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## **The Integration of Supply, Demand and Value: A Coherent Theory of the Supply Chain**

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**Abstract:**

*This paper presents a refined means of conceptualizing the combination of sets of integrated business processes and activities that since the late 1980s has come to be known as the “supply chain.” It identifies specific sets of processes and activities, “channels,” by the primary economic value that each contributes to products and services as they move from the sourcing of raw materials to final delivery. The paper further drills down to the way in which value is developed, aggregated, and completed through the interaction of functional areas, “subchannels,” at different, discrete locations throughout the supply chain. Value is not complete in a product or service until final delivery, and if, at final delivery value is less than full, then it is the result of supply chain inefficiencies. The concept of economic value as something contributed by supply chain processes is not new, and has its origins long before “supply chain” was coined (circa 1988) in traditional discussions of time and place value associated with transportation and logistics, form associated with manufacturing processes, and possession associated with marketing processes. This paper develops coherence in supply chain theory by further adapting some of the discussion of the values associated with traditional processes to an integrated concept of supply, demand, and value, and concludes that the fundamental manner in which a modern supply chain should be conceived and managed must be in the knowledge and spirit of that integration; an unbalanced emphasis on any one of the three elements of supply, demand, or value without regard to their systemic relationship is neither optimal theory or practice.*

**Key Words:**

*Supply, demand, supply chain, transport costs*

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## 1. Origins and conceptual developments

The concept of “supply chain” as we know it today came from the experience of the American military in World War II under the leadership of General George C. Marshall. Under Marshall’s logistics strategy, supply management focused on integration of processes and activities to the end of getting “beans, bullets, and black oil” (Carter *et al.*, 1953)<sup>4</sup> to where and when they were needed.

This focus on integration was the seed that eventually became the idea of “supply chain;” briefly put, the supply chain concept now incorporates a wide scope of identifiable sets of interdependent business processes and activities from the sourcing of raw materials to the ultimate destination of the product. When the Axis were defeated and America demobilized, the former military personnel who had been trained in and who had implemented Marshall’s logistics strategies then brought their expertise with them to work in academia, the private sector, and government.

The metamorphosis of “logistics” since the post World War II era owes to the flowering of the seeds sown by Marshall. Although it isn’t clear who first coined the term, “supply chain,” it began to appear in articles and books circa 1988, and encapsulated the notion that logistics, marketing, manufacturing, and other important process areas were best viewed as integral parts of a larger whole. This conceptual development was reflected in the three name changes of a respected American professional logistics organization:

- 1963 – National Council of Physical Distribution Management,
- 1985 – Council of Logistics Management,
- 2005 – Council of Supply Chain Management Professionals.

This conceptual development was also reflected in the progression of computerization in the business world. The development of Material Requirements Planning (MRP I) occurred around the need to support increasingly complex manufacturing activities, such as the production of IBM mainframes, Boeing 747s or Ohio class nuclear submarines, and coordinated those complex activities by detailing a production schedule and a bill of materials that injected resources as needed into that schedule.

By the early 1980s Oliver Wight, one of the original pioneers who helped originate and advocate Materials Requirements Planning, coined the phrase, “Manufacturing Resources Planning,” or MRP II, and proposed a methodology for implementation

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<sup>4</sup> Rear Admiral Carter’s memoirs contrasted the situation at the beginning of the war when America could not coordinate most elements of supply management to the end of the war when Marshall’s strategies had made it possible to efficiently source, produce, and deliver goods.

(Mabert, 2007). Some large companies had experienced such success with Materials Requirements Planning that they then began to embark on extending the efficiencies realized from it to the wider enterprises of which their manufacturing sectors were a part. In this way, Manufacturing Resources Planning, or MRP II was born; the irony in the name is that it was not just about manufacturing.

Not all companies were able to realize the benefits of MRP I and MRP II in those pioneering years. The user interface with computers was a cumbersome process involving many different people and specialized equipment, e.g. key punch machines and card readers<sup>5</sup>. MRP II in particular acquired a poor reputation in the context of technology that had not yet caught up to the idea; but, in the early 1990s, when mainframes and then minis gave way to client server desk tops, MRP II rose Phoenix-like from the ashes in a new form as Enterprise Resource Planning (ERP) (Anderegg, 2011).

Meantime, in 1985, Michael Porter presented the concept of “the value chain” or a chain of activities in which the products of a firm interact in passage with activities from which the products gain value (Porter, 1985). His “diamond cutter model” focused on firm infrastructure, although by later extrapolation it was applied to distribution networks and supply chains. The categories of “support activities” and “primary activities” that Porter used in his model are said to be the means by which costs are incurred and value created; however the rationale for the categories isn’t clear, e.g. why is procurement a support activity and operations a primary activity? What exactly is “operations?”

Porter did not identify and explicate values, nor link them systematically to business processes and activities; but, he did originate the “value system” concept. Using contemporary terminology to describe it, Porter’s value system in 1985 included the value-creating interactions of the firm, its suppliers, the firm’s distribution channels, and the final consumers. This concept elaborated on by many others and in subsequent works by Porter, came to be known as the “value chain.”

The concept of value as something contributed by business processes pre-dates Porter, and occurred long before “supply chain” was coined (circa 1988), in traditional discussions of time and place value associated with transportation and logistics, form associated with manufacturing processes, and possession associated with marketing processes. For example, discussions of locating sites for factories and rationalizing transportation costs often drew on the work of Alfred Weber, who dwelt on the effects on transportation costs of weight gain and weight loss of manufactured products in relation to the weight of the raw materials that were used to produce them (Weber, 1929). In Weber’s theory, weight-gaining prominently

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<sup>5</sup> Mabert does a good job describing some of this specialized equipment, pp. 346-348

occurred because of the presence of “ubiquities” in the manufacturing process, including air and water. For example, soft drinks are a perfect example of Weber’s theory. Syrups are shipped to bottling plants and mixed with water. The finished product is distributed in a market immediately near the bottling plant.

In fact, in Weber’s time, economists concerned with the costs of retailing products already gave consideration to other factors such as land acquisition costs. A prominent nineteenth century German landowner and economist, Johann Heinrich von Thunen, in 1826 came up with the theory of marginal productivity (Von Thunen, 1826). His idea was that the maximum rent or price that any economic development could pay for land was the difference between the price of its goods in the marketplace and the cost of transporting the goods to the marketplace. Von Thunen’s assumption was that the price charged by the seller to the buyer covered all other overhead of the seller and would return a profit. Simplified:

$$\text{PRICES} - \text{TRANSPORT} = \text{PROFIT} = \text{MAXIMUM LAND PRICE or RENT}$$

Von Thunen believed that cities were the quintessential marketplace, the epitome of economic development. Those activities that can pay the most for land will be located in the center of the city and along major transportation corridors.

The works of Von Thunen, Weber, and Porter, among others are all about searching for the nature of value that is imbued in a product from the time raw materials are sourced to the time the completed product has final form in the possession of its last buyer. In the temporal and cultural context of each work, there was more or less attention to the wide scope of business processes and activities involved, and up to this time no writer has proposed a coherent system of business processes and activities based on the primary economic values associated with those processes.

## **2. Definition of terms**

Clarity in any discussion is best served by defining major terms at the outset. Our purpose in this paper is to identify and explicate the way in which value is developed, aggregated, and completed through the interaction of the functional areas of processes within supply chains that extend from the sourcing of raw materials to the ultimate delivery of products or services. Therefore the major terms that we need to define are as follows:

- economic value,
- supply chain,
- channel,
- functional area (or sub-channel),
- transformation point.

“Value” exists in many different forms; some economists will no doubt consider the term “economic value” to be a redundancy, since they hold to the idea that anything which is said to have value can be quantified and assigned a cost or price. What, for instance, is the cost of a mother’s love? Is it quantifiable in terms of the time a mother spends taking care of her child? Is it quantifiable in terms of the ability of a child to function in society? Is it quantifiable in terms of how or whether the child moves on to raise its own children? Obviously there is an argument to be made that there are intangible aspects to the concept of value that, try as we might, are resistant to being quantified, and in that spirit, we do not consider “economic value” a redundancy. Therefore, our working definition of the term is the type of value directly associated with the production, distribution, and consumption of goods and or services.

There are many definitions of “supply chain” at use in textbooks today. Some of them are better than others, but none are based on the concept of systematically incorporating economic value into the supply chain concept. It is not our purpose here to review existing definitions of “supply chain,” but rather to offer one that makes sense in the context of the creation of economic value by a system and the value embodied in products and services. Therefore, our working definition of the term is of wide scope: the supply chain is a combination of identifiable sets of business processes and activities that extend from the sourcing of raw materials to the final destination of the product or service. The sets are identified by the primary economic values that they add to products or services moving through the supply chain. Creation of value is not complete until the product or service is finally delivered.

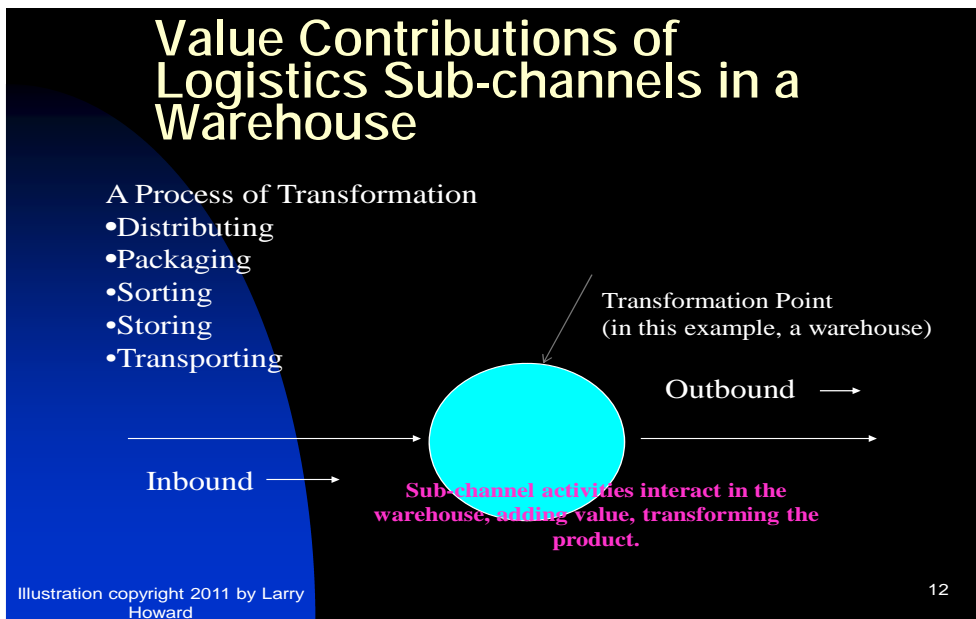
“Channel” is defined as a set of business processes and activities that extend from the sourcing of raw materials to the final destination of the product or service and despite the seeming variety of these processes is identified as being related because each adds the same primary economic value to products or services moving through the supply chain.

Functional areas or sub-channels are processes that act in discrete locations along a supply chain but do not extend along the entire system from the source of raw materials to the final destination of product or service. Each functional process is related to others in the larger “channel” because of the primary economic value that it helps add to the product or service.

A “transformation point” is a discrete location in the supply chain where channels interact through their functional areas to create and add value. In Figure 1 (below) the transformation point depicted is a warehouse at a discrete/strategic location in the supply chain where sub-channels of the logistics channel interact with other channels through their functional areas to create and add value. Site location is a

subchannel of logistics and adds real economic value when a warehouse is strategically placed in fair proximity to materials/sources, to hubs in distribution networks and to markets.

**Figure 1: Value contributions of logistics**



### 3. How channels work

It has long been realized that value is relative to the benefits of a product or service as perceived “in the eyes of the beholder” (Flint, 1007). For example, in the nineteenth century, uranium was not considered a significant natural resource and most people didn’t know of its existence; today in context of it being a nuclear fuel, it is perceived to have critical value to national power and economy, and businesses and individuals secure economic, professional and political status from it.

Without perceived value there can be no demand, and no interest in supplying a product or service. Even the most idiosyncratic perceived value generates some level of demand, however small.

A product or service is transformed into something of value, generating demand, through the interaction of the channels that combine to create a supply chain. There are at least six major channels in the supply chain. Each is composed of several subchannels, the functional areas by which economic value is created and aggregated in discretely located transformation points along the supply chain until

the product or service is finally delivered. Figure 2 lists the major channels and some of their functional areas.

**Figure 2: Major channels and functional areas**

| Channels        | Primary Economic  |  |
|-----------------|---|--|
|                 | Value   | Some Associated Functional Areas   |
| Communications  | Integration   | electronic transmittal, oral, written, official publications, MIS (including MRP and MRP II)   |
| Finance         | Exchange of Value   | accounts receivable and payable, audits, budgeting, tax compliance, insurance, credit  |
| Human Resources | Recruitment, training & maintenance of a qualified work force | hiring, training, compliance, job design, safety, morale, compensation, termination  |
| Logistics       | Time & Place  | business continuity and other strategic planning, inventory management, forecasting, procurement, materials handling, packaging, security, transportation, warehousing |
| Manufacturing   | Form  | product and service design, development testing, production scheduling, assembly, quality control all form postponement processes                                      |
| Marketing       | Possession  | market research, branding, distribution strategy, pricing, promotion, product management, sales  |

Integration is the glue that holds all supply chain processes together; but, it shouldn't be viewed as more important than any other of the primary economic values identified in Figure 2. Take any of the primary economic values out of the system and output is degraded. Derived from communications processes, integration is the value of leveraging knowledge into the management and coordination of activity within the supply chain. For example, suppose a ship arrives from a foreign port in the harbor of an American port without any preceding communication to the ship's agent, the port authorities, or the coast guard. Because the captain did not send an estimated time of arrival, nor comply with any of the conventional requirements of notification of various parties about his impending arrival, operations are severely retarded and value therefore diminished: no berth is available for the ship, and no tugs present or linesmen present even if there was a berth. Stevedores did not set up gangs to work the ship; there is a pretty long list of activities that do not happen because of the lack of communication. To dramatize the point one step further, it is

most likely that any commercial ship arriving foreign without preceding notice would never be allowed by the coast guard to venture into commercial traffic lanes.

The value derived from the Finance Channel is vital in that if there are no means by which buyers, sellers, and associated parties can exchange the perceived values of the goods or services in question, all transactions are still-born. The best example of exchange of value being a primary economic value is money. What is money? Is it the paper currency we sometimes have in our wallets? Or is it coin? Is it the handy plastic credit card? Is it the electronic read out on the terminal that verifies the amount in our bank or credit account? "Money" encompasses all of those things. It is a representation of the value that accrues to us through labor, appreciation of assets, and other means and gives us a means to use that value, to spend, to invest. Money is an important medium by which exchange of value occurs, the specific mediums differing over time and technology, from culture to culture. For example, during the Cold War, Eastern Bloc currencies were generally not convertible; East-West transactions often occurred, as in the case of American wheat sales to the Soviet Union, using gold or barter arrangements. Today, specialized and secure electronic platforms allow instantaneously the sale and diversion of cargo in transit in a more homogenous and more global marketplace.

Job seekers can be forgiven if they think of Human Resources departments as obstacles to landing a job; the conventional, if cynical wisdom is that HR exists so as to help current hiring managers find a way to say "no." Screening applicants, however, is an important part of the recruitment dimension of the primary economic value that Human Resource processes contribute. The other dimensions of that economic value are to train and maintain a qualified work force. In an optimal supply chain, screening out applicants does not overshadow any other part of recruitment nor does it overshadow any processes in the other dimensions of value.

In fact, knowledge and skills in the work forces of contemporary supply chains are increasingly a dynamic proposition; if HR does not consistently and effectively train employees it cannot maintain a qualified work force to create, design, produce, sell, distribute, and/or service modern products, many of them derived from technology and methodology that didn't exist just a few years before. For example, can an auto mechanic not trained in the latest automated diagnostics and engine configurations efficiently service a 2011 hybrid model? A firm may hire away good workers from a competitor as part of its strategy to maintain a qualified work force; but, a strategy dependent exclusively on that practice would be costlier and effective only in the short term.

Training is also a way for employees to personally develop their careers; a company that doesn't have opportunities for training and personal development creates a drag on employee morale. Low morale translates into low productivity. Imagine then a



supply chain in which has gone missing the primary economic value derived from the processes of the human resources channel. Extrapolate to the example depicted in Figure 2 and imagine a warehouse in which workers don't understand how to read the Warehouse Management System data and act on it, so sorting is degraded; imagine employees who mess up the shrink wrapping 40% of the time, who clumsily operate forklifts, who watch the clock. Without the optimum contribution of the recruitment, training, and maintenance of a qualified work force, all other value contributions from the communications, finance, logistics, manufacturing, and marketing channels will be obstructed.

Time and place utility is the primary economic value contribution of the logistics channel; it is simply defined if sometimes hard in actual practice to attain. Whether in the "beans, bullets, and black oil" context of World War II, or in the modern context of the leanest Just-in-Time (JIT), produce-to-order operation, time and place utility is all about getting things where they are need at the time they are needed. Typical undergraduate logistics textbooks express this concept; they sometimes also blur the interactive relationship with other channels by suggesting that the value contributions of those channels are being derived from logistics. Here is one example (Murphy Jr., P.R. and Wood, D.):

*Although form utility generally has been associated with production and manufacturing logistics can also contribute to form utility. For example, to achieve production economies (i.e. lower cost per unit), a soft -drink company may produce thousands of cases...Through allocation, logistics can break the thousands of cases of diet colas into the smaller quantities that are desired by customers.*

Allocation or "sorting" as we call it here does not create nor add form; rather the temporal and spatial interaction with the form postponement functions of the manufacturing channel, and the packaging function of logistics, enables several different form possibilities for the soft drink product. There are several market outlets for soft drinks including vending machines, retail shelves, coolers, and fountain taps, and final form occurs at the time the buyer acquires the drink at one of those outlets. Part of the product design includes configuring the product to be compatible with the outlet; sorting enables and supports the form postponement operation but doesn't cause it.

Another logistics sub-channel, packaging, interacts even more intimately with manufacturing processes in the soft-drink example, and that is packaging. Without containment, the soft-drink could not be conveyed well to the customer at the time and place the customer wants to enjoy it; but, the nature of the product design is such that in some instances, the container is part of the product form in addition to serving to add time and place utility. If the value contributions of different channel processes in interaction with one another are recognized for what they are, specific

issues of optimization can be better addressed. Supposing some problem with the soft drink containers in the afore-mentioned soft-drink packaging example, if the problem were addressed as purely a logistics issue, the manufacturing processes of product design and configuration would be left out of or at the back end of any troubleshooting and resolution.

People who do Marketing try to manage the markets in which they are involved by setting up exchanges and working relationships; they try to create the value of possession by convincing customers that making a buy will satisfy their needs and wants. The simple definition of possession is that it is the decision to acquire a product or service.

Adding the value of possession is a creative process that depends upon the customer perceiving that all the value imbued in a product or service at the time of a purchase is worth the customer changing his/her status quo by making the buy. If the marketing channel processes in a supply chain are efficient and successful, they reveal aggregated value to customers; this means that marketing processes are interdependent with each of the other channel processes involved in a supply chain, because optimum value cannot be revealed to customers if those other channel processes have not made their value contributions.

The functionalist school of thought (Sheth *et al.*, 1988), one of the twelve schools of thought in marketing theory, explains marketing processes as being within a system of interrelated structural and interdependent dynamic relationships in which economic value can occur through exchanges between the consuming parties, supplying parties and the channel of distribution.

In functionalist theory, total customer value mainly includes the value perceived to be in the products and services. The early concept was that markets are assumed to be homogenous, and in perfect markets, the needs and wants of consumers (demand) match the products and services offered in the market (supply) by price adjustment.

Alderson (1965) first proposed that markets are not homogenous but rather are heterogeneous. According to him, value creation is only possible by progressive differentiation of products and services, and this can only be understood by the concept of transvection. To explain the concept, Hunt, Muncy and Ray (1981) clarified Alderson's elements by providing primary propositions. One of them is about the relationship of demand, supply and creating value. They suggested that since demand, supply and requisite institutions are heterogeneous, in order to provide economic value in products and services to consumers, some sorting and transformations are necessary to match demand and supply.

Alderson perceives transvection as the outcome of a series of transactions, but it includes the complete sequence of exchanges and various transformations which create value to consumers.

In terms of Figure 1, Alderson's sorting function can be explained as occurring at the transformation point of a warehouse, warehousing processes such as sorting being a functional area of logistics, interacting with the marketing subchannel of distribution strategy, and in that interaction, adding the economic values of time and place and possession. These aforementioned value additions are transformations of individual products within the supply chain at the discrete location of the warehouse. Without the sorting in the warehouse, optimum value cannot easily be revealed to the ultimate customer.

Another example involving sorting includes interaction with the manufacturing channel. In "push systems" and in all but the leanest "pull" or produce-to-order systems, Manufacturers typically make a large quantity of a limited portfolio of products, whereas consumers desire only a limited quantity from that portfolio. The interaction of the logistics sorting function with the manufacturing process helps to solve this discrepancy so as to match demand and supply. This type of activity is epitomized in collaborative planning, forecasting, and replenishment (CPFR); without the value added by the logistics and marketing interactions with the manufacturing channel, a product cannot be transformed to realize its final form in the hands of a customer.

## **5. Conclusions**

The supply chain is not a traditional chain with solid links; instead it is better understood as a dynamic set of processes which can be identified on the basis of the primary economic values that they contribute to products and services moving from one end of the supply chain to the other. One of the benefits derived from looking systemically at such a process flow is that we come to understand how important integration is to optimizing a system and gaining the best output, whether it is soft-drinks at diverse market outlets or just-in-time supply of a mass retail outlet.

The term "supply chain" has gained usage since about 1988; but, not without attempts to relabel the concept. In addition to "value chain," another concept, "demand chain," (Blackwell and Blackwell, 1999) has gained some prominence in professional discussions. Just as those who today use the term "value chain" focus on adding value to products and services, "demand chain" adherents emphasize customer demand; both eschew the prominence of suppliers, hence the attempt to refocus and rename.

The issue really isn't whether to emphasize suppliers, values, or demand because none can exist independently of each other, just as not one of the afore-mentioned economic values and the processes that contribute them can exist independently of each other and produce optimal output. An emphasis on any one of the three elements of supply, demand, or value without regard to their integration in a systemic relationship is neither optimal theory, nor optimal practice.

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