Logistics Management: A Firm's Efficiency Performance Model

A Thesis Presented to the Honors Tutorial College,

Ohio University

In Partial Fulfillment of the Requirements for Graduation from the

Honors Tutorial College

with the degree of Bachelor of Business Administration

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June 2012

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This research aims to create a model able to rate the success of a company's logistics processes by rating the success of each logistics activity. It determines and defines four logistics activities and finds them to be the most vital to a firm's logistics success. Those logistics processes found to be of the utmost importance are: transportation, warehousing, packaging, and inventory management. Optimal efficiency is used as the determinant for success, and the basic efficiency equation is manipulated for use in the business world. Value-added and associated costs are the variables of the efficiency ratio, which is financially driven. An analysis of the soft drink industry in the United States is provided, as the created model is implemented through use of this industry's data. Findings include flexibility of the model in managers' favor and the potential use of the model to evaluate success at the industry, firm, and product levels.

Introduction

"Logistics encompasses all of the information and material flows throughout an organization. It includes everything from the movement of a product or from a service that needs to be rendered, through to the management of incoming raw materials, production, the storing of finished goods, its delivery to the customer and after-sales service" (Gunasekaran, 2003). As an operation of companies that provides so much value to customers and ultimately to the company, logistics is an often-overlooked aspect in the business world. This research will identify the most important aspects of logistics, weigh them by their significance, and create an equation that evaluates a company's success.

Performance measurement can be defined as the process of quantifying the efficiency and effectiveness of an action and is a set of metrics used to quantify the efficiency and/or effectiveness of an action (Neely et al. 1995, Gunasekaran, 2006).

Gunasekaran also claims "performance measures and metrics are essential for effectively managing logistics operations" (Gunasekaran, 2006). This research will provide a model that will allow firms to see which logistics activities are most important to them, and then how much value the firms are gaining from these activities relative to their costs. Performance measurement systems such as the one in this research are important for many reasons, including: decision-making, identifying successes, evaluating customer satisfaction, identifying problems and improvement areas, ensuring decisions are based on facts, and showing the effects of implemented decisions (Gunasekaran, 2006). The overall goal is to create a model that will rate firms' logistics management based on multiple factors. This model will serve as a tool for companies to use in order to pinpoint and improve struggling areas of their logistics management.

This research will look at the soft drink industry in order to provide an example for how to utilize the model. But, the model will work for any firm that requires logistics as a part of its operations. Companies can simply insert their specific data into the model in order to determine an overall score. This model can be used to calculate the logistics success of an industry, company, or even an individual product.

Literature Review

There is a great deal of research on success measures within logistics. There are several models, metrics, and performance measures for capturing success, as well as many ways to define success (efficiency, effectiveness, customer satisfaction,

maximizing profits, etc.). Managers must have performance measures in order to locate their failures and successes, determine the potential impacts of decisions, evaluate the real impact of implemented decisions, etc. "The real challenge for managers…is to develop suitable performance measures and metrics to make right decisions that would contribute to an improved organizational competitiveness" (Gunaskaran, 2006). The attention paid to performance measures and metrics is a trend in practice as well as in research/literature (Kaplan and Norton, 1997). The use and development of these measures is a continuous process that is necessary for managers to evaluate their work and to make the best possible decisions in the future. Lambert and Pohlen created metrics that determine supply chain success based on creating shareholder value in their 2001 article "Supply Chain Metrics." In another Gunasekaran article, the aim is to measure performance at all levels of supply chain management (strategic, tactical, and operational) and key performance measures are presented. The performance measures deal with suppliers, delivery performance, customer service, and inventory/logistics costs. The performance metrics are then 'aligned' with customer satisfaction, basically making customer satisfaction the definition of success. "Previous research has shown that excellence in performing logistics activities and capabilities is associated with superior organizational performance" (Lambert and Burduroglo 2000; Lynch, Keller, and Ozment 2000.) Fugate, Mentzer, and Stank (2010) attempt to determine logistics success through the combination of efficiency, effectiveness, and differentiation. They refer to measuring logistics success as a "high priority."

Model Development

This research intends to identify the many major aspects of a company's logistics activities. Once identified, the aspects involved are weighed in accordance with their importance to success in this area of the firm. The importance of each aspect is based on the costs of the specific logistics activity in comparison to the costs of the other logistics activities analyzed. This model is similar to the models used to evaluate an individual's credit score or an NFL quarterback's "QB Rating." Each model selects the most important factors for acceptable credit and a successful quarterback and then assesses weights to these factors based on each factor's significance (Gutner, 2005 and Baseball Statistics, 2002). Then, a rating system is provided and applied to each component in order to produce an overall score, in the case of this research, for a specific industry, logistics branch, or product. A ratings system is used in order to create a way for companies to more easily evaluate their logistics management, and to compare their success to others in their industry. There are many practical advantages of ratings systems, including: ease of implementation, ease of a respondent's use, speed, and approximate interval properties (Coote, 2011).

We begin by first defining logistics. To select the most important factors to logistics success, a solid definition is essential. Merriam-Webster defines logistics as "the handling of the details of an operation." Stevenson (2009) defines logistics as "the part of a supply chain involved with the forward and reverse flow of goods, services, cash, and information." He includes the managing of all transportation,

material handling, warehouse inventory, order processing and distribution, third-party logistics, and reverse logistics in logistics activities (Stevenson, 2009). The Air Force Journal of Logistics defines logistics as: essentially moving, supplying, and maintaining military forces (Air Force Journal of Logistics, 2010). This definition is more useful for business purposes if adapted to read: logistics is essentially moving, supplying, and maintaining valuable materials and goods. Gunasekaran's (2003) definition found in the introduction refers to logistics as: encompassing all of the information and material flows throughout an organization, including everything from the movement of a product, to the management of incoming raw materials, production, the storing of finished goods, their delivery to the customer, and after-sales service (Gunasekaran, 2003). Therefore, with these definitions in mind, we will define logistics as: the management of the flow of goods from production through to after-sales service, including: transportation, warehousing, inventory management, packaging, etc.

In order to create a model that rates success, success in logistics management must also be defined. This success can be defined in many ways, including low costs, profit maximization, optimal efficiency, or customer satisfaction. Logistics performance can be defined as "effectiveness and efficiency in performing logistics activities" (Mentzer and Konrad 1991). Fugate, Mentzer, and Stank (2010) claim that logistics can "create value through efficiency, effectiveness, and differentiation." The success of logistics can clearly be defined as efficiency, though other measures, such as effectiveness, differentiation, or a combination of those or other factors, could be

used. But, for the purposes of this research, success will be defined as how efficiently a firm's logistics activities operate.

This research focuses on US-based firms and is most useful to firms that require logistics activities as daily operations. The created model is intended for companies that sell physical goods rather than providing services. This research focuses on forward logistics rather than reverse logistics (which refers to the activities involved in customers returning goods). Due to the enormity of logistics operations, not all aspects will be covered in this research, but rather those that are determined to be of the most importance and significance to a firm's success. The addition of more success factors to the created model is a recommended extension of this research.

This research analyzes the four factors of logistics that have been determined to be the most vital to logistics success. Transportation, or the movement of goods from any value-adding location to another, will be used and its success will be quantified in this model. As "the flow of goods" is a part of the definition, transportation seems a natural piece of logistics and therefore a vital factor. Warehousing will be another factor considered, as it is necessary for essentially all firms that generate revenue through the sales of physical goods. Also, Stevenson (2009) included the management of "material handling" and "warehouse inventory" in his definition of logistics management. Warehousing will be considered storing and moving inventory for later revenue generation, or any activities that are related to the warehouse and add value to goods. Packaging is the third activity to be considered.

Packaging "includes the activities of enclosing finished products for protection while handling in warehouses and transportation vehicles" (Kenyon and Meixell, 2011). A majority of products require some type of packaging in order to add value and make them available for sale to consumers. Packaging has many purposes including: protecting goods, aiding in advertising or marketing, and making goods easier for transport (for both the company and the consumer), among other functions. It is an essential activity for many products and will be included as a key success factor to logistics. Inventory is one of the largest assets for any company and optimal management of inventory is one major part of maximizing sales. Almost every good that is sold is considered inventory at some point in its life, and so clearly the managing of inventory is going to be important. Because inventory management is a vital aspect of logistics, its efficiency will also play a part in this model.

McGinnins and Kohn (1990) refer to the logistics responsibilities in their article about logistics strategies. Those responsibilities are broken down into stages and include: outbound transportation, 'intracompany' transportation, inbound transportation, finished-goods field warehousing and finished-goods plant warehousing, order processing, and finished-goods inventory management and raw materials/work-in-progress inventory management. The inclusion of these aspects of logistics makes them out to be some of the most important aspects in the field. They will be narrowed down to simply: transportation, warehousing, and inventory management, with packaging also being considered.

The industry to be used for illustration in this research is the soft drink industry. This industry generates revenue through the sale of physical goods and logistics are a major part of its operations. Also, the effect of each logistics activity analyzed in this research will be evident, as transportation, warehousing, packaging, and inventory management are all necessary activities in the process of selling soft drinks. As with almost every good, transportation of soft drinks is necessary to move it from the bottling process to a point-of-sale (grocery, vending machine, etc.). This statement leads into packaging, as any sale of a liquid will require packaging if it is not to be sold or transported though pipelines. Whatever type of soft drink, it must be sold in a bottle, can, or other container. Warehousing is necessary and opportune for the soft drink industry as its products can and need to be stored for periods of time and this does not affect the quality of product. Inventory management is directly related to warehousing and is vital to the soft drink industry as the players in the industry want to consistently have the optimal amount of product available for their buyers. The information for this industry is taken from the database "Passport GMID." All information comes from the year 2011 and is restricted to the industry's operations in the United States.

Efficiency

As stated in the 'Model Development,' efficiency is the determinant of success for our purposes, and must therefore be clearly defined. Merriam-Webster defines efficiency as "effective operation as measured by a comparison of production with

cost (as in energy, time, and money)," or as, "the ratio of the useful energy delivered by a dynamic system to the energy supplied to it." Efficiency "pertains to getting the most out of a fixed set of resources" (Stevenson, 2009). Fugate, Mentzer, and Stank (2010) define efficiency as "the internal functioning of logistics and [as] generally [being] considered best represented through some ratio of the normal level of inputs to the real level of outputs." In order to define efficiency mathematically, we will start with the most basic efficiency equation, the physics efficiency equation. This equation reads as follows:

$$\text{Efficiency} = \text{Work}_{\text{Out}} / \text{Energy}_{\text{In}} \qquad \text{(i)}$$

To relate this equation to business for our purposes, we will simplify it to:

$$\text{Efficiency} = \text{Output} / \text{Input} \qquad \text{(ii)}$$

Finally, we will consider the output to be what is gained through some logistics activity and the input to be what is required in order to complete this specific activity. This model will be financially driven, and therefore what is gained through the activity and what is required to perform the activity will be financially based. Output will be defined as value added from the activity (in dollars) and input will consider the costs associated with this activity (in dollars):

$$\text{Efficiency} = (\$) \text{ value added} / (\$) \text{ costs.} \qquad \text{(iii)}$$

This definition and equation fits perfectly with Mentzer and Konrad's (1991) work, as their work considers efficiency to be "the ratio of resources utilized against the results

derived." Fugate, Mentzer, and Stank (2010) come to a best definition of efficiency as "how well the resources expended are utilized." This is the definition being modeled through the efficiency equation in this research. The equation expects that whatever costs are associated with some logistics activity, the firm would expect to add at least as many dollars of value to the good as it costs to perform that activity. For example, if it costs five dollars to transport an item from a warehouse to a retail location or point-of-sale, that item should be worth at least five dollars more than it was in the warehouse. This also implies that the efficiency equation should always be equal to at least one (1). That implication leads directly into the "value added" term. Value added refers to any additional value created at a particular stage of production by a key production factor, or the difference between the value of the good before a particular activity and the value of the good after this particular activity (Clements and Price, 2007). The costs refer to all costs associated with the particular activity. With the transportation logistics activity used as an example, costs would include: driver wages, costs of the vehicle (truck, train, airplane), fuel costs, etc.

With efficiency chosen as the success determinant in this research, it is assumed that the goal of efficiency is to maximize it or to create the most optimal efficiency. Merriam-Webster defines optimal as "most desirable or satisfactory" and optimization as "an act, process, or methodology of making something (as a design, system, or decision) as fully perfect, functional, or effective as possible" or "the mathematical procedures (as finding the maximum of a function) involved in this."

Mathematically, optimization is the maximum or minimum of a function, depending on which is desired. Because success is defined as maximum efficiency, optimization is defined as the maximum point of efficiency for the purposes of this research. Optimal efficiency is the point in the efficiency equation (value-added / costs) at which increasing or decreasing the denominator (costs) any further would reduce the ratio. A simple example of optimization is represented by this graph of a quadratic function:

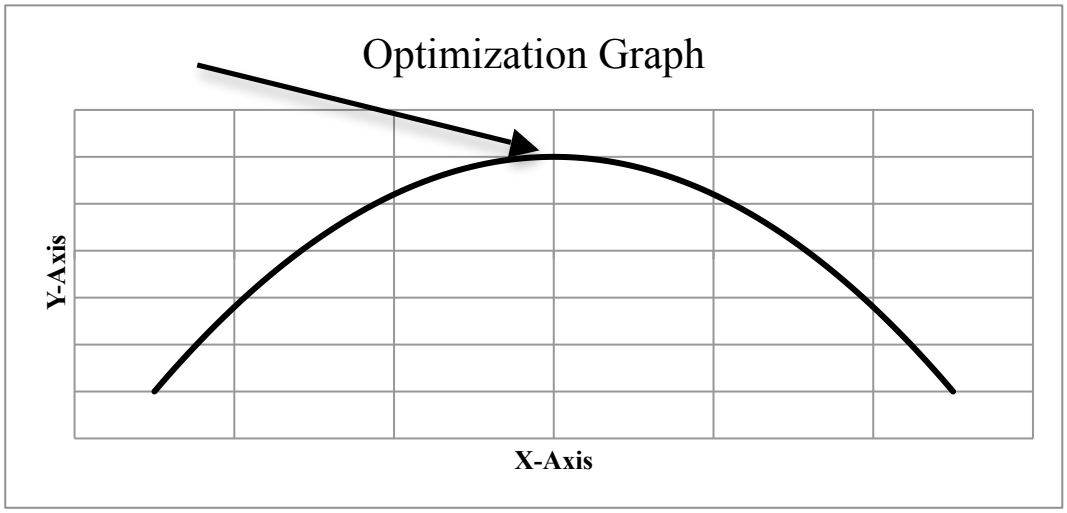

Figure 1: Optimization Graph

The arrow points to the optimal point of the graph, as moving any further to the left or right on the X-axis would decrease Y. A graph for efficiency in this research would depend on the variables of value-added, costs, and the ratio of all values-added to costs and would be a 3D graph.

Transportation

Transportation will be defined as the activities involved in shipping any goods or finished products from suppliers to a facility or to warehouses and sales locations (Kenyon and Meixell, 2011). It is included because it is a major part of the supply chain due to its power to add value to some goods by moving them from their current location to a more advantageous location. Through research, (Atos, 2012; Kenyon 2011; Xiande, 2008; Hausman, 2005; Blanchard, 2004; Schmitz, 2004; Gunasekaran, 2003; Lambert, 2000; and Tate 1996) transportation has been found to be a major factor in logistics processes. It is mentioned in virtually all research regarding this topic and is often the main focus of articles discussing logistics.

Efficiency Equation (iii) will be used to determine efficiency for each aspect of logistics analyzed in this research. Therefore, an equation for each activity will be shown. For transportation, we will consider the output to be what is gained through transporting goods and input to be what is required in order to transport goods. Output will therefore be value added to goods through the transportation of these goods and input will be the costs associated with transporting those goods (fuel costs, wages, costs of vehicles, etc.):

Transportation Efficiency = ($) value added from transportation / ($) costs of transportation (iv)

Also written as:

$$T_e = TVA / TC \quad \text{(v)}$$

(a complete table of variables is available in Appendix B)

Value-added is the difference between the value of a good at its starting location (i.e. manufacturing facility or bottling facility in this case) and the value of the good once it reached its point of sale location (i.e. retail store or vending machine). Obviously, a product has more value at a retail store than it does in a company's warehouse, because in the retail store it is available for sale. At the store it can generate revenue, while in the warehouse it is simply sitting there waiting to be moved. This is where transportation adds value to goods. Whether the good is moved from the manufacturer to the warehouse and then to a retail store, straight from the manufacturer to the retail store, or simply from one warehouse to the next, the product becomes more valuable to the company as it moves closer to being sold. Costs of transportation include the costs of the vehicles (truck, train, airplane), costs of fuel, wages for those controlling the vehicle, etc. Transportation efficiency will depend on how much value a company is able to gain based on how much they are able or willing to spend on transportation.

Warehousing

Merriam-Webster defines a warehouse as "a structure or room for the storage of merchandise or commodities." This will be the definition used for the purposes of this research. Kenyon and Meixell define warehousing as "the storage of components, raw materials and finished goods." Just like every other part of the supply chain, a warehouse is used to add value to some good, as the good is stored for some purpose or passed through the warehouse for some purpose. Warehousing can also be referred to as materials handling. The term 'materials handling' is similar to or encompassed

by the term ‘warehousing’ and refers more to actions taken on the goods such as their movement within facilities, their stacking or organizing prior to sale or transport, or any further processes necessary to create a finished product.

Once again, optimal efficiency will be the definition of success for warehousing. Therefore, the efficiency equation for warehousing reads:

Warehousing Efficiency = ($) value added from warehousing / ($) costs of warehousing. (vi)

Also written as

$$W_e = WVA / WC \quad \text{(vii)}$$

When a good goes through all necessary processes such that it is ready for sale to the final consumer, it may not be optimal for the good to be delivered to a sales location immediately. This is one instance when warehousing or storing the good is necessary. Also, the good may require further processes within the warehouse that qualify as warehousing activities. These may include some type of movement of the product or stacking process, etc. Either way, these activities add value to the good and therefore make up a major part of the warehouse efficiency equation. Costs associated to warehousing include costs of the actual warehouse facility, warehouse workers’ wages, warehouse equipment (i.e. fork-lifts or pallets), etc.

Packaging

Chan, Chan, and Choy (2005) consider packaging to be "one of the most important activities in the distribution systems and supply chains." They claim that by treating packaging as a simple protective activity, companies "inhibit manufacturing efficiency and productivity." Packaging should be a way to benefit handling, distribution, and to protect the product, among other purposes. By viewing packaging in this sense, it becomes a greater value-adding activity and is seen as a more important activity of logistics. Burgess, et. al. (2005) call logistics "one of the major drivers of packaging requirements." Packaging can also be effective as a marketing or advertising tool or to make stacking and loading more efficient. The versatility of packaging is shown through Cervera's (1998) three levels of packaging: primary, secondary, and tertiary. Primary packaging involves packaging an individual item for sale and is known as "consumer packaging", secondary packaging is known as "transport packaging" and packages items together that are already packaged in the primary step, and tertiary packaging is packaging "involving several primary or secondary packages grouped together on a pallet or load unit" (Cervera, 1998). In the case of our example throughout this research, the soft drink industry, primary packaging would be the bottle or can enclosing some drink, secondary packaging would be grouping the cans or bottles into a case with cardboard or plastic, and tertiary packaging would be combining several cases on a pallet for transport.

For these reasons, packaging has been determined to be a key success factor in logistics management and will be analyzed in this research. Again, optimal efficiency in packaging will be the determinant of success and the packaging efficiency equation will start from the same basic efficiency equation used throughout this research:

Packaging Efficiency = ($) value added from packaging / ($) costs of packaging (viii)

Also written as:

$$P_e = PVA / PC \quad \text{(ix)}$$

Most products hold great value alone, but in order to be sold to a final consumer, much value can be added through packaging the final product. In the case of soft drinks, packaging is necessary, as a liquid cannot be sold without being put in some sort of container. With this as an example, it is obvious that packaging can add a great amount of value to a product. The costs associated with packaging could include any type of container, case, label, etc. For the example used in this research, soft drinks would obviously be packaged with a bottle, can, or other container, etc.

Inventory Management

Stevenson (2009) defines an inventory as a stock or store of goods. It can also be considered as stocks of anything necessary to do business (Hedrick et al., 2008). Either way, any company that sells goods likely has the materials necessary to sell their products as well as finished products on-hand. These materials and finished

products kept on-hand are the company's inventory. Stevenson (2009) refers to inventories as "a vital part of business," as they "are necessary for operations…[and] they also contribute to customer satisfaction. Hedrick states that "stocks…must be well managed in order to maximize profits" and "many small businesses cannot absorb the types of losses arising from poor inventory management." Clearly inventory management is important to business and vital to logistics success.

In terms of management performance, return on investment (ROI) is a common measure to evaluate success and inventory has a lot to do with a healthy ROI. A 'typical' firm has about 30% of its current assets in inventory (Stevenson, 2009), meaning that much of its investment is in inventory and the management of this inventory will weigh heavily on what the company's ROI is. It is also noted that the ratio of sales to inventories is a widely used ratio in several industries to determine the state of the economy. Companies must pay a great deal of attention to their inventory management in order to get it just right. Too much inventory locks up a company's capital when it could be used for other purposes, while too little inventory will fail to satisfy customers, as the company cannot get its product to its buyers. Too much inventory also leads to higher holding costs, which are the costs associated with keeping inventory in a facility. A simple example is the stocking of perishable goods such as dairy products. In order to prevent spoiling, dairy products must be kept in proper temperatures and/or humidity, and there are costs associated with maintaining these types of environment. While not all products require this type of holding cost or

costs to this extent, there is always some requirement of money to keep inventory. For all of the purposes mentioned, inventory management is a major logistics activity and fits into the scope of this research. Inventory management is integrated with at least one of the other activities analyzed (transportation, warehousing, or packaging) in some fashion, always depending on the industry of discussion.

Like the other activities discussed, success in inventory management will be determined by how efficient it is. Efficiency will again be defined by the equation used throughout this research, and will show as follows for inventory management:

Inventory Management Efficiency = ($) value added from inventory management / (x) ($) costs of inventory management

Also written as:

$$IM_e = IMVA / IMC \quad \text{(xi)}$$

The importance of inventory management has been stated above. Without proper inventory management, companies can miss out on potential sales or can lock up too much money in inventory and miss out on other opportunities to make money. Value is added through inventory management because a good is worth more to a company (or seller) when it is worth more to a consumer (buyer). Therefore, if a company has great demand for their product, but does not have enough product in inventory, then these potential sales cannot take place and the company misses out on the opportunity to make money. Properly keeping inventory can also be a factor in determining prices and therefore revenue generators, as a less available product

becomes more expensive if the demand is there, but this type of inventory management is not the focus of the research. Optimal inventory management is making supply meet demand and adding as much value as possible with the assets at hand. The costs associated with inventory management are related to being knowledgeable about supply, demand, current inventory, trends, etc. with each product or good being valuated. In order to determine demand, companies must conduct research for newer products, or maintain data on demand trends for older or ongoing products. Items such as scanners make keeping a total inventory count easier, but incur costs. For smaller companies, manually counting inventory may be the best option, but would require wages to be paid to those employees working at this task. New technologies such as RFID are now coming into play with inventory management. Though they may be more expensive, these options provide more data faster and keep current inventory levels for companies. They will likely be the methods used in order to add the most value to goods if they are not already.

Completed Model

The complete model involves costs of logistics activities, value-added by those activities, the efficiencies of each activity, and weights based on the activities' importance to the industry, company, or product. The weights used for each logistics activity analyzed come from the specific company's allocation of costs among the four activities. Thus, every company, industry, or even any individual product (depending on which is being analyzed) will have its own weights for the different logistics

functions. This provides flexibility in the rating system, because as every company and every industry requires different allocations of funds for different logistics activities, every company and every industry will have different weights for those activities. And, since managers strategically decide how to allocate funds among the logistics activities, they essentially determine the weights associated with each activity. Because all businesses are different, every company will be required to spend more in different areas. Specific to this research, every logistics branch will need to spend differently in the four areas of logistics. By making weights different for each, companies can still earn higher scores while spending more in areas more important to their business than in areas of less consequence. Also, companies strive to spend so that they will create more value in the areas that are most important to them, which leads to companies allocating more funds and placing more weight on those operations.

There are three steps necessary to finding the weights for any specific company or industry:

1. Determine 'Activity Costs' incurred for each of: transportation, warehousing, packaging, and inventory management.
2. Add all costs to come up with a 'Total Logistics Cost.'
3. Divide each 'Activity Cost' by the 'Total Logistics Costs' and multiply each by 100 to calculate a percentage (or weight) for that specific activity.

With the weights calculated, the next step involves value added and optimal efficiency. Each efficiency equation must be formulated and calculated. Each of the four efficiency equations (transportation efficiency, warehousing efficiency, etc.) has a weight attached to it, which it will be multiplied by. Next, every value attained through multiplication is added together to come up with a final score. If all four logistics functions are working efficiently, the overall score should be no less than 100, with weights adding to 100 and efficiency as defined by the equation being at least one (1). In its most generic form and fully written out, the model reads as follows:

$$\text{Total Score} = T_W*(TVA_J / TC_J) + W_W*(WVA_J / WC_J) + P_W*(PVA_J / PC_J) + IM_W*(IMVA_J / IMC_J) \quad \text{(xii)}$$

By substituting for the four efficiency equations, we can simplify this equation to:

$$\text{Total Score} = T_W*T_e + W_W*W_e + P_W*P_e + IM_W*IM_e \quad \text{(xiii)}$$

The basic idea behind the model is now apparent. First weigh each of the four key logistics activities by the importance management gives them (based on allocation of costs), then determine the efficiency of each of the four key logistics activities with the equation provided in this research (value added through some activity divided by the costs associated with that activity), next, multiply the weight of the given activity by the efficiency of that given activity, and finally add together all of the individual activities' scores to reach an overall score.

For the purposes of a company's use, this model is very easy to use. The biggest difficulty arising in this work was the inaccessibility of information in order to calculate companies' logistics scores. However, companies know their own costs of transportation, warehousing, packaging, and inventory management. They also can calculate value-added along each step. With this information available, it is simple to calculate a total logistics score.

This model can be used to calculate the logistics success of entire industries, which would be very useful as a benchmark for companies in the industry. Scores could range greatly from industry to industry, company to company, and product to product. Therefore, industry scores would give companies a good place to look to determine where they stand in each activity's efficiency as well as in overall efficiency, making benchmarking easy. Comparisons can be made company to company as well. Simply evaluating a company by comparing its score side by side with a competitor's score or multiple competitors' scores shows where that company stands in logistics with respect to its competitors. Another way to use this model at the company level is to compare scores from fiscal quarter to fiscal quarter or year-to-year. By assessing their company's logistics habitually, managers can see how their efficiency and success is progressing, where it is stable, and where they should look to improve. It shows a clear picture of the costs of each activity and the value added by these activities, allowing managers to step back and see if they can add more value without incurring further costs, or whether allocating more funds to a particular

activity will ultimately add more value and generate greater revenues. The ultimate goal is always optimal efficiency (the case in which reducing or increasing costs will no longer increase the ratio of value-added to costs). Also, the weighted system shows managers where they are allocating most funds within logistics management and therefore which logistics activities should receive the most focus in order to increase total efficiency and success.

At a product level, companies can use this model to evaluate the logistics management of individual products. This can help determine how one product is out performing another or how to make the logistics activities of a new product more efficient. This process works the same as on an industry or company level. Simply calculate the costs and value-added of that individual product for each logistics activity to come up with weights and efficiencies.

Soft Drink Industry's Logistics Analysis: An Illustration

The industry used for analysis in this research is the soft drink industry. The model created here will be applicable to any industry, company, or product (given that they sell physical goods and products rather than services). Data used was obtained through "Passport GMID", which provides global information, statistics, and analyses across all industries and countries.

The soft drink industry is one that has historic growth and that has a sustainable future. Passport GMID defines the industry as "mineral waters and aerated

waters, unsweetened, unsweetened and non-flavored waters" and "waters, with added sugar, other sweetening matter or flavored, i.e. soft drinks (including mineral and aerated), non-alcoholic beverages not containing milk fat, non-alcoholic beverages containing milk fat." From 2000-2009, the American market grew at 4% per annum and reached almost $66 billion. In this time period, carbonated drinks and bottled water were the highest selling products. Market growth is expected to slow in the near future due to "health- and budget-conscious American consumers." The main customers of the industry are far and away households, which account for 95.4% of the market. The only other notable group of consumers is restaurants, bars, and canteens accounting for 2.7% of the market. The goods provided by soft drink companies are physical in nature (rather than a service), and require transport, warehousing activities, packaging, and inventory management. This sets up perfectly for providing an example, which will utilize all pieces of the model. (The data used is for the United States only and is comprehensive for the industry).

Costs for the efficiency equations were taken from Passport GMID. This database provided cost information for transportation, warehousing, and packaging. The totals paid to suppliers in the industry were listed and then sorted in order to calculate total costs for each of these three activities. These costs are shown in Table 1.

To determine costs related to inventory management, data from a representative example company within the soft drink industry was taken from IBIS World. The selected company is not a market-share leader, but is a major player in the industry. This is so that the calculated inventory management data for the industry will be more accurate as it comes from a successful company that has average to above average market share. In this case, PepsiCo, Inc. is used due to its role as a company that produces both soda and bottled water and can be used as a representation of the entire industry.

To calculate specific inventory management costs, multiple steps were undertaken. PepsiCo has six major business segments that are organized geographically and/or based on their main products sold. Therefore the segment linked to this example (Pepsi-Cola - North America) is examined. This business segment's total inventory is provided in Table 1. The percent of inventory to total assets (inventory/total assets) for all of PepsiCo, Inc is also available in Table 1 and is used as the percent of inventory to total assets for Pepsi-Cola - North America. This percentage is used to calculate the inventory of Pepsi-Cola – North America for the years 2010 and 2011. It is then assumed that 60% of the inventory for Pepsi-Cola – North America is for use in the United States. The 'Pepsi-Cola – North America Inventory' is therefore multiplied by 60% (or 0.60). This number gives us the beverage-related inventory that PepsiCo holds in the US, and is used as an average inventory for a US soft drink company. Because it is assumed to be the average, this

number is multiplied by the total number of soft drink companies in the US in order to come up with an estimate for the total value of the soft drink industry's inventories. Finally, the assumption is made that soft drink companies incur costs of 1% of their total inventories for inventory management. The costs of the other three logistics activities are calculated from numbers available on Passport GMID and are shown more simply in Table 1. At the bottom of Table 1 are the total costs of logistics-related activities.

Table 1: Costs Associated with Logistics Activities

Costs	US $mil 2010	US $mil 2011
Transportation	**1,468.40**	**1,473.30**
Road Passenger and Freight Transport	591.90	595.20
Renting of Land Transport Equipment	342.30	341.60
Post and Courier Services	237.80	237.30
Air Transport	204.30	206.90
Transport via Railways	71.40	71.50
Motor Vehicles, Trailers and Semi-trailers	20.70	20.80
Warehousing	**345.90**	**344.10**
Cargo Handling, Warehousing and Travel Agencies	324.60	322.70
Lifting and Handling Equipment	21.30	21.40
Packaging	**11,970.80**	**12,103.60**
Metal Packaging, Wire and Other Fabricated Metal Products	6,271.80	6,306.10
Plastic Products	4,603.20	4,703.70
Corrugated Paper, Paperboard and Containers	829.00	827.10
Glass and Glass Products	258.10	258.00
Packaging Services	8.70	8.70
Inventory Management	**4,693.68**	**5,011.10**
Pepsi Cola North America Total Assets	31,622.00	31,187.00
PepsiCo Inventory/Total Assets	4.95%	5.25%
Pepsi Cola North America Inventory	1,564.56	1,637.61
US-related Inventory	938.74	982.57
Soft Drink Companies	500.00	510.00
Total US Inventories	469,367.68	501,110.16
Total Logistics Costs	**18,478.78**	**18,932.10**

Source: Passport GMID, Google Finance, PepsiCo.com, and OneSource.

Once total costs of each logistics activity and logistics as a whole are found, weights can be determined for each activity. As is every industry, the soft drink industry is unique and therefore its weights will be very different from those of other industries. Even companies within the soft drink industry could vary greatly from how much they spend on each logistics activity, depending on how much importance their managers put on each. Nevertheless, weights are calculated next by dividing each logistics activity cost by the 'Total Logistics Costs.' The tables below display the data used to calculate weights, as well as the weights to be used in the model for the years 2010 and 2011. The weights always add to 100.00, as they come from a percentage of costs.

Table 2: Logistics Activities' Costs and Weights

	US $mil 2010	**US $mil 2011**
Transportation Weight	**7.95%**	**7.78%**
Transportation Costs	1,468.40	1,473.30
Warehousing Weight	**1.87%**	**1.82%**
Warehousing Costs	345.90	344.10
Packaging Weight	**64.78%**	**63.93%**
Packaging Costs	11,970.80	12,103.60
Inventory Management Weight	**25.40%**	**26.47%**
Inventory Management Costs	4,693.68	5,011.10
Total Logistics Costs	**18,478.78**	**18,932.10**

Table 3: Logistics Activities Weights

	2010	2011
Transportation Weight	7.95%	7.78%
Warehousing Weight	1.87%	1.82%
Packaging Weight	64.78%	63.93%
Inventory Management Weight	25.40%	26.47%
Total	100.00%	100.00%

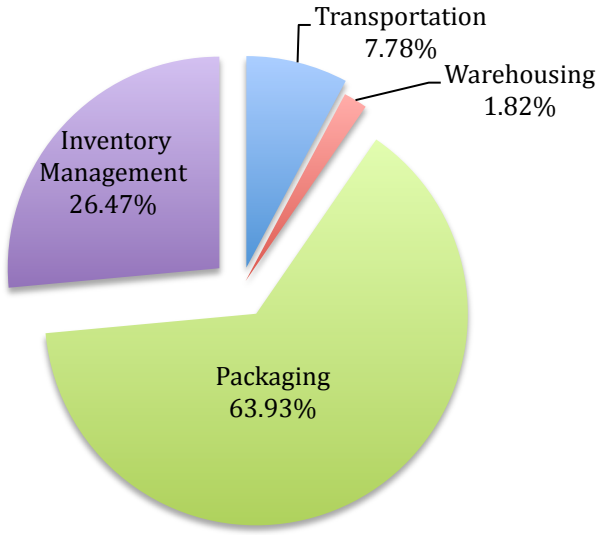

Figure 2: 2011 Activity Weights

With all costs found for the soft drink industry, the next step is to determine value-added from each activity. For this step, some assumptions were necessary due to a lack of available information. Value-added assumptions are included and determined for the soft drink industry specifically. For transportation, value-added was considered to be 15% above the costs of transportation. Warehousing was determined to be an 8% increase in value, while inventory management was deemed more important at a 10% increase in value. The biggest value-addition of the four

logistics activities is that which comes from packaging. Based on the nature of the industry and the products sold, packaging seems to add a great deal of value. Liquids cannot be sold without some container and containers play a great role in the advertising and marketing of soft drinks. The value added from packaging is set at 20%. These numbers are all estimates and are determined due to the nature of the industry. Companies using this model for their own purposes have access to more accurate numbers to come up with more accurate scores. But, providing an example of this model's use is valuable to the research. Table 4 includes total costs of each activity, as well as the assumed value-added from each activity in percentage form. Costs are multiplied by one (1) plus the percent value-added, or (1 + %), to calculate the value-added from each activity.

Table 4: Value-Added from Logistics Activities

	2010	2011
Transportation	**1,688.66**	**1,694.30**
Total Transportation Costs	1,468.40	1,473.30
Percent Value-Added	15.00%	15.00%
Warehousing	**373.57**	**371.63**
Total Warehousing Costs	345.90	344.10
Percent Value-Added	8.00%	8.00%
Packaging	**14,364.96**	**14,524.32**
Total Packaging Costs	11,970.80	12,103.60
Percent Value-Added	20.00%	20.00%
Inventory Management	**5,163.04**	**5,512.21**
Total Inventory Management Costs	4,693.68	5,011.10
Percent Value-Added	10.00%	10.00%

Due to value-added being based on assumptions of percentage increases on costs incurred, each efficiency equation will be equal to these percentages of value-added. But, with more accurate numbers inserted into the model by companies, this will not be the case. Table 5 shows the efficiencies of each activity in the soft drink industry. The efficiencies calculated are the ratio of value-added to costs and the numbers should look familiar.

Table 5: Logistics Activities' Efficiencies

	US $mil 2010	US $mil 2011
Transportation	**1.15**	**1.15**
Transportation Costs	1,468.40	1,473.30
Transportation Value-Added	1,688.66	1,694.30
Warehousing	**1.08**	**1.08**
Warehousing Costs	345.90	344.10
Warehousing Value-Added	373.57	371.63
Packaging	**1.20**	**1.20**
Packaging Costs	11,970.80	12,103.60
Packaging Value-Added	14,364.96	14,524.32
Inventory Management	**1.10**	**1.10**
Inventory Management Costs	4,693.68	5,011.10
Inventory Management Value-Added	5,163.04	5,512.21

Now that we have all of the necessary data for the logistics success model, we can calculate a total score. As described in the 'Completed Model' section, each activity's efficiency will be multiplied by that activity's weight and all of these products will be added together, reaching a final, overall score:

$$\text{Total Score} = T_W*T_e + W_W*W_e + P_W*P_e + IM_W*IM_e \quad \text{(xiii)}$$

2010:

$$7.95*1.15 + 1.87*1.08 + 64.78*1.20 + 25.40*1.10 = 116.84$$

2011:

$$7.78*1.15 + 1.82*1.08 + 63.93*1.20 + 26.47*\ 1.10 = 116.75$$

For the year 2010, the soft drink industry has a total logistics score of 116.84 and for the year 2011, the industry's score is 116.75. These two calculations are very close in value, but clearly not that same. As it is only a difference of one year, there is not much time for cost allocation changes within the industry, but there are significant changes in the packaging weight (64.78 to 63.93) and the inventory management weight (25.40 to 26.47) from 2010 to 2011. The model allows for changes in the strategies of the industry (changing allocation of logistics costs) while still achieving a high logistics score. It is also important to remember that this example uses assumptions in value added, and that they are steady over 2010 and 2011, whereas in reality, value-added likely changes from year-to-year. With more accurate information, the total logistics scores for each year would probably show more change. Also, because it is an entire industry, cost allocations are unlikely to change very much.

By simply calculating a total logistics score for the soft drink industry, companies within the industry already have a tool to use as a benchmark to evaluate their own logistics success or to evaluate one of their individual product's logistics success. Also, by compiling scores over time and over multiple industries, the scores will become more valuable and meaningful. Table 6 breaks down the scores achieved by each logistics activity over the past two years. This makes it easier to evaluate where changes occurred. In the example here, activity scores are going to go up or

down based on what their weight does (efficiency scores are not going to change due to value-added being calculated with fixed percentages), but with a larger data set, this table would be very useful in decision making, as it is easy to tell which sections are struggling and need improvement, or which sections are doing well as the current strategies of the company or implemented projects are succeeding.

Table 6: Total Logistics Score

	2010	2011
Transportation	**9.14**	**8.95**
Transportation Weight	7.95%	7.78%
Transportation Efficiency	1.15	1.15
Warehousing	**2.02**	**1.96**
Warehousing Weight	1.87%	1.82%
Warehousing Efficiency	1.08	1.08
Packaging	**77.74**	**76.72**
Packaging Weight	64.78%	63.93%
Packaging Efficiency	1.20	1.20
Inventory Management	**27.94**	**29.12**
Inventory Management Weight	25.40%	26.47%
Inventory Management Efficiency	1.10	1.10
Total Score	**116.84**	**116.75**

The definition of success in this research is optimizing efficiency. Since efficiency is defined as the ratio of value-added to costs (equation iii) in this research and optimality is maximum efficiency in this research, a higher score correlates to more successful logistics. This goes for total logistics score as well as individual

activities' scores. Scores can change based on weights changing or efficiencies changing. In order to determine why a total logistics score or an individual activity's score changed, weights and efficiencies must be broken down separately. If the transportation score goes down, it could be due to management spending less on transportation, therefore decreasing transportation's weight (assuming the ratio of 'value-added from transportation' to 'transportation costs' stays the same). The transportation score decreasing could also be due to less value being added from transportation with costs staying the same, or from management increasing costs but not gaining the additional value-added that they expected.

Since the value-added variable is based directly off of costs in this analysis, graphing the relationship of changes in value-added or changes in efficiency to changes logistics score does not provide much insight (it is a linear relationship). Simply, if value-added from transportation increases by 1% and costs remain the same, then efficiency increases by 1% and the transportation score increases by 1%. Likewise, if the value-added for each activity increases by 1% and costs remain the same, then the total logistics score increases by 1%.

Table 7: Effect of Efficiency Changes

Transportation Original	2010	2011
$Transportation_0$	**7.601**	**7.155**
Transportation Weight	0.066	0.062
$Transportation\ Efficiency_0$	1.150	1.150

Transportation plus 1%	2010	2011
$Transportation_1$	**7.677**	**7.227**
Transportation Weight	0.066	0.062
$Transportation\ Efficiency_1$	1.162	1.162

With transportation efficiency originally being 1.15, an increase of 1% implies 1.15*1.01, which equals 1.1615, or the new transportation efficiency number. As shown in the table, this equates to an increase in the transportation score from 7.601 to 7.677. The mathematics of finding the percent increase in the transportation score is as follows:

$$(7.677 – 7.601) / 7.601 = 0.01$$

This shows that a percentage increase in value-added equates to the same percentage increase in efficiency and the same percentage increase in score. The same process works for equal percentage increases across all activities and that same percentage increase in total logistics score. Different increases or decreases in value-added, costs, or efficiency will have different effects on the total logistics score, largely based on the magnitude of the changes and on the weights associated with each activity.

Conclusion and Future Considerations

Through this research, a model has been created for use in determining the logistics success of an industry, company, product, or group of products. Four logistics activities have been found to be the most important to a company's success and the details of those activities have been described. The created model is financially driven and success is based on optimizing efficiency. It provides an easy method for producing a rating, and is most effective when financial data is available. The model is flexible enough to be accurate in all industries and to give managers the opportunity to establish the most important activities to their companies. The continued use of this model will make it more valuable, as it will provide benchmarks and show successive progress or decline in the efficiency of logistics activities. The analysis of the soft drink industry provides a concrete example of the model's use. It shows that every industry is unique, as transportation and warehousing were initially thought of as the most key logistics success factors, but it turned out that the soft drink industry placed more importance on packaging and inventory management through its allocation of costs.

The main recommendation for advancing the research conducted here is to consider more variables. Though this research means to analyze the most vital factors of logistics, there are many other factors out there to be examined. Another recommendation that has already been noted in this research is to use the given model on more industries, companies, and products, and to use past financial data as well as

current data. This may be the most important aspect of improving this research, because it will add value to the numbers calculated and provide benchmarks so as to make the model useful to more companies.

For the purposes of this research, transportation within America was considered. Therefore, the common transportation methods considered include trucking, rail, air, and sea. International transportation would include *more* use of air transportation and sea transportation. Also, this research does not discuss the use of goods transportable by pipeline or by cable.

Appendix A – Definitions

Logistics – the management of the flow of goods from production through to after-sales service, including: transportation, warehousing, inventory management, packaging, etc.

Efficiency – getting the most out of a fixed set of resources.

Optimality – the most desirable or satisfactory process.

Transportation – the activities involved in shipping any goods or finished products from suppliers to a facility or to warehouses and sales locations.

Warehousing – a structure or room for the storage of components, raw materials and finished goods; also includes materials handling.

Packaging – a way to benefit handling, distribution, and to protect a product through the technology of enclosing or containing.

Inventory Management – the management of a stock or store of goods for the purpose of maximum sales and customer satisfaction.

Metrics – refers to definition of the measure, how it will be calculated, who will be carrying out the calculation, and from where the data will be obtained (Neely et al. 1995) (Gunaskaran, 2006).

Appendix B – Table of Variables

Variables	Description of Variables
J	Set of goods {1,2,3…,j…,J}
TC_j	Transportation cost of j
WC_j	Warehousing cost of j
PC_j	Packaging cost of j
IMC_j	Inventory Management cost of j
T_e	Transportation Efficiency
W_e	Warehouse Efficiency
P_e	Packaging Efficiency
IM_e	Inventory Management Efficiency
TVA_j	Value added due to transportation
WVA_j	Value added due to warehousing
PVA_j	Value added due to packaging
$IMVA_j$	Value added due to inventory management
T_W	Weight given to transportation
W_W	Weight given to warehousing
P_W	Weight given to packaging
IM_W	Weight given to inventory management

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