Supply Chain Differentiation: A Quantitative Fuzzy Application to Segment Demand Driven Supply Chains

Lucas Alves S. Santos[1] and Kleber Francisco Espôsto[2]
Department of Production Engineering
São Carlos School of Engineering
University of São Paulo
São Carlos, Brazil
[1]lucassantos@usp.br
[2]kleberesposto@usp.br

Abstract

Companies are confirming that in a VUCA (volatile, uncertain, complex, and ambiguous) world, it is possible to gather improvements from becoming demand driven. To achieve this, it is important for organizations to be aware of the Supply Chains present on its operations to apply different segmentation approaches in managing them. We analyzed several segmentation models in order to adapt one of them to identify a Demand Driven Supply Chain (DDSC) in a company object of study. The objective was to quantify the percentage of produced volume which has DDSC characteristics, based on the buying behavior of two previously identified customers group. The proposed model enabled the organization to identify that 47,94% of group A volume and 85,07% of group B volume were adherent to a DDSC. By using gathered data from a real application, the model strongly supports the use of a quantitative fuzzy methodology to segment supply chains, since the results were coherent to the reality pointed by the experts from the studied industry. The adapted model contributed to the alignment of the Supply Chain of the studied industry, providing a more accurate evaluation methodology than other proposed models in literature, facilitating the indication of strategic paths to realignment.

Keywords
Supply Chain Segmentation, Fuzzy Inference System, Demand Driven Supply Chain, DDSC

1. Introduction
Satisfying customer is companies' main purpose. In order to achieve this goal, they must perfectly manage their flows and deliver their products on time (Miclo et al. 2015). Most of modern approaches rely on only one strategy to attend all the clients; however, enterprises that recognize the differences between clients and then align the value delivery strategy according to these differences have a superior performance (Gattorna, 2006). Differing customer requirements – and the fact that Supply Chain Management (SCM) is applied as a means of differentiation from competitors – led to the perception that a *one-size-fits-all* approach to SCM seems to be inadequate (Christopher et al. 2006). According to Mayer et al. (2009), organizations that apply different segmentation approaches in manage their Supply Chains are more successful than their pairs that uses the *one-size-fits-all* approach.

Companies deal with distinct groups of clients, with requisites that differentiate them among each other, in order to improve their treatment, it is important to develop supply chain strategies that are specific for each group (Christopher 2000). The success or failure of supply chains are going to be determined in the market by the end customers. Make the right product, at the right price on the right time gets to the customer is no longer a competitive success factor, but also a survival one (Mason-Jones et al. 2000). In the present manufacturing scenario, agility is an important factor for industries to compete in the markets (Grantham et al. 2007).

Agility on Supply Chain Management relies on responsivity. Conventional supply chains are long, with great lead-times and tend to be forecast-driven. On the other hand, agile supply chains are short and then to be demand driven (Cristopher et al. 2004). The Demand Driven Supply Chain (DDSC) is a system of technologies and processes that senses and respond to demand in real-time across the network of customers, suppliers and employees (Barrett and Barger Jr. 2010). As stated by Stabilini and Belvedere (2014), in order to become more competitive, companies need to shorten their production lead-times and rapidly receive sales feedback from retailers in order to adapt their production to actual demand and launch products that will immediately fulfill the market needs.

The ability to correctly interpret the market tendencies and to immediately initiate the launch and production of goods that customers are willing to buy is called market sensitivity (Christopher et al. 2004). According to Panley and Boerner (2006) the DDSC integrates the supply chain beyond the barriers of the organization, integrating the suppliers and customers removing natural distortions caused by transactions and inconsistencies in the material flow while increasing speed and responsivity of the Supply Chain. Pohlen et al. (2009) affirm that another important aspect that has implications in every process of the Supply Chain is the choice of the production model. Companies who succeed in becoming more agile were able to redesign their business models and move from a Make to Stock (MTS) logic to a Make to Order (MTO) logic, which, in almost every case, is a pre-requisite for a DDSC (Stabilini and Belvedere 2014).

Companies that are in the 'early adopter' phase of Demand Driven SCM, however, are quickly having it confirmed that, even in a VUCA (volatile, uncertain, complex, ambiguous) world, it is possible to gather SCM performance improvements from becoming demand driven (Eagle, 2017). Bennet and Lemoine (2014) affirms that the acronym VUCA represents a condition in which efforts to understand the future and to plan responses are render useless. The VUCA world is a reality in the fertilizer mixing company object of this study. This sector is highly volatile and subjected to high demand variations. The fertilizer demand is influenced by, among other factors, the evolution of planted areas, crop mix, crop prices, fertilize-to-crop price ratio, subsidy regimes and climate changes (YARA, 2018).

Several authors point the importance of supply chain segmentation in the development of the organization strategy when they face uncertainty (Lovell et al. (2005), Simchi-Levi (2013), Alicke et al. (2017)). However, many companies still have difficulties to understand the different segments, to combine the value proposal with the operations strategy and to design an end-to-end chain supply chain segmentation that attend their business model (Simchi-Levi 2013). Despite de existence of several studies focused on supply chain segmentation (Fisher 1997, Christopher et al. 2006, Gattorna 2015, Ferreira 2017) none of them brought the concept of the DDSC as it is stated in the current literature.

In order to fill this perceived gap, this study aims to adapt a segmentation model that would provide means for an industry to identify the presence of a DDSC within its supply chains. As subject for this study, the authors analyzed the supply chain of a Brazilian fertilizer mixing industry that attend two very distinct customer segments. This study has two main objectives, the adaptation of a quantitative method to identify a DDSC and the proposition of strategies for alignment of the analyzed company processes with the identified Supply Chain.

2. Literature Review

This section of the work brings an overview on relevant literature for the proposed theme. The first subsection is an overview on the DDSC. The second subsection is a review of the relevant supply chain segmentation models and the last subsection is a brief review on fuzzy numbers theory.

2.1 The Demand Driven Supply Chain

The first studies connecting the concept of agility to supply chain management were dated from 1996. According to Gould (1997) agility as a business strategy can be defined as the ability of an organization to thrive in an environment of fast and unpredictable changes which design their products and processes in a way that they can answers to changes in an appropriated way in an acceptable speed. Naylor et al. (1999) defined an agile supply chain as the one that uses the knowledge of the market and the virtual corporations to explore opportunities to profit in a volatile environment.

An organization cannot become agile unless its relationship with the supply chain is also agile (Veeramani and Josh, 1997). According to Gunasekaran and Yusuf (2002) an agile supply chain emphasizes the market sensitivity and a fast customer response. To provide these elements, it must improve its processes and its functional integration using advanced manufacture and information technology. Roh et al. (2014) states that agile supply chains can rapidly transmit the demand from customers to every process to ease the real time connection between the different processes in different functions. Agile supply chains encourage organizations to integrate with external partners to generate opportunities to improve the intelligence of collaborative processes and enable companies to create value and rapidly detect changes in demand (Qi et al., 2017). Organizations with agile supply chains have better responses to

unpredictable events. Besides, agile supply chains are inherently more focused in the market because are better in synchronize supply and demand (Swafford et al. 2008).
The DDSC concept evolved from the study of Agile Supply Chains and draws many of the same characteristics. Agarwal et al. (2007) in a review on agility on supply chain bring some components of an agile supply chain, such as lead-time reduction, market sensitivity and fast new products introduction, which, according to the authors, are characteristics of a DDSC. A DDSC can be defined as a supply chain in which every part involved are sensible and responsive to the generated demand information from the end customer and rapidly answers its variability, without incurring in higher costs (Cecere et al. 2004; Ayers, 2006)

The traditional supply chains were developed to operate in an anticipatory way, or pushed. The most frequent result of this pushed model if that a great part of the incorrect stocks is being pushed into the wrong markets. This misalignment results in companies using incentives to stimulate customers to buy products that they have available to sell and not the product that the customer needs (Bowersox et al. 2008). In a DDSC, the customer activates the flow from the retailer, which activates the distributor, which activates the manufacturer who acquires the needed raw materials. The flow can be activated by the real demand or by the demand forecast (Hull 2005).

Barrett and Barger Jr. (2010) summarize 4 functional strategies that guides a DDSC. (1) Become market oriented: to improve the ability to rapidly sense and translate demand, leaders must be focused on the market. The customer voice is always heard; (2) Guide innovation in products and services: be quick in launching profitable products that are in high demand; (3) Create value in the Supply Network: considering that 2/3 of a manufactured product is acquired from other partners, the supply chain must be agile. Most of the companies still focus all efforts on the 1/3 that they manufacture; (4) Orchestrate the Demand Driven response: become demand driven requires a focus on sense and shape demand at the same time that the organization works to reduce errors.

Chatzopoulos et al. (2012) affirm that DDSC suffers with problems of profitability and costs. Too much customized orders impose a great level of diversity that end to penalize parts of a DDSC with efficiency problems. In such a dynamic environment, DDSC seeks not only a pull system that deals with information and material flow, but also with new stock policies. According to them, every material flow needs at least a dissociation point in order to provide customized entities at a low cost.

To cope with the needs of DDSC of changes in how material, information and stocks are managed, a rethinking of the MRP logic was created by Ptak and Smith (2011) which was called the Demand Driven Material Requirements Planning (DDMRP). According to Miclo et al. (2019) DDMRP draws elements of Lean Systems and TOC to improve the overall performance and effectiveness of the MRP logic in dynamic environments. This rethinking challenge some of the fundamental assumptions of MRP, such as the replacement of safety stocks for dynamic buffers.

2.2 Supply Chain Segmentation Models
The task of segmenting the Supply Chain is not trivial (Ferreira, 2017). According to Godsell et al. (2011) there are too many normative models and little studies with application outside simulated environments. Fisher (1997) states that the root of the problems that affects the supply chain is the misalignment between the type of product and the type of supply chain. In one of the first attempts to segment supply chains, the author proposed two categories of products: functional and innovative. Functional products need an efficient supply chain and innovative products needs a responsive supply chain.

In order to achieve the proposed objective of this research a review on segmentation models was made focusing on the ones that contemplate the Agile Supply Chain or the Responsive Supply Chain. We used these criteria because of the perceived similarity between theses supply chains and the DDSC. Six segmentation models were studied, and the review of them can be found on Table 1.

Fisher (1997) proposed the segmentation model by product attributes and it was one of the first models of supply chain segmentation that it is widely known by organizations in general (Roscoe and Baker 2014). According to Fisher (1997) categorization will always follow one of two categories: products are primarily functional or innovative. Each category requires a different type of supply chain. The author proposes two types of supply chains, efficient and responsive and each product must align with one of these two types.

Table 1. Review of the studied Supply Chain Segmentation Models

Segmentation Model	*Author*	*Element of analysis*	*Dimension*	*Supply Chain Segmentation*
Product Attributes	Fisher (1997)	Functional Product; Innovative Product	Type Type	Efficient Supply Chain Responsive Supply Chain
Mix Variability and Volume	Naylor et al. (1999)	Mix Variability; Volume Flexibility	High/low High/low	Agile Supply Chain Lean Supply Chain
Order Winners and Order Qualifiers	Mason-Jones et al. (2000)	Order Winners; Order Qualifiers	Type Type	Agile Supply Chain Lean Supply Chain
Demand Predictability and Replenishment Lead-time	Christopher et al. (2006)	Demand; Lead-Time; Type of Product	Stable/Volatile High/Low Special/Regular	Lean Continuos Replenishment Agile Quick Response Lean Planning and Execution Leagile Production
Buying Behavior	Gattorna (2015)	Buying Behavior	Collaborative Efficient Dynamic Project Acc. Innovative	Continuous Replenishment SC Lean Supply Chain Agile Supply Chain Campaign Supply Chain Fully Flexible Supply Chain
Fuzzy-based Quantitative	Ferreira (2017)	Lead Time; Volume; Variability	Low to High Low to High Low to High	Collaborative Supply Chain Lean Supply Chain Agile Supply Chain Campaign Supply Chain Fully Flexible Supply Chain

Naylor et al. (1999) brought the idea that the lean and the agile paradigms differentiate from each other on its emphasis on flexibility to market responsivity. The authors proposed that an agile supply chain needs a rapid reconfiguration, but will not have emphasis on waste elimination. On the other hand, in a lean supply chain, every waste must be eliminated, but it will not emphasize the flexibility.

Moving the analysis from the product itself, Mason-Jones et al. (2000) proposed that a supply chain must excel on its order winner criteria and be highly competitive on its order qualifiers criteria. According to Hill (1993), order qualifiers are those criteria, which the organization must follow in order to be considered a possible supplier for a product, and order winners are those criteria that will decide if the organization will be a supplier. The most order winners a supplier has, the most chance it has to win the order. Mason-Jones et al. (2000) stated that only through the understanding of the product characteristics, market needs and managerial challenges the right strategy for the supply chain must be planned to establish a competitive advantage.

Christopher et al. (2006) propose a classification that considers the replenishment lead-time of products. The authors justify their proposal due to the critical impact that replenishment lead-time has on demand responsivity and how globalization tended to increase these lead-times. When the authors add the characteristics of supply and demand, different types of supply chains arise, expanding the previous context of a bi-dimensional supply chains (agile X lean; responsive X efficient).

According to Christopher and Gattorna (2005) the best way to segment the markets is through the customer buying behavior, unfortunately, most of organizations uses internal parameters that provides little indications of how the customers wants to buy products and services. According to Gattorna (2015) the key point to develop a supply chain that answers to the customer needs in a satisfactory way is to understand the mix of the five proposed buying behaviors (collaborative; efficient; dynamic; project accumulation and innovative) for a determined market. For each buying behavior, Gattorna (2015) proposes a type of supply chain. Besides being normative, the proposed model is inaccurate for decision-making. The evaluated factors based on opinions carried with uncertainty and inaccuracy (Ferreira 2017).

Ferreira (2017) proposes a model which adapt the product segments characteristics in terms of the DWV^3 model proposed by Christopher and Towill (2000) and the dynamic alignment model proposed by Gattorna (2015). These models together were the foundation for the rules of the Fuzzy Inference System (FIS) to process the quantitative variables to obtain qualitative information. According to Ferreira (2017) the model uses customer's sales data classified as low, medium or high, as input variable and as output has the most adequate supply chain for that customer.

According to Ferreira (2017) the lead time variable is represented by the mean time of delivery of an item to the evaluated client. The difference between the billing date and the order input of the client is the used lead time. The volume is represented by the sum of items bough by the client during the analyzed period. The variability is represented by the coefficient of variation (CV) of the orders for each client. The coefficient of variation is represented by the equation (1), where $\boldsymbol{\sigma}$ is the standard deviation of the population and $\boldsymbol{\mu}$ is the order volume mean for that specific client.

$$Cv = \frac{\sigma}{\mu} \quad (1)$$

Ferreira (2017) indicates that the coefficient of variation is not the perfect measure for the variability but, it is capable of provide a degree of predictability for the planning process. Higher the CV, farther from the average is the data, making it more difficult to make any prediction on the data behavior.

As stated previously in the researched segmentation models (Table 1), most of them relies in qualitative data in order to segment the Supply Chain. According to Anderson (2010), the use of qualitative data is more time consuming and relies heavily on the individual skills of the researcher. The use of qualitative data limits the application of the segmentation models for practitioners, especially small and medium enterprises (SMEs). Regarding this matter, the application of a Fuzzy Inference System (FIS) can make the theory more accessible for every organizations that plans to align its processes to the Supply Chains.

2.3 Fuzzy Inference Systems

The Fuzzy Inference System (FIS) is one of the applications of the fuzzy logic, allowing the representation of inaccurate knowledge and data (Jang et al., 1997). It is used for modeling decision-making processes based on imprecise and vague information such as judgment of decision makers. Qualitative aspects are represented by the means of linguistic variables, which as expressed qualitatively by linguistic terms and quantitatively by a fuzzy set in the respective membership function (Osiro et al., 2014).

Every knowledge of the FIS about the process to be controlled is stored as inference rules, or control rules, from the knowledge base. This way, the rules have great influence in the system behavior and should be carefully modeled (Zimmermann and Zysno, 1980). To simulate human judgment, the FIS use organized linguistic values in rules "if… then". FIS implementation needs a knowledge base that allows the establishment of rules using the fuzzy numbers (Bojadziev and Bojadziev, 2007).

A fuzzy number is a fuzzy set in which the membership function satisfies the conditions of normality and convexity (Osiro et al., 2014). A triangular fuzzy number is commonly used in decision making due to its intuitive membership function (Osiro et al., 2014) and are frequently applied in finance and social sciences (Bojadziev and Bojadziev, 2007). The membership function $\mu_A(x)$ of a triangular fuzzy number is given by Figure 1.

$$\mu_A(x) = \begin{cases} 0, & if\ x < a \\ \dfrac{x-a}{m-a} & if\ x \in [a, m] \\ \dfrac{x-a}{m-a} & if\ x \in [a, m] \\ 0, & if\ x > b \end{cases}$$

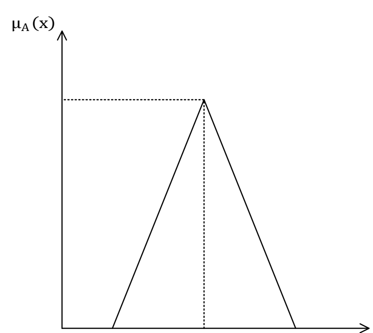

Figure 1. Triangular Membership Function

Mandani and Assilian (1975) proposed a system capable of use the Boolean logic to describe the process state by means of linguistics variables and to use these variables as inputs for the rule base of the inference engine. The process of data analysis using FIS is described in Figure 2. The inference process starts with the attribution of terms to the input variables. In a system used to evaluate client satisfaction, possible input variables may be delivery time, discount and satisfaction. The variable "delivery time" might include the terms "low", "medium" and "high". The rules connect the input variable with the output variable and are based on the description of the state of the variable, obtained by the definition of the terms of the linguistics variables.

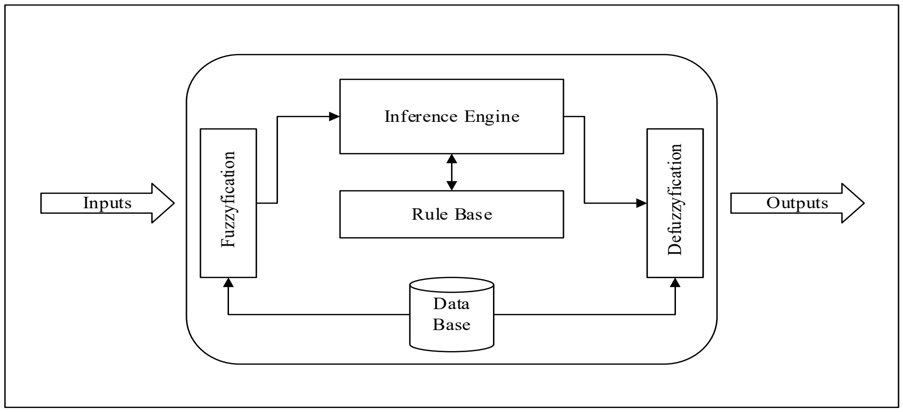

Figure 2. FIS data analysis process

After the application of the inference engine, it is necessary to run the defuzzification process. This step is necessary in systems where the expected answer is numeric instead of linguistic. Mathematically, defuzzification is the mapping of the vector of the linguistic variable to a real number (Von Altrock, 1997).

3. Methodology and Application

3.1 Proposed Methodology

The proposed model for analysis is represented in the Figure 3 and is divided in three different steps. In the first step, the existent segmentation models were studied together with the features of DDSC. The main objective of the first step is to identify a segmentation model that could be used. After identification of the segmentation models, it was important to identify the most suitable one that was used to identify a DDSC based on the information gathered from the literature review on DDSC. With both information, it is possible to define which linguistic terms are going to be used and the rule base for categorization of the DDSC.

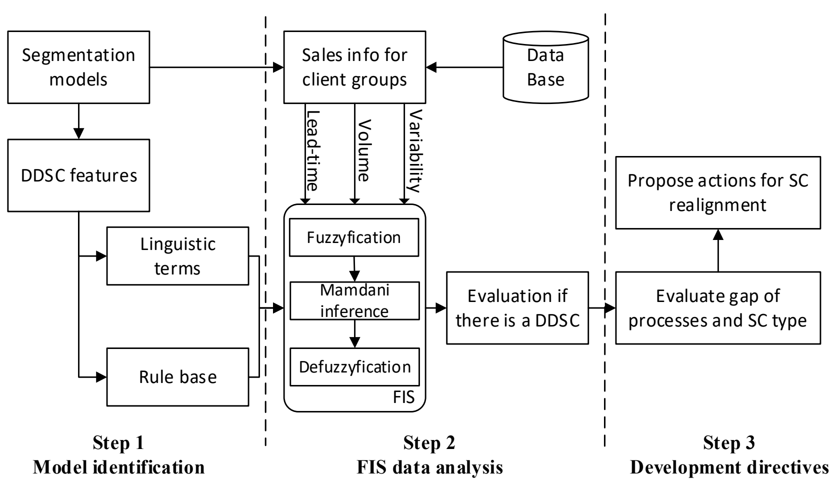

Figure 3. Proposed model for analysis

The second step is where the available data is treated to become the input for the fuzzy inference system. The type of data used as input was decided after the identification of the most suitable segmentation model for the proposed analysis. The output of the fuzzy inference system is how much that client group sales data is adherent to a DDSC. The third step of the proposed model is the analysis of data to develop directives for improvement. In this moment, tools and possible action plans are going to be proposed based on the current literature on DDSC.

From the studied models, the quantitative data were analyzed based on the model proposed by Ferreira (2017). To implement the fuzzy inference system the software FuzzyTECH 8.40b was used on its student trial version. The software has several advantages, such as possibility to change the membership functions and the rule base even on its free version.

As shown in Table 1, the model proposed by Ferreira (2017) is based on the supply chains proposed by Gattorna (2015) which, among them, have no segmentation for a DDSC. This way, in order to develop the rule base and the linguistic terms it is necessary to collect evidences of what distinguish a DDSC from other Supply Chains. Using the elements of analysis proposed by Ferreira (2017), Table 2 shows the relation between lead-time, volume and variability for the DDSC.

Table 2. DDSC characteristics

Element of analysis	Characteristic	Source
Lead Time	**Low** – The DDSC can respond to demand and its variation fast and with low cost	Gunasekaran and Yusuf (2002); Cecere et al. (2004); Ayers (2006)
Volume	**Low to High** – The DDSC has market sensitivity, which is, to respond rapidly to demand variation in volume and variety. A DDSC is present in low and high volumes.	Agarwal et al. (2007); Christopher (2000)
Variability	**Medium to High –** Every part of processes is sensitive and responsive to demand information. Making it vary with the same intensity of the demand.	Cecere et al. (2004); Ayers (2006);

With this information, it was possible to create the block of rules of the inference system. Table 3 is a representation of the rules that were used as input in the FIS to generate the results if there is a DDSC in the group of clients analyzed. Every result outside the provided ones were ruled as "Another Supply Chain" since the main objective of this work is to identify the presence of a DDSC in the analyzed company.

Table 3. Rule Base of Inference System

INPUTS				OUTPUTS
Rule	**Volume**	**Variability**	**Lead Time**	**Supply Chain**
1	Low	Medium	Low	Demand Driven Supply Chain
2	Low	High	Low	Demand Driven Supply Chain
3	Medium	Medium	Low	Demand Driven Supply Chain
4	Medium	High	Low	Demand Driven Supply Chain
5	High	Medium	Low	Demand Driven Supply Chain
6	High	High	Low	Demand Driven Supply Chain

3.2 Model Parametrization

The model parametrization begins with the creation of the membership functions and the identification of the linguistic variables for the rule bases of the FIS. In order to do that, an assessment was held with a sales representative, the commercial manager and the industrial director of a company where the misalignment of processes and supply chain was previously identified. Initially it was presented to the specialists the how evaluation model would work together with the concepts of fuzzy analysis.

The membership functions for variability, lead-time and volume are presented in Figure 4. For the input variability it was used the parameters suggested by Ferreira (2017) where a coefficient of variation lower than 0,3 being considered low, a coefficient of 0,5 being considered medium and a coefficient higher than 0,7 being considered high. For the input lead-time, the team decided that a low lead-time is any lead-time lower than 2 days, a lead-time of 3 days is considered medium and any lead time higher than 5 days is considered high for the team. Finally, to the input volume, any volume lower than 4 ton (4.000 kg) was considered low. A volume of 8 ton (8.000 kg) was considered medium. For the team, any volume higher than 16 ton (16.000 kg) was considered high.

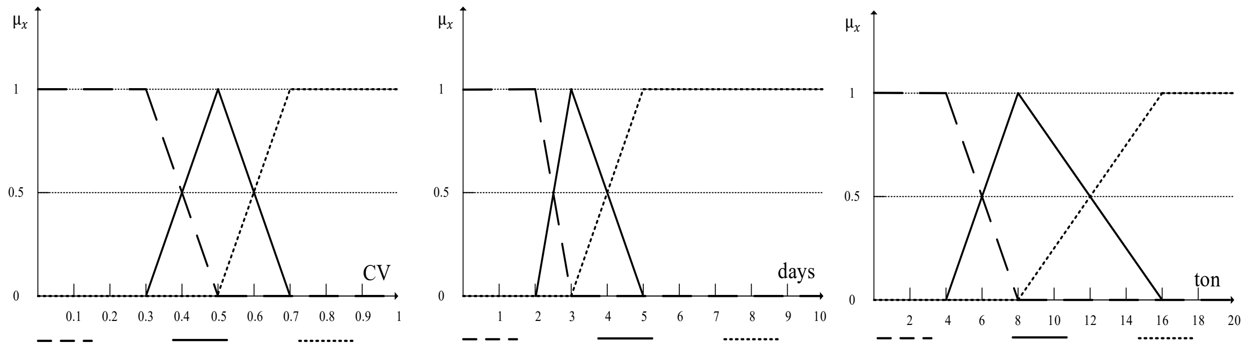

Figure 4. Membership function for variability, lead-time and volume

The team decided that two different types of clients should be analyzed for evaluation of the supply chains. The first group was called Group A. Group A is composed by clients which firmed supply agreements for the whole year. These agreements are made for clients who need a high supply volume and certainty that their will have their product when they need it, the clients who sign the agreements receive the product within an agreed lead-time between the order input and the product dispatch. The great advantage in firming the agreement is the predictability in terms of supply and price. In the analyzed year, supply contracts were responsible for 37% of the total demand of the company.

The second group was called Group B. Group B is composed by smaller clients or clients who did not want to firm the agreements. These clients have a buying behavior based mostly on the demand variation and are composed by retailers and small properties who use the product in a much lower scale than Group A. Besides using the product in a lower scale there are a higher number of clients in this group. In the analyzed year, Group B represented 63% of company's total demand.

For each client from each group the average variability, lead-time and volume for one entire period was calculated. The period chosen for analysis was composed for one whole in, from the first day of January to the last day of December. The information gathered was used as input for the FIS, as output, the FIS gave the percentage of clients of that group which had a buying behavior adherent to a DDSC or to another SC.

3.3 Model Application

The Inference System was modeled in such way that it would return, in percentage, how much the clients buying behavior from a specific group is adherent to a DDSC. The data was weighted according to the volume of each client, which means that a result of 100% DDSC indicates that the total volume produced for the clients followed the buying behavior within the logic of a DDSC. The same is true for a 0% DDSC result, meaning that no volume was produced for clients with a DDSC buying behavior.

The results of the FIS output are presented in the Figure 5. As shown in the results, 47.94% of the volume of the clients of Group A was adherent to a DDSC. To the company's experts who participated in the analysis this result was partially expected since the contracts provide a more stable environment, with a better time for program and deliver the orders. Another factor pointed by the experts is that the volume is higher for contracts, which promotes higher lead-times, which are expected and tolerated by the clients.

For the Group B the results revealed a rather different reality. According to the outputs of the inference system, 85.07% of the Group B clients' volume had features of a DDSC. According to the experts' evaluation, the market that the company is inserted is highly volatile, with a huge dependence on climate factors, which promotes a very high demand variability with order sizes varying from 0.5 ton to 750 ton in one single order. Another important factor is the price variability, with the raw material indexed in USD. This way, the faster you deliver the order, the most protected you are from any variation in the price, forcing a low lead-time and the need for maintaining an idle capacity.

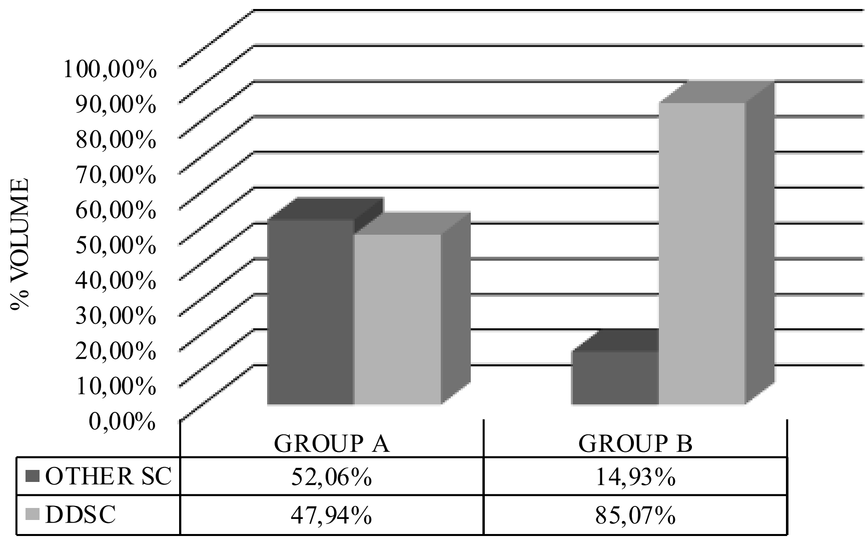

Figure 5. DDSC segmentation for Groups A and B

4. Results Discussion

The purpose of the work was to identify a DDSC in an organization in order to improve the alignment between processes and the different supply chains that coexists within its operations, following Christopher (2006) affirmation that one operation strategy does not fit every supply chain in the organization. There are several segmentation models that were extensively tested on literature, but most of them lacks the rules for application and tend to the qualitative analysis rather than a quantitative one.

As stated by the company's experts, the results obtained by the FIS were coherent to the reality. As shown in Figure 5 the results for the Group A were inconclusive to affirm if this group behave as a DDSC, this is a representation of the reality of stable orders, long lead-times and little volume variation between orders. On the other hand, the client's volume of Group B had a high adherence to a DDSC, because of its high volume, order size variability and exigence of a small lead-time.

The gathered result made clear and brought empirical evidence to the company of some aspects that were only supposed by some of its employees. The results made possible to observe if the supply chain strategy was aligned to the different groups of clients, which, in the case of the studied company, was not a reality. The separation of clients in different groups with the possibility for tailoring agreements is as a first step into the supply chain dynamic alignment, however, as stated by Santa-Eulalia et al. (2011), the dynamic alignment implies in the definition of different strategies for order fulfilment, including, different levels of communication, price, product quality, collaborative approaches and so on.

The importance of Group B for the company is undeniable. It represents 63% of the volume and have a higher margin, since the agreements firmed within the clients of Group A tend to be with lower prices. The adoption of different strategies would become a highly competitive advantage for the studied company, as Mayer et al. (2009) stated. For a DDSC, certain strategies have emerged in the last decade, which involves all the decision levels of the company. At the strategic level, there are approaches like the Demand Driven S&OP, which is a rethinking of the Sales and Operation Planning for a more flexible reality (Bozutti and Esposto 2019).

Another strategy is the adoption of the Demand Driven Material Requirement Planning (DDMRP), which, according to Kortabarria et al. (2019) was developed as an answer to the volatile markets. Miclo et al. (2019) pointed that DDMRP is only one part of a broader approach of the Demand Driven Adaptive Enterprise (DDAE) to improve planning, schedule and overall management is this new reality of volatile markets. Identifying a DDSC enables the company to be more certain of their real positioning among their clients and give them an indication of which tools and strategies to implement in order to take competitive advantage from its reality.

5. Conclusion

This work main proposal was to adapt a supply chain segmentation model to assess the identification of DDSCs in industries. It is important to develop new approaches to enable companies to better positioning themselves and to guide them into finding new methods and tools to thrive in this more turbulent and dynamic markets. This study illustrates the adaptation and application of a fuzzy methodology to identify a DDSC in a fertilizer mixing industry. Aligned with the main objective, the proposed model was able to evaluate the current patterns in the clients and company behavior from a quantitative set of data. According to the data obtained from the model application, 47,94% of the demand from Group A and 85,07% of the demand from Group B were adherent to a DDSC.

There are many segmentation models, but none of them seeks to identify the Demand Driven environment. This work adapted a model that, according to Ferreira (2017), united two strong and different schools in supply chain segmentation (the lean-agile and the dynamic alignment schools), in order to accomplish the objective of identify the DDSC. The results confirmed the initial affirmation of two distinct customer segments, deepening the understanding that, besides clients, the supply chains were significantly different. Another objective of the work was to propose strategies for the company to align their operations with the supply chain. As previously shown, the model proposed by Ptak and Smith (2018) called DDAE might be a solution for the company to adapt their strategy to the DDSC identified in the study.

Despite the results, we recognize that our study is not a definitive model for quantitatively segmenting supply chains. It is needed further research and exploration in order to accomplish important and necessary advancements. As proposed future research, we suggest (1) a better characterization of the DDSC; (2) tests with another segmentation models in order to seek a faster result and (3) the creation of methods to remove the human judgment in the creation of the parameters for the membership functions, such as Neurofuzzy techniques, making the segmentation happen in real time.

References

Agarwal, A., et al., Modeling Agility of Supply Chain, *Industrial Marketing Management*, v. 36, pp. 443-457, 2007

Alicke, K. et al., Supply Chain 4.0 in consumer goods, *McKinsey & Company Insights*, April, 2017

Anderson, C. Presenting and Evaluating Qualitative Research, *Am J Pharm Educ.,* v. 74, n. 8, pp. 141, 2010

Ayers, J. B. *Supply Chain Project Management: A structured collaborative and measurable approach*, 2nd Edition., CRC Press, New York, 2006

Barrett, J., and Barger Jr., R., *Supply Chain Strategy for Industrial Manufacturers: The Handbook for Becoming Demand Driven*, GARTNER, New York, 2010

Bennet, N. and Lemoine G., What a difference a word makes: Understanding threats to performance in a VUCA world, *Business Horizons*, v. 57, n. 3, pp. 311-317, 2014

Bojadziev, G. and Bojadziev M., *Fuzzy logic for business, finance and management*. 2nd Edition, World Scientific Publishing Co., Singapure, 2007

Bowersox, D. et al. *Start Pulling your chain! Leading responsive supply chain transformation*. 1st Edition, OGI Enterprises, New York, 2008

Bozutti, D., Esposto, K. Sales and Operations Planning: a comparison between the demand-driven and traditional approaches, *International Journal of Production Management and Engineering,* v. 7, n. 1, pp. 23-38, 2019

Cecere, L., et al., Driven by demand: a demand-driven supply network (DDSN) requires a clear view of the customer that is shared throughout the organization, *Supply Chain Management Review*, v. 8, 2004

Chatzopoulos, C., et al., Demand-Driven Supply Chain using Lean & Agile Principles: A culture for Business Excellence. *Proceedings of 5th International Conference EIRD*, Sofia, 2012

Christoper, M. and Towill, D., Supply Chain Migration from Lean and Functional to Agile and Customized, *Supply Chain Management: An International Journal*, v. 5, n. 4, pp. 206-213, 2000

Christopher, M. The Agile Supply Chain: Competing in Volatile Markets. *Industrial Marketing Management*, v. 29, pp. 37-44, 2000

Christopher, M. and Gattorna, J., Supply chain cost management and value-based pricing, *Industrial marketing Management*, v. 34, pp. 115-121, 2005

Christopher, M., Lowson, R. and Peck, E., Creating Agile Supply Chains in the Fashion Industry, *International Journal of Retail & Distribution Management*, v. 32, n. 8, pp. 367-376, 2004

Christopher, M., Peck, H. and Towill, D., A taxonomy for selection global supply chain strategies *International Journal of Logistics Management*, Vol. 17, No. 2, pp.277-287, 2006

Eagle, S., *Demand-Driven Supply Chain Management: Transformational Performance Improvement,* 1st Edition. Kogan Page Limited, New York, 2017.

Ferreira, R., *Proposta de um modelo quantitativo com base em lógica fuzzy para caracterização de cadeias de suprimentos em empresas*. 2017, Dissertation (Masters in Production Engineering), EESC – USP.

Fisher, M., What Is the Right Supply Chain for Your Product? A Simple Framework Can Help You Figure out the Answer. *Harvard Business Review*, v. 75, pp. 105-116, 1997

Gattorna, J., *Dynamic Supply Chains: How to design, build and manage people-centric value networks*. 3rd Edition, Pearson Education Limited, Harlow, 2015.

Gattorna, J., *Living supply chains: how to mobilize the enterprise around delivering what your customer wants*, 1st Edition., Prentice Hall, New Jersey, 2009

Godsell, J., et al., Enabling supply chain segmentation through demand profiling, *International Journal of Physical Distribution & Logistics Management*, v. 41, n. 3, pp. 296-314, 2011

Gould, P. What is Agility? *Manufacturing Engineering*, v. 79, n. 1, pp. 28-31, 1997

Grantham, C., Ware, J. and Williamson, C., *Corporate Agility: A revolutionary new model for competing in a flat world*, AMACOM American Management Association, New York, 2007

Gunasekaran, A. and Yusuf, Y., Agile manufacturing: a taxonomy of strategic and technological imperatives. *International Journal of Production Research*, v. 40, n. 6, pp. 1357-1385, 2002

Hill, T., *Manufacturing strategy*. 2nd Edition. Basingstoke, UK: MacMillan, 1993.

Hull, B., Are supply (driven) chains forgotten?, *The International Journal of Logistics Management*, v. 16, n. 2, pp. 218-236, 2005

Jang, J., et al., *Neuro-fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence*, 1st Edition, Prentice Hall, New York, 1997.

Kortabarria, A. et al. Demand Driven MRP – Nuevo método para la gestión de la Cadena de Suministro: um estúdio de caso, *Dirección y Organización*, v. 67

Lovell, A., Saw, R. and Stimson, J., Product value density: managing diversity through supply chain segmentation, *The International Journal of Logistics Management*, v. 16, n. 1, pp. 142-158, 2005

Mamdani, E. and Assilian S., An experiment in linguistic synthseis with a fuzzy logic controller. *International Journal of Man-Machine Studies*, v. 7, n. 1, pp. 1-13, 1975

Mason-Jones, R. et al., Lean, Agile or Leagile? Matching Your Supply Chain to the Marketplace, *International Journal of Production Research*, v. 38, n. 17, pp. 4061-4070, 2000

Mayer, S. et al. Supply Chain excellence amidst the global economic crisis*, 6th European A.T Kearney/ELA Logistics Study*, European Logistics Association, Brussels, 2009

Miclo, R. et al., Demand Driven MRP: assessment of a new approach to materials management, *International Journal of Production Research*, v. 57, n. 1, pp. 166-181, 2019

Miclo, R. et al., MRP vs. Demand-Driven MRP: Towards an Objective Comparison, *International Conference on Industrial Engineering and Systems Management (IESM)*, Seville, pp. 1072-1080, 2015

Naylor, B., Naim, M. and Berry, D., Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain, *International Journal of Production Economics*, v. 62, n. 1-2, pp. 107-118, 1999

Osiro L. et al. A fuzzy logic approach to supplier evaluation for development, *International Journal of Production Economics*, V. 153, n. 7, pp. 95-112, 2014

Panley, M. and Boerner, S., Demand-Driven Supply Networks: Advancing Supply Chain Management, *SAP INSIGHT*, June, 2006

Pohlen, T., Klammer, T. and Cokins, G. *The handbook of supply chain costing*, 1st Edition, Council of Supply Chain Management Professionals, Lombard: IL, 2009

Ptak, C., and Smith, C., *Orlicky's Material Requirements Planning*, 3rd Edition., McGraw Hill, New York, 2011

Ptak, C., and Smith, C. *The demand driven adaptive enterprise,* 1st Edition. Industrial Press, Inc. South Norwalk, 2018

Qi, Y., et al., The impact of operations and supply chain strategies on integration and performance, *International Journal of Production Economics*, v. 185, pp. 162-174, 2017

Roh, J., et al., Implementation of a responsive supply chain strategy in global complexity: The case of manufacturing firms, *International Journal of Production Economics*, v. 147, pp. 198-210, 2014

Roscoe, S. and Baker, P., Supply Chain Segmentation in the Sporting goods industry, *International Journal of Logistics Research and Applications*, v. 17, n. 2, pp. 136-155, 2014

Santa-Eulalia, L. et al., Projeto de Cadeia de Suprimentos e Alinhamento Dinâmico: Proposta de um Quadro Conceitual sobre Potenciais Trade-Offs de Sustentabilidade Ambiental, *INGEPRO – Inovação, Gestão e Produção*, v. 3, n. 9, pp. 14-26, 2011

Simchi-Levi, D., *Operations rules: Delivering customer value through flexible operations*, 1st Edition, MIT Press, Cambridge: MA, 2013

Stabilini, G. and Belvedere, V., Alternative Models of Demand Driven Supply Chains: Size-specific Solutions in Italian Fashion Companies, *Fashion Practice*, v. 6, n. 2, pp. 221-241, 2014.

Swafford, P., et al., Achieving supply chain agility through IT integration and flexibility, *International Journal of Production Economics*, v. 116, pp. 288-297, 2008

Veeramani, D. and Joshi, P., Methodologies for rapid and effective response to requests for quotation (RFQs), *IIE Transactions*, v. 29, n. 10, pp. 825-838, 1997

Von Altrock, C. *Fuzzy Logic & Neurofuzzy application in business & Finance*. 2nd Edition, Prentice Hall, New York, 1997

Yara, *Yara Fertilizer Industry Handbook*, 2018, available in: <https://bit.ly/2YJc5gR>

Zimmermann, H. and Zysno, P. Latent Connectives in Human Decision Making. *Fuzzy Sets and Systems*, v. 4, pp. 37-51, 1980

Biographies

Lucas Alves S. Santos earned his Master’s Degree in Production Engineering at University of São Paulo (USP), São Carlos School of Engineering, Brazil. He earned his Bachelor Degree in 2015 from the Pontifical Catholic University of Goias (PUC-GO), Brazil. Santos has worked as an Operations Management Consultant, focused on Supply Chain Management and Lean Manufacturing. His current research interests are Supply Chain Management and Production Planning and Control, specifically Demand Driven Material Requirements Planning (DDMRP), Demand Driven S&OP and Demand Driven Adaptive Enterprise.

Kleber Francisco Esposto graduated PhD in 2008 in Production Engineering at University of São Paulo (USP), São Carlos School of Engineering, Brazil. Advisor of thirteen Master Thesis and advisor of one PhD Thesis finished; advisor of seven Master Thesis and one PhD in development. Mr. Esposto has previous background as a consultant in Supply Chain Management and Lean Manufacturing. Research interests include the following topics and their integration: supply chain management, lean manufacturing, lean healthcare, performance measurement and management, industry 4.0 and circular economy.