper, we show some typical characteristics of the portals like their handling of a huge range of goods in terms of transactional values or volumes. Subsequently, we have identified three types of generic product-delivery logistics of the portals with various intermediate entities or trading partners. Then, a completely different approach using an extreme point method rather than the traditional central-tendency-based statistical methods has been suggested.

INTRODUCTION

E-Business Portals

An e-business model, like any other business models, evolves around a basic revenue-generation model, supported by the other necessary business activities like finance, marketing models etc. (Afuah and Tucci 2001; Alt and Zimmerman 2001; Boyle and Ruppel 2006). The business model spells out how a company generates revenue by specifying where it is positioned in the value chain. The revenue generation processes can be direct or indirect and can actually be a multi-level hybrid of other simple models. The web has incorporated radical paradigm shifts in the traditional business models (Bouton et al 2000; Bouwman and Wijngaert 2003; Chen and Dubinsky 2003; Deitel et al 2001), and also has given rise to new kinds of business models. The web has actually complemented or reinvented tried-and-true models and has opened hitherto unseen revenue-earning models (Jayaraman and Baker, 2003) for companies. Across the four crucial strategic quadrants that were identified in a survey on e-business models (Westland and Au, 1998), i.e. technology, brand, service and market, it was generally found that laggard companies who failed to implement an e-business strategy never made it past the technology quadrant. Leading and medium-performing organizations, on the other hand, quickly moved their focus from technology to business delivery aspects. They migrated toward a market strategy by concentrating either on a brand strategy or service strategy. Few migrated directly to a market strategy. Leaders like Lufthansa and Motorola etc used Web technologies with a view to harnessing them for leadership in business terms i.e. matching appropriate technology to business strategy and customer requirements, with planned and demonstrated, adequate and appropriate technology capability and capacity either available in-house or through partnering. Innovations in the service strategy worked for a significant proportion amongst the leaders. Over the time, the challenges for these companies graduated from technical ones, e.g. “the complexity of integrating Web sites with legacy systems and business processes,” to marketing or service strategies like “sort out channel conflicts,” and the need “to include the whole management team and employees in the transformation process.” The key learnings were:

1. Being first technology mover is not always a successful strategy even when applied to a viable business model.
2. Information-systems success carries its own risks. In addition to using technology strategically, companies must deploy it in the appropriate organizational and managerial context. (Alt and Zimmerman, 2001; Travica, 2005)
3. When technology is treated as an asset with a role in transforming the business, there is much greater likelihood of technology leadership and eventual business payoff. (Bouwman and Wijngaert 2003)

Consequently, many services related to traditional business or e-business models and processes have been e-enabled and have thus become better defined, structured, measurable (Bouwman and Wijngaert 2003; Deitel et al 2001, Lu et al 2005). Some business processes in this context pose bigger challenges than others because of the more number of variables (internal / external: third-party-dependent/ outsourced, can be e-enabled or not) and variants (e.g. with options for in-house/ maintained/ outsourced etc.) involved in them. Efficient, cost-effective logistics and distribution management is one such process which is still seen as the bane of most companies' existence.(Eon-Kyung and Kim, 2001; Fu-ren et al 2002) The distribution network is still seen as a significant bottleneck with many mid-warehouses, intermediaries etc. (Cheung and Liao, 2003; Choi et al 2002; Eon-Kyung and Kim 2001) More emphasis is being placed on product delivery with the explosion of e-tailing and retail stores that require smaller shipments to be made more frequently. In some cases, product delivery performance can be improved with technology, namely in the form of automated sorting systems for e-tailers (e.g., Amazon.com), catalog distributors (e.g., J. Crew), and retailers (e.g. Wal-Mart). Operational decisions must also be answered and economic factors as well as the throughput of the system will be considered. The problem in maximizing the efficiency of logistics networks is that information, applications and processes have been stove-piped. (Cheung and Liao, 2003; Eon-Kyung and Kim 2001) These vertical silos of information have engendered years of disarray and inefficiency in logistics management, customer service and analysis capability. A recent survey presented by Cheung et al shows "demand-side obstacle factors in the form of perceived low e-shopping comparability, e-shopping inconvenience, e-transaction insecurity, and poor Internet privacy...translate into...supply-side hurdles." (Cheung and Liao, 2003) In this environment, processes and information systems are separate, uncommunicative parts of the organization that often work at cross- purposes.

New solutions are being suggested to address these logistics decision problems. For example, there is the two-part IT model to build, manage and integrate logistics networks; (Choi et al 2002; Fu-ren et al 2002). First model depicts a technical architecture that deploys extraction, transformation and loading (ETL) tools; enterprise application integration (EAI) tools; and business analytic (BA) tools, and second model- the use of these sophisticated tools to perform complex analysis to enable better distribution decisions and collaboration between trading partners. (Koster, 2003) Collaboration between manufacturers, distribution centers and retailers is now the key to success in e-business, with the merging or replacing of old-line, standalone ETL, EAI and BA tools with flexible, scalable, intelligent information networks that route data to and from information-craving entities based on prescribed business rules. But information sharing is not necessarily the panacea for all ills. Choice, design and implementation of the decision making tools and processes based on shared information can actually make the information productive and the decision more effective. In this context, we propose a new approach using Data Envelopment Analysis (DEA) as the method of decision making for B2C horizontal portals' distribution problems based on information sharing of the trading partners involved in the distribution network. We develop the method of using DEA for the decision making process and incorporate a set of decision variables into the process.

E-Business Horizontal Portals

Horizontal portals in the context of e-business models have a broader user base due to its capability to cater to the versatile areas of interest of the users. Examples include Indiatimes.com, yahoo.com etc. which are often B2C type in nature. On the contrary, the vertical portals serve a particular industry or a user community's supply chain. For example, indiamart.com acts as the e-marketplace for automobile industry i.e. automotive components manufacturers and automobile companies. (Hung et al 2005)

For the vertical portals, the supply chains are mainly B2B supply chains which are quite well-defined by traditional business and can be followed in e-business as well, because they can operate using EDI and bulk business. The issue of distribution logistics therefore can be handled and resolved in a much better and elaborate form in vertical portals as compared to the horizontal portals. (Koushik and Joodi, 2000; Mahadevan, 2000)

The horizontal portals operate primarily as e-shopping malls wherein a diverse range of products of various companies are available. These portals eliminate mid-warehouses and thereby also eliminate the necessity of an effective inventory management and control system. Instead they handle the orders by acting as in intermediary between the product manufacturers, importers or dealers. They have to cater to the demands of individual customer with small size orders and varied transactional values, which is a unique distribution problem in itself. How the distribution channels can be used optimally and cost-effectively, is a major concern. While minimizing on the cost

of distribution, at the same time, the customers have to be satisfied with the speed of order fulfillment and delivery of goods.

The key to profitability in the entire E-supply chain (Bouwman and Wijngaert 2003; Deitel et al 2001) can be summed up as under:

- It has to inspire confidence from supplier to customer
- It should be more available than possible in the physical world
- It must protect data integrity to ensure future growth.

The first two elements are primarily dependent on the value-chain including procurement and distribution issues. This paper handles these issues relating to the distribution models of e-business portals focusing on speed of delivery and customer satisfaction which reflects the quality of service aspect, customer relationship and cost associated with distribution channels.

Business Models of Horizontal Portals

Some of the successful business models of the horizontal portals (xDeitel et al 2001; Gordijn et al 2001; Hedman and Kalling, 2003; Mahadevan, 2000) are mentioned and analyzed in this section which strongly corroborates our claim that collaboration between the partners in the distribution network is the key factor of effective functioning of these models.

⇒ Direct Producer-Consumer Model (e.g. B2C)

In this model, E-business removes intermediaries from the supply chain, creating a direct, efficient link between producers and consumers. Here, a manufacturer sells directly to customers, increasing profitability while reducing consumer costs by eliminating warehouse and reseller markups. Even the primary contact for service and support also moves through online channels resulting in reduced overhead and speedy service response. Biggest drawback of this model is that the choices of consumers are restricted to just one manufacturer and also the customers' inability of 'seeing & feeling' the product that of course happens to be a generic problem of any e-business scenario.

⇒ E-Business Intermediary Model (e.g. B2B2C)

In the second business model, E-business introduces an intermediary for creating an E-Market where none has existed before. This is the biggest area of e-business with a great number of e-shopping malls and horizontal portals operating. Some of the common examples are indiatimes.com, easybuymusic.com, planetmindia.com, amazon.com etc.

⇒ C2C and Customizable Models

The third model has prominent examples of online business, which include auction houses and online brokerages. By opening their networks to ordinary consumers, these organizations create investing and merchandising opportunities that were previously impossible. Example: baazee.com

For effective and timely functioning of the order fulfillment cycle of any of these types of portals, it is very crucial for the portals to define suitable distribution models for the products they sell. If the portals' business is entirely IT-enabled and service-oriented like the airline/ railways reservation systems or accommodation booking systems etc., the supply chain is not a major issue. For example an on-line train ticket booking portal, which delivers the e-booked tickets overnight, can use any eminent courier company and take the delivery charges i.e. courier charges from the customer, which he/ she is ready to pay for the convenience of the service. But as regards the portals which sell a diverse range of goods from different manufacturers and importers, distribution becomes a crucial bottleneck in the order fulfillment cycle. For example, when a customer buys a microwave from an e-shopping horizontal portal, how will the portal company deliver the product to the customer? Getting it couriered is an expensive and un-safe option (the product quality may suffer) and the consumer is not likely to pay for a substantial

extra amount just because he is having the facility of buying it from the net. In order to tackle such situations there are a number of options available for the distribution models applicable which are explained in the next section.

B2C Horizontal Portals

B2C (Business-To-Consumer) is one of the main categories of e-business applications and concerns business transactions with consumers through the Internet. Examples of popular B2C portals are Amazon.com, Yahooshopping.com etc. As established business-to-consumer (B2C) companies set out to take advantages of the Internet, many have found the task far more difficult and potentially destabilizing than they had anticipated. No more business tool, the Internet goes to the heart of the corporation, challenging its existing business models and customer relationships.(Afuah and Tucci, 2001)

The challenges force traditional companies to address some fundamental questions, like:

1. What do the Internet and its associated technologies can do for their existing business and business models?
2. How can it affect or effect the firm's competitive strategy and information-systems strategy?
3. Which former imperatives need to be considered and which business processes need to be re-engineered in order to build a sustainable Internet business?
4. How can a firm leverage the speed, access, connectivity and economy created by Web technology to extend the reach of it's business?
5. And, how should they organize in order to execute their Internet business strategy?

The answers to these questions largely determine the success of a company's Internet initiative. To investigate how organizations can effectively deal with the challenges, a survey has been conducted which examined 58 major B2C corporations from three continents and a wide range of industries. According to the survey, leaders shared generic characteristics that distinguished them from other companies. (Koster, 2003) First, the move to the Internet was an evolutionary process for bricks-and-mortar companies; second, it involved planning and flexibility in the face of market and technology developments. They also are seen to follow distinctive routes. Although they may have started with strategy based upon the idea of technology leadership, they migrated through interim stages to a market strategy. Only then were they capable of yielding sustainable, consistent e-business profits. Leaders were the fastest and most focused at moving from an "e" that stands for electronic to an "e" that represents earnings.(Westland and Au, 1998)

B2C implementation minimally includes the following (not exhaustive) activities: Web Marketing, Sales, Payments, Order Fulfillment and Logistics, Customer Service, Inventory Management, Supply Chain linking etc.

The quality and the cost of these applications are two significant factors which influence the competitiveness of a B2C enterprise. An enterprise that introduces B2C and e-business practices and wants to maintain and enhance its market share must take into account the international nature of the new e-market. As Information and Communications Technology (ICT) infrastructure improves, more distribution channels and more e-business applications are appearing and so the global e-market is also increasing. Customers, suppliers and competitors from all over the world with different cultures, behaviors and expectations are getting closer.

Typical characteristics of B2C portals, especially horizontal portals, include, say for example,

- the huge range of transactional values and getting it linked with customer loyalty/ CRM/ customized delivery services/ service commitments,
- variations in the volume/ value/ handling requirements of different categories of products etc.

The traditional mathematical foundation of distribution logistics has been operations research techniques like transportation and assignment models which can be applied to solve these problems by modeling them accordingly e.g. an LP or an Integer Programming or Goal programming problems across various decision variables mentioned

before, e.g. cost, transaction value, volume etc. In addition to these decision variables, the B2C horizontal portals also have different options for distribution ranging from having an intermediate warehouse, own logistics chain to no warehouse, third-party logistics- type distribution models. Selection amongst various options that are available to decide on distribution logistics can also be inherently dependent on the type of business model the portal uses. For example, for a B2C portal, which wants to have distribution cycle-time as one of their critical sources of competitive advantage, will rather have an intermediate warehouse and logistics than outsourcing distribution and logistics to third parties. But for a B2C portal which follows the 'cost leadership' strategy or 'lowest price' strategy may not see distribution as one of their core-competency processes and can therefore might outsource the entire distribution process to third parties. If we model the decision making process this way, i.e. considering not only the variables but also the options available across these variables, we can consider each of these options as a Decision making Unit (DMU). Then we can apply the concept of DEA (Data Envelopment Analysis) to these DMUs to generate an efficiency frontier, evaluate the DMUs' relative efficiencies, and consequently choose the most efficient DMU i.e. distribution option. This is what we are precisely going to suggest in this paper, in the following sections.

RESEARCH QUESTION

B2C Order Fulfillment and Logistics

For a B2C transaction to be completed, the order should be fulfilled and should be delivered to the customer in the time that was announced /agreed. The fulfillment of the order is one of the most important tasks in e-business and requires the application of an integrated Logistics Plan (LP). Besides the management of inventories and the control of the stock, packaging, shipping and delivery of the product should be accomplished within quality standards and cost limits.

A B2C company should be involved in the following processes: Operation of a warehouse or multiple warehouses, pulling inventories from shelves, packing them for shipment, retaining a delivery service, helping customers to track their order, dealing with returns. Also the company must always take account of and try to improve the integration of the above processes with its supply chain. In fact the integration of the front with the back office processes is a critical factor in determining a more efficient operation of the whole enterprise. Using technology as a tool for this integration, the procurement time (for purchasing or production) as well as the order fulfillment cycle-time can be minimized. Integrating B2C front office processes with financial services and ERP processes, like Master Production Scheduling (MPS), Capacity Planning Scheduling (CPS), MRP (Material Requirements Planning) and Production (or Purchasing) Orders Release (POR), the chain of the processes of the whole enterprise can be made unique, bottlenecks and queues can be reduced, inventories minimized, set-up and waiting times reduced and productivity and lead times improved. Also in this chain the delivery and distribution processes should be considered thus extending it right up to the door of the customer. The degree of integration and the processes to be integrated depend on the size, the type and the activities of the enterprise. For example, for a small shop, the integration could involve a limited number of processes like packaging, shipment and re-ordering from its suppliers. But on the other hand a SME with both commercial and production activities must consider seriously the integration of its processes that may include warehousing, inventory management of large quantities, production planning, MRP, etc.

A Logistics Plan (LP) includes all activities from the receipt of the customer's order to the final delivery to the customer. As the LP is prepared and its processes are designed the following issues should be considered: Types of products and packaging, average orders, ways of shipping, delivery quality standards, inventories, returns, international orders, seasonal demand, relations with suppliers and partners, types of warehousing and fulfillment centers, insurance, handling of exceptions, management of multiple suppliers and distribution channels. Consequently, possible functions of B2C Software solutions include mechanisms/ modules for order tracking, priorities, linking with warehouse / distribution operations, integration with back office, etc.

Another very important factor that influences significantly the cost of order fulfillment is the cost of shipment. It is determined mainly by the shipping distance, the package weight and the delivery time. In general the B2C enterprise should calculate precisely the whole cost of order fulfillments and should be able to allocate these costs (both direct and indirect) to each delivery package.

Finally a very important issue, that a B2C enterprise should consider, is to what degree it should outsource certain activities/processes from the total fulfillment process. The answer to this question is not simple and depends, among others, on the size of the company, its warehousing and distribution infrastructures, its business and investments plan and its general policy for B2C involvement. As a general assertion we can say: the smaller a company is the more outsourcing it will need.

Summarizing the above discussion, the basic models that become identifiable for B2C order fulfillment are-

- a. Full in-house order fulfillment. (Purchasing/Production, Warehousing, Deliveries are accomplished by the B2C company)
- b. Partially in-house order fulfillment. (Certain activities of the whole value chain are outsourced. Such activities may concern production, warehousing, distribution channels, customer order tracking and status information, customer payments, etc.)
- c. Completely outsourced order fulfillment. (The application of this model implies that the B2C company maintains mainly the Web site that interacts with the customers and almost all the other activities are outsourced. This model is implemented basically by B2C companies that are small and did not exist before as brick-and-mortar enterprises).

TYPES OF DISTRIBUTION OPTIONS FOR B2C HORIZONTAL PORTALS

For portals like yahooshopping.com selling a huge range of goods from different manufacturers and importers, there are several distribution channels available to complete the order fulfillment cycles with a defined efficiency and in a cost-effective way. These models are shown in Figure 1, which has been developed by the authors based on the study of operations of various popular horizontal portals like amazon.com, yahooshopping.com etc.

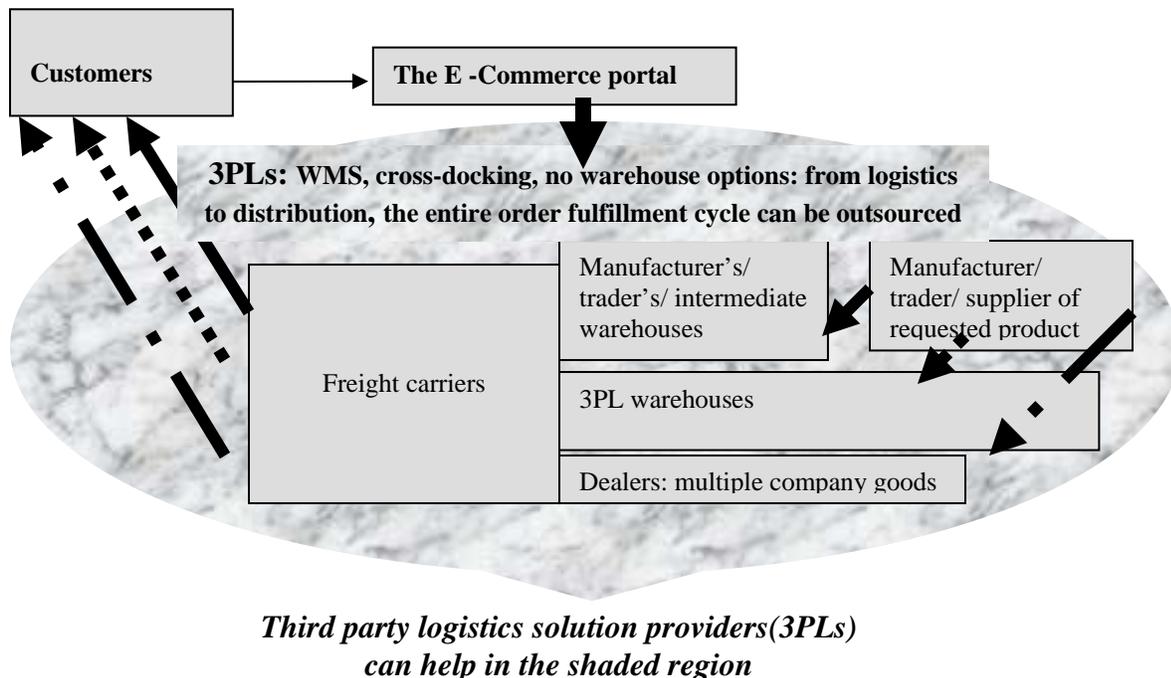
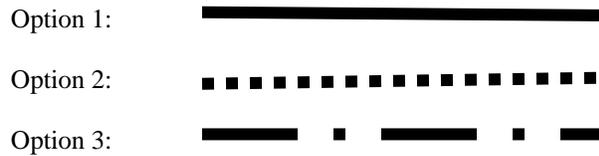


Figure 1: Options for Order Fulfillment in Case of a B2C Horizontal Portal.

Three possible distribution channels can be identified with the following index:



Comparative Analysis of the Three Options

Option 1:

Advantages:

- It eliminates mid-warehouses completely.
- Best quality product is available since company inspected goods are sent straight to customers without getting stored by dealers.

Disadvantages:

- It may not prove to be cost-effective.

The decision parameters here will include

- Relative locations of company warehouses and customer.
- Scale of business.
- Transactional value.
- Product price/profitability i.e. .if the profit involved can justify the freight charges or not.

Option2:

Advantages:

- Relative location advantages can be taken.
- Bulk handling will result in lesser freight.

Disadvantages:

- Dealers' commission can not be eliminated. So the company can not get maximum profit and so is unable to pass on cost savings to customers.
- Quality control can not be ensured.

Option 3:

Advantages:

- Shared distribution channels / transportation infrastructure/ shared costs are possible between companies.

Disadvantages:

- It can not eliminate dealers' margin.

Selecting an Option

With the advent of the concept of core competency, 3PL can be thought as a direct implementation of the concept, where specialist third-parties manage the entire order fulfillment cycle of a portal virtually leaving the portal to focus on developing it's competencies in line of e-marketing, customer segmentation, market strategies and so on. The concept is outsourcing and is being used in practically every industry and by more than 70% of Fortune 1000 companies. Small firms to multinational companies are benefiting from the economies of scales that third-party logistics companies achieve by handling large volumes of goods through its warehouse and distribution operations.

One of the hottest trends today is the outsourcing of logistics or third-party logistics. Without question, third-party logistics also referred to as outsourcing or contract logistics is in the midst of rapid global expansion. A significant reason for such growth is that business dealings are shifting from transactional-based strategies to relationship based alliances such as partnerships. Without question the future of third party logistics is in the midst of rapid global

expansion. Undoubtedly the growth will be a result of the marketplace. Logistics requirements are shaping the market direction; this is fueled by the growth in outsourcing. As logistics capabilities of 3PL providers improve so do higher expectations of the services being provided. Higher expectations such as speed and accuracy will increase, those same expectations are causing the cost to either remain the same or decline. All 3PL providers will not only meet these expectations, but also need to exceed them. In order for 3PL providers to continue to grow and be competitive they must demonstrate a clear market or cost advantage. Users are looking for logistics expertise, improved service, and lower cost, not outsourcing for the sake of outsourcing. In many organizations such higher expectations can best be met by the use of a 3PL provider. Certainly never before has the logistics industry had the number of major corporations seeking logistics excellence.

The ultimate goal of any contract with a 3PL provider is to establish a fair, solid, and productive partnership. Preparation has five main components: (1) Determine whether outsourcing makes sense for your company; (2) clearly define your operating and system requirements; (3) research and select the 3PL; (4) understand the negotiation criteria; and (5) make the deal.

Companies are acknowledging that they can gain a competitive advantage by leveraging the resources and expertise sold by these new third-party providers. What companies used to imagine is now a reality: A warehousing / distribution operation that runs at a higher rate of efficiency and cost-effectiveness almost without clients' involvement, freeing them to focus on strategic planning rather than tied down in day-to-day operation uncertainty. There seem to be three key reasons that some companies hesitates to outsource its logistics operations:

- Providers can not provide adequate service levels, systems, and capacities.
- 3PL providers are not cost-competitive with well-managed in-house operations.
- Supply chain operations are too complex, large and too critical to outsource.

One of the biggest enemies in the supply chain for companies is time. If a company has a reputable 3PL provider on board, the provider can indirectly increase revenues through a solid logistics network. Solid logistics delivers solid sales by providing the customer with an accurate and timely order. A customer is more likely to do business with a supplier if he believes his orders will come in accurate and on time. A well-run supply chain compresses time, reduces expensive distribution processes as well as costly buffer inventories.

Logistics outsourcing continues to grow rapidly. Advancements in the information field, along with this growth, are leading to greater specialized methods. All this new technology is stretching the ability of third party providers to fulfill their commitments to their customers. For these pressing reasons based on the reality, we are taking up the 3PL as the primary option for a portal to manage it's order fulfillment process. Then the research question translates down to: How to choose the right 3PL provider for a B2C horizontal portal company?

3PL

Over 50 percent of all contract logistics companies have only been in the industry for a very short time, and they vary greatly in size. (Vachon and Klassen, 2002) The typical third party provider is generally divided into asset and non-asset based and usually will offer a minimum of 15 different types of services to their customers. It is crucial that prospective customers of third-party logistics be extremely careful in their evaluation, selection, and bidding process. Miscommunications and service failures are leading to the deterioration of many business alliances and partnerships. Specified expectations must be clearly and thoroughly understood from the beginning, and contingencies built in. When selecting a 3PL provider there are key issues that must be addressed with respect to parameters like: confidentiality, performance, subcontractors, reporting, mediation, arbitration & escape, and rates or pricing.

The evaluation of a third-party logistics provider begins with the establishment of a selection criterion. The initial criteria should include quality; cost, capacity, and delivery capability are traditionally used to evaluate the providers' core capabilities. As the selection process gets more specific, other criteria such as financial strength, information systems infrastructure, operating and pricing flexibility, depth of management expertise and cultural differences play a vital role in the process. The selection criteria must closely reflect the company's goals and objectives. The criteria will be used as the baseline for the client company's RFP (request for proposal). Analysis involves both qualitative

and quantitative tools. Analytical tools are usually used when employing the selection criteria. Typically, critical qualifying criteria are developed, and weights are assigned to them. This technique will help in identifying the best service provider from the pool of potential candidates. Although analytical tools help in the selection process, often non-tangible or gut feeling also helps the process of selecting a provider. For example, trust- an intangible asset is essential in a successful logistics partnership. Agreement at all levels within the client company that outsourcing is the right approach will strengthen the clients' position during negotiations. In context of this paper, the client means a B2C horizontal portal company. Services a portal might require a vendor to provide include warehousing, transportation, inventory management, value-added functions (packaging, labeling, kitting and assembly), and IT support (online product tracking, electronic bills of lading, and proof of delivery).

Growth factors and scalability support are also important as a 3PL relationship is a long-term partnership. These future needs should be the foundation of vendor selection criteria. Price is important, but no matter how costly or cheap a solution is, if it does not fit the company's requirements, the venture heads for problems. Contract negotiating criteria vary from provider to provider. In general, the cost for outsourcing common warehouse services includes the amount of space required, the activity or touches essential to move product through the warehouse, and any value-added functions. Typical methods for determining the cost of 3PL warehouse services involve a cost per square foot of space used, a cost per product touch, and a cost per shipment. The 3PL provider should explain these terms in detail.

USING DATA ENVELOPMENT ANALYSIS FOR DECIDING ON THE DISTRIBUTION OPTIONS OF HORIZONTAL PORTALS

In the previous sections, we have discussed about the horizontal portals, some of their common business models and the distribution options that are predominantly available for these portals to deliver the goods to their e-customers. Now we come to the critical point of how a portal will decide on which of these options to choose from, while deciding on the distribution on an individual order, individual customer basis. This individual handling of orders and customers is important for the purpose of minimization of cost of distribution and maximization of customer's perceived value and satisfaction and in the long run, customer retention and CRM. The viability of the trading parameters and their roles in the distribution network is also to be incorporated in to the analysis. One observation in this context is required to be made, that is, no solution in this context can 'absolutely' satisfy both the objectives of cost minimization and profit maximization. Therefore, traditional central-tendency-based statistical methods which focus more towards 'absolute' efficiencies than relative or optimal efficiencies are not typically suited for horizontal portals' distribution problems. This is where the benefits of a new approach using DEA can be fully exploited which, as explained in the following section, is an extreme point method and works better for relative efficiencies rather than for absolute efficiencies.

DEA and it's Applicability

Data Envelopment Analysis (DEA) is commonly used to evaluate the relative efficiency of a number of producers of any goods/ services. "The DEA approach is essentially to find a set of criteria weights which present each entity in the best possible light", (<http://www.managementscience.org/research/wpall.asp>).

A typical statistical approach is characterized as a central tendency approach and it evaluates producers relative to an average producer. In contrast, DEA is an extreme point method and compares each producer with only the "best" producers or DMUs (Decision Making Units).

The extreme point method assumes that if a given producer, A, is capable of producing $Y(A)$ units of output with $X(A)$ inputs, then other producers should also be able to do the same if they were to operate efficiently. Similarly, if producer B is capable of producing $Y(B)$ units of output with $X(B)$ inputs, then other producers should also be capable of the same production schedule. Producers A, B, and others can then be combined to form a composite producer with composite inputs and composite outputs. Since this composite producer does not necessarily exist, it is typically called a virtual producer.

The solution lies in finding the "best" virtual producer for each real producer. If the virtual producer is better than the original producer by either making more output with the same input or making the same output with less input then the original producer is *inefficient*. The subtleties of DEA are introduced in the various ways that producers A and B can be scaled up or down and combined.

The procedure of finding the best virtual producer can be formulated as a linear program. Analyzing the efficiency of n producers is then a set of n linear programming problems. For example, we have a vector describing the percentages of other producers used to construct the virtual producer, and the input and output vectors for the analyzed producer. The producer's efficiency will reflect the comparative efficiency.

Typical Characteristics of DEA

1. DEA can handle multiple input and multiple output models.
2. It does not require an assumption of a functional form relating inputs to outputs.
3. DMUs are directly compared against a peer or combination of peers.
4. Since DEA is an extreme point technique, noise (even symmetrical noise with zero mean) such as measurement error can cause significant problems.
5. DEA is good at estimating "relative" efficiency of a DMU but it converges very slowly to "absolute" efficiency. In other words, it can tell you how well you are doing compared to your peers but not compared to a "theoretical maximum."

Examples of DEA Applications

The existing DEA applications in engineering in general have focused on the evaluation of alternative design configurations, performance improvement interventions for various traditional organizational processes/ services/ systems like design process or production systems at the disaggregated level, and assessment of process/ system, performance and benchmarking them. Regarding processes, in order to make any reasonable suggestion for a process improvement intervention there has always been a need for the input/output variables of the empirical function to effectively represent the underlying production processes, i.e., accurately denote how inputs are transformed into outputs. An example application of DEA in this context is well documented (Triantis, 2003).

One of the DEA modeling approaches that has been proposed to measure and improve disaggregated process performance is the network model (Cooper et al, 2001). The fundamental concept behind this approach is to open the "input/output transformation box" represented by the DM, for example, intermediate outputs of one stage may be used as inputs into another stage. This application of DEA is useful where one wants to evaluate the efficiency performance of the specific production stages (represented by nodes) as well as the overall performance of the DMU. This approach facilitates the allocation of the resources between the customer oriented activities and the traditional production activities and consequently one can also study the satisfaction of different goals associated with each node.

Goal Programming and Data Envelopment Analysis (GODEA) (Triantis, 2003) is another approach using DEA approach that combined conflicting objectives of efficiency, effectiveness and equity in resource allocation for service organizations for example banks or financial services institutions. "Data Envelopment Analysis (DEA) has been a popular technique for bank efficiency studies, however, DEA requires that units operate in consistent "cultures" to produce fair and comparable results" (Vaneman and Triantis, 2003). DEA has been appropriately applied "to measure performance in the service sector...as a means of measuring performance and possibly as a monitoring tool for use in the longer term" (<http://www.managementscience.org/research/wpall.asp>). DEA mathematical programming formulations were expanded using fuzzy set theory to incorporate 1) imprecision in the data (Kabnurkar,2001), 2) missing data and imprecise linguistic data as in (Kao and Liu, 2000), 3) fuzziness in the objective function and constraints (Kabnurkar,2001). Another most interesting application of DEA has been in the context of dynamical systems, be it historical, causal or closed (Triantis, 2003), which exhibit a high degree of correlation between the variables at the initial time t_0 with the variables at the final time t . Here, DEA techniques have been defined and developed as the dynamic data envelopment analysis (DDEA) by adding the element of time to the DEA model.

Characteristics of Problems Suitable for DEA Applications

From the above section, we can see that problems which can be better solved by DEA other than the traditional Operations Research approaches or fuzzy set theories or similar alternatives, have some typical characteristics which actually can be directly mapped on to the characteristics of DEA. Problems with multiple inputs and outputs with different units of measurement, unstructured, not well-defined where no or minimally stable functional forms are available or can be assumed to relate inputs to outputs, problems dealing with similar level player comparisons, problem domains which have no/minimal/ extremely dynamic or changing/ evolving benchmarking standards (extreme point techniques can actually be useful to derive the benchmarks in such situations), where “relative” efficiency is more important than “absolute” efficiency are more suited for DEA applications than traditional statistical analysis methods.

Distribution Option Selection Problem of Horizontal Portals and DEA Applicability

The problem of selecting a viable distribution option for horizontal portals on an individual customer/order basic, as discussed in section 4, on analysis reveals some typical characteristics i.e.

1. Generally solutions in this context can not be the best i.e. absolute because none of the options will necessarily be maximum cost effective as well as yielding maximum customer satisfaction for speedy delivery etc. So the solution has to be ‘relatively’ better or more optimal than the other options. This is the fundamental application potential of using DEA in this problem.
2. The set of parameters can be varying, another aspect which DEA can handle very well.
3. The unit of measurements for different parameters can also vary which again can be well taken care of by the DEA method.
4. The traditional methods of statistics or operations research do not address these issues adequately. This is where DEA method proves to be more useful than those traditional ones.

THE DEA METHOD FOR SELECTING AN OPTION

The horizontal portals have to decide on their distribution options and consequently the trading partners which are the DMUs in DEA application context. These DMUs can be relatively evaluated for various objectives i.e. maximization of customer satisfaction, cost minimization etc.

The assessment and decision making process is hereby developed and discussed as a process model which can later on be mapped onto an algorithm or a flow chart with more specific application orientation. In this paper the process model is developed and presented so that a generic understanding of the process can be achieved.

The procedure of finding the best option can be formulated as a linear program. The best option may, but not necessarily, coincide with a real option. If it does not coincide with a real option, it can be taken as the virtual best option. Analyzing the efficiency of n options is then a set of n linear programming problems. The following formulation is one of the standard forms for DEA. λ is a vector describing the percentages of other options used to construct the virtual option. λX and λY and are the input and output vectors for the analyzed producer. Therefore X and Y describe the virtual inputs and outputs respectively. The value of theta is the option's applicability.

DEA Input-Oriented Formulation

$$\min \theta,$$

$$s.t. \quad Y \lambda \geq Y_0,$$

$$\theta X_0 - X \lambda \geq 0,$$

$$\theta \text{ free}, \quad \lambda \geq 0.$$

LP of this form must be solved for each of the options. The first constraint forces the virtually best option to generate at least as much output (e.g. customer satisfaction parameters' maximization) as the studied option. The second constraint finds out how much less cost input the virtually best option would need or incur. Hence, it is called input-oriented. The factor used to scale back the inputs is theta and this value is the applicability of the option.

The DEA Method

The basic constant returns to scale output maximization (output-oriented) DEA problem model with *n* options (DMUs), *s* output variables and *r* input variables can be expressed as:

Minimize

$$e'_0 = \frac{\sum_{i=1}^r v_i X_{i0}}{\sum_{j=1}^s w_j Y_{j0}}$$

subject to:

$$\frac{\sum_{i=1}^r v_i X_{im}}{\sum_{j=1}^s w_j Y_{jm}} \quad \text{for } m = 1 \text{ to } n$$

$w_j \geq 0$ for $j = 1$ to s

$v_i \geq 0$ for $i = 1$ to r

Note that this is the reciprocal measure of the input minimization model, which considers the ratio of weighted outputs over weighted inputs. Here e'_0 is therefore a reciprocal of the usual efficiency score. The variables w_j and v_i are weights on the input variables, also known as virtual multipliers. The option under evaluation is known as *option 0*.

After calculating the virtual best option and then the real option values for their corresponding minimum cost variables' values and maximum satisfaction variables' values (with their appropriate weightings), the variances between the best virtual option and the real options are calculated.

The minimum variance option is chosen as the best real option for the specific parameter value-set and weightings used in that particular instance of the selection problem.

The Decision Variables

Table 1 shows the key business parameters associated with decision making which are to be used as the decision variables here for choosing an option out of the three alternatives as mentioned in the section 4. These variables reflect the aspects which have been discussed in the introduction, i.e. the first two parameters T1 and T2 include the cost aspect, T3 and T4 deals with customer value which in turn reflects indirectly customer satisfaction and relationship parameters. T5 incorporates the value of the trading partner. For example, whatever options among options 1, 2, 3 the portal has been using for previous deliveries, cumulative values of those transactions with it's trading partners (the manufacturer in case of option 1, the exclusive dealer in case of option 2, or the multi-company dealer in case of option 3) can be retrieved from the historical transactional data warehouses. This can reflect a particular trading partner's value and effectiveness to the portal. Many other relevant parameters may be included which can be business/ context-specific and the table can be further extended.

Table 1: Decision Variables.

<i>T1</i> : Relative location of individual customers and company/ warehouses X transport cost per unit distance	<i>T2</i> : Freight charges: based on weight OR volume	<i>T3</i> : Transactional value	<i>T4</i> : Cumulative historical transactional values with the customer	<i>T5</i> : Trading partners value: total cumulative transaction value of deliveries via the partner
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An Example of Using DEA for Selecting the Best Available Order-Fulfillment Process Option

Now, suppose a B2C horizontal portal company has four possible options for fulfilling the orders, namely:

1. It’s own distribution system with company-owned mid-warehouses across locations (like Walmart’s basic supply-chain without cross-docking and vendor-managed inventories) : say ODI
2. It’s distribution system through various distributors’ warehouses: say DDI
3. A third-party logistics solutions provider, say 3PL1
4. Another third-party solutions provider, say 3PL2.

Among the variables listed in Table 1, in this example we take T2 and T3 as output variables and T1 as the input cost variable and construct a table as shown in Table 2 below:

Table 2: Example DEA Application for Three Variables Construct for Selection of a Particular Order-Fulfillment Process for the B2C Portal.

Options	T2 (cumulative for each option across a time-period T, in say X1000 USD)	T3 (cumulative for each option across a time-period T, in say X1000 USD)	T1(cumulative for each option across a time-period T, in say X1000 USD)
ODI	156	63	25
DDI	78	32	20
3PL1	96	67	19
3PL2	36	45	14

Using ratios, the T2/ T1 (output1/ cost) and T3/T1(output2/ cost) values are shown in Table 3.

Table 3: Output Variables/ Cost Ratios for all Options.

Options	T2 /T1	T3 / T1
ODI	6.24	2.52
DDI	3.9	1.6
3PL1	5.05	3.53
3PL2	2.57	3.21

If we plot these values in an equi-distance scale (per unit distance = 1000 USD) as shown in figure 3 below, we can see the emergence of a simple efficiency frontier, as shown by the dotted line.

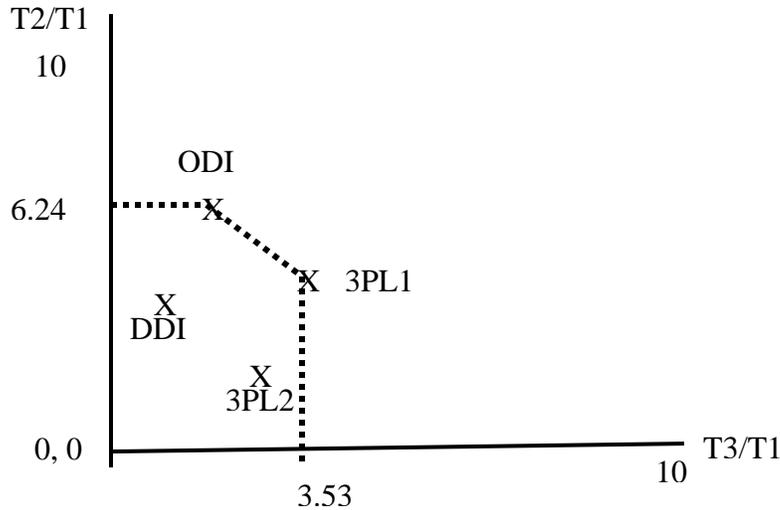


Figure 2: A Simple Example of an Efficiency Frontier.

The positions on the graph represented by ODI and 3PL1 demonstrate a level of performance which is superior to the other options DDI and 3PL2. A horizontal line has been drawn, from the y-axis to ODI, from ODI to 3PL1, and a vertical line from 3PL1 to the x-axis. This line is called the efficiency frontier, which envelops all other data points, the reason for which the method is called Data Envelopment Analysis. It is easily seen that mathematically the efficiency frontier is the convex hull of the data. Following the efficiency frontier in figure 3, we can say that, based on only three variables T1, T2 and T3, ODI and 3PL1 are better options than DDI and 3PL2.

This simple example now can be extended to take into consideration m no. of input variables and n no. of output variables. Thus, a linear model can be constructed in a multi-dimensional space (each dimension representing a ratio between the input/ output variables, depending on which orientation has been used in the construct). There are several ways to implement DEA, the simplest starting from converting it to an LP problem and then solving using MS-Excel solver. Then there are a number of analytical software solutions available which specialize in analysis of performance or efficiency, and most of them support DEA. There are also specialized software solutions to solve DEA constructs, for example: Frontier Analysis software from Baxia Corp. U.K., EMS (efficiency Measurement System) package etc.

HIGHLIGHTS OF THE PROPOSED METHOD

The method proposed in the previous section can be seen as:

1. A fresh approach, unbiased on the side of traditional operations research techniques, is reflected in this method which takes care of typical e-business aspects discussed in section 1.
2. The method is flexible and has a solid mathematical foundation so that it can be easily integrated to traditional mathematical/ statistical formulation of the same problem and therefore a suggested expansion potential of this method is development of hybrid solution methods using the goodness of traditional methods in combination with the extreme point-based DEA method
3. This method therefore need not completely replace the well-researched areas of transportation and assignment problems but can complement them by addressing typical e-business issues in addition to the traditional business issues that are well handled by the traditional methods.

4. This method does not necessarily give the best or most cost-effective absolute solution, but it gives a realistic and easily usable way to evaluate various options relatively.
5. The method is mathematically simple and easy to comprehend.

Some aspects of this process can be extended further i.e. other parameters exclusively applicable to any particular e-business scenario/ architecture/ company-specific requirements can be included. This process only takes into account the tangible values of the decision variables. Intangible ones can also be added, as one of the major strength of DEA method is that it can handle variables with different units of measurement too.

CONCLUSION

The DEA method, as has been shown here with various examples and research/ application instances, has some typical characteristics being an extreme-point, relative-efficiency-based method which makes it a better suited one for the distribution decision problem for portals which also typically shows similar nature. The method is also easy to implement and execute. It does not necessarily guarantee a best solution, actually it converges very slowly to the best solution than the traditional central-tendency-based statistical methods. But, it does address the distribution issues typical to various horizontal portals more effectively where a relatively better solution works fine than any theoretically best one. The extension possibilities are great as the method is simple, mathematically validated, flexible, scalable and being expressed in an LP form can be modified easily to suit specific business/ context requirements.

Ultimately, coming out of the traditional mindset in dealing with this type of issues would make the e-business environment all the more competitive. Such efforts will also allow the new business models exploit the goodness of these new methods to optimize their operational gains.

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