2
Literature Review on Demand Driven Supply Chain (DDSC)

2.1
Demand Driven Supply Chain Concepts

This chapter reviews the concepts of DDSC described in the literature and will support the identification of key DDSC components.

Before defining the DDSC concept, it is very important to review the concept of Supply Chain Management, as it will serve as the foundation to build the DDSC concept. To that end, the Council of Supply Chain Management Professionals (CSCMP) defines Supply Chain Management as follow:

"…Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates **supply** and **demand** management within and across companies…".

And the boundaries and relationships are also defined as:

"…Supply chain management is an integrating function with primary responsibility for linking major business functions and business processes, within and across companies, into a cohesive and high-performing business model. It includes all of the logistics management activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities, with and across marketing, sales, product design, finance, and information technology…"

Based on this definition, it can be pointed out two key concepts responsible for the success of Supply Chain Management initiatives in manufacturing and service companies: Supply Management and Demand Management.

Bayraktar et al. (2009) also confirm the importance of demand management. They tested a framework identifying the causal links among supply chain management and information systems practices in small and medium size companies in Turkey. They performed hypotheses tests that indicate that both supply chain management and information systems practices positively and

significantly influence the operational performance of 203 manufacturing companies considered in the analysis. One of the SCM practices identified was “close partnership with customers” or deemed by demand chain management.

Emmet & Crocker (2006) stated that Supply Chain Management is strategic and also operational. By strategic, he gives an example that a company located in any one country needs to be thinking about global sourcing of raw material and packaging, new markets across the world, as the success of the business will ultimately depend on the success of this end-to-end supply chain of which the company is only part.

On the other hand, the supply chain is also operational, because the end-to-end supply chain concept has to work in practice, and this is all about getting supply chain thinking and skill-sets into every level of management and supervision, and into execution in every business function, in every player in the value chain. The drive for change needs to come from the top senior management, and the leadership of change to convert supply chain thinking into operational practice, must be taken up as a boardroom responsibility.

Emmet & Crocker (2006) stated that Logistics and Supply Chain are new concepts, emerging only in the 80s and 90s. He argues that supply has a connotation of being a push system, and for many the word “demand chain” is more meaningful, and that these concepts are being combined as “the Demand–Driven Supply Chain” (DDSC). He also explains that chains are being replaced by networks in an attempt to find new expressions to demonstrate how the thinking and practice can move forward.

Hull (2005) states that in a demand driven chain, a customer activates flow by ordering from the retailer, who reorders from the wholesaler, who reorder from the manufacturer, who reorder raw materials from the suppliers. Orders flow backward, up the chain, in this structure. The activator can be either actual customer demand as shown in figure 2, or forecasted customer demand.

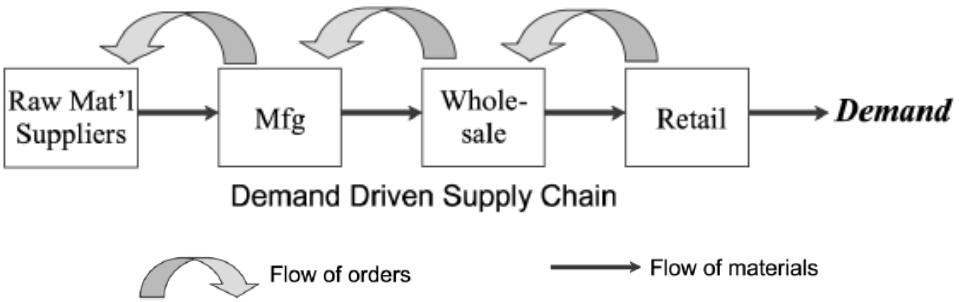

Figure 2 – Demand Driven Flow (Hull, 2005)

AMR research report (2005) defines the term “Demand Driven Supply Network” (DDSN) as a system of technologies and business processes that sense and respond to real-time demand across a network of customers, suppliers, and employees. The report also states that DDSN leaders are more demand sensing, which means being able to understand market drivers that impact demand, have more efforts for demand shaping, which means being able to influence the demand through specific market activities like special promotions, and focus on a profitable demand response.

AMR proposes 5 cross-functional strategies to become DDSN. These strategies are outlined on the AMR DDSN framework in figure 3:

- **Being Market driven and not Marketing driven:**
  In Demand Driven Supply Chain companies, processes are built from the outside-in, which means, they are based on a clear view of the customer, what is important for them and the requirements for account profitability. These companies become zealots on new product introductions and use their supply networks to shape and respond to demand.

- **Develop products that generate demand:**
  AMR argues that one of the successful factors of the AMR TOP 25 Supply Chain companies is excellence in innovation. Being quick to market with profitable products that are in high demand is a core competence of a DDSN strategy. For DDSN leaders, innovation excellence is a key to success, and it is infused into all supply chain processes. AMR research shows that 75% of new products fail, and **42% of companies lack a common set of internal standards for managing New Product Development & Introduction process**.

- **Have a Channel-driven fulfillment process:**
  Channel-driven fulfillment is the redesign of order processes to become demand driven, not order driven, and the supply chain strategy used is based on service level agreement for pull-based replenishment to define an order. Replenishment decisions are evaluated continuously for each channel based on profitability and product placement goals. Supply chain velocity and demand visibility are key elements for a successful execution of channel driven.

- **Have a Demand-driven replenishment process**

  Demand-driven replenishment is the alignment of distribution and manufacturing processes for a pull-based response, and is built on the principles of lean manufacturing – waste reduction and pull-based replenishment. It connects these principles of local execution with global planning process using pull-based network design and constraint-based planning in Sales and Operations Planning (S&OP). These principles are closely linked to manufacturing, procurement and logistics decisions in building agile networks.

- **Have Agile networks for a customer-centric response**

  Agile networks are built to align materials suppliers, contract manufacturers, and logistics providers to a demand signal. An agile network starts with the design of the network for pull-based replenishment, and is continually refined through New Product Development & Introduction processes.

  Agile networks start with the design and flexibility based on joint agreements (contract relationships and demand visibility are essential). The key elements of agility and reliability are balanced with cost for the selection of manufacturing sites, supplier qualifications and modes of transportation.

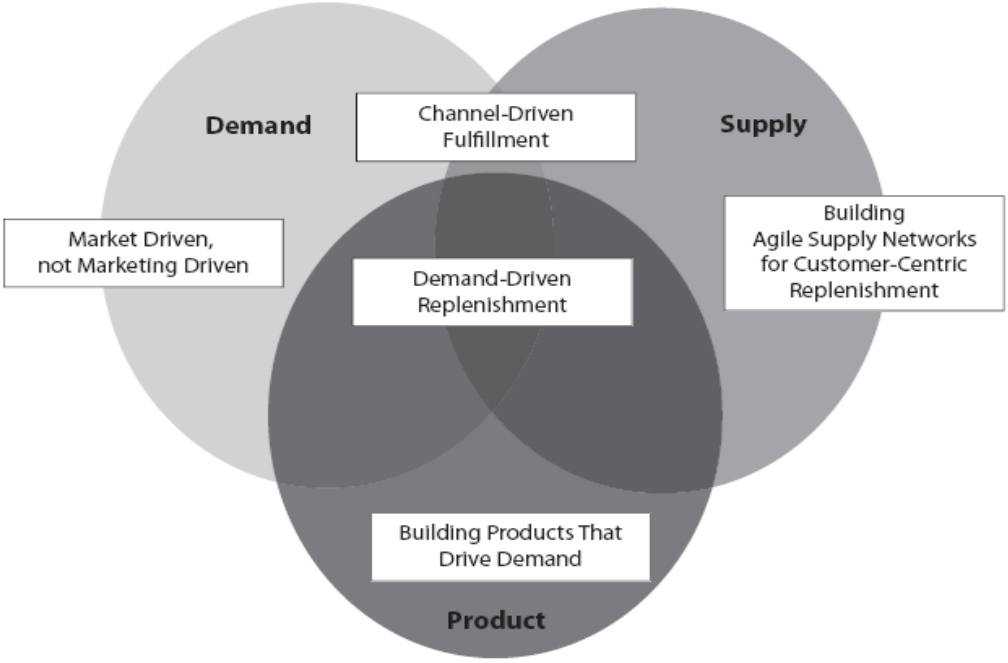

Figure 3 – AMR DDSN Framework (AMR, 2005)

Ayers and Malmberg (2002) describe a Demand-Driven Supply Chain as one in which the company is trying to shift from “build to forecast” to “build to order” discipline. The Demand-Driven Supply Chain is one that derives the information for production and inventory decisions from actual, real-time demand, and not forecasts – even if the forecasts use past sales history as a basis. He also argues that the property of being demand-driven is one of degree:

- Being “zero percent” demand-driven, means all production / inventory decisions are based on forecasts, and so, all products available for sale to the end user is there by virtue of a forecast. This could be the case of fashion goods, where the designer may not know how buyers will react to a new design, or the beverage industry, where products are produced based on a given forecast.
- A “100 percent” demand-driven is one in which the order is received before production begins. In this model, the commercial aircraft industry comes close to this description.

Bowersox and Lahowchich (2008) describe that traditional supply chains have been designed to operate in an anticipatory, or a “push mode”. The prevailing distribution process is a time-consuming, forecast driven, volume oriented, functionally centric consolidation process designed to “push” products to market destinations in anticipation of future demand. The frequent result of this anticipatory push process is far too much of the wrong inventory being pushed to the wrong markets, and this missed alignment of inventory often results in firms using incentives to entice consumers to buy products they have available to sell, rather than providing the exact product the consumers desire to purchase.

Throughout different industrial segments, business leaders and consultants had difficulty explaining why, at the end of the week, or month, despite inventories reaching high levels, out-of stocks were excessive. It is also difficult to fully understand why 70 – 80% of trade sales of some consumer products like beverage, food, disposable diapers, occur in the last week of the month or at the end of the business quarter. The chart in figure 4 gives an example of the high sales variability due to promotions faced by a beverage company in one region of Brazil:

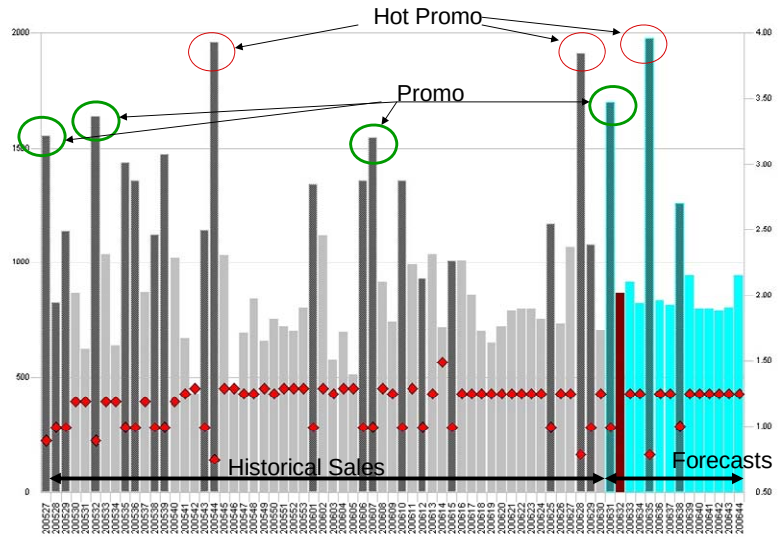

Figure 4 – Weekly Sales Volume of Brazilian Beverage Company

The reason for such sales concentration is that companies are required to meet monthly, quarterly or annually sales goals, and to achieve these objectives, they provide incentives in the form of product promotions or price discounts in order to achieve a lift in the customer demand and therefore, meet the required business objectives. This focus on “sell in” to the customer, instead of focus on “selling out” from the customer to the consumer, increases inventory levels, but does not reduce out-of-stock implications, as more frequently, the products that receive incentives are those with high volume impact, and out-of-stock usually happens in products with low volume impact. This type of characteristic is frequently found in sales driven companies, which should not be confused with demand driven companies.

Michael L. Eskew, recently retired chairman and CEO of UPS, presented the overall transformation challenge from the perspective of global companies and their service providers at the 2007 Longitudes conference:

“*Consumer pull requires one-to-one solutions and supply chains that can deliver them. The world is no longer driven by producers pushing products through their supply chain. Increasingly, power is in the hands of consumers who now pull products through the system. They pull what they want, when they want it, from whomever they choose anywhere in the world, and consumers want and expect a personal, relevant, individualized experience, and this is a big shift that will only intensify.*”

As there are many definitions of Push vs. Pull systems, it is important to clear define the two concepts, as they are keystone in the demand driven concept.

At the 2005 Aspen Institute Roundtable on Information Technology, 25 thought leaders discussed the broad implications of push versus pull economies, generating the following definitions:

- A push economy is the kind of economy that was responsible for mass production in the 20th century, and is based on anticipating consumer demand, and then, making sure that needed resources are brought together at the right place, at the right time, for the right people. A company forecasts demand, specifies in advance the necessary inputs, regiments production procedures, and then pushes the final product into the marketplace using standardized distribution channels and marketing;
- A pull economy is the kind of economy that appears to be materializing in online environments, and is based on open, flexible production platforms that use networking technologies to orchestrate a broad range of resources. Instead of producing standardized products for mass markets, companies use pull techniques to assemble products in customized ways to serve local or specialized needs, usually in a rapid or more informal, “on-the-fly processes”.

Hopp and Spearman (2003) provide a brief history of the Pull system and also a more clear definition of strategic and tactical Pull system, as well as Push system:

- Strategic Pull can be defined as establishing a takt time to set the output of the production plant to be equal to demand
- Tactical Pull system is the one that explicitly limits the amount of work in process that can be in the production system.
- By default, it is implied that a Push production system is the one that has no explicit limit on the amount of work in process that can be in the system.

The good news about this definition of Pull is that it implies that pull can be implemented in a variety of ways. To illustrate this argument, Hopp and Spearman (2003) give some examples of common systems found in industry and how they should be classified in either Push or Pull, as detailed below:

- MRP is a push system because releases are made according to a master production schedule without regard to system status. Hence, no a priori work in process (WIP) limit exists.
- MRP with a WIP constraint is a pull system.
- Classic Kanban is a pull system, as the number of kanban cards establishes a fixed limit on WIP.
- Classic Base Stock System is a push system because there is no limit on the amount of work in process in the system.
- Installation stock (Q,r) is a push system as it does not impose a limit on the number of orders in the system.

They also argue that there are three primary logistical reasons for the improved performance of pull systems:

- Less congestion – Comparison of an open queuing network with an "equivalent" closed one shows that the average WIP is lower in the closed network than the open network given the same throughput.
- Easier control – WIP is easier to control than throughput since it can be observed directly.
- WIP Cap – The benefits of a pull environment owe more to the fact that WIP is bounded than to the practice of "pulling" everywhere.

Ashayeri and Kampstra also provide a concise definition, as described below:

- PUSH – Node performs order planning for succeeding node. Control information flow is in the same direction of goods flow.
- SEMI PUSH or PUSH – PULL – Succeeding node makes order request for preceding node. Preceding node reacts by replenishing from stock that is rebuilt every fixed period.
- PULL – Succeeding node makes order request for preceding node. Preceding node reacts by producing the order, which involves all internal operations, and replenishes when finished.
- SEMI PULL or PULL – PUSH – Succeeding node makes order request for preceding node. Preceding node reacts by replenishing from stock that is rebuilt immediately.

Harrison (2003) describes 3 different supply chain strategies that a company can implement:

- Push-based strategy in which production and distribution decisions are based on long-term forecasted demand. In this case, it takes much longer to the company to react to the changing marketplace. As the strategy relies on forecasts, it is most of the time difficult to match supply and demand.

- Pull-based strategy in which production and distribution are demand driven, so that they are coordinated with true customer demand rather than forecast. In this case, the company does not hold any inventory and only produces to order. These systems are intuitively attractive since they allow the company to eliminate inventory while responding to customer demand. Unfortunately, it is very difficult to implement a pull based strategy when lead times are so long, that it is impractical to react to demand information. Similarly, it is frequently more difficult to take advantage of economies of scale, since production and distribution decisions are made in response to specific customer demand, and therefore, batch production or efficient transportation modes, such as truckloads, are hard to achieve.

The advantages and disadvantages of Push and Pull supply chain strategies have led companies to look for a new supply chain strategy that exploits the best of both worlds: The Hybrid Push-Pull supply chain strategy.

- Hybrid Push-Pull strategy in which some stages of the supply chain, typically the initial stages, are operated in a Push-based manner, while the remaining stages are operated in a Pull-based strategy, and the interface between the Push-based stages and the Pull-based stages is usually referred to as the “Push-Pull boundary”.

Harrison (2003) also argues that the challenge for the firms is to define which of the three supply chain strategies described above is most appropriate for each product. Figure 5 below provides a framework to match supply chain strategies with products and industries. In the vertical axis, it is shown information on uncertainty in customer demand, while the horizontal axis represents the importance of economies of scale, either in production or distribution:

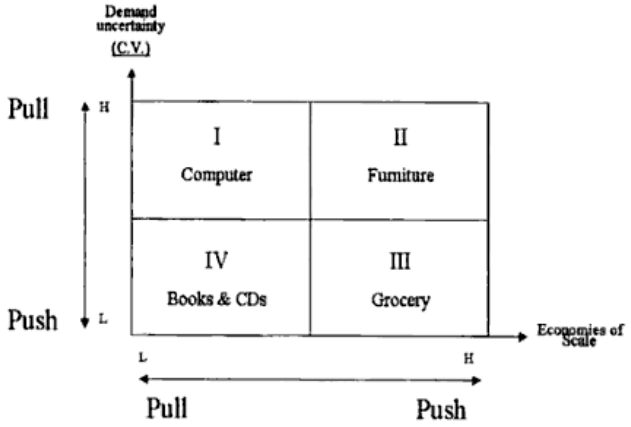

Figure 5 – Matching Supply Chain Strategies with Products (Harrison, 2003)

Assuming everything else being equal, the higher the demand uncertainty, the more the firm would prefer managing the supply chain based on realized demand, that is, based on a Pull strategy. On the other hand, the smaller the demand uncertainty, the more the firm would be interested in managing the supply chain based on forecast, that is, based on a Push strategy. The same logical is true for analyzing the economies of scale, that is, the higher the importance of economies of scale in reducing cost, the more important is to aggregate demand, and thus, the more important is to manage the supply chain based on forecast.

Based on the framework illustrated in the figure 6, Harrison (2003) summarizes when to use each one of the 3 supply chain strategies:

- Push based supply chain strategy, usually suggested for products with small demand uncertainty, as the forecast will provide a good direction on what to produce and keep in inventory, and also for products with high importance of economies of scale in reducing costs.
- Pull based supply chain strategy, usually suggested for products with high demand uncertainty and with low importance of economies of scales, which means, aggregation does not reduce cost, and hence, the firm would be willing to manage the supply chain based on realized demand.
- Hybrid Push – Pull strategy, usually suggested for products which uncertainty in demand is high, while economies of scale are important in reducing production and / or delivery costs. One good example of this strategy is the furniture industry, where production strategy has to follow a Pull-based strategy, since it is impossible to make production decisions based on long-term forecasts. On the other hand, the distribution strategy

needs to take advantage of economies of scale in order to reduce transportation cost, using a Push-based strategy.

For a hybrid Push-Pull strategy, a second important decision is to define where to locate the Push-Pull boundary in the supply chain. Harrison (2003) states that the Push part is applied to the portion of the supply chain where demand uncertainty is relatively small, and thus, managing this portion based on long-term forecast is appropriate. On the other hand, the Pull part is applied to the portion of the supply chain where uncertainty is high, and hence, it is important to manage this part based on realized demand. One illustrative example is Dell, who implemented the Push-Pull strategy by locating the boundary at the assembly point.

Wanke et al. (2010) argue that the perception of logistics systems being complex is confirmed by several authors, but it is not always clear what does it mean. They defined complexity in logistics in terms of quantifiable scales and based on the notion of numerous actors or parts that are interconnected and can be captured by measures such as the company's gross revenue, its number of suppliers, active customers, number of employees, number of employees involved in supply chain management, active stock keeping units (SKUs), number of distribution centers, orders processed and new product launches per year.

They proposed that logistics complexity is a driver to define the way a company manages and emphasizes the different supply chain objectives and decision areas, and based on this, a contingency approach for supply chain management is required, where different contextual conditions drive the way the supply chain choices are made and management activities are performed, as opposed to a best practice approach where there would be some universally applicable principles that would be appropriate regardless of the particular conditions under study.

Zeithaml et al. (1988) describe that the essential premise of the contingency approach is that effectiveness, broadly defined as organizational adaptation and survival can be achieved in more than one way. They give the example that there is more than one way to organize effectively, and more than one leadership style that can achieve organizational goals. The contingency approach therefore, suggests that it can be observed wide variations in effectiveness, but that these variations are not random. Effectiveness depends on the appropriate matching of

contingency factors with internal organizational designs that can allow appropriate responses to the environment.

One example of contingency approach applied to supply chain management comes from Fisher (1997). He proposes a framework to define what is the best supply chain for a company's product. He argues that the first step in devising an effective supply chain strategy is to consider the nature of the demand for the products. To that end, many aspects are important, for example, product lifecycle, demand predictability, product variety, and market standards for lead time and service. He proposes to classify products on two categories: They are either primarily **Functional** or primarily **Innovative**, as summarized below:

Functional Products:

- Product do not change much over time;
- Have stable and predictable demand;
- Long life cycles;
- Lower potential growth.

Innovative Products:

- Great variety of products;
- Increase unpredictability (volatile demand);
- Short life cycles;
- Higher potential growth.

The next step should be to decide whether the company's supply chain is "**Physically Efficient**" or "**Responsive to the Market**", as described in the table 1 below:

Table 1 – Physically Efficient vs. Market Responsive Supply Chains (Fisher, 1997)

	Physically Efficient Process	**Market Responsive Process**
Primary purpose	Supply predictable demand efficiently at the lowest possible cost	Respond quickly to unpredictable demand in order to minimize stock outs and obsolete inventory
Manufacturing focus	Maintain high average utilization rate (reduce setups)	Deploy excess buffer capacity
Inventory strategy	Generate high turns and minimize inventory throughout the chain	Deploy significant buffer stocks or end products in the chain
Lead time focus	Shorten lead time as long as it does not increase cost	Invest aggressively in ways to reduce lead time
Approach to choosing suppliers	Select primarily for cost and quality criteria	Select primarily for speed, flexibility, and quality
Product-design strategy	Maximize performance and minimize cost	Try to postpone product differentiation for as long as possible in the supply chain

After determining the nature of the product demand and the supply chain priorities, managers can employ a matrix to formulate the ideal supply chain strategy. Fisher proposes to plot the nature of the demand for each of the product families and its supply chain priorities, in order to allow identify whether the process used for supplying products is well matched to the product type, which means, an efficient process for functional products and a responsive process for innovative products. In figure 6, the author shows an example of the proposed matrix applied to a practical case in the beverage industry:

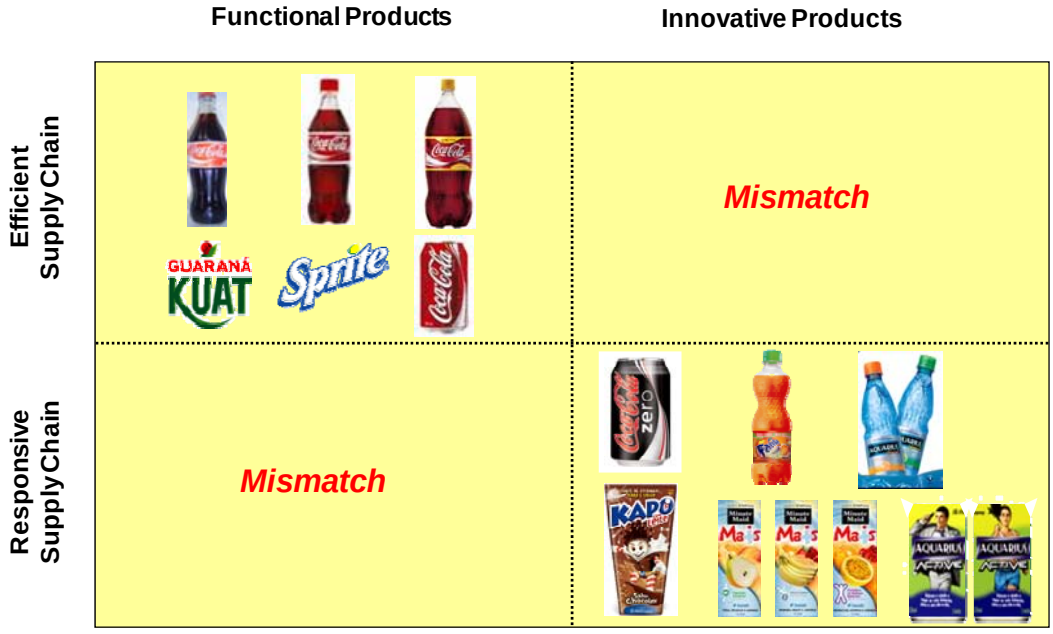

Figure 6 – Example of Product and Supply Chains Applied to Beverage Industry

Ayers (2006) advocates that the Demand-Driven Supply Chain changes many of the conditions that cause wasteful variation in supply chain production. He states that, it is the foundation of the “lean” supply chain, and its implementation helps establish the operating range for low-cost production supply chain.

He proposes a three-phase roadmap to implement the Demand-Driven Supply Chain concept. The phases are listed and also illustrated in the figure 7:

1. **Moving from long to short lead-times** – Overall lead-time is composed of individual cycle-times for multiple processes. This step involves shortening the cycle-time at each step in the critical path processes from the point of purchase to the start of production for the entire supply chain.
2. **Replacing the batch with the flow model economics** – Flow model economics encompass low-cost ways to vary mix and volume. Lean manufacturing is a discipline that has the same goals as flow economics. Examples include “**single minute exchange of dies**” (**SMED**) in

manufacturing, which will be specified in chapter 5, and mixing different products on production lines. Batch picking for multiple customers in a warehouse would represent a non-manufacturing example. A flow model will synchronize supply chain steps and increase the overall supply chain ability to respond to changes.

3. **Basing decisions on actual demand rather than forecasts** – This step requires efficient sharing of information up and down the chain. An ideal process is to have all supply chain partners with access to real time sales, as well as, to the business rules to react based on demand signal.

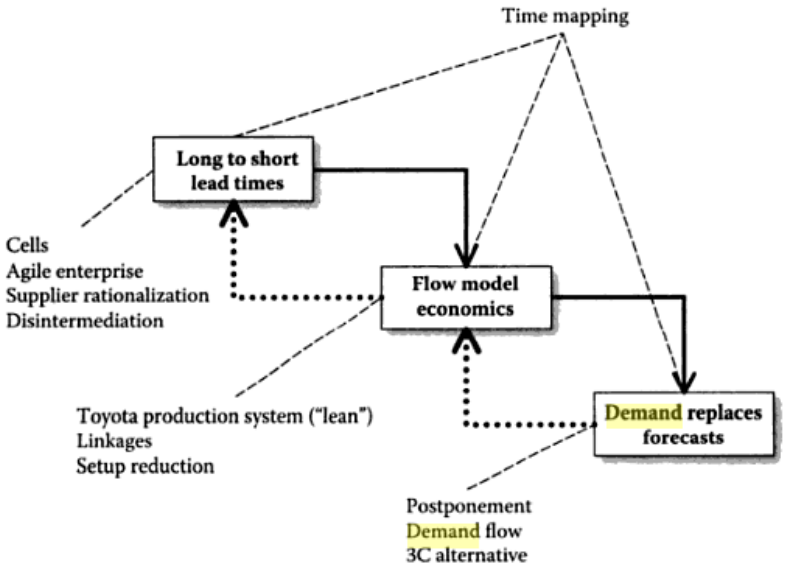

Figure 7 – 3 Phases Roadmap for Implementing a DDSC (Ayers, 2006)

Evolution to a demand-driven supply chain will likely proceed in the order proposed above. Shortening the lead-time is fundamental to changing batch model economics. Basing decisions on demand comes after adopting the economics of the flow model. Along the path, there is feedback to earlier steps. For each phase in figure 8, there are 3 to 4 methodologies to be applied towards a DDSC operation.

Another key concept related to Demand-Driven Supply Chains is the concept of Agile. Christopher (2000) presents the concept of agility as a business wide capability that embraces organizational structures, information systems, logistics processes, being flexibility one of the key characteristics. He also identifies the 4 characteristics of an agile supply chain as market sensitive, network based, process integration and virtual supply chains, being this last characteristic defined as the information sharing network between buyers and suppliers.

He explains the difference between **agile** and **lean** concepts. He defined Lean as doing more with less, and explains that the term is often used in connection with lean manufacturing to imply a zero inventory approach. However, there are certain conditions where a lean approach to supply chain makes sense, in particular where demand is predictable and the requirement for variety is low and volume is high. The problem arises when attempting to implant the lean concept into situations where demand is less predictable, the requirement for variety is high and the volume at the individual SKU (Stock Keeping Unit) level is low, which is the regular characteristics of several markets and products around the world.

On the other hand, agility is defined as the ability of an organization to respond rapidly to changes in demand, both in terms of volume and variety. The figure 8 summarizes the three critical dimensions – variety, variability (or predictability) and volume – that determine which approach – agile or lean – should be deployed.

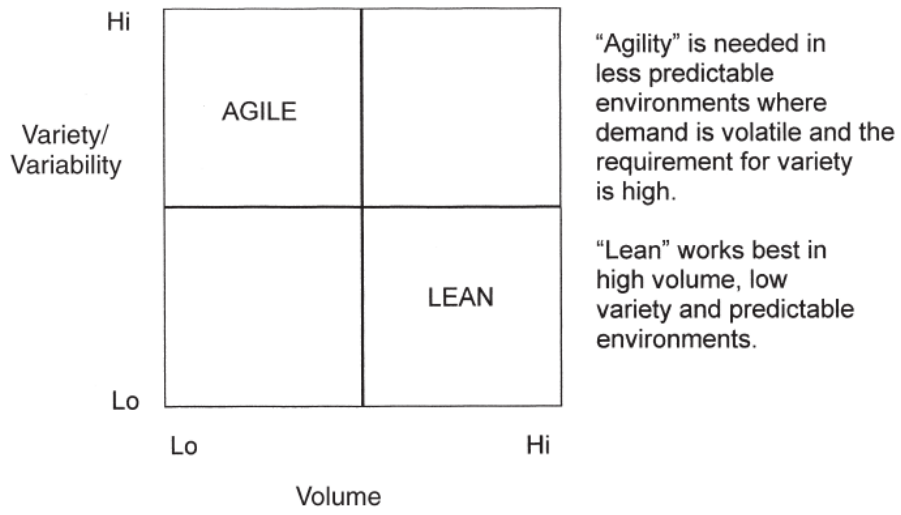

Figure 8 – Characteristics of Agile and Lean Concepts (Christopher, 2000)

Christopher (2000) also states that to be truly agile, a supply chain must possess 4 distinguishing characteristics, being one of them **Market sensitive,** which means that the supply chain is capable of reading and responding to real demand or being demand-driven. The problem is that most organizations are forecast-driven rather than demand-driven. In other words, because they have little direct feed-forward from the marketplace by way of data on actual customer requirements, they are forced to make forecasts based on past sales or shipments, and convert these forecasts into inventory.

One of the biggest barriers to agility is the way that complexity (product and brand proliferation, organizational structure and management processes) tends to increase as a company grows and expands its market coverage. The reduction of complexity should be a major priority for Marketing and Logistics functional areas to allow a company become agile.

Agarwal et al (2007) review the literature on supply chain agility, touching some of the components of DDSC like lead time reduction, market sensitiveness, new product introduction, and propose to apply Interpretive Structural Modeling (ISM) to show the interrelationship of different 15 variables to supply chain agility.

Huang et al. (2009) propose an agile approach for supply chain modeling using a generic label correcting (GLC) algorithm. The rough set theory, which is a mathematical approach to manage vague and uncertain data or problems related to information systems, indiscernible relations and classification, is applied to reduce the complexity of data space when running the algorithm.

Ismail and Sharifi (2006) present a structured framework to provide a practical approach for implementing agile supply chains (ASC), based on the concepts of supply chain design and design for supply chain.

2.2
Methodologies for Assessing Demand Driven Supply Chain

In terms of methodologies to assess and identify company's performance, several articles show the importance of having a structured process in order to improve performance overtime. However, when it is specifically related to methods for assessing performance based on Demand Driven Supply Chain (DDSC) concepts, the articles available do not meet the research criteria which is to have a clear and practical framework to support companies identify their current state based on DDSC concepts.

Dale and Ritchie (2000) argue that companies must have an appropriate performance measurement system to be applied on a regular basis to identify areas to be improved in order to establish a sustainable continuous improvement process. They proposed to use self-assessment process, which can be defined as a comprehensive, systematic and regular review of an organization's activities and results against a model of business excellence. The self-assessment will

allow organizations to clearly discern its strengths and gaps, and define improvement actions linked to the business planning process.

They state that there are some necessary criteria for a successful self-assessment process:

- Gaining commitment and support from all levels of staff
- Action being taken from the previous self-assessment
- Incorporation of self-assessment into the business planning process
- Not allowing the process to be “added on” to employees existing workload
- Developing a framework for performance monitoring

In terms of benefits of the self-assessment, there are both immediate and long term benefits:

Immediate benefits:

- Facilitates benchmarking, drives continuous improvement, encourages employees involvement and ownership, provides visibility in direction, raises understanding and awareness of quality related issues, develops a common approach to continuous improvement across the company.

Long term benefits:

- Keeps costs down, improves business results, provides a disciplined approach to business planning, increases the ability to meet and exceed customers’ expectations.

Chin et al. (2003) also developed a knowledge-based expert self-assessment (KES) training toolkit to measure and assess organizational performance based on the evaluation criteria of the renowned business excellence model – The Malcolm Baldrige National Quality Award (MBNQA).

The concept of self-assessment brings a valuable contribution to reduce complexity, time and cost to apply the DDSC assessment framework on a global basis, as each company should be able to self-assess its current state.

Salama et al (2009) review the importance of supply chain and operations audit process which represents a fundamental step to support improvement projects. They argue that the core element of audits is the diagnostic stage and that no audit can be considered successful unless it really provides a thorough understanding of how the constituent elements of an organization interact with

one another (e.g. people, processes and technologies), that is the interactions which constrain the system, and how these interactions are reflected on the market-driven performance. The provided a very clear set of features and requirements for an audit methodology that can be considered when developing a DDSC assessment:

- Quick / Accurate – The methodology should be based on tools, steps and an “engine” which were designed to deliver a result as accurate as possible in the shortest time possible.
- Not invasive – The methodology should be built in order to require the least possible effort from organization’s resource.
- Scalable – The methodology should be scalable
- Avoid bias / theoretically grounded – The methodology should be built in a way to reduce possible bias in the diagnostic stage, while exploiting the knowledge that people who daily work in an organization have on their processes.
- Stimulate consensus building – The stimulation of consensus building can be achieved in different ways. The most important are:
    - Possible recycles in the diagnostic stage
    - Empirical support of critical findings
    - Quantification of value together with scenario analysis
- Transparent – All tools and steps used in the methodology should be clearly described in all parts. No “secret engine” is behind the methodology.

The proposed new audit methodology by Salama et al. (2009) were tested through 3 European research initiatives, and also showed an example of a master best practice relationship map for the demand management process.

Moon (2002) also provides direction on the importance of auditing process related to sales forecasting. He states that sales forecasting audit process has three objectives:

- Understand current status of forecasting practice (a company’s “as is” state)

- Visualize the goals of forecasting process improvement (the “should-be” state)
- Develop a roadmap for achieving the goals (the “way forward”)

Trkman and McCormack (2009) describe that supply risk or supply disruptions is emerging as a key challenge to supply chain management, and that the ability to identify which supplier has greater potential of disruption is a critical step in managing the frequency and impact of these disruptions.

Their contribution was to use the contingency theory approach to propose a new method for the assessment and classification of suppliers based on their supply chain characteristics, its structure and supplier’s attributes and performances, modified by factors in the supplier’s specific environment namely exogenous and endogenous uncertainty. The contingency approach is a value contribution to be considered when developing the DDSC assessment framework as different companies and industries can have different time and market requirements to move or not to move towards DDSC.

Filho et al. (2010) developed a framework to measure safety culture in the Brazilian oil and gas companies. They applied a 5 level safety culture maturity model (e.g. pathological, reactive, bureaucratic, proactive and sustainable) using 5 dimensions (e.g. information, organizational learning, involvement, communication and commitment) to identify current state of safety practices in petrochemical companies.

A maturity model can be described as a structured collection of elements that describe certain aspects of maturity in an organization, and aids in the definition and understanding of the different organization processes. A maturity model can be a valuable tool to describe the different maturity levels in the DDSC assessment process.

One of the key objectives of DDSC is to reduce demand amplification as it brings extra costs and inefficiencies like extra resource capacity, higher inventory levels, etc. Taylor (2000) reviews the effect of demand amplification in the supply chain and also proposes a practical approach to eliminate it through a 7 step process. A pilot test was performed in UK automotive industry and showed an increase from 70% to 100% on the composite measure of delivery to time along the supply chain, and also a reduction of 30% in total supply chain inventory.

Childerhouse et al. (2002) proposed a methodological framework to develop focused demand chain strategy for each cluster of products commercialized by a company. The methodology consists of 6 steps described below and has the objective to define the best facility, production layout requirements and control mechanisms for each specific product / service offered by the company.

- Step 1: Develop holistic demand chain strategy. This leads from highlighting of core competencies and resources, and its primary purpose is the identification of specific markets to be targeted plus the overall corporate strategy
- Step 2: Identify specific product / service offering. These are tailored to the target markets with emphasis placed on priorization of service, quality, cost or lead times
- Step 3: Categorize demand chain types. Given the specific products and their related service criteria, the DWV3 classification variables (duration of lifecycle, time window for delivery, volume, variety and variability) are used to categorize the products into clusters with similar characteristics. Output is a clear definition of the requirements for each demand channel.
- Step 4: Identify facility requirements. Facilities need to be tailored to achieve the desired objectives (e.g. products with high service level may require distribution warehouses located near the marketplace).
- Step 5: Define production layout and control mechanisms (e.g. Kanban, MRP, etc.)
- Step 6: Implement focused demand chains

The proposed methodology was applied to a UK lighting company and showed several benefits like 75% reduction in product development time, 27% reduction in manufacturing costs, and 95% reduction in delivery lead times.

Bowersox and Lahowchich (2008) propose a Responsive Supply Chain Business Model and describe it as a "*customer-facing organization and operational strategy focusing the highest priority on providing exacting and sustainable customer service"*. They explain that the Responsive Supply Chain business model represents a blend of six imperatives, or essential elements – 1) Consumer connectivity, 2) Operational excellence, 3) Integrative management, 4) Real-time responsiveness, 5) Leveraging networks, and 6) Collaboration, and each of these 6 imperatives represents a firm's unique supply chain DNA.

Verdouw et al. (2010) analyzed the European fruit market and identified that fruit supply does not sufficiently meet demand requirements. They proposed that the fruit supply chains needed to become demand driven, that is, being able to continuously match supply capabilities to changing demand requirements. In a demand driven supply chain, all actors involved are sensitive and responsive to demand information of the ultimate consumer and meet those varied and variable demands in a timely and cost-effective manner. As a consequence, information must be shared timely throughout the supply chain and the early alerted firms have to respond quickly to changes in demand or supply, which imposes stringent demands on the interoperability and flexibility of the enabling information systems.

They presented a reference model for designing business processes in demand-driven fruit supply chains. The model consists of a reference modeling framework that defines process models at different levels of abstraction and includes a method of how they can be composed from a repository of building blocks. However, they did not provide any structured assessment approach to evaluate different business segments / industries in light of demand driven supply chain concepts.

Georgiadis et al. (2001) present a paper describing the design and implementation of a demand driven freight transport application, but they focus mainly in the IT system architecture of the solution, called ATLog (Attika Traffic Logistics), not providing any direction on how to assess and determine a company current state based on DDSC concepts.

Ayers and Malmberg (2002) touch very briefly DDSC concepts, providing a 4 stage maturity model to show how enablers of supply chain improvement support the introduction of information technology to the supply chain, and one of these elements is the demand-driven as illustrated in the figure 9 below. However, they did not provide a detail maturity model and a robust methodology to assess a supply chain, in order to determine its current state in terms of the demand driven concepts.

Exhibit 3. *Enablers of Supply Chain Improvement*

	Stages of Supply Chain Evolution			
	1	2	3	4
	Infrastructure	**Cost Reduction**	**Collaboration**	**Strategic Contribution**
Supply Chain Organization	Capability building Execution of basic tasks	Root cause analysis Item stratification "Optimal" buys	Intercompany improvement programs Financial sharing arrangements	Customer-focused organization structures along supply chain Supply chain level steering committees
Demand-Driven Supply Chain	Supplier reduction Negotiations Mostly forecast driven; backorder and simple service level indicators	Quality systems Outsourcing Supplier ratings Lead-time reduction (cells, small batches) Modest JIT/pull arrangements; 25 % of demand-driven potential	Design changes Postponement strategies Information exchange (inventories, forecasts, demand) 50 % application of demand-driven potential	Segment strategies New product involvement 80–90% implementation of demand-driven potential

Figure 9 – Enablers of Supply Chain Improvement (Ayers and Malmberg, 2002)

Table 2 below provides a summary of the current literature review on assessing DDSC:

Author	Contribution
Dale and Ritchie (2000)	Proposed to use self-assessment process to evaluate company's performance on a regular basis as part of the continuous improvement process
Chin et al. (2003)	Developed a knowledge-based expert self-assessment (KES) training toolkit to measure and assess organizational performance
Salama et al (2009)	Review the importance of supply chain and operations audit process
Moon (2002)	Provides direction on the importance of auditing process related to sales forecasting
Trkman and McCormack (2009)	Argue that supply risk is one of key challenge to supply chain management and propose a new method for assessment and classification of suppliers

Filho et al. (2010)	Developed a 5 level maturity model to measure safety culture in the Brazilian oil and gas companies
Taylor (2000)	Reviews the effect of demand amplification in the supply chain and also proposes a 7 step process to eliminate it
Childerhouse et al (2002)	Proposed methodological framework to develop focused demand chain strategy for each cluster of product commercialized by a company
Bowersox and Lahowchich (2008)	Propose a responsive supply chain business model
Verdouw et al (2010)	Proposed a reference model for designing business processes in demand driven fruit supply chain in Europe
Georgiadis et al	Describe the design and implementation of demand driven freight transport application
Ayers and Malmberg (2002)	Provide a 4 stage readiness model to show how enablers of supply chain improvement support the introduction of information technology to the supply chain

In this thesis, it is proposed to define the components of DDSC, then develop a structured methodology that will help companies assess their current state in light of demand driven supply chain concepts and identify their current strengths and gaps, and therefore, define a strategic plan to evolve and become more efficient and competitive.

Based on the research presented so far, and to the best extent of our knowledge, it can be seen that the proposed subject meets the originality criteria, as it could not be found any paper that covers all the aspects proposed in this research, and it also meets the relevance criteria, as there are extraordinary financial and operational positive impacts that companies, which apply DDSC concepts, face in their business results.

2.3
Benefits of Demand Driven Supply Chain

Despite of the limited information available on the benefits of becoming demand driven, two different studies provide a direction on the financial and operational benefits companies can capture when implementing a demand driven supply chain.

Based on internal benchmark data, AMR reports that the most advanced demand-sensing companies have 15% less inventory, 17% better perfect order performance, and 35% shorter cash-to-cash cycle time. In terms of top line results, DDSC leaders have 10% higher revenue and 5% to 7% better profit margins than their competitors. These extraordinary results captured by demand-driven companies, show the importance of having a structured methodology for assessing the current state against DDSC concepts, in order to help companies evolve in the implementation of DDSC components and tactics.

Another reference comes from SAP Insight report (2006), which argues that based on existing customer studies, analyst comments and industry pooling, the implementation of DDSC can generate the following results:

Revenue: Increase fill rates (defined as cases delivered divided by cases ordered) and reduce out-of-stocks by 3% to 10%
Operating cost:

- Increase production efficiencies by 1% to 5%
- Decrease freight costs by 5% to 15%
- Improve personnel productivity by 7% to 12%
- Reduce obsolescence and waste by 35% to 50%

Working capital:

- Reduce inventory levels by 7% to 15%
- Improve asset utilization by 10% to 15%
- Decrease cash-to-cash cycle by 10% to 30%

As it could be seen, there are great benefits on becoming DDSC, but the question that most companies face is ***how to rapidly evolve from current state in the direction of demand-driven supply chain***.