Universidade de Aveiro
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Departamento de Economia, Gestão e Engenharia Industrial

Alexander Alexandrovitch Kharlamov

Abordagem Analítica à Segmentação da Cadeia de Abastecimento

Analytical approach towards supply chain segmentation

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Engenharia e Gestão Industrial, realizada sob a orientação científica do Doutor Luís Miguel Domingues Fernandes Ferreira, Professor Auxiliar do Departamento de Economia, Gestão e Engenharia Industrial da Universidade de Aveiro e co-orientação da Doutora Janet Godsell, *Senior Lecturer* na *Cranfield School of Management, Cranfield University*.

"Ideas are like fish.

If you want to catch little fish, you can stay in the shallow water. But if you want to catch the big fish, you've got to go deeper.
Down deep, the fish are more powerful and more pure. They're huge and abstract. And they're very beautiful."

David Lynch in “Catching the Big Fish” (2006)

o júri

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agradecimentos

A tese é só um documento formal que reflecte uma pequena parte de um extraordinário caminho de descoberta – da ciência, das pessoas e da identidade própria. Tudo isto converge numa dimensão comum, o tempo.

Assim, reconhecendo que não há nada mais precioso que o tempo, estou eternamente em dívida perante todas as pessoas que mo ofereceram, tornando o meu esforço possível.

Dr Luís Ferreira, por tudo, um sincero obrigado.

Dr Janet Godsell por ter encontrado valor em mim, oferecendo-me a possibilidade de continuar a evoluir.

E ainda:
Família directa, pela educação e apoio incondicional.

Rui Pires, lembrando-me todos os dias que a ignorância é o fim.

Paulo Leal, cedendo os dados para o caso de estudo.

E à todos aqueles que ficaram privados da minha atenção ao longo deste exercício egoísta.

palavras-chave

Cadeia de abastecimento; Segmentação da cadeia de abastecimento; Estratégia de cadeia de abestecimento; Estudo bibliometrico; Estudo empírico; Bens de grande consumo; Procura

resumo

O tema da definição de estratégia da cadeia de abastecimento está a ganhar importância e não existe uma estratégia ideal. Consequentemente, de forma a ganhar vantagem competitiva sustentável as organizações devem escolher as estratégias de abastecimento mais adequadas tendo em conta as características quer da procura quer dos produtos alinhando a oferta com a procura.

Para a definição do foco da tese, é feito um estudo bibliometrico da literatura. De seguida, definiu-se uma sequência de passos para a segmentação da cadeia de abastecimento e sua consequente aplicação num caso de estudo, uma empresa alimentar B2B. O estudo exploratório contribui com uma série de ideias originais: Uma nova variável de classificação é proposta, uma análise de produtos com base nos componentes comuns, e finalmente, uma nova abordagem às compras baseada nas características da procura. Tudo isto permite uma abordagem prática à segmentação ao longo de toda a cadeia de abastecimento.

keywords

Supply chain management; Supply chain segmentation; Supply chain strategy; Bibliometric study; Empirical study; Fast moving consumer goods; Demand; Profiling

Abstract

Segmented supply chain strategy is becoming an eminent topic, and “one size does not fit all”. Consequently, in order to achieve sustainable competitive advantage, companies must select the best matching supply chain strategy concerning product and demand characteristics matching supply with demand.
To define the focus of the thesis a bibliometric approach on literature is used. Next, a roadmap for supply chain segmentation is defined and applied on a single case study, a B2B food company. The exploratory study contributes with a number of original insights: A new classification variable, product analysis based on common raw components, and finally, a new insight on sourcing based on demand characteristics. This research enables a practical approach on supply chain segmentation at both ends.

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Acronyms

B2B – Business to Business

B2C – Business to Customer

BOM - Bill of Materials

BTO – Build to Order

DWV^3 – Life Cycle Duration, Time Window for Delivery, Variety, Volume, Variability

EDI – Electronic Data Interchange

ETO – Engineer to Order

FMCG – Fast Moving Consumer Goods

MDS – Multidimensional Scaling

MFS – Manufacture from Stock

MQ – Market Qualifiers

MTF – Make to Forecast

MTO – Make to Order

MTS – Make to Stock

OW – Order Winners

SC – Supply Chain

SCM – Supply Chain Management

SKU – Stock Keeping Unit

VMI – Vendor Managed Inventory

1 Introduction

"In fact the opposition of instinct and reason is mainly illusory. Instinct, intuition, or insight is what first leads to the beliefs which subsequent reason confirms or confutes; but the confirmation, where it is possible, consists, in the last analysis, of agreement with other beliefs no less instinctive. Reason is a harmonising, controlling force rather than a creative one. Even in the most purely logical realms, it is insight that first arrives at what is new."

Bertrand Russell (1914), in *Our Knowledge of the External World*

1.1 Chapter outline

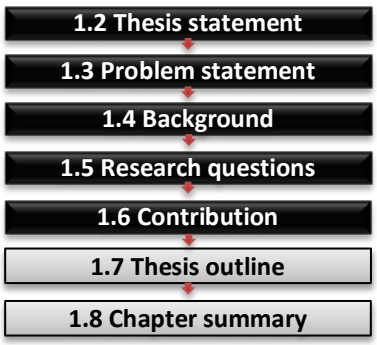


Figure 1: Chapter 1 structure

As illustrated in Figure 1 the structure of the present chapter starts with the thesis statement – being the position towards the problem which is defined next in section 1.3. After, it is given the background to that problem as well as the research questions in scope of this study. It is then presented the actual contribution of this thesis. Closing the chapter is the thesis formal organization and a brief chapter summary underlining the key ideas.

1.2 Thesis statement

This thesis focuses on the topic of "*analytical approach towards supply chain segmentation*". Facing different clients, different suppliers and different products, companies must develop different supply chain strategies (Fisher, 1997).

1.3 Problem statement

Companies and particularly supply chains (SCs) are going towards a more challenging market due to various reasons: markets are evolving; clients are becoming more and more demanding and unpredictable; product variety is rising; time windows are shrinking; and error tolerance is decreasing day-by-day. As a result, SCs compete with others SCs, rather than

simply between firms (Christopher, et al., 2009; Cunningham, 1990). So, it is critical that companies focus on proper SC strategies development.

First of all, "What is the right SC?" It is worth to say that there is no perfect solution, nor even, an ideal paradigm that could fit all cases: - Firstly, "one size does not fit all" (Shewchuck, 1998); secondly, "achieving the global optimum within a SC does not necessary lead to a win-win situation" (Porter, 1985); and finally, "companies that seek blindly to achieve solely efficiency most likely will fall" (Lee, 2004). Consequently, managers are struggling for solutions and this particular field can be considered as being immature as many firms did not even reached the supply chain management on its full concept. However, in the academic world, supply and demand mismatch is not a new problem (Vitasek, et al., 2003; Fisher, 1997; Jahns, et al., 2009; Godsell, et al., 2011; Whitten, et al., 2012) and the concern on proper SC strategy is even older (Porter, 1985; Oliver & Webber, 1982; Harland, et al., 1999; Frohlich & Westbrook, 2001; Lee, 2002; Christopher & Towill, 2002).

So, concerning the competitive world we are living in, managers are now facing a greatest challenge ever due to the market evolution and actual worldwide economic crises which do not forgive poor performing SCs based on incorrect strategies. On one hand this can be regarded as a negative factor, but on the other hand, it is a great window of opportunity for empirical research because practitioners (in spite of survival) are, more than ever, receptive to new ideas about how improving their SCs (if not, they should be), as these are possible the basis for endurance and ultimately to success (Jahns, et al., 2009). As well as, most of the actual management is system 1, as being the intuition or "gut-feeling" driven; which is most of the times unconscious, fast and emotional; in contrast, system 2 is conscious, effortful, slow and based on rules (Stanovich & West, 2000).

At last, the research problem is supply and demand mismatch. Because on one hand, SC strategy is often adopted rather than adapted as there is a general tendency to develop "paradigm driven" SCs and companies often generalise products overlooking clients' need differences. This leads to an internal "one-size-must-fit-all" what causes poor SC performance.

1.4 Background

SC management is becoming more and more critical to remain competitive in the market (Gattorna & Walters, 1996; Jahns, et al., 2009). Consequently, the problematic of the "right" SC has been alive for a while and after some decades of research there are already many conceptual models and frameworks (Harland, et al., 2004; Jüttner, et al., 2010; Godsell, et al., 2011; Payne & Peters, 2004; Christopher, et al., 2009; Christopher & Towill, 2002; Mason-

Jones, et al., 2000; Schnetzler, et al., 2007; Giannakis & Croom, 2004; Christopher & Towill, 2001). One of the first clear references on the problematic (and one of the most cited articles) is Fisher's (1997) seminal work "What is the right SC?" Later, Naylor et al. (1999) suggested the integration of the lean/agile paradigms into the total SC strategy. Then, going to higher conceptual levels, Lee (2004) published the well-known article "Triple-A SC" stating that the SC strategy should be developed in spite of adaptability, agility and alignment. Thus, these contributions possibly are the best foundation of differentiated (segmented) SC strategies and as further publications suggest, have inspired many people to go deeper (Selldin & Olhager, 2007; Whitten, et al., 2012; Godsell, et al., 2011; Qi, et al., 2011).

Firstly, one of the bottom-lines in the literature is that matching customer requirement with product characteristics and ensuring delivery should be one of the greatest concerns for the management (Li & O'Brien, 2001; Aitken, et al., 2003; Holweg, 2005; Demeter, et al., 2006; Payne & Peters, 2004). Therefore, it is important to align SC strategy and products classification variables accordingly to the target market (Christopher & Towill, 2002; Payne & Peters, 2004; Qi, et al., 2009). SC market orientation is more and more necessary what requires classification variables identification (Fisher, 1997; Frohlich & Westbrook, 2001; Schnetzler, et al., 2007). On this idea, Christopher and Towill (2000; 2002) and other authors created models by considering dominant classification variables using a set of variables such as duration of life-cycle, lead-time, volume, variety and variability (Childerhouse, et al., 2002; Vitasek, et al., 2003; Cigolini, et al., 2004) known as DWV^3 (Christopher & Towill, 2000).

Secondly, SC dependence of product and market characteristics is clear (Fisher, 1997; Lamming, et al., 2000; Godsell, et al., 2011). For example, one way of distinguishing products is regarding its functional or innovative nature (Fisher, 1997) best matched by different SC configurations: physically efficient SCs for functional products and market-responsive SCs for the innovative ones. Following the same principle, Lamming (2000) expanded the Fisher's model (1997) by considering the product uniqueness and complexity, while Lee (2002) focused the analysis on supply and demand uncertainty, which is one of the main issues in SC management (Simangunsong, et al., 2011).

Finally, as SC is dependent on customer requirements, market and product characteristics, these may be considered as the three possible drivers of SC. (Figure 2)

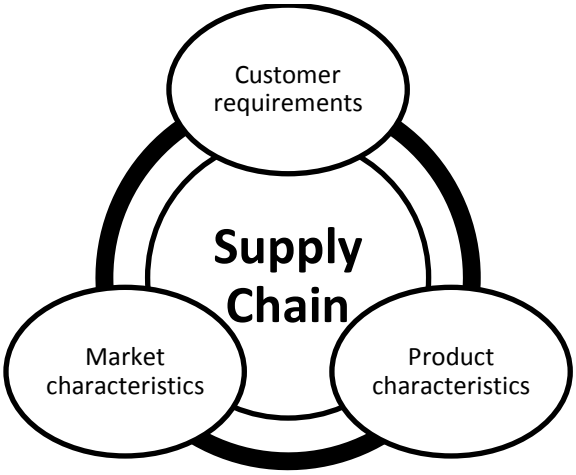


Figure 2: SC drivers

In summary, this leads towards differentiated SCs which are based on segmentation. Mostly due to the link between SC processes with product life cycles and the business strategy (Hayes & Wheelwright, 1979; Hayes & Wheelwright, 1984), life-cycle and SC strategy (Aitken, et al., 2003) , and finally integration of SC strategy and marketing (Jüttner, et al., 2010). This outlines the three bodies of literature which should be used to approach SC segmentation and all three must be aligned with the business strategy (Oliver & Webber, 1982; Gattorna, 1998; Porter, 1985). Finally, this suggests that SC segmentation is based on SC management, SC processes and finally marketing. (Figure 3)

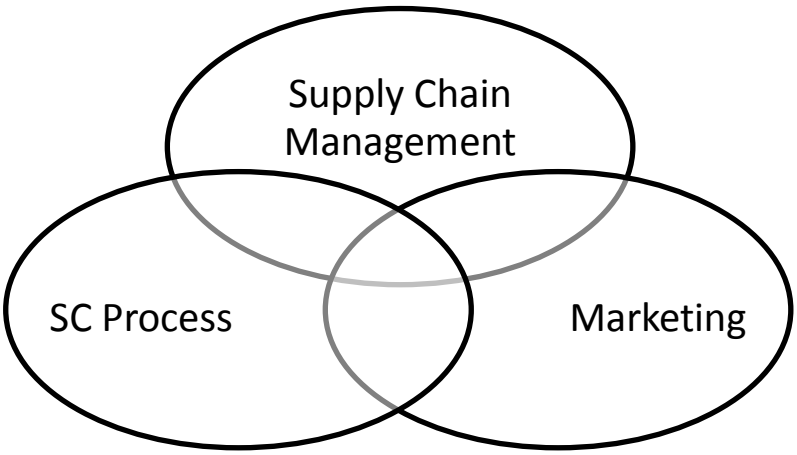


Figure 3: Key bodies of literature

The identified research gaps are the lack of empirical (quantitative) studies on the problem and poor conceptual alignment between parallel research segments, the intellectual structure of the SC strategy topic is so far unknown (the big picture). Additionally, regarding "SC segmentation" in particular, Scopus SciVerse search reveal only fifteen matches (in any field) which is an evidence of this specific topic immaturity.

1.5 Research Questions

Facing the above mentioned problem, the main research question is:

"What is the most appropriate approach for implementing supply chain segmentation to enable better alignment of demand and supply in a FMCG context?"

To answer this question, it is necessary: a) to create/identify a framework; b) to collect the pool of classification variables; c) set up a set of methods for its analysis; d) to discuss whether quantitative research is better than qualitative for the case, or maybe both are reasonable; and finally, e) to discuss which are the classification variables that are useful for the specific case.

Thus, this thesis is intended to empirically explore SC segmentation through quantitative and qualitative approaches, analysing the numerous developed concepts and qualitative empirical studies, seeking to identify a new combined approach towards the supply and demand mismatch.

Research questions	
RQ1.	What are the main supply chain strategy paradigms?
RQ2.	What is the main stream of research on differentiated supply chain strategies?
RQ3.	Which classification variables are used for supply chain segmentation?

Table 1: Research questions

Finally, besides the main research question, a number of secondary research questions stand up listed in Table 1. Further work will be developed towards an answer to each of the research questions.

1.6 Contribution

This work is meant to approach first through literature review followed by an exploratory case study on the problem of:

"What is the most appropriate approach for implementing supply chain segmentation to enable better alignment of demand and supply in a FMCG context?"

Before the above mentioned research question full formulation, the generic question on how to choose the best SC strategy arose. The review objective was to outline the so far evolution of this topic (state of the art), highlighting the main stream, the key research gaps and to provide insights on further research. The application of the bibliometric approach on this particular topic is novel, laying foundations for further bibliometric analysis in order to complete the intellectual structure of the topic, i.e., "the big picture". The second bibliometric review structures and organises the main stream of research highlighting the bridge between SC management and supply network management. Finally, another contribution of the

literature review is the gathering of SC classification variables through the literature used to classify SCs, finishing with the comparison and alignment of various contributions using three main SC paradigms. (Figure 4)

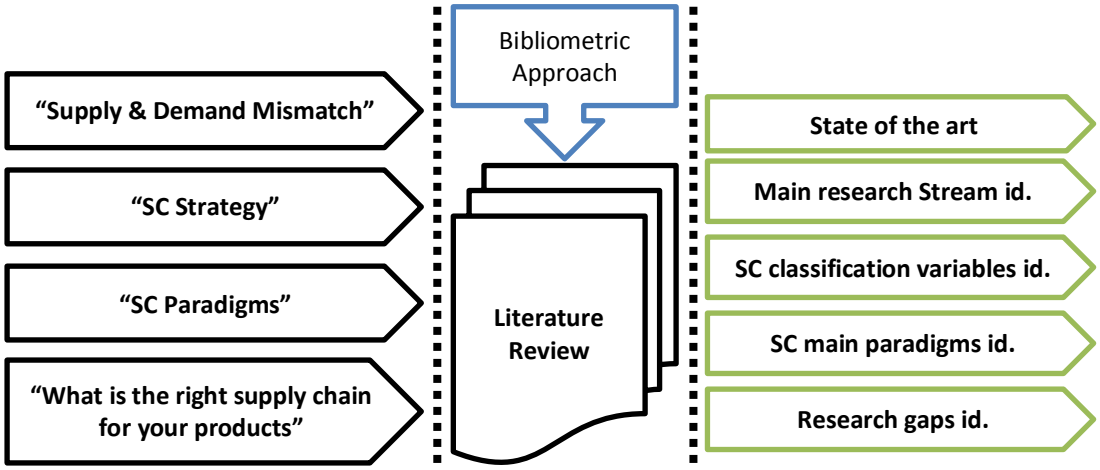


Figure 4: Literature review summary

The second part is mostly of conceptual nature. For the case study approach, a down-top (Baker, 2003) roadmap is proposed based on various contributions focused on the end customer as the key driver of the SC illustrated in the Figure 5. Are then defined the necessary key steps to perform the raw components, products and clients segmentation as well as the respective managerial suggestions to build the differentiated SC strategy and segment prioritisation based on revenue and variety. In addition, the multidimensional scaling is applied as a method to infer whether postponement and late differentiation are suitable, addressing the product common components.

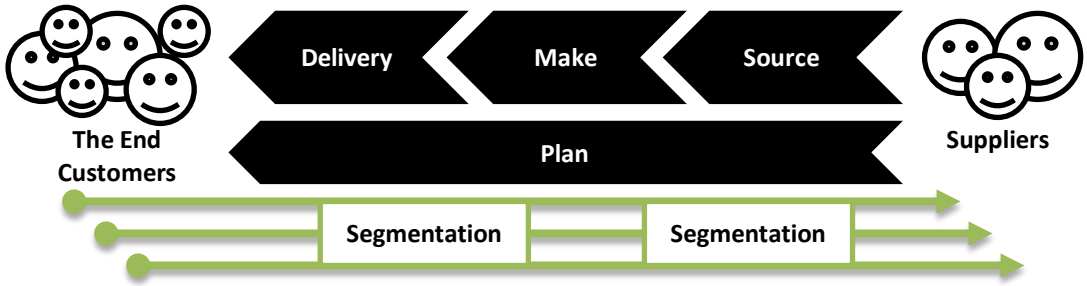


Figure 5: Demand driven SC logic followed in the proposed roadmap

The third part concerns the empirical exploratory research based on a case study which is particularly interesting because it addresses several secondary research gaps: Firstly, the B2B segmentation is an immature field (Blocker & Flint, 2007; Steenkamp, 2005) requiring empirical research; secondly, the SC segment instability is one of the major issues (Blocker & Flint, 2007) and this particular approach focuses on demand equalisation and instability

buffering by matching the proper SC 'tailored practices' (Lapide, 2006) on the instable segments; finally, the overall problem of food SCs is poorly developed and regarded as one of the most difficult to manage (Ronga, et al., 2011), and this research proposes a practical roadmap focused on several food SC particularities. (Figure 6)

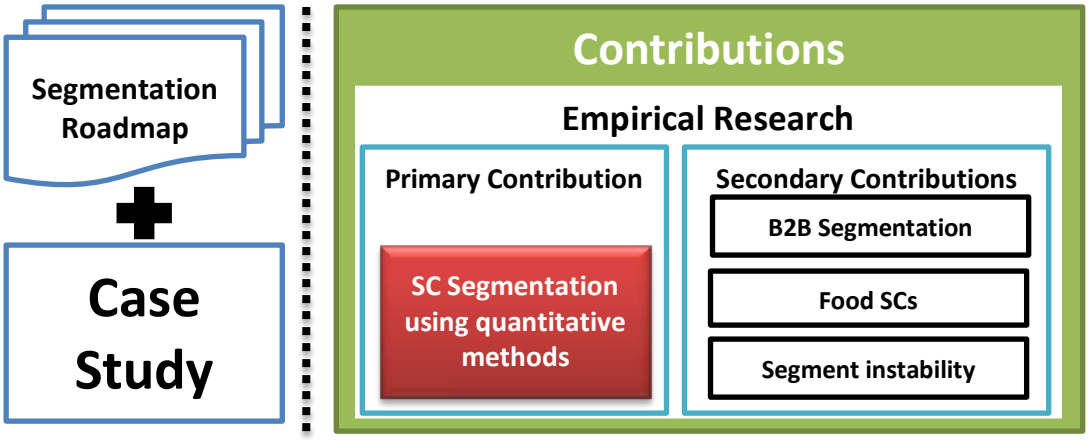


Figure 6: Thesis practical part main contributions

In particular regarding segmentation through the empirical research, several hypotheses arise. First, segmentation enables better setting of service standards as different segments require different targets and require different management addressing the cost to serve. Second, it enables better match between customer expectations and what company is willing and capable of providing. Third, it provides ground for negotiation of service standards with customers. Fourth, it is also found to be an enriched alternative to the Pareto tool for client prioritisation, reflecting not only profitability, but reducing the client variety making management easier. Finally, it is proposed a new segmentation concept on procurement based on the client's demand which segments the components as key and specific, either stable or variable, suggesting different SC 'tailored practices' (Lapide, 2006) for each segment which is an alternative to the price driven portfolio approaches focused on the bargain power balance described by Kraljic (1983).

As a conclusion, this study also suggested that SC segmentation is essential for agile, aligned, and adaptable SCs described by Lee (2004) due to its extension through the whole SC, possibility of re-segmentation enabling real-time adaptability retaining the needed level of agility by not falling into strict paradigms. As well as, it is a move towards the merging of system 1 and system 2 thinking, thus enabling more rational managerial decisions.

Finally, several further research recommendations are made, as this research only scuffed the tip of the iceberg on the new-born topic of segmented SCs.

1.7 Thesis outline

This thesis has a logical evolutionary design illustrated in Figure 7.

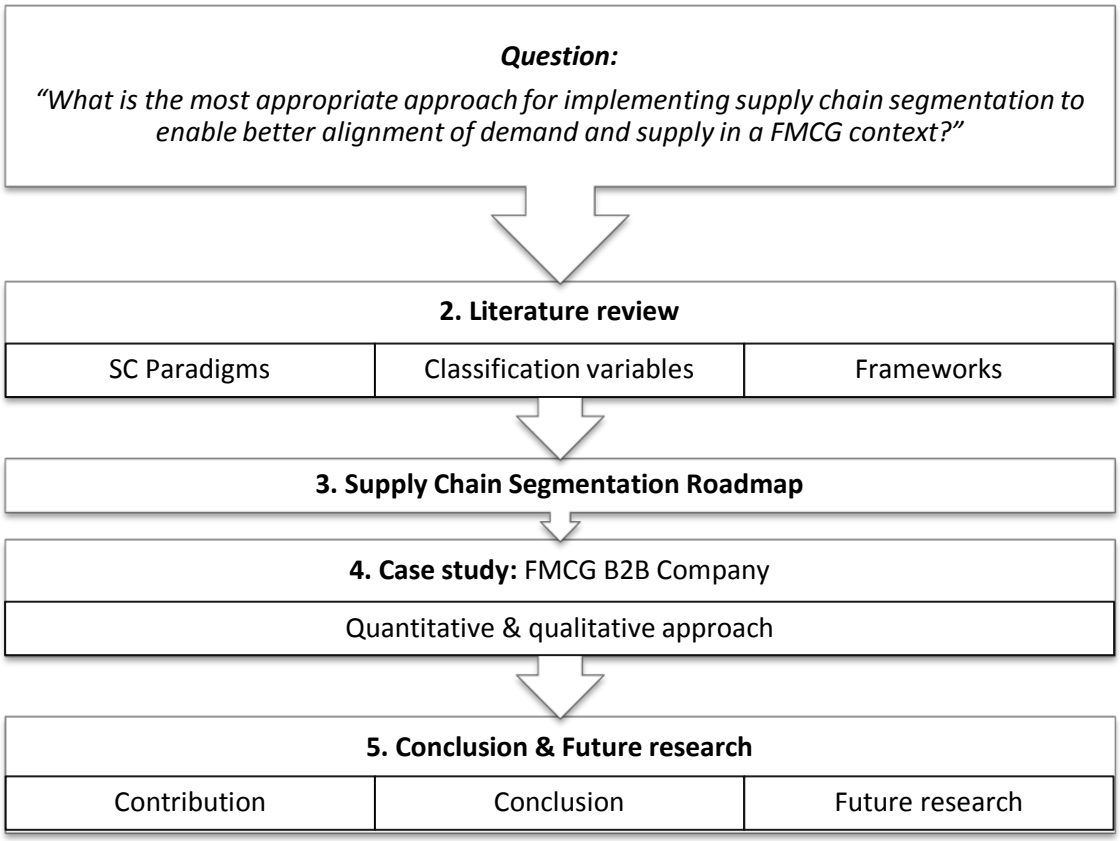


Figure 7: Thesis design

First, the question is set based on a primary literature review further supported by a profounder literature review in section 2 which allowed a better insight on the current state of the art. Consequently, several research 'gaps' were identified which justified further developments.

It is then defined a SC segmentation roadmap in section 3, which purpose is to outline the essentials for a generic approach on SC segmentation. The proposed roadmap is an outcome of a critical approach on the reviewed body of literature.

The case study is structured following the defined roadmap. The empirical application main objective is to criticise and draw up a set of possibilities, proposed tools as well as result interpretation. The value of this chapter is not the possible company's benefits, as those are secondary, but the exploratory walkthrough of the defined roadmap and testing ideas which are the foundation of this thesis. This approach based on empirical exploratory research is because SC segmentation is a nascent field, for example, a search on "SC segmentation"

keyword in Scopus SciVerse database revealed only fifteen matches (in any field), which is an evidence of this specific topic immaturity.

This is a single instrumental case concerning a business-to-business (B2B) food company operating in Europe and North Africa. The company was particularly interesting because it is a specialised company, which grew too fast, producing fruit composites integrated into dairy products (core business). Predominantly B2B, it suffers great demand variability due to the bullwhip effect (Forrester, 1961) regarding its position in the chain. It works on a pure make-to-order basis with no forecasting, producing over one thousand unique products, each engineered exclusively for only one client following very strict quality requirements (typical to B2B food industry) and short time-windows (due to the product perishability). Faced with the company's initial challenge for improving forecast accuracy, the suggestion was the broader concept of SC segmentation because the previous literature review converged on it as a possible way of approaching supply and demand mismatch.

The thesis closes with its contributions, conclusion and further research recommendations. This can be regarded as the most important part of the work as it states the key critiques and lessons learned from this particular case of research, giving practical directions for future research.

1.8 Chapter summary

This section core function is to define the scope, organisation and contribution of the present thesis. The need for differentiated supply chains is now clear as well as it gives the reader the basis for understating the underlining reasons of its organisation.

Before the detailed analysis of literature which does converge on the foundations of the need and means of achieving differentiated SC strategy (Fisher, 1997), it is stated that as one size no longer fits all (Shewchuck, 1998), analysis on product, demand and supply characteristics is critical (Christopher & Towill, 2002; Godsell, et al., 2011; Lee, 2002). Thus, it is about "how to" choose the right supply chain strategy and not about strategy itself. Being this research focused on three key bodies of literature: marketing, SC management and SC processes – the specific focus is the customer, as being the ultimate reason for supply chain existence, what suggest demand driven studies consequently converging on segmentation applied to SCs.

To support and close one of the identified gaps in literature, an exploratory empirical study is carried on. It is meant to address the identified gap in literature regarding the lack of quantitative studies. These hold a strong focus on system-one thinking in management, as

being the intuitive one. This makes evident the need towards system-two (Stanovich & West, 2000), as being the objective and analytical approach towards decisions.

2 Literature Review

"A stupid man's report of what a clever man says is never accurate, because he unconsciously translates what he hears into something that he can understand."

Bertrand Russell (1945) in *A History of Western Philosophy*

2.1 Chapter outline

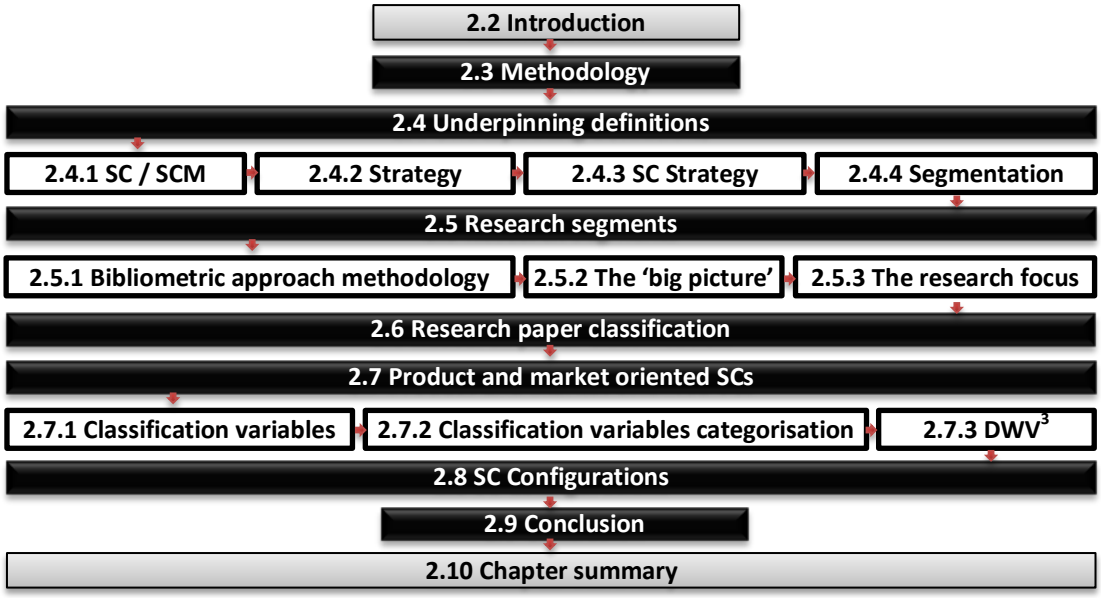


Figure 8: Chapter 2 structure

As illustrated in Figure 8, the following chapter is one of the most extensive and important of this thesis. It defines the theoretical background of the identified problem as well as lays the foundation for the practical case study. Following the 2.2 introduction providing a more complete insight on the literature, it is then explained the adapted methodology for the review of literature.

Firstly, in order to align the understanding behind the core concepts underlying this thesis, section 2.4 underpinning definitions defines: what is supply chain and supply chain management; what is strategy and in particular, SC strategy; and finally, what is segmentation in scope of management.

Secondly, Section 2.5 is meant to define the body of literature defining the key contributions on this matter, using a bibliometric approach described in section 2.5.1, two different points of view are analysed: 2.5.2 the 'big picture' and the 2.5.3 specific research focus.

Thirdly, it is then analysed the nature of the focus research papers in section 2.6, in particular its nature as being conceptual or/and either quantitative or qualitative, as well as its focus

sector. This converges on a specific types of SCs, product and market oriented SCs (2.7) which are characterised by a number of classification variables (2.7.1) as well as its categorisation (2.7.2), closing with the most recurrent set of variables named DWV^3 widely applied to many different sectors. Finally, three dominant SC paradigms are described in section 2.8, as well as the comparison of various literature contributions regarding the three main paradigms: lean, agile and leagile.

Finally, follows the 2.9 conclusion which bolds the probable research gaps, further research needs and some final thoughts regarding the topic. Closing the chapter come a brief summary about the core ideas essential for the following chapter.

2.2 Introduction

SC management is becoming more and more critical to remain competitive in the market (Gattorna & Walters, 1996). Matching customer requirement with product characteristics and ensuring delivery should be one of the greatest concerns for the management (Li & O'Brien, 2001; Aitken, et al., 2003; Holweg, 2005; Demeter, et al., 2006; Payne & Peters, 2004).

Therefore, it is important to align SC strategy and products classification variables accordingly to the target market (Christopher & Towill, 2002; Payne & Peters, 2004). There is no such thing as a "one-size-fits-all" SC strategy (Shewchuck, 1998), thus strong market orientation is more and more necessary in order to identify classification variables (Fisher, 1997; Frohlich & Westbrook, 2001; Schnetzler, et al., 2007). Christopher and Towill (2000; 2002) and other authors created models by considering dominant classification variables using the combination of variables such as duration of life cycle, lead time, volume, variety and variability (Childerhouse, et al., 2002; Vitasek, et al., 2003; Cigolini, et al., 2004). Those five classification variables are also known as DWV^3 (Christopher & Towill, 2000). On the other hand, Lee (2004) defined three key dimensions of competitive and sustainable SCs: agility; alignment; and adaptability.

Many authors tried to develop a framework that could embrace the complexity of the topic leading the management towards the right SC strategy (Harland, et al., 2004; Jüttner, et al., 2010; Godsell, et al., 2011; Payne & Peters, 2004; Christopher, et al., 2009; Christopher & Towill, 2002; Mason-Jones, et al., 2000; Schnetzler, et al., 2007; Giannakis & Croom, 2004). Two key perspectives arise, regarding SC configuration and SC management. On one hand, researchers of SC configuration (known as supply networks), focused on the number, role and locations of the various SC actors, as it is individual role in it (Nassimbeni, 1998; Harland, et al., 1999). On the other hand, research has been focused on the SC management, identifying the

practices that can lead to better SC and product alignment, as for example the use of information-sharing tools, quality management practices, co-design approaches, etc. (Lamming, et al., 2000; Giannakis & Croom, 2004; Bruce, et al., 2004; Harland, et al., 2004; Christopher, et al., 2004).

The dependence of product and market characteristics is clear (Fisher, 1997; Lamming, et al., 2000; Godsell, et al., 2011). One way of distinguishing products is regarding its functional or innovative characteristic (Fisher, 1997). This leads to different SC configurations: physically efficient SCs for functional products and market-responsive SCs for the innovative ones (Fisher, 1997). Lamming (2000) expanded the Fisher's model (1997) by considering the product uniqueness and complexity, while Lee (2002) focused the analysis on supply and demand uncertainty, which is one of the main issues in SC management (Simangunsong, et al., 2011).

SCs have evolved, growing into networks, and broadening management scope beyond organization boundary, downstream into their customers and customers' customers, and upstream into suppliers, and then into suppliers' suppliers. Competitive reality changed too; the proposition is that networks compete with networks, rather than simply firms with firms (Cunningham, 1990; Christopher, et al., 2009).

Regarding the sustainability; social, environmental and economic dimensions, choosing the appropriate SC strategy is critical. First, concerning environmental dimension, more efficient SC means fewer wastes, less resource consumption, which consequently leads to the economic dimension through fewer costs. Second, in order to sustain competitive advantage the ability of choosing the right SC makes companies more competitive and more resilient to market and demand changes what by itself means increasing the probability of company survival and consequently local stability, development and employment what completes the third, social dimension of sustainability.

This literature review purpose is to highlight the key perspectives on the problem of matching the SC with product and market characteristics. This chapter is organized in sections: After a brief research methodology explanation follows the identification of research segments by means of a bibliometric approach, then research gaps following with an insight on relationship between product characteristics and customer requirements, a summary of perspectives on classification variables that appeared in recent literature which can be used for developing different product/market segmentation. Further, SC configuration and 'tailored practices' (Lapide, 2006) are described followed by the summary of literature contributions on

product classification regarding three SC configurations: - Lean, agile and leagile. Finally, the chapter closes with further research recommendations. The objective of this section is to gather and organize some of the most influential developments on the question of SC strategy in order to support further development.

2.3 Methodology

This literature review concerns the topic of "choosing the right supply chain", which converges on SC segmentation.

Figure 9 illustrates how the research converged on the specific topic at the different stages. After a brief introduction stating the major developments, follows the methodology explanation. The adopted methodology is a systematic bibliometric approach as visual schematizations are considered to be a powerful way of seizing complex ideas. It is divided in two groups: The "big picture" which is a higher level search on "supply chain strategy" keyword; and a more focused and critically selected body of papers, encompassing a wider range of keywords that are related to the topic. This approach from two different flanks on the same issue regards the known limitations of the bibliometric analysis which tends to overlook similar ideas under different terminologies and the database limitations.

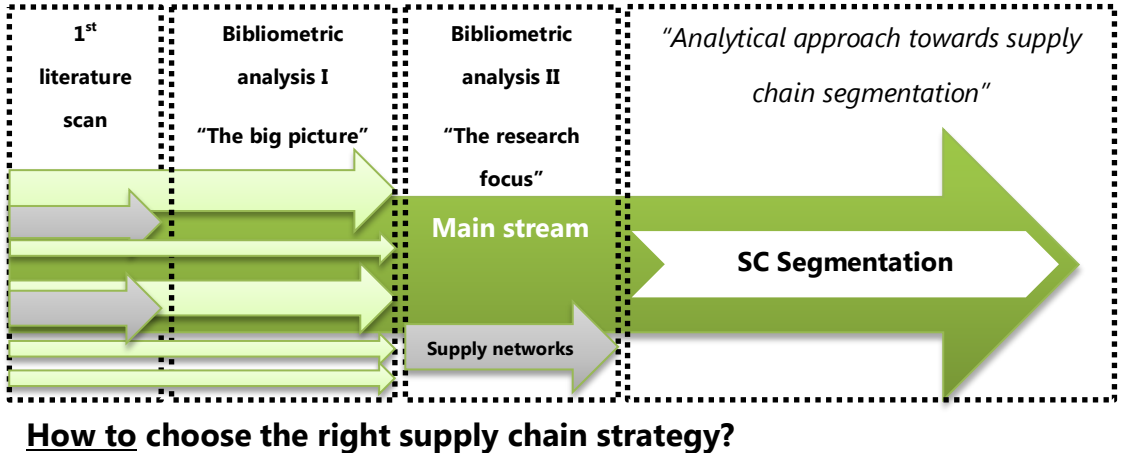


Figure 9: Research evolution

The first approach follows the basic rules for such analysis and is as neutral as possible and regards only one database, in contrast, the second breaks several rules by using different research databases and a wide range of keywords. That way, it is possible to constraint the field of interest enabling more efficient approach on the main interest yet aware of the various streams of research. Once the research segments are identified, the paper focuses on the densest cluster of contributions which can be considered the main stream. This main stream is then analysed on the abstract and keyword level, followed by individual paper

reading and respective selection. This allows the identification of strongly related contributions which the general bibliometric approach failed to identify due to its' inherit limitations.

The literature analysed in this review has been collected through two major scientific research databases: SciVerse ScienceDirect and Emerald Group Publishing Limited. The keywords used to search the business and management research journals were "supply chain management"; "strategy"; "market specific"; "market segmentation"; "management techniques"; "product classification"; "product attributes"; "demand chain management"; "aligning supply chain"; "matching supply chain". However these keywords resulted in an excessive amount of papers so the initial triage requisite was the term "supply chain management" in combination with others, followed by abstract reading and classification. The identified papers are then categorised into three main groups: Conceptual papers on SC strategy; and empirical case studies of quantitative or qualitative nature.

2.4 Underpinning definitions

2.4.1 Definition of supply chain

Supply chain (SC), at its basis, is the overview of the various elements from the initial source of raw material (supplier) to the ultimate customer; quoting:

"…a single entity rather that relegating fragmented responsibility for various segments in the supply chain to functional areas such as purchasing, manufacturing, distribution and sales." (Oliver & Webber, 1982) and *"Collection of activities that are performed to design, market, deliver and support its product"* (Porter, 1985)

And concerning its management, "supply chain management" is the management of a network (complex chain) of interconnected businesses involved in the provision of product and service packages required by the end customer in a supply chain (Harland, 1996)

2.4.2 Definition of strategy

Strategy is the art of organisation. It is originally from the Greek word *'strategos'* understood as 'general'. However, the modern use of the word 'strategy' is different as it regards to a plan of how to get to a desired position. Focusing on economic terms, it is 'how' to achieving objectives (Andrews, et al., 1965).

2.4.3 Definition of supply chain strategy

Supply chain strategy is part of a more general business strategy (Porter, 1985). It is considered essential to the success of most contemporary business organisations and its

definition is so far ambiguous and varied (Hines, 2004). However, this thesis philosophic position focused on the customer as the ultimate purpose of a supply chain (Brace, 1989; Childerhouse, et al., 2002; Hines, 2004), thus the presented definition is proposed by Hines (2004) as:

> *"Supply chain strategies require a total systems view of the linkages in the chain that work together efficiently to create customer satisfaction at the endpoint of delivery to the consumer. As a consequence costs must be lowered throughout the chain by driving out unnecessary costs and focusing attention on adding value. Throughput efficiency must be increased, bottlenecks removed and performance measurement must focus on total systems efficiency and equitable reward distribution to those in the supply chain adding value. The supply chain system must be responsive to customer requirements."*

2.4.4 Definition of segmentation

The concept of market segmentation concerns the market division into different segments (groups) of customers sharing similar product/service requirements and demand pattern (McDonald & Dunbar, 2010). The main purpose of segmentation is to enable better demand perception so the company can best satisfy the clients' needs. It is considered to be essential for successful marketing and business development (McDonald & Dunbar, 2010).

2.5 Research segments – Bibliometric approach

In nowadays, the number of people contributing to research is rocketing. More and more contributions are coming up and when the amount of information exceeds the human limit, bibliometric approaches (de Bellis, 2009) should be used to embrace the growing world of concepts. Such approach should be seen as a support of human literature analysis and never as an exact or absolute stand-alone method as it has several constraints.

This method is an efficient way of identifying possible intellectual structures in the scope of research (Charvet, et al., 2007; de Bellis, 2009). Citation and co-citations analysis are a powerful visual approach on discovering research sub-fields and it is applied in this work to define its focus (de Bellis, 2009). However, search keywords have a strong influence on the output of this kind of approach. To address this issue, the bibliometric approach using a citation and co-citation analysis was applied on two different groups. Firstly, we performed an independent search in a single database by means of a neutral keyword such as "supply chain strategy/strategies". The second was an analysis to the selected papers, which were considered relevant for this study and are cited through the work.

The two key research questions to address with this particular approach were:

- Which is the main stream of research about supply chain strategy in a global scale?
- Which is the intellectual structure of the selected body of references?

2.5.1 Bibliometric approach methodology

The bibliometric approach is used to identify possible intellectual structure within a field of research, namely the selected body of literature, based on two methods: citation and co-citation analysis. The first, citation analysis concerns the direct counts of references received from other documents which can be used to assess the impact of the cited work (de Bellis, 2009). The idea is to highlight heavily cited papers, as they are like to hold a great influence on the subject in scope. The co-citation analysis concerns on the common references between each pair of selected papers allowing the identification of proximities between topics, authors or research methods. These proximities, specifically the proximity matrix, allow a space plot using heuristics for spatial scaling, multidimensional scaling (MDS) ProxScal function in the IBM SPSS for example (Charvet, et al., 2007). In detail, multidimensional scaling is a data analysis technique which is used to display a structure of data as a geometrical picture, by means of distance-like data, e.g. proximities matrix; and it is mostly used to understand similarity of discrete entities (Schiffman, et al., 1981).

To perform such analysis, we must first select a pool of documents and prepare the data. The more neutral are the keywords the more efficient is the tool as it is less prone to form artificially induced clusters. However, this approach might prove to be useful applied on handpicked articles, which we already know to be similar.

The interpretation of the bi-dimensional plots is simple. Contributions holding higher rankings of proximity are closer while most of the novel/independent segments appear in the periphery as they lack of common references.

2.5.2 The big picture: Supply chain strategy intellectual structure

Research insight is always limited to the field of study. Any field, as broad as it may seem have a bigger picture which is sometimes difficult or impossible to grasp. So, there is certainly a bigger picture than the particular focus of this work, we performed a parallel research on the keywords “supply chain strategy” and “supply chain strategies” contained in the title, abstract and key wording on the SciVerse Scopus database limited to business/management journals only. This approach is less prone to artificially induced clusters because the more general is the key wordings the more neutral are the obtained results, thus more are the chances of research segment successful identification of the intellectual structure.

The query resulted in 326 raw papers with the respective citation count and references. The obtained data were codified as being "First author surname + publication year" and the respective references using the same process. Cases when one author held more than one publication during the same year, letters such as B, C, or D were assigned. This caused almost 10K lines of data, so in order to reduce the variety, we only selected publications containing one of more common reference what resulted in 244 master articles that are connected on different degrees. The 244 articles were organized in a square 244x244 matrix containing proximities that were imported into IBM SPSS for dimensional scaling using ProxScal function. Due to the size, the referred table was not included in the work, but an example of its format can be seen in Appendix 5.

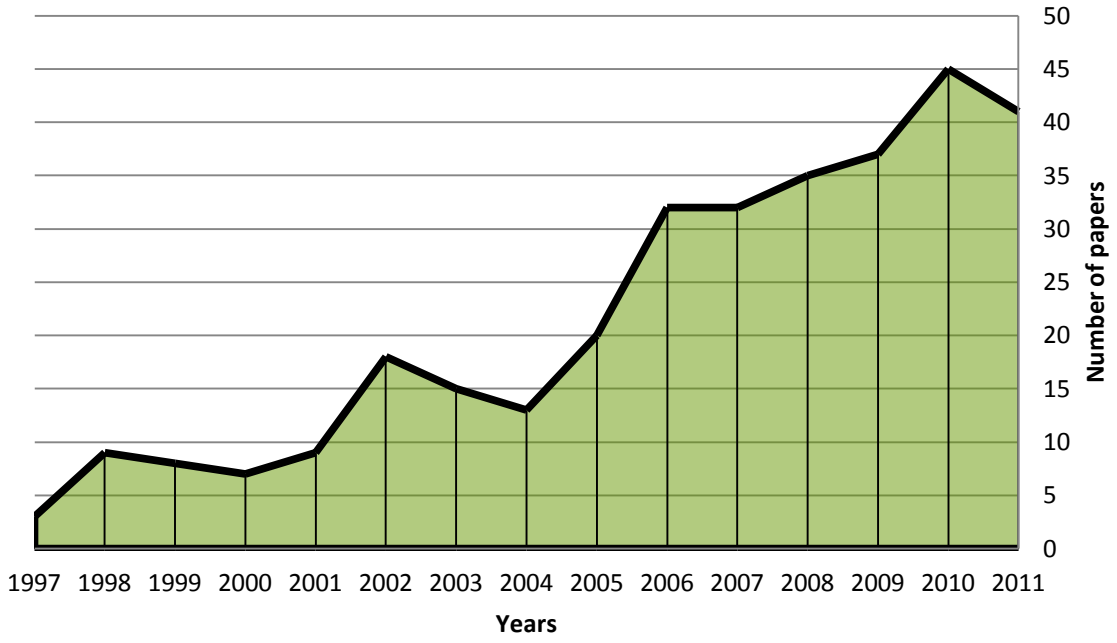


Figure 10: Number of articles per year from 1997 to 2012 (total of 326)

The Figure 10 clearly shows that "supply chain strategy" subject is becoming an eminent topic as the number of publications rose significantly from 1997 to 2011 dipping slightly in 2004 for so far unknown reasons. Concerning this particular search, one of the first key contributions to the topic was by Naylor et al., (1999), at least one of the first to refer explicitly "supply chain strategy", being among the most cited works so far. This can be seen as the genesis of the problem that remained in the background during the next three years. However, it is important to keep in mind that such analysis is limited to the existent database, constrained by keyword limitations and may induce in wrong conclusions if considered as absolute and definitive. Seminal articles such as Fisher's (1997) or the famous book by Gattorna & Waters (1996) does not come up in this database search. Another interesting observation is the peak

of contributions in 2002, one year after the publication of one of the most cited papers by Frohlich & Westbrook (2001) on the subject of SC strategy which is also one of the best examples of quantitative approach on the problem.

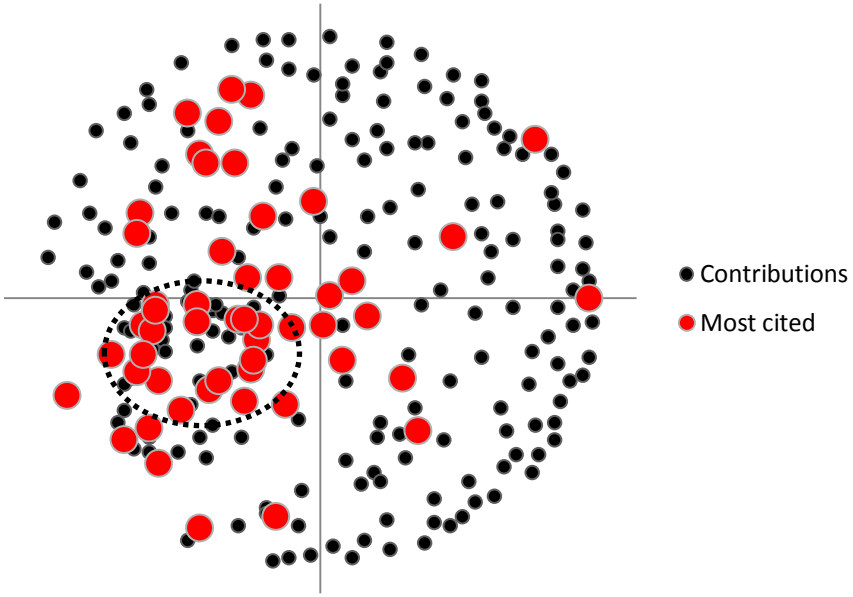


Figure 11: Most cited contributions

Firstly, for evaluating the impact distribution in the big picture, a quick analysis on the number of paper citations by other researchers considering that a "most cited" article is above the average number of citation of the total sample showed that it is not equally distributed. It is possible to identify that there are some concentrations of more influential (cited) contributions (Figure 11), however, one obviously group stand out which will be described further as the main segment of research on the topic of SC strategy. For example, the concentration of "heavily" cited papers located in the plot's top, is a research segment that concerns the SC strategy in terms of SC integration with focus on environmental factors, additionally, a central zone leans towards information technologies as the enabler for SC integration, e-business, and performance evaluation. Consequently, many other hotspots arise which require deeper research.

The usefulness of this approach lies in the possibility of identifying intellectual fronts of some given subject. Further analysis must be made on other clusters as it may contain any different insights on the topic; this work focuses on the densest cluster of contributions generally connected to the lean-agile paradigms in the SC context.

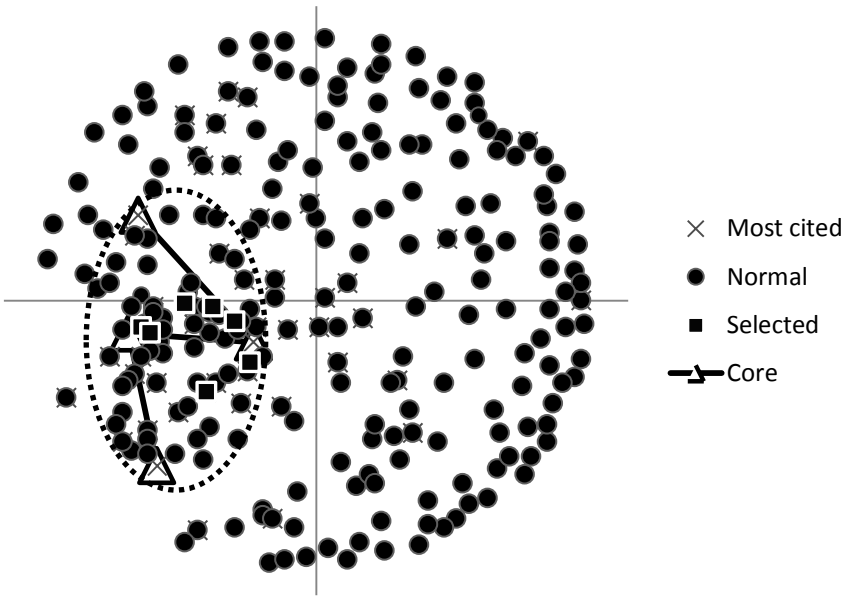


Figure 12: MDS plot of 244 articles (keyword "supply chain strategy")

In Figure 12 where the focus segment is outlined by the dotted ellipsoid, it is clear that there are concentrations representing similar segments of research, a labelled plot of the same information can be observed in the Appendix 2 and the complete listing of the 244 contributions in Appendix 3. To define this article's scope, further analysis will focus on the selected and core articles, enriched with other contributions found suitable to the topic. The conclusion drawn out of the above analysis which is also the answer to the first research question on what is the main research segment on this subject is that lean-agile school is one of the dominant segments, yet, there are other hotspots of contributions on the same matter which require more research.

	Journal	Counts	%
1	**Supply Chain Management**	**18**	**7%**
2	**International Journal of Production Economics**	**15**	**6%**
3	**International Journal of Operations and Production Management**	**11**	**5%**
4	International Journal of Physical Distribution and Logistics Management	9	4%
5	Journal of Operations Management	9	4%
6	International Journal of Production Research	7	3%
7	European Journal of Operational Research	5	2%
8	Industrial Management and Data Systems	5	2%
9	Journal of Supply Chain Management	5	2%
	Others	160	66%
	Total	**244**	

Table 2: Key journals

Finally, analysing Table 2 listing the top 9 journals regarding the number of contributions of the sample, it is obvious that "Supply Chain Management" journal is the top one. However,

the topic seems to be evenly distributed through many other journals what is yet another evidence of the growing general interest on the matter.

2.5.3 The research focus

As the concepts of "supply chain strategy", "supply network strategy", "configuration", and "segmentation" are often used to refer to the differentiated supply chain, this research selected a body of literature accordingly. It resulted in a list of articles which may be consulted in the Appendix 4 and the respective proximity matrix in Appendix 5 achieved using the script seen in Appendix 1.

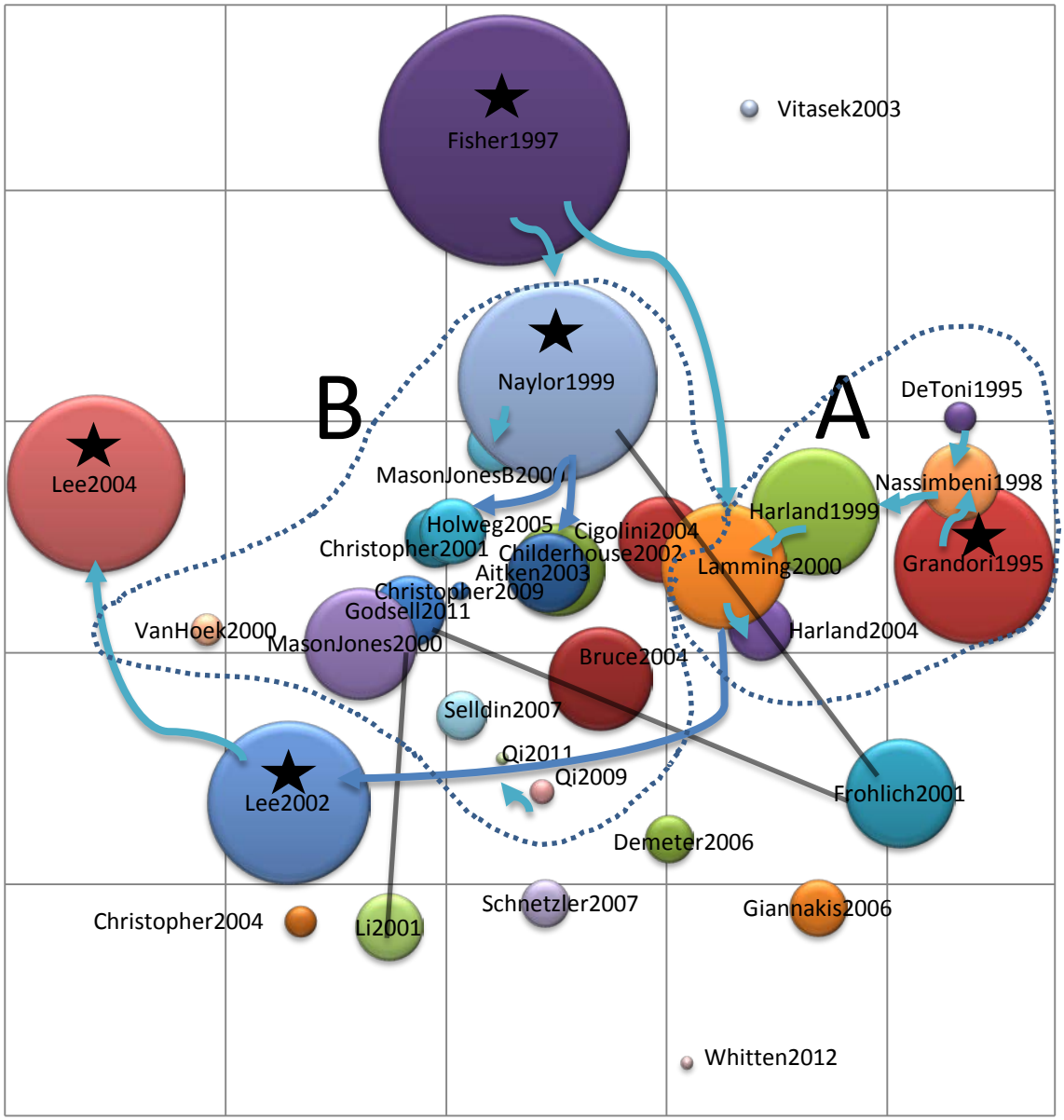


Figure 13: Bi-dimensional plot representative of the selected references in this work.

As may be seen in Figure 13, bubble sizes are proportional to direct citations achieved to the date of this writing and arrows indicate the influences: dark arrows represents strong/direct influence and grey is indirect but related. Note the article "constellation" marked with dark straight lines which also appears in the big picture analysis in Figure 12 and Appendix 2. There are five obvious "stars" in the selected literature. Judged by the number of citations works by Grandori and Soda (1995), Fisher (1997), Naylor et al., (1999) and Lee (2002; 2004) are the foundation of most of the further developments. The problematic of the "right" SC has been alive for a while, and many conceptual studies arose. The clearest reference on the topic, cited in hundreds of further researches, is in Fisher's (1997) seminal work "What is the right supply chain?". Some years later, Naylor et al., (1999) suggested the integration of the lean/agile paradigms into the total SC strategy expanded and discussed as being both complementary (Christopher & Towill, 2001). Further, going to higher conceptual levels, Lee (2004) publishes the well-known "Triple-A Supply Chains" article saying that the SC must be developed in spite of adaptability, agility and alignment.

This trinity of contributions is possibly the best foundation of the differentiated SC strategy. Facing different clients, different suppliers and different products, we must develop different SC strategies, i.e. SC segmentation through demand and product characteristics.

Concerning the forth "star", Grandori and Soda (1995), belong to a parallel school focused on SCs as supply networks. The bridge between the two different schools can be observed in the contribution by Lamming et al., (2000). It is proposed a classification of supply networks as an extension of SCs stating that the so far existing SC models were too simplistic, linear and unidirectional while the supply network concept takes into account lateral links, reverse loops, two-way exchanges and so on encompassing upstream and downstream activities. On the other side some years later, Cigolini et al., (2004), suggests a new conceptual framework for SC management (SCM), with focus on SCM strategies, establishing it on many references common to Lamming et al., (2000).

There is some degree of confusion between the two concepts. This literature review took into account the supply networks, too, as both concepts are meant to serve the same purpose: satisfy as efficiently as possible the need of the end customer.

2.5.3.1 A – Supply networks school

SCs and supply networks are meant to serve the same purpose: its final customer need. Thus, in order to get an insight on different configurations the present work took into account both perspectives. The most relevant contribution identified is the one by Grandori and Soda

(1995) which concern was the antecedents, mechanisms and forms of different interfirm networks. Its key contribution is the organization of the so far developments in the field regarding the assessment of different forms of networks, the organizational mechanisms and main variables (similar to classification variables previously mentioned). In the same year, however much less cited is the work by de Toni and Nassimbeni (1995) that similarly focused on the genesis, stability and logistical implications of the supply networks. However, it was a case study comparing two different industrial districts identifying the variables that determine or impede the formation of efficient buyer-supplier relationships. Amongst three different propositions, they analysed the influence of the product structure and the nature of the process on the networking process.

Following this, Nassimbeni (1998) developed taxonomy of network structures and co-ordination mechanisms, proposing a new framework for the classification of the main network structures. One year later, more focused on the idea of strategy, Harland et al., (1999) presented an article on the conceptualization or supply strategy backed by a Delphi survey. Then Lamming et al., (2000) suggest yet another classification for supply networks with a clear strategic purpose. Both these works by Harland et al., (1999) and Lamming et al., (2000) are completed with the model presented in the contribution by Harland et al., (2004), a more complete conceptual model for researching the creation and operation of supply networks. Despite the common authors, it is observed a clear shift towards strategy and network differentiation through classification variables. Again, the approach towards this important issue is mostly conceptual and qualitative.

2.5.3.2 B – Lean-agile school

This concentration of papers is characterised to be mostly concerned on the lean-agile paradigms applied to the SCM. Most of the contributions share common authors generally from business schools in UK, namely Cranfield and Cardiff. The most citied and one of the oldest contributions is the one by Naylor et al. (1999), who suggested the integration of lean and agile manufacturing paradigms into the total SC strategy in order to meet the demand characteristics, strongly influenced by Fisher (1997). Following that same idea, Mason-Jones et al., (2000) published a work on the leagile SC integrating both lean and agile paradigms into one. In the same year, Mason-Jones et al. (2000) contributed with another work focused on the three SC configurations: Lean, agile or leagile, and the best way of choosing between them accordingly to the marketplace.

Two years later, Childerhouse et al., (2002) starts a slightly different segment of contributions along with Aitken et al., (2003). . It is one of first sector-focused studies followed by many

others. It is also the appearing of the demand chain management as a new demand driven SC. The aim is to answer two key questions, one regarding strategy and other the tactics: "what facilities are required and how should they be laid out to enable the necessary focused demand chains?" and "which focused demand chain is appropriate for this product?" respectively. In the meantime, Aitken et al., (2003) uses the same case study to analyse the impact of the product life cycle on the SC strategy. The concern of "matching the product characteristics and customer requirements" explicitly appear as a solution to remain competitive in the modern marketplace. The ability to develop and match the SC strategies to products accordingly to its life-cycle stage is shown as the key to success. Further, Bruce et al., (2004) applies the lean and agile paradigms to the textiles and clothing industries. Likewise, it discusses each one and the combination of both, the leagile SC.

Still in 2004, Cigolini et al., (2004) developed a new conceptual framework for SCM from an operational perspective. Very practical, this article set out a combination of management techniques and supporting tools used to analyse and describe SCM strategies backed up with a large set of SCM case studies from seven different industries.

In the following year, Holweg (2005) promoted a new conceptual model related to the three dimensions of responsiveness. It was based on agile production, identifying the key factors that determine the responsiveness of a SC system. Different SC strategies can be developed by means of the proposed model as each SC settings are matched to the unique profile obtained. The selected key-factors are the product, process and volume as well as others.

It took almost ten years to someone finally test the well-known Fisher's (1997) model. Seldin and Olhager (2007) confirmed the relationship between product design and SC design by means of an extensive empirical survey to 128 companies. The key findings were the significant relationship between product types and SC types, as well as the significant impact of alignment on performance.

The most recent developments in the lean-agile school are focused on the classification of the value streams and SC segmentation through the empirical application of the DWV^3 classification variables (Christopher, et al., 2009); (Godsell, et al., 2011).

One of the key characteristics of this cluster is the empirical application of almost all of its contributions, what can be a solid argument about the practical usefulness of the discussed developments. However, most of its empirical applications are qualitative.

2.6 Research papers classification

Choosing the right SC based on products and markets has been an eminent topic trough the last decades. The literature review has shown that regarding the period between 1982 and 2012, most of the publications are conceptual. Both empirical research using case studies and exploratory surveys/interviews are qualitative and the lack of quantitative empirical research is obvious. (Table 3)

Author	Year	Conceptual	Empirical (Quantitative)	Empirical (Qualitative)	Type of industry
Whitten *et al.*	(2012)		●		Mix
Qi et al.	(2011)	●	●		Mix
Godsell *et al.*	(2011)		●	●	FMCG
Qi et al.	(2009)		●		Mix
Christopher *et al.*	(2009)		●	●	Mix
Selldin & Olhager	(2007)		●		Mix
Schentzler *et al.*	(2007)	●		●	Electroacoustic
Demeter *et al.*	(2006)			●	Automotive
Holweg	(2005)	●		●	Automotive/Electronic
Cigolini *et al.*	(2004)	●			Mix
Lee	(2004)	●			Mix
Giannakis & Croom	(2004)	●			Mix
Bruce *et al.*	(2004)			●	Textile/Clothing
Harland *et al.*	(2004)	●		●	Mix
Christopher *et al.*	(2004)	●			Fashion
Aitken *et al.*	(2003)			●	Lighting
Vitasek *et al.*	(2003)		●		Mix
Christopher & Towill	(2002)	●		●	Clothing
Childerhouse *et al.*	(2002)	●		●	Lighting
Lee	(2002)	●			Mix
Li and O'Brien	(2001)		●		Mix
Frohlich & Westbrook	(2001)		●		Mix
Van Hoek	(2000)	●			Mix
Mason-Jones *et al.*	(2000)	●		●	Mix
Lamming *et al.*	(2000)	●		●	Mix
Harland *et al.*	(1999)	●			Mix
Nassimbeni	(1998)	●			Mix
Fisher	(1997)	●			Mix
Gattorna & Walters	(1996)	●			Mix
Oliver & Webber	(1982)	●		●	Mix

Table 3: Research papers classification and type of industry

The dearth of quantitative empirical research can be logically explained by the associated complexity of quantifying most of the SC related elements. Vitasek et al. (2003) addressed the supply-demand mismatch by analysing both the volume and variability of demand for

products enabling a statistical approach on the problem. Li and O'Brien (2001) analysed the relationship between product types and SC strategies in a quantitative approach, testing the conceptual model developed by Fisher (1997); three strategies: make-to-order, manufacture-from-stock and make-to-stock (MTO; MFS; and MTS) – were tested against two key factors, impact of demand uncertainty and value adding index. Still focused on Fisher's model Seldin and Olhager (2007) successfully tested the relationship between products and SCs using an empirical survey. Frohlich and Westbrook (2001) conducted an empirical research on SC strategies characterizing each with a different "arc of integration", which represented the direction (towards suppliers and/or customers) and the degree of integration activity quantifying each element showing that the degree of integration was positively correlated with the performance improvement. Later in the same year, Frohlich and Dixon (2001) performed a cluster analysis on a large sample of codified qualitative data, seeking to validate manufacturing strategies (Frohlich & Dixon, 2001). Christopher *et al.* (2009) successfully applied DWV[3] approach on several different industries in order to classify different value streams; here we find one of the rare applications of SC matching on healthcare. Whitten et al. (2012) performed the performance measurement of Lee's model showing the positive correlation between SC strategy, SC performance and organizational performance with stronger relation between SC performance and marketing performance rather than with financial performance.

Purely conceptual models with no empirical validation or clear historical empiric evidence remain useless despite all the great ideas that it could encompass unless someone perform a practical validation. Thus, practical application of various already developed conceptual models should be the main concern of further research. Codification of qualitative data allows the use of statistical methods, enabling the quantitative analysis by decreasing the problem complexity.

Regarding the focus sector, most of the empirical studies are on manufacturing sector, e.g. automotive, textile, apparel, lighting or electro-acoustic, etc. There is an evident scarcity of SC studies for services, although some conceptual models mentioned above seem to be applicable on services.

Quantitative and qualitative strategies for research are often discussed. There are many different positions and while some researchers take on of the sides as the "right" one, other argues for a "best of both worlds" approach that combines quantitative and qualitative approaches (Bryman, 1988).

On one hand, quantitative research is characterized by the high degree of control and if it is reliable it can be replicable. It enables clear operational definition as it can be defined step by step and inherit measures what significantly decreases the ambiguity and subjectivity of the study. Most important, such approach allows sophisticated statistical analysis. However, it has its limitations. It is difficult to define and control all the variables, quantification can become an end in itself and it can lead to misleading generalizations (Burns, 2000).

On the other hand, qualitative research is best suited to understand adequately events in context in a more natural way as nothing is predefined. This approach often allows finding issues that are often missed by quantitative approaches. It better describes complex relationships, causes, effects and dynamic processes. As it lacks of statistical analysis, practitioners most likely understand qualitative research outputs as they take a narrative style. Nonetheless, it is very subjective and the conclusions may apply only to some specific context. It is difficult to test its reliability, validity as its replication is impossible, and no generalizations can be made to wider context that the one studied, as there is no confidence to support it. The time required for data collection, analysis and interpretation is lengthy. Its interpretation may vary significantly from one researcher to another (Burns, 2000).

Finally, there are strengths and weaknesses in both approaches. The combination of quantitative and qualitative studies is more powerful than each one alone. Findings from one study are checked against the findings from the other type. Qualitative studies are better to provide background information on context and subjects while qualitative enable generalizability. Quantitative research allows the researcher to establish relationships among variables but fails to explore the reasons for those relationships (Punch, 1998).

In the present context, empirical qualitative research is a powerful way of developing very context dependent frameworks based on empirical studies while quantitative approaches may provide insights on its generalization and cross application. Thus, it is important to be able to replicate the success achieved in one particular case on others and it is only possible by means of new frameworks based on both quantitative and qualitative empirical approaches.

2.7 Product and market oriented supply chains

The concept of SC suggested by Brace (1989) and considered in this work as the ultimate SC purpose is: …"the whole manufacturing distribution process may be seen as a sequence of events with but one end in view: it exists to serve the ultimate customer." That way, companies that seek blindly to achieve solely efficiency most likely will fall (Lee, 2004). And this link between production and marketing was first introduced by Hill (1985).

Product characteristics are closely connected to customer requirements (Hines, 2004) what makes the distinction sometimes difficult and confusing, although there are factors like product complexity, uniqueness or customer demand patterns for some functional or innovative product that can be used for this purpose. Thus one of the possible ways of matching the product characteristics with the customer requirements is by product segmentation based on products' and demand characteristics and only then design the SCs. Segmentation is an important marketing concept as it allows customer group creation which shares a common need or need characteristic (Freytag & Clarke, 2001) and it must be accessible, measurable, responsive, substantial, actionable and stable (Kotler, 1994). In particular, business-to-business segmentation is so far an immature field of studies (Blocker & Flint, 2007; Steenkamp, 2005) and constant requirements change makes it much more instable than the business to customer segment (Mitchell & Wilson, 1998; Achrol & Kotler, 1999). Thus, accordingly to Blocker and Flint (2007) segment instability (SI) is one of the major problems in segmentation (in particular for business to business) and its external drivers are pointed as being: 1) macro-environmental; 2) downstream customers; 3) suppliers; 4) competitors – Resulting in several outcomes: a) Customer need-offer mismatch (supply-demand mismatch); b) market-strategy mismatch; c) resource allocation mismatch; d) market performance impact. However, segmentation of products is a dynamic process due the continuous customer requirements change (Joshi & Campbell, 2003; Blocker & Flint, 2007) and managers should address the segment instability by constantly reanalysing segments (Goller, et al., 2002). As well as the life cycle of a product evolves these requirements change, so SCs must change accordingly in order to maximize competitiveness thus, different product segments in different life cycle stage require different strategies (Aitken, et al., 2003). Which consequently require different SC practices (Mason-Jones, et al., 2000) and are based on different classification variables (Christopher & Towill, 2000), reviewed further in the work.

For example, Fisher (1997) distinguished between functional and innovative products based on six classification variables such as product innovation; demand volume stability; product life cycle duration; make-to-order lead-time; product variety and end-of-sale mark down. Lamming (2000) expands above exposed Fisher's (1997) ideas by distinguishing products also regarding its innovation, uniqueness and complexity. Lee (2002) makes a step further Fishers' (1997) model and introduces the demand and supply uncertainty, where on the demand side products can be either functional (low uncertainty) or innovative (high uncertainty) and on the supply side can be stable processes (low uncertainty) or evolving processes (high uncertainty). Albeit different, Vitasek (2003) uses just two key variables for product segmentation, volume

and variability, developing a simple yet powerful profiling framework. A more detailed approach can be observed in other contributions which segment SCs through demand profiling (Christopher, et al., 2009; Godsell, et al., 2011; Payne & Peters, 2004) essentially based on demand volume and variability.

Next section firstly gives a brief insight on supply network critical activities and next, gathers classification variables from SC management context. Then, the SC classification variables are categorised accordingly to its nature. Finally, it is made a description of each of the most recurrent classification variables: lifecycle duration, time window for delivery, volume, variety and variability – the DWV^3 (Christopher & Towill, 2000).

2.7.1 Classification variables

Linking market segment considerations and product characteristics to enable SC segmentation can be accomplished through factors that do link marketing, manufacturing and product strategy (Oliver & Webber, 1982).

Literature present many particular case studies, hence it worth keeping in mind that the enablers for some specific successful example does not necessary lead other companies SCs to success. Consequently, it is logical that there are general classification variables that apply to the most of case studies. It is likely that companies of the same sector present similar profiles, yet it all depends on the selection of the appropriate classification variables (Godsell, et al., 2011; Christopher, et al., 2009; Christopher & Towill, 2000).

On one hand, focusing on the relation between firms, SCs or supply networks can either be seen as a set of upstream and downstream organizations from the original source of raw material to the end customer. On the other hand, the emphasis can be on a particular product, only analysing factors contributing someway to the manufacture, distribution and sale of that product (Harland, et al., 2004).

Regarding the relation within the firms and its classification variables, Harland *et al.* (2004) suggest that the success of supply networks creation and operation is enabled by factors such as the use of technology to transfer for example drawings and specifications during the new products development, information sharing and processing to support partner selection activity. The existing relationships in networks connect and commit different parties, easing conflict resolution. However, the same successful factors may be both "enablers" and "constraints" like the example of information sharing technologies: - electronic data interchange (EDI) enabling quicker order exchange between partners but requiring compatible information systems and common standards of data specification on both sides.

Cooperation between firms is the key enabler of successful SCs, although ambiguous. Grandori *et al.* (1995) showed the importance of consortia, franchises and other modes of inter-organizational cooperation mechanisms as an important coordination mechanism, this leads to the concept of motivation reflected in those business models, being sharing of property rights one of the strongest. Contemporary de Toni *et al.* (1995) highlighted the importance of the relationship management within SCs suggesting the development and use of adequate procedures for the selection, evaluation and monitoring of the suppliers, systems of incentives (alike the above cited), risk and reward sharing with suppliers as well as tools to control any possible opportunistic tendencies. For example, large customers pressuring typically smaller suppliers through "squeeze" policies looking out for maximum advantages only lead to a local and short-term benefits, mostly because these suppliers will naturally avoid serious investments in the relationship thanks to the customers' opportunistic behaviour. Harland *et al.* (2004) identified through an exploratory survey and literature review nine critical activities and five contextual factors applicable on the relational perspective. (Table 4)

Critical activities and contextual factors (supply networks)	
Activities	Contextual
Partner selection; Resource integration; Information processing; Knowledge capture; Social coordination; Risk and benefit sharing; Decision-making; Conflict resolution and; Motivating.	Market environment; Product/service package; Operations process; Supply network structure and; Focal firm SC strategy;

Table 4: Critical activities and contextual factors (adapted from Harland *et al.*, (2004))

Finally, the market oriented perspective of classification variables rests on agile, aligned and adaptable SC proposed by Lee (2004) encompassing a large variety of product and market characteristics on a very high level approach. When companies move into new markets or new technologies, they must have its SCs ready for the new business challenges and opportunities. Despite the high-level of this approach, it takes into account the uncertainty referring the concept of agility (responsiveness[1]) and adaptability[2]. Fishers' (1997) functional and innovative

[1] Responsiveness is the ability to react purposefully and within an appropriate time-scale to customer demand or changes in the marketplace, to bring about or maintain competitive advantage. (Holweg, 2005)

[2] Adjust supply chain design to accommodate market changes. (Lee, 2004)

product differentiation focuses only on demand uncertainty. As follows, it is critical to take into account the uncertainty of demand and supply. Thus, being part of the previous focus on products perspective it embraces the time perspective.

Contribution / Classification variables	Oliver & Webber (1982)	Gattorna & Walters (1996)	Fisher (1997)	Mason-Jones *et al.* (2000)	Lamming (2000)	Li and O'Brien (2001)	Christopher & Towill (2002)	Lee (2002)	Childerhouse *et al.* (2002)	Vitasek (2003)	Aitken *et al.* (2003)	Bruce *et al.* (2004)	Christopher *et al.* (2004)	Cigolini *et al.* (2004)	Lee (2004)	Holweg (2005)	Christopher *et al.* (2009)	Godsell *et al.* (2011)
Product life cycle			●	●	●		●	●	●		●	●	●	●	●	●	●	●
Lead time	●	●	●	●	●		●	●	●		●			●	●	●	●	●
Volume			●	●	●		●	●	●	●	●			●	●		●	●
Product Variety	●		●		●		●	●	●		●					●	●	●
Variability			●	●	●	●	●	●	●	●	●	●	●	●	●		●	●
Nature of demand	●		●	●	●		●	●		●		●	●	●	●	●	●	●
Point of product configuration					●	●								●	●	●		
De-coupling point				●											●	●		
SC response time	●			●	●										●	●		
Customer expectations				●	●	●									●	●		
Demand pareto analysis										●						●		
Reliability of delivery	●	●			●										●			
Reliability of supply	●	●			●			●							●			
Flexibility	●	●			●									●	●			
Minimum run size	●														●			
Change over	●																	
Range	●				●													
Frequency of delivery		●													●			
Profit margin				●		●	●								●			
Product complexity				●	●									●	●			

Table 5: Classification variables considered among literature contributions

Regarding the classification variables referred in different contributions, uncertainty is one of the major concerns expressed through variability, reliability of supply/delivery and customer expectations. Nature of demand can also be linked to customer expectations, volume, variability and frequency of delivery due its interconnected nature. Vitasek *et al.* (2003) and later Godsell *et al.* (2011) came up with a framework for solving the supply-demand mismatch by analysing both the product volume and variability of demand, matching each cluster of products to different manufacturing and distribution strategies based on the demand profile in order to drive high service levels while minimizing inventory. Most of the contributions relied on duration of life cycle, lead-time, volume, variety and variability; so-called DWV^3 classification variables influenced both by lean and agile thinking (Christopher & Towill, 2000). (Table 5)

2.7.2 Classification variable categorization

Literature gives us a wide range of different classification variables. However, there are differences between them; some applies on products, others on the demand patterns/client and some on the process logic.

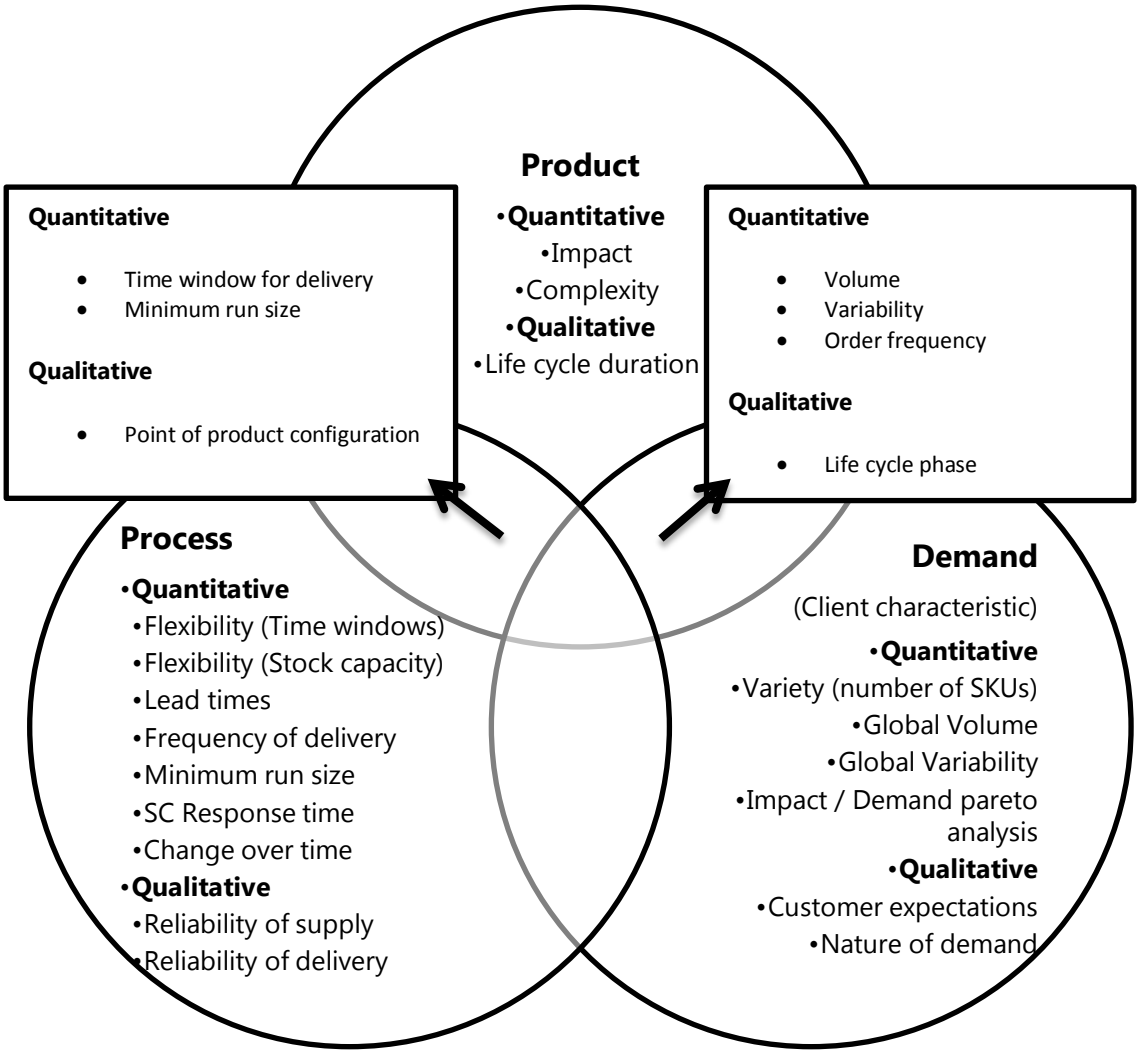


Figure 14: Classification variables categorization

Variables might be either quantitative or qualitative, qualitative factors have already been used for value stream classification by Christopher et al. (2009), while quantitative approach is rather poor and unknown. The challenge is the quantification of each factor: how much is complexity?; How much is Flexibility?; How much is the variability of some given demand flow? – These are some of the questions that must be made when we want to apply them into practice related to a specific context requiring proper index definition. So far, literature does not present a clear categorization and metrics of the SC classification variables.

Based on the description of the different factors and the critical approach on whether it can be quantified, the Figure 14 presents the suggested categorization accordingly to the three key focus dimensions being either quantitative or qualitative: product; process; and demand.

It is important to remember that some classification variables, depending on the context, may change its category, e.g. if the minimum run size is independent of the product characteristics and is determined by the management based on anything else but product, it may be categorized as purely process characteristic.

Product, also referred as SKU further in the work, holds some characteristics that are independent on the demand characteristics and others that are demand or process dependent. Impact for instance is its unitary price; complexity can be both measured as the number of components or production steps. Concerning qualitative measures, its final application and life cycle duration are also possible classification variables.

Demand or client characteristic, hold both quantitative and qualitative factors. While it is difficult to measure the customer expectations or the nature of demand, we can measure exactly its variety through the number of assigned SKUs, the global volume in product unit and its variability, measuring the impact on our business in currency applying techniques such as Pareto analysis and others.

The intersection of product and demand classes gives the particular SKU average volume characteristic, its variability related to the way the client orders that specific product and the order frequency. The life cycle phase is a quality that does influence the supply strategy; however, its measurement/analysis is difficult.

Regarding the process class, many SKU attributed characteristics are product independent which is the time window for production, stock capacity, lead times or even the frequency of delivery. Minimum run sizes are often determined motivated by the start-up costs and SC response time can be agreed with the client to match its process logic. However, some characteristics like reliability of either supply or delivery are subjective and difficult to measure being better suited by qualitative evaluations.

The intersection of process and product holds factors such as time window for delivery witch may be determined based on the product and process particularities, e.g. in the food industry products often vary its shelf life and there might be shorter time windows for delivery after production. Minimum run sizes are often both product and process dependent while the point of product configuration might give us an insight on whether we are allowed some degree of flexibility and process optimization.

The context is decisive for both selection and classification of classification variables as many of them do not hold any importance when applied into different industries as well as new factor definition may be necessary.

2.7.3 DWV³ - Most recurrent variables

Variables such as duration of life cycle, lead time, volume, variety and variability are known as DWV³ (Christopher & Towill, 2000). This set of variables has been applied on several different industries: lighting; electronics; healthcare; FMCG; retail and clothing; (Christopher & Towill, 2002; Christopher, et al., 2009; Godsell, et al., 2011).

2.7.3.1 Duration of life cycle

Short life cycles require rapid time to market, short end-to-end pipelines enabling demand to be continuously replenished during the cycle, demand chains being able to "fast track" product development, manufacturing and logistics to get most of the ever-decreasing windows of opportunity. Replenishment lead times must be matched to each stage of product life cycle in order to reduce lost sales and obsolescence risks. The analysis of key order winners (OW) and market qualifiers (MQ) characteristics during each stage of a product lifecycle eases the identification of SC engineering requirements (Aitken, et al., 2003).

2.7.3.2 Time window for delivery

Also known as lead-time, it requires a rapid response to replenish fashionable goods that are selling well at a particular point in time. Many demand chains compete based on the shortest window for delivery of customized products. Example of such practices is the responsive SC by Zara committed to deliver ephemeral fashion goods at affordable prices in record times, holding the impressive Design-To-Rack time of fifteen days. On the other hand, SCs of perishable goods like food are highly dependent on this classification variable.

2.7.3.3 Volume

High volume products for mass markets allow lean-type production and make-to-forecast strategies enabling economies of scale hence lower volume markets benefit from flexibility both in production and the demand chain. Volume should be measured at the SKU level regarding its quantity and not value. However, volume alone is not sufficient to decide on the proper SC practices.

2.7.3.4 Variety

Great variety means large number of stock keeping units (SKUs), continuous product analysis must be made during product life cycle as popular variants in the introductory stage may not

be as popular during the decline stage. Variety may be useful to decide whether we need to apply profiling or segmentation on the SKU (Wedgwood, 2006). Some SKUs may justify individual analysis (profiling) due to its impact on the overall company profit.

2.7.3.5 Variability

Demand unpredictability reflected through demand spikes causes well known problems like bullwhip effect in which demand variations downstream in the SC result in huge inventory build-ups upstream at the supplier's levels (Forrester, 1961; Lee, et al., 1997) as well as "boom and bust" effect along SC (Sterman, 2000). Demand with low variability is predictable and forecasting models are efficient enabling lean practices however high variability turns forecasting highly inaccurate and consequently making agile configurations more appropriate.

2.8 Supply chain configurations and tailored practices

Achieving the global optimum within a SC does not necessary lead to a win-win situation (Porter, 1985). To choose for a specific SC configuration we need to select the classification variables, segment our products and analyse the market in order to understand what kind of supply and demand the company or a particular product is facing. SCs are a joint effort of various players and management focus must transcend the organization boundaries (Gattorna & Walters, 1996). There are two ways of looking at this problem. On one hand, it can regard the SC paradigms, and on the other hand, as SC practices. The last, however, cannot be regarded as 'gold blocks' which bring benefits to the chain, thus, each practice must be regarded to the context, specific needs and other practices. This has been addressed by Lapide (2006) as 'tailored practices', which are essential to achieve SC internal alignment.

Christopher *et al.* (2002) took three basic variables such as "products" which can be either standard or special, "demand" that can be either stable or volatile (variability) and "lead times" as being long or short, quite similar to demand/supply uncertainty framework proposed by Lee (2002). Special products with volatile demand should have innovative and agile short SCs whether special products with stable demand have been recognized as a rare exception thus ignored. Standard products with volatile demand require a high capacity able to meet extreme demand short SCs while stable demand can be served through high volume, long and lean SCs so to take advantage of economies of scale. Short SCs should be able to react quickly to demand changes, relying normally on domestic suppliers while long SCs reach lower cost foreign suppliers, this "length" can be understood as logistic distance.

For example, split sourcing is one of the possible ways to achieve greater responsiveness, splitting the base and surge demand allows the firm to purchase components or materials in

advance of demand from low-cost sources and manufacturing or assembling the final product locally. Such kind of strategy is one of the key reasons for the success of Zara and consequently applicable on other fashion retailers exhibiting leagile practices.

Nonetheless, Lee (2002) focused on uncertainty and considered that functional products (standard) demand uncertainty is low by default and high for the innovative ones (special). On the supply side, uncertainty can be either stable or evolving. SC configuration is determined by SC strategy and before setting up any SC strategy, it is indispensable to understand the sources of uncertainty (Simangunsong, et al., 2011).

Although uncertainty (variability) is impossible to avoid, its reduction is possible by appropriate strategies and 'tailored practices' (Lapide, 2006), e.g. it is crucial to share demand information and synchronized planning across the SC so to reduce the increasing fluctuations of orders placed upstream the SC, also known as bullwhip effect (Forrester, 1961; Lee, et al., 1997), thus reducing supply and demand variability. Practices like engaging supplier replenishment programs as well as abolishing pushing strategy practices like rebates, quantity discounts or anything else that induce demand spikes does help to deal with uncertainty.

People often think that cost efficiency in SCs is the key driver towards success, although Lee (2004) made a perspicacious observation stating that organizations did not gained a sustainable advantage over competition by developing efficient and cost effective SCs, worse than that was the fact that those companies performance steadily deteriorated over time. Thus, high-speed, low-cost (lean) SCs are unable to respond to unexpected changes of demand or supply. Although, this same idea has been dealt from different perspectives and some confusion may emerge.

Lee (2004) outlines agility, adaptability and alignment in order to achieve sustainable competitive advantage. Agile as being able to respond to short-term changes in demand or supply quickly and handling external disruptions smoothly while adjusting SC design to adapt to structural shift in markets and modify supply networks strategies, products and technologies aligning the interests of all stakeholders and involved organization in the SC with their own.

Bruce *et al.* (2004) described lean, agile and "leagile" (hybrid both lean and agile) SCs. Lean SCs are cost efficient with minimal waste. Agile SCs are the ones able to respond effectively to a constantly changing and highly competitive business environment focusing on minimal lead times. Finally, being the combination of both lean and agile configurations derives the leagile approach.

This review, seeking for some clarification of terminology will rely on the lean, agile and leagile SC classification further described.

Lean SC configuration, also known as physically efficient (Fisher, 1997), tend to minimize cost and maximize performance while holding lead times as short as possible as long as it doesn't increase cost; cost/quality are the key drivers for suppliers selection and inventory should be kept as low as possible maintaining high average utilization rate of the manufacturing process. The demand is normally stable and predictable what makes forecasting and production planning suitable in order to reduce production costs. These SCs key characteristic is high capacity production and distribution, enabling scale economies and optimization techniques. Just-in-time systems, automation, facility layout optimization, workflow streamlining, direct shipping (i.e. intermediaries' reduction) are some of the practices held in this kind of SCs.

Agile SCs focus on holding the minimal lead times being able to meet constantly changing demand dealing at the same time with manufacturing, supply complexity and uncertainty. Highly innovative companies face both great opportunities and risks what makes this kind of SCs the most challenging to manage. Decoupling point strategy can be rewarding as it creates inventory buffers to minimize the mismatch of sales forecast and actual demand in other words, the manufacturing process should deploy excess buffers capacity and buffer stocks of parts or finished goods in order to handle demand spikes. As well as any means of shortening new product development times reduce response times and uncertainty, thus practices like sharing among SC partners detailed prototype plans, production plans, shipping schedules and test results reduce not only response times but also minimize supply and demand mismatch (Vitasek, et al., 2003). Consequently, these kinds of SCs require tight strategic partnerships in order to share information and resources remaining competitive in the market. Postponement and modular design are the best product-design strategies. Suppliers should be selected based on flexibility, speed and quality. Lead times should be kept as short as possible even if it that means investment or cost increase. This kind of configurations is oriented towards stable supply processes of innovative, low complexity products with highly variable low volume demand.

Leagile configuration is the combination of both lean and agile combined at a decoupling point being agile on downstream enabling high service levels and lean upstream for cost effectiveness from the decoupling point in the SC (Mason-Jones, et al., 2000) (Naylor, et al., 1999).

All above encompasses the ability to respond quickly to market demands maintaining competitive advantage or in simple words it is the balance between effective and efficient service level adjusting the SC design and practices based on product and market characteristics. Comparing the SC configuration description in different contributions, we classified the products into three distinct categories accordingly to what is described above, ignoring the originally given classifications and focusing mainly in its characteristics. (Table 6)

Contribution	Supply chain configuration		
	Lean	**Leagile**	**Agile**
Godsell *et al.* (2010)	High volume /Low variability		Low volume /High variability
Cigolini *et al.* (2004)	Mature phase Simple products	Mature phase Complex products	Introduction/Growth/Decline phases Simple & Complex products
Lee (2004)			Triple-A supply chain's
Bruce *et al.* (2004)	Raw textile materials	High street fashion products	Fashion goods
Christopher *et al.* (2004)			Fashion goods
Vitasek *et al.* (2003)	"A" High volume / Low variability products	"B" Medium Volume / Low-med variability	"D" Med-High volume / High variability "C" Low-volume products low-high variability
Christopher and Towill (2002)	Standard Products with stable demand	Standard Products with volatile demand (Top-up agile)	Special Products with volatile demand
Lee (2002)	Stable supply process/functional products	Stable supply process/Innovative products	Evolving supply process Innovative & functional products
Manson-Jones *et al.* (2000)	Commodities (mechanical precision products)	Electronic products	Fashion goods (Carpet manufacture)
Lamming *et al.* (2000)	Low complexity functional products	High complexity Functional products	High & Low complexity Innovative/Unique products
Fisher (1997)	Functional Products		Innovative Products

Table 6: Supply chain configurations and literature contributions

The Table 6 main purpose is to simplify and align the various research contributions which purpose is similar. For example, Lee (2002) defines four SC strategies: efficient; responsive; risk-hedging; and agile. Lee's (2002) responsive and agile are both meant to be responsive and flexible to changing and diverse needs of the customers, however, the main difference are high risk of supply shortage in the agile strategy (evolving supply process for innovative and functional products), which is hedged by pooling inventory or other capacity resources. Thus, responsive SCs purpose (stable supply process and innovative products) matches leagile paradigm (Naylor, et al., 1999; Mason-Jones, et al., 2000) which is agile downstream and lean upstream, in contrast, Lee's agile (2002) equals agile considered as one of the key paradigms of the main stream (Christopher & Towill, 2001; Mason-Jones, et al., 2000; Shewchuck, 1998). Following the same logic, the description of efficient SCs by Lee (2002) pairs lean paradigm

(Mason-Jones, et al., 2000). Finally, Lee's (2002) risk-hedging SCs are characterised by evolving (uncertain) supply and stable demand, which best match is agile paradigm, as it takes into account both upstream and downstream instability as agility is meant to exploit opportunities in a volatile market place. This is one of the examples, and the logic for the above mentioned organisation is the same, which main purpose is to simplify and embrace various approaches on the same problem: matching SC strategies with products and markets.

2.9 Conclusion

This review is meant to align, compare and contrast some of the main developments on matching SCs to products' and markets' characteristics. In literature, this topic is frequently termed as "supply chain strategy", "supply chain segmentation", "value stream classification", or simply, as the problem of matching the SC with the context. The body of literature reviewed, does show some similarities and few outliers of the mainstream of researchers on the topic, which is the "lean-agile" segment which mostly grew out of the concept of lean and agile paradigms integration into the total SC (Naylor, et al., 1999). However, Fisher's (1997) model in particular, shows to be the so far most popular among most research works, as many contributions have been developed in order to improve it (Lamming, et al., 2000; Lee, 2002). This similarity, suggests that instead of working under different paradigms, it is more suitable to gather a universal pool of practices, which combination defines the SC strategy itself. Many companies are using hybrid approaches (Christopher & Towill, 2001), to avoid conceptual misalignment, further research should change its direction away from paradigms.

Firstly, matching product characteristic with customer requirements relies on product segmentation accordingly to different classification variables being the main concern as: serve the ultimate customer (Brace, 1989). Also, segmenting products is a dynamic process due the continuous customer requirements change. So, as the life cycle of a product evolves these requirements change too, so, SCs must change accordingly in order to maximize competitiveness (Aitken, et al., 2003). Finally, classification variables depend on the company sector, products, markets and client characteristics, although there are universally applicable classification variables such as DWV^3 (Christopher & Towill, 2000). Variability expresses the demand uncertainty which efficient management is one of the main concerns in the SC literature (Simangunsong, et al., 2011; Lee, 2002). The plethora of classification variables should be revised and empirically tested towards a new, refreshed insight on what is the proper pool of classification variables which can be used for SC strategy segmentation.

Secondly, concerning SC strategies and ideals, two major streams arise which complement and support each other. On one hand, there are three basic paradigms of SCs in the main stream of research: Lean, leagile and agile SCs (Mason-Jones, et al., 2000). Specifically, lean as being the efficient SC, agile as the one capable of handling the uncertainty and finally, leagile which combines lean and agile breaking the chain in the decoupling point (Naylor, et al., 1999). On the other hand, "Triple-A" SC (Lee, 2004): Agility, adaptability and alignment - proposed as a way of achieving sustainable competitive advantage. In detail, "agile" (different from the agile described as a paradigm) as being able to respond quickly to short-term demand or supply changes and handling external disruptions smoothly while adjusting SCs design to adapt to structural shift in markets and modify supply networks strategies, products and technologies aligning the interests of all stakeholders and participating organization in the SC with their own what embraces almost all identified classification variables. Ultimately, the goal of both perspectives is the same: serve the ultimate customer – yet, one is closer to the tactical level (more practical) while the second is to the strategic (more abstract).

Finally, this review contribution is that it identifies the main stream of research on the topic, compares and contrasts the major contributions, identifies some possible research gaps, gathers different classification variables from the literature and suggests a logical categorization scheme. Concerning research gaps, the main gap is the lack of empirical quantitative research, few researchers carried on quantitative analysis (Li & O'Brien, 2001; Frohlich & Westbrook, 2001; Qi, et al., 2009). Empirically created models based on particular sector case studies allow cross application, what enables the development of generic frameworks for proper SC selection. Consequently, many different conceptual frameworks are available (Payne & Peters, 2004; Fisher, 1997; Christopher & Towill, 2001; Lamming, et al., 2000), however, not all of them were properly validated, lacking of quantitative application. All considered researches focus on goods SCs and only one about healthcare services. Therefore, the above-mentioned gaps should be the concern of further research.

2.10 Chapter summary

This section is meant to outline the necessary foundations for a practical approach on SC segmentation. It compares and contrasts some of the key perspective, identifies a set of SC classification variables, some of the practices and the main paradigms all to be used next to define a possible roadmap for "how to choose" the proper supply chain, namely the logic of such kind of approach. Its basis is the focus on the product, demand and supply characteristics in order to match the SC practices with the needs with one main purpose: serve the ultimate customer.

3 Supply Chain Segmentation Roadmap

"Management of many is the same as management of few. It is a matter of organisation."

Sun Tzu (476-221 BC) in *The Art of War*

3.1 Chapter outline

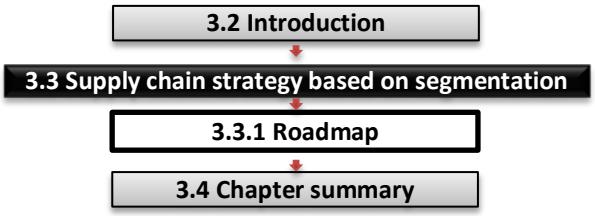


Figure 15: Chapter 3 structure

The chapter regarding the supply chain segmentation roadmap is intended to prepare the structure and the conceptual basis for the practical approach, illustrated in Figure 15. Following a brief introduction (3.2) discussing the purpose of strategy and setting the body of contributions on this particular matter, follows the specific insight on SC strategy based on segmentation (3.3) clarifying what is SC segmentation, its purpose and the necessary roadmap to achieve it (3.3.1). Finally, the chapter closes with a brief summary regarding the core ideas to retain for the forthcoming, practical application of the pre-set roadmap.

3.2 Introduction

Strategy is the art of arrangement. Being a high level insight of the problem; it defines a set of tactics which enable achievement of objectives, in this case: serve the ultimate customer (Brace, 1989). The previous review enabled the definition of what is essential for SC strategy building. There is no magic formula that could fit all cases; however, it is possible to define groups of customers by means of demand differences/similarities analysis, matching different SC types with the demand particularities. Thus, it is essential to set a roadmap for the analytical approach towards SC segmentation. Those are abstractions of a complex processes, meant to support empirical applications. Worth noting that there are some successful SC strategy models/frameworks for this problem which are the base of the proposed roadmap of this work (Jüttner, et al., 2010; Payne & Peters, 2004; Childerhouse, et al., 2002; Christopher, et al., 2009; Godsell, et al., 2011; Christopher & Towill, 2002).

3.3 Supply chain strategy based on segmentation

Framework development is not this thesis's focus; it is SC segmentation which is a new-born topic, lacking of empirical application. Thus the proposed logic results from the case study exploratory research inspired by the already existing frameworks.

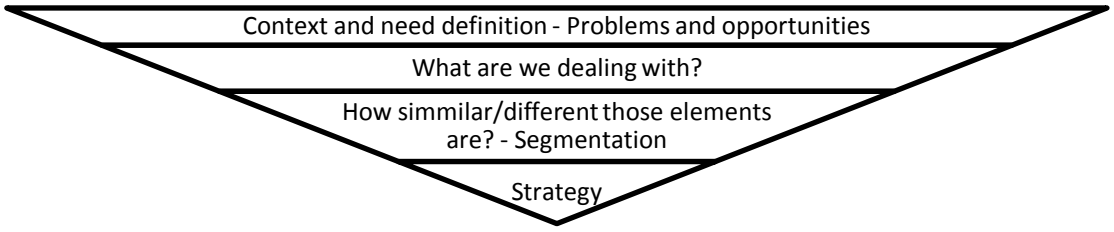


Figure 16: Strategy definition logic

The Figure 16 illustrates what is believed to be the best logic for demand driven SC strategy building (being also applicable for supply driven SCs), which foundations are the context and needs (Parnaby, 1995). Strategy based on segmentation is the answer to the need of dealing with numerous entities which cannot be controlled individually. Each entity has a set of individual attributes. Ideally each entity would have a separate approach, resulting in an individual, unique, set of tactics which would lead towards the optimum (yet ephemeral, thus requiring constant adaptation). However, due to the impossibility of managing each entity individually, it is critical to explore similarities and differences allowing them to be grouped, i.e., segmented. As Figure 17 suggest, SC segmentation is the balance between the "one-size-fits-all" and "individual-size-for-each-one", i.e., one general stream vs. individual streams, seeking for the best compromise between resources spent on management (cost to serve), and the best way of delivering the right product, on the right moment, and in the right place.

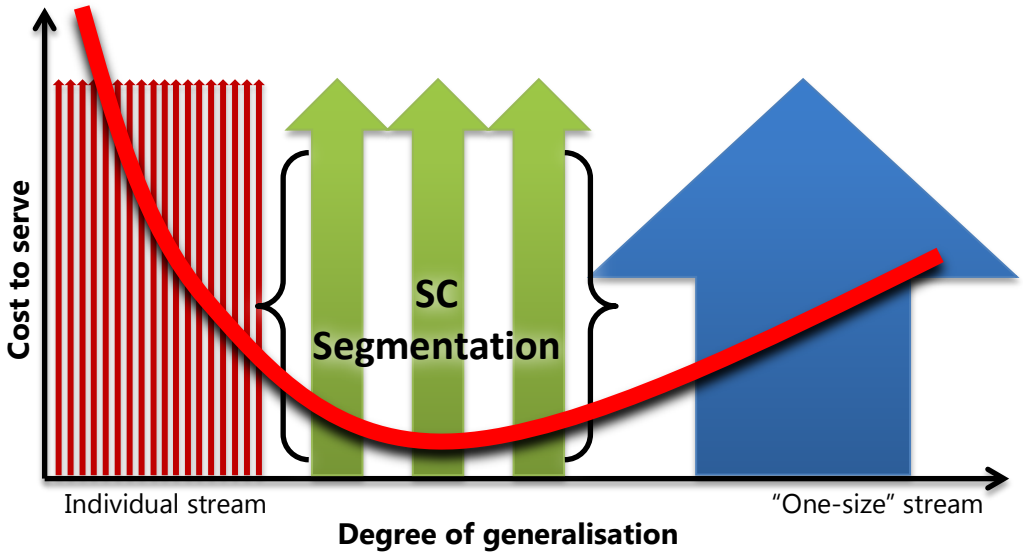


Figure 17: Supply chain segmentation concept: Cost to serve vs. degree of generalisation

Segmentation is only possible when we are aware of what are we dealing with, its characteristics, and the "normal" behavioural which can be expected to remain similar in the future. And finally, everything above mentioned is in some specific context, thus, it is vital to be aware of the market characteristics, the different actors' needs in the system, and the main problems and opportunities. The practical approach towards this issue must be down-top, which is the reason for the Figure 16 inverted position. Moreover, this same inverted logic have already been mentioned as being the "demand chain management" which is the "turning of the supply chain on its head, and taking the end user as the organisation's point of departure and not its final destination" (Baker, 2003).

Next, is defined a more detailed roadmap based on the previous contributions with adaptations, which schematises step-by-step the empirical application further described in this work.

3.3.1 Roadmap

The Figure 18 illustrates the roadmap followed in this work.

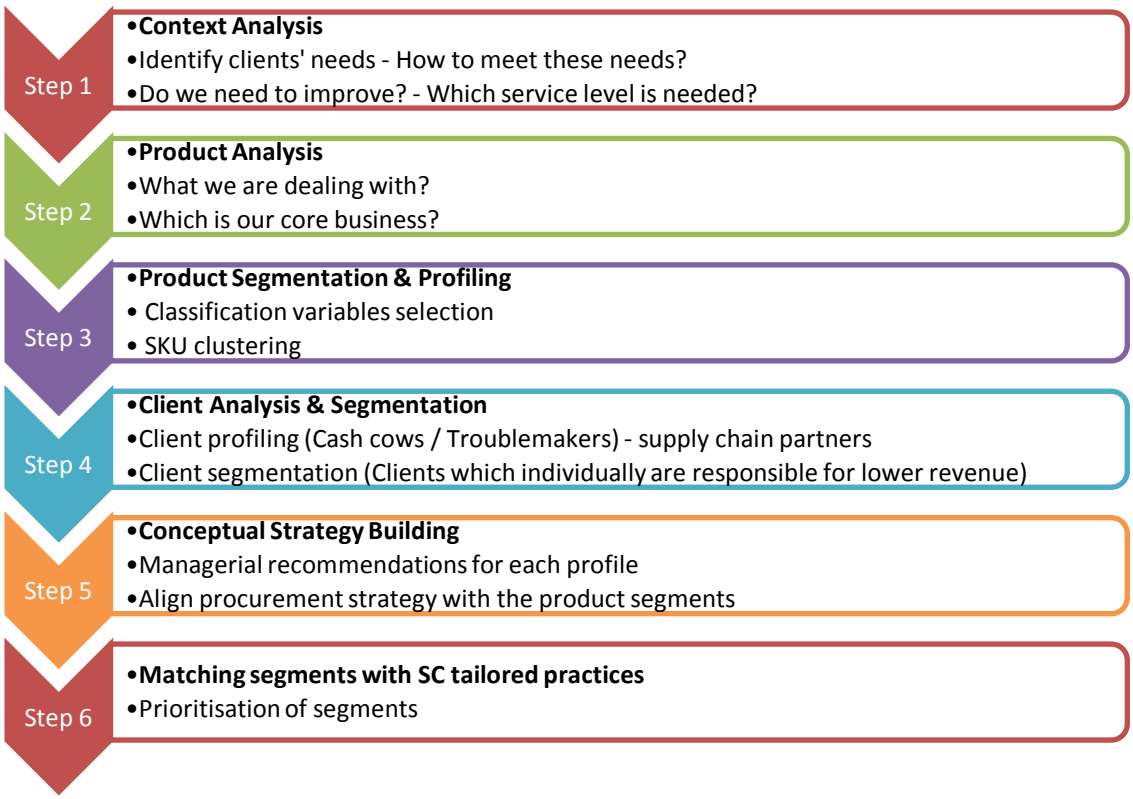


Figure 18: Supply Chain Segmentation model roadmap step-by-step.

SCs are strongly dependent on context (Parnaby, 1995). Context analysis is the understanding of the nature of the customer's needs, which is the ultimate objective of a SC: serve the final customer (Brace, 1989). The best way of gathering information on the context is by means of

open interviews with practitioners (Burns, 2000). Here, the best approach is qualitative research as it is the first exploratory insight on what is the problem, laying the fundamentals for all the further development. In the context analysis it is crucial to identify the customer needs, competitors, and the specifics of the business, products and manufacturing processes. Once outlined and understood the context, we must define how we are going to meet these needs. What we are doing now, what we should be doing and what the client is expecting from us. The final question of the first stage of the present workflow is the simple question: "do we need to improve?"- Mostly because if the client is expecting, for example, a service level of 90%, he will not be much happier if we spent resources on offering him a "better", service level of 99%. It might even be worthwhile to consider lowering service levels if the client agrees as it can bring general benefits and lower prices to all the parties of the chain. This requires negotiation as neither party is interested in service levels which are less profitable in the long-term perspective (Christopher, 2011).

The second stage concerns the product portfolio. What we are dealing with? We are certainly producing different products, for different markets, with different components. It is critical to identify and categorise our product portfolio so we do not pursue further comparisons and quantitative analysis on products that cannot be compared together, e.g. business to business products have too different demand patterns and characteristics from those of business to customer (Blocker & Flint, 2007), as the former presents batching, less numerous and orders in higher quantities. Once separated the portfolio into segments, it is important to assign differentiators on each SKU so during the analysis it is possible to filter as needed. In this step, we need to identify our core business, what we will be looking at because segmentation is suitable for numerous entities. In cases when there are not enough products to justify segmentation, individual profiling must be done instead (Wedgwood, 2006).

The third step focuses on the classification variables. From the identified pool of variables, we must select the ones that might apply and define its respective metrics. There are different degrees of importance for each variable. The most effective way is to perform the first triage logically and only after analytically. It might be needed to assign new case specific variables to the analysis, which reflect the business particularities and come up during the context analysis phase. Each variable hold different discriminant power and for successful segmentation the ones that provide clear distinction between groups are recommended. This phase is dependent on the availability of data, thus it should be regarded to the historical data of the company, e.g., the last year of activity on the SKU/order level of detail. After classification variables selection, cross comparison and correlation analysis must be done. Once aware of

the dependencies, it is now possible to perform cluster analysis grouping similar items accordingly to different sets of classification variables. There should be a rational limit of the number of selected variables, being the most successful combinations that are possible to represent graphically because it eases the visualisation of the process and it outcome, thus, bi-dimensional or tri-dimensional comparisons are recommended, e.g. volume vs. variability plots (Godsell, et al., 2011; Vitasek, et al., 2003), which may be enriched with fourth and fifth dimension as symbol or proportional coding (e.g. bubbles). Visual analysis should be regarded as one of the most important methods because human visual pattern recognition is much more powerful than any artificial methods, as it can provide guidance on what might be the right path to follow in the exploratory phase.

The fourth step focuses on clients. As SKUs are now characterized, they affect the respective clients' profiles. Classification variables which are related to both product and demand, such as average sum of ordered volume, characterise the client on a global level when we consider his orders or ordering patterns. Consequently, key clients arise as well as outliers which are likely to be causing different sorts of issues. The first ones should be profiled rather than segmented as they are responsible for a significant share of our business, thus, extra managerial effort is justified. Key clients are important business partners and strategic partnerships enabling better information sharing, long term agreements and integration efforts are most benefitting. Along with the key clients, there might come up problematic clients, e.g. those exhibiting demand patterns that hold a negative impact on our business. For those, it is worthwhile to look for possible causes for such behaviour characteristic and possible improvement measures. "Troublemakers" can be considered as important/critical as key clients as the disruption's magnitude might be similar. As for the rest, least significant clients can be segmented accordingly to recognizable patterns and dealt in groups.

Step five, concerns on the practical output of the former analysis, it the strategy building phase. To each segment or profile, both for client and products, should be matched a set of SC 'tailored practices' (Lapide, 2006). This is one of the most important steps as it will enable the integration of the analysis with the processes. It is worth noting that high degrees of complexity in the profiles and segments can be negative. Thus, it is recommended to keep a certain level of simplicity so to ease its application. The second part of this step concerns the strategic alignment of the total SC, right from the raw material sourcing to the end customer. This approach enables to affect the raw components of each product with its profile characteristic though the bill of materials as a key. This way, we are highlighting key-components common to many products as well as the specific ones. By characterising, for

example, raw components with the characteristic of the sum of monthly volume and average variability of its demand, it is possible to distinct both volume and stability of its need which may be used for better procurement strategy based on the real demand shifting away from the price driven models such is the example of Kraljic's matrix (Kraljic, 1983) which is criticised for its price focus and hostility towards suppliers (Gelderman & Van Weele, 2005). The section closes with SC control, namely the key performance indicators. This approach towards SC strategy requires the definition of different control targets for each segment enabling control and monitoring, so the performance and improvement can be further assessed.

Finally, the sixth step concerns the match between the segments and the SC 'tailored practices' (Lapide, 2006) assigned in the previous step. This it is meant to work as a roadmap of managerial priorities adapted to each segment specifics as well as its prioritisation.

The roadmap is meant to support quick context scan followed by managerial recommendations and once the first cycle is complete, the following only concern about what changed what makes it less times consuming and efficient. Re-segmentation based on the latest demand records addresses segment instability (Blocker & Flint, 2007), leading the global SC towards adaptability. (Figure 19)

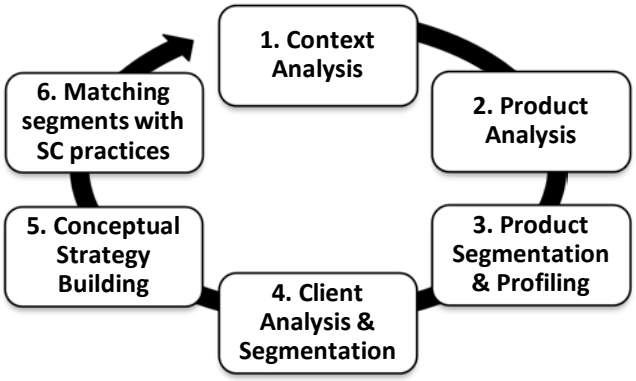


Figure 19: Roadmap cyclic nature

3.4 Chapter summary

The chapter defines the roadmap which structures the case study, underlining the key concepts behind this approach, e.g. the splitting of the SC flow into separated flows, each matched to the context, namely product or market characteristics. Its extent to both ends of the supply chain as well as cyclic nature is essential for its value understanding, enabling so a number of advantages as well as enhancing its cross applicability to other sectors.

4 Case Study

"In reality, all arguments from experience are founded on the similarity which we discover among natural objects, and by which we are induced to expect effects similar to those which we have found to follow from such objects. And though none but a fool or madman will ever pretend to dispute the authority of experience, or to reject that great guide of human life, it may surely be allowed a philosopher to have so much curiosity at least as to examine the principle of human nature, which gives this mighty authority to experience, and makes us draw advantage from that similarity which nature has placed among different objects. From causes which appear similar we expect similar effects. This is the sum of our experimental conclusions."

– David Hume (1748) in *An Enquiry Concerning Human Understanding*

4.1 Chapter outline

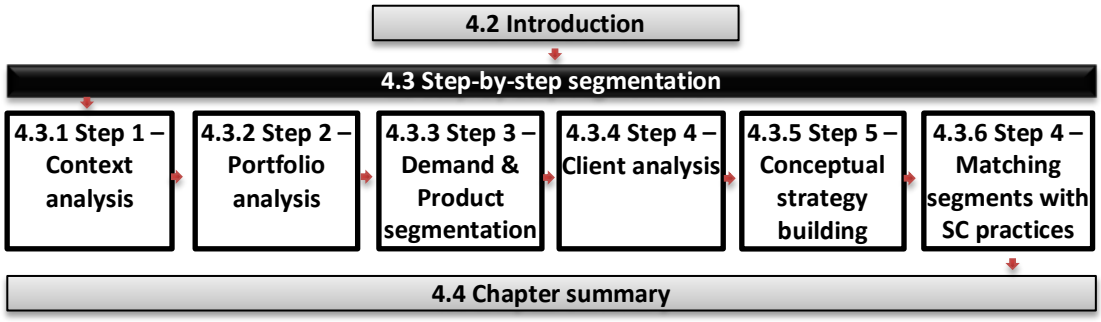


Figure 20: Chapter 4 structure

The case study chapter, as illustrated in Figure 20, regards the empirical walkthrough the case using the previously defined roadmap. Following the 4.2 introduction stating why this particular case interesting and suitable for segmentation. Next, 4.3 step-by-step segmentation, is described in detail how the case was carried on regarding each step. The chapter closes with a brief summary (4.4) underlining the core outcomes of the empirical research.

4.2 Introduction – Why is the particular case interesting?

This study is based on the empirical application of the previously described roadmap on a food industry. Focused on the business to business market segment (B2B), the company produces fruit composites in a tailor made basis for the food industry being one of the top European players. Its portfolio has a wide range of food applications like dairy products, ice-creams, juices & beverages and also industrial pastry. Founded more than two decades ago, it

supply's the major players in the food industry. Besides the B2B segment, the company is also working on business to customer products, however it is a minor share of its business.

In order to maintain the required confidentiality, the company will be kept anonymous, under a fictitious name of "SWEET". The presented data is distorted and codified; as it is shown with an illustrative purpose only. However, all the conclusions drawn are real, being based on the true data and output discussion and interviews with practitioners.

Concerning the interest of this case study, after a brief literature review on food SCs and business to business segmentation, three key gaps arose.

Firstly, food industry, more specifically food SC management has received little attention in the literature despite the fact that food sector hold a major relevance in nowadays world and the possible reason may be the difficulty caused by product and processes specifics, which consequently limit the SC integration (Ronga, et al., 2011). One of the major concerns in the food SCs is maintaining high food qualities which are dependent on environmental conditions, storing and transportations (Labuza, 1982), fact that is even more critical when these chains are business to business oriented. Flows of products with different attributes and different end customers should be delivered in different distribution channels as one of the main drivers for SC management in the food industry is the integration of product quality and logistics, named "quality controlled logistics" (Vad Der Vorst, et al., 2007). This suggests that the further practical application is beneficial as it covers one of the actual problems in the food SC management: The matching different SC flows with product and customer characteristics.

Secondly, business to business segmentation is also an immature field of studies (Blocker & Flint, 2007; Steenkamp, 2005) and constant requirements change makes it much more instable than the business to customer segment (Mitchell & Wilson, 1998; Achrol & Kotler, 1999). Thus, accordingly to Blocker and Flint (2007) segment instability (SI) is one of the major problems in segmentation (in particular for business to business) and its external drivers are pointed as being: 1) macro-environmental; 2) downstream customers; 3) suppliers; 4) competitors – Resulting in several outcomes: a) Customer need-offer mismatch (supply-demand mismatch); b) market-strategy mismatch; c) resource allocation mismatch; d) market performance impact. And, the SC strategy building based on segmentation, addresses most of this issues as it concerns both downstream customers and suppliers, and its purposes, besides serving the customer need, are to reduce the supply-demand mismatch as well as better strategic alignment. Finally, the proposed roadmap can be used as a regular diagnostic check tool to

constantly re-assess segments based on the most recent demand history partly solving the problem of demand dynamics (Goller, et al., 2002).

Finally, to summarise the interest of the proposed roadmap application in business to business food industry is that, besides the core research questions of this thesis, it addresses three particular research gaps in the literature: a) food SCs; b) business to business empirical segmentation studies; and c) segment instability as it is based on demand's latest history data. These will be regarded as research sub-questions.

Next, follows step-by-step description of the empirical application of the proposed roadmap.

4.3 Step-by-step segmentation

4.3.1 Step 1 – Context Analysis

The first step concerns the context analysis, first the identification of the clients' needs, followed by ways of meeting these needs, finishing with the simple inquiry concerning the problems and if there is any need for improvements.

SCs without the context are vague abstractions. Thus, for its understandings it is critical to gather information describing internal and external factors. SC strategy is part of a more general, business strategy (Porter, 1985).

Porter (1979), in his seminal work about business strategy states that the essence of strategy formulation is coping with competition, thus, the state of competition in an industry depends on five basic forces. Considering five forces governing competition in an industry, the focus is on the bargain power of customers and suppliers, thereat of new entrants and substitute products/services, while in the middle is the industry which is jockeying for position among current competitors. (Figure 21)

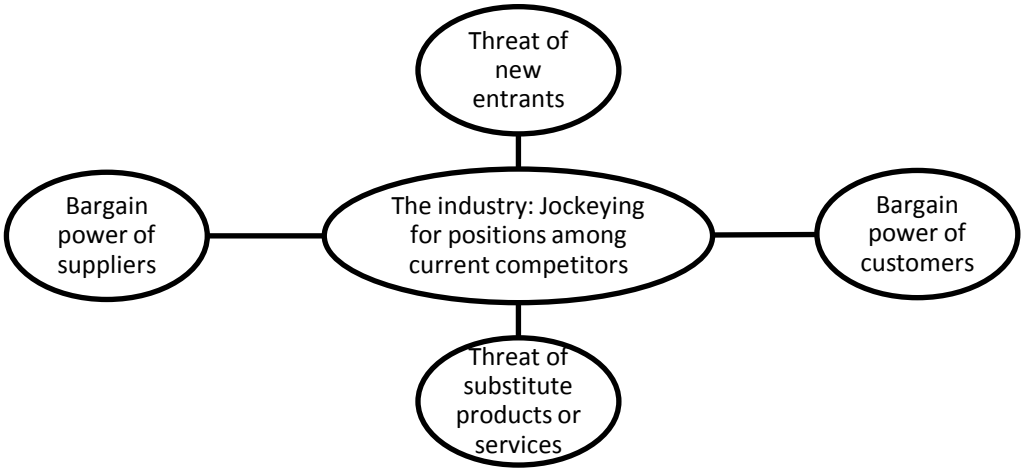


Figure 21: Porter's five forces governing competition in an industry (Porter, 1979)

This particular case, concerns a food industry. The best word to describe it is: "Responsiveness" – working on a pure MTO basis (Figure 22) and ETO for new product development. As, accordingly to the statement of the SC manager:

"…what the client wants, we deliver it. If he wants star shaped Earliglow strawberries collected at 6 o'clock in the morning on the southern side of a mountain in a specific place of the world, we will engineer a process and find what is needed to deliver him that star shaped Earliglow strawberries…"

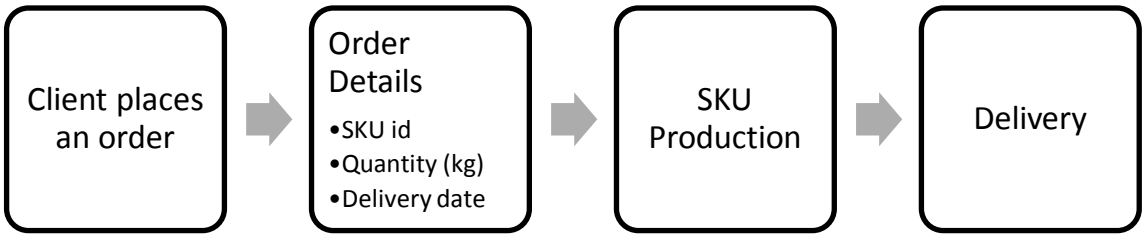


Figure 22: Normal ordering process of a regular SKU

The company is one of the major European players in the sector and there are virtually no direct competitors in the region. Operating in two different markets, European and North-African, SWEET does not face major threats neither concerning new entrants nor substitute products as its key business is B2B (about 94% of the products) of highly specific products (fruit composites that are used as raw component in other products). As far as bargain power is concerned, on one hand some customers hold great power as they are few and very heterogeneous, e.g., there is a client which alone represents more than 50% of the company's business. Yet, the company is always a strategic supplier, fact that eases negotiation and enables strategic partnership and closer business relationships, i.e. the client usually hears what SWEET have to say. On the other hand, there are numerous minor clients who cause most of the great variety (each SKU is exclusive to only one client), because of the generally lower volumes of consumption, it causes instability and affects negatively the SC. This majority of small clients have products located in the low volume high variability zone. Regarding suppliers, it is mostly a mature and stable market which does not present any serious supply issues. Additionally, the bargain power is most of the times on the company's side which is a key enabler for demand driven approach. Thus, the major risk factor for supply is SWEET's own instability of needs and this plays the key role for procurement strategy development as the scarcity of a raw component can delay the whole manufacturing process. Due to the fact that this company does not have any direct competitors in its market region, both the geographical position and excellence makes it a dominant and probably unique. All this suggest a very positive idea, however, the company grew too fast and the SC is gradually less

capable of keeping up, which soon will turn into a major issue e.g., lost opportunities, waste, loss of clients, and others.(Figure 23)

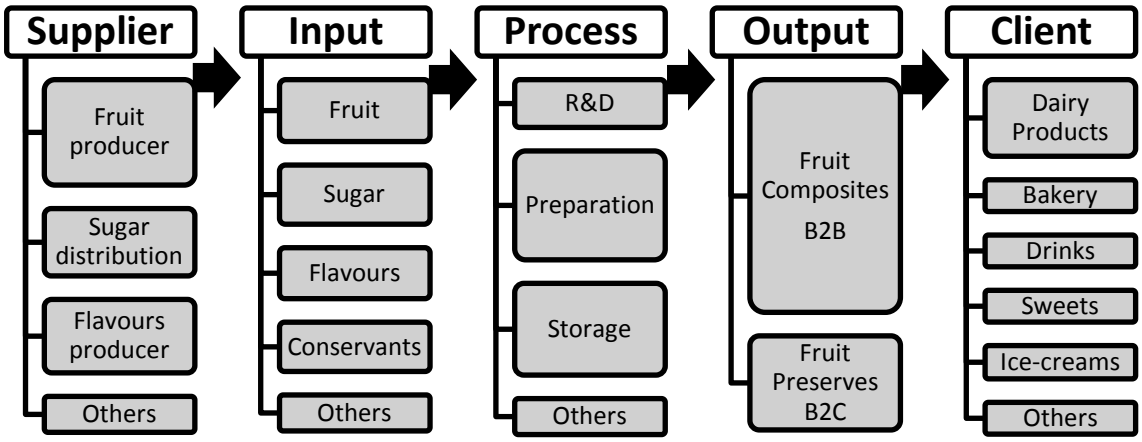


Figure 23: Company's SIPOC representation

Holding a very high variety of different products (almost one thousand SKUs), and more than one hundred clients, it works on a pure MTO basis offering total customization and very strict quality requirements. As it deals with food, time windows for delivery are pre-agreed and often short (mostly about 20 or 30 days after production) as the product itself normally have a short shelf life. And to the moment of this writing, there is no forecasting at all, neither late differentiation nor postponement.

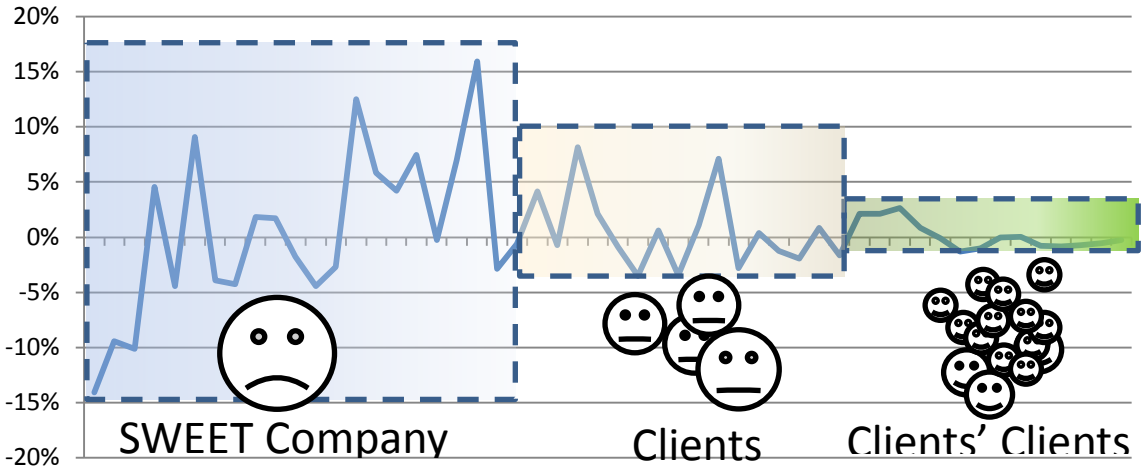


Figure 24: Illustration of demand amplification through supply chain tiers

Demand unpredictability reflected through demand spikes causes well known problems like bullwhip effect in which demand variations downstream in the SC result in huge inventory build-ups upstream at the supplier's levels (Forrester, 1961; Lee, et al., 1997) as well as "boom and bust" effect along SC (Sterman, 2000). Due to the fact that it is B2B, its position in the chain takes the Bullwhip effect at its maximum (Figure 24). All this is the consequence of order

and production batching, client's poor inventory management, lack of visibility and information sharing (Lee, et al., 1997); the company must bear volatile and unstable demand. Along whit that, there are known patterns of demand. Besides seasonality, clients' marketing strategies, e.g. summer promotions, are causing a great deal of instability in the SC.

Last year scenario	
Max Weekly Peak	96,28%
Annual capacity usage	74,88%
Installed annual capacity	
Industrial units	**%**
Unit1	9%
Unit2	54%
Unit3	9%
Unit4	9%
Unit5	20%
Total	100%

Table 7: Last year scenario and the installed production capacity

Concerning the service level, the company is now holding the perfect order rate of 95.9%; however, it delivered 98.8% of the ordered quantity. This is a satisfactory service level for the case and client expectations are well served accordingly to the SC manager. The customer needs are simple and regarding the fact that the company operates on a totally responsive basis, this can be considered positive indicators.

The Figure 25 shows the client's contrast regarding sales volume. Out of the total 103, five clients represented 80% of the annual business. This is positive because SC management is easier with fewer entities. Key clients are likely to be suitable business partners for strategic partnerships (the SWEET company is always regarded as a strategic supplier). It eases SC practices such as information sharing, direct replenishment, and other various forms of client integration. On the other hand, the other 83 clients share represent only 20% of business, thus, its high fragmentation requires client segmentation and a more generalised approach.

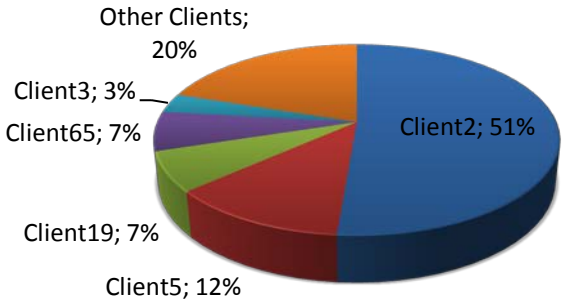


Figure 25: Annual revenue per client

In spite of dealing with such volatility, agility is attained by excess of manufacturing capacity so the company can bear the demand peaks, i.e. the surge demand is absorbed by free capacity. There are five industrial units strategically located in both focus markets, with different capacities and orders can be transferred between units, however, it can be constrained by geographical factors or client's specification. Last year average capacity usage was about 75%, producing more than 40 million tonnes. The possible problem, however, lies in the demand peaks which cause increased production. The maximum production peak reached more than 96% of the total SWEET's capacity (week 19 in the Figure 26), which is a serious risk because once SWEET runs out of capacity, it will be unable to satisfy customer orders and given the fact that is a strategic supplier, this is likely to seriously disturb the SC downstream. (Table 7 & Figure 26)

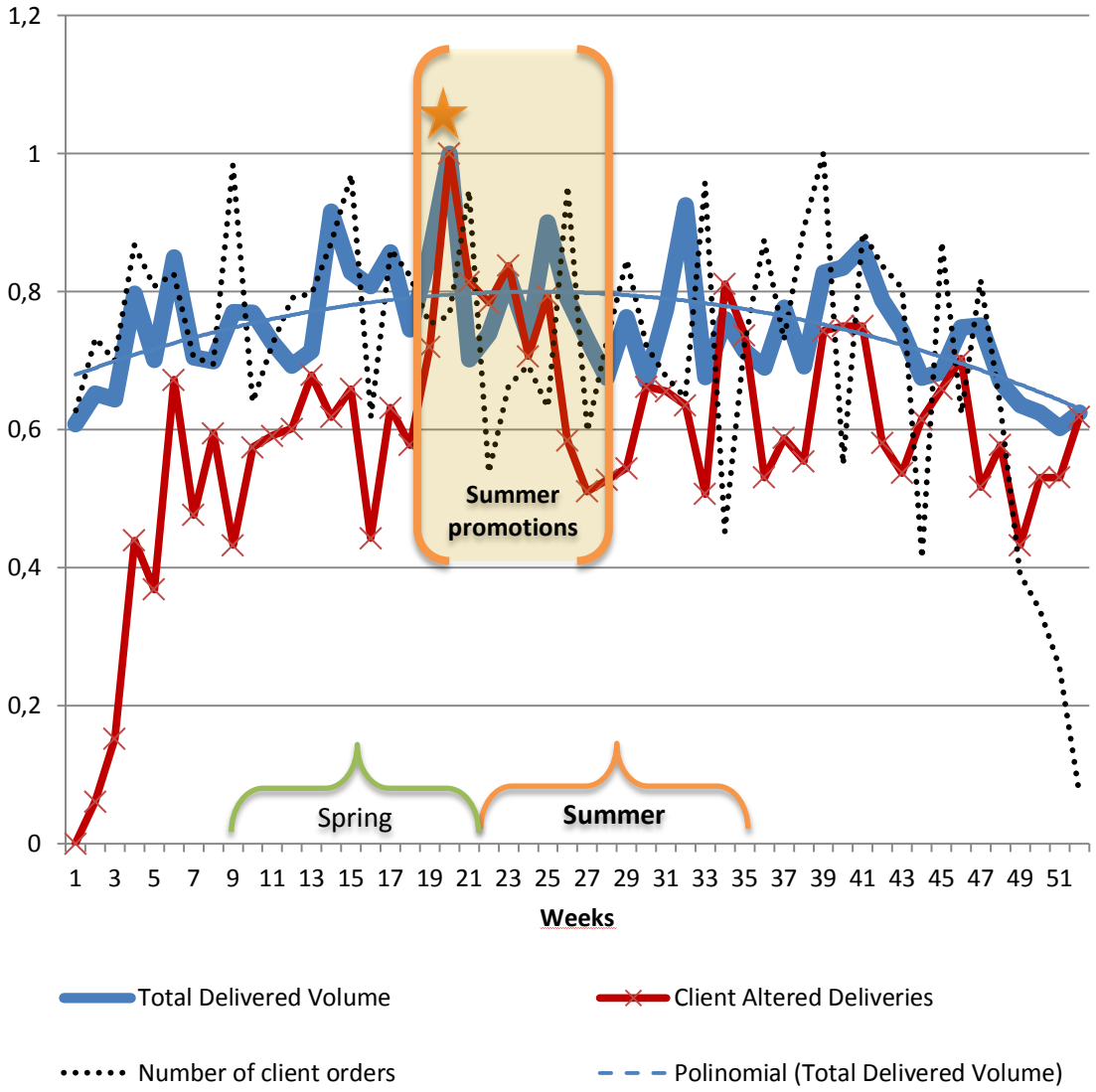


Figure 26: Annual production, orders and client altered deliveries (normalised)

The need for production levelling is eminent. Running out of capacity is not an option as the client expects the company to deliver almost faultlessly all year long. One of the identified reasons for production peaks was the number of order corrections done by the client as the ratio of corrected orders has a positive and strong correlation with delivered production pattern. The top three order corrections are: firstly, the delay of the delivery date (about 32%), secondly, the anticipation of the delivery date (about 19%) and finally, production planning (13%). Worth noting that the production planning is dependent on orders, so this is directly related to the client demand behaviour and not only an internal constraint. Thus, the demand causes all the instability with its patterns (variability) and also clients' managerial actions such as order corrections which heavily disturb the manufacturing scheduling and finally, procurement or raw materials. The Figure 26 shows that the number of client orders is stable through time; however the delivered production is greater and more variable during summer (2^{nd} degree polynomial regression of total delivered volume) and of the delivered production peaks are related with the client altered deliveries. Thus, the most evident example of this problem happened in the 19^{th} week, when the delivered production volume almost reached its capacity limit while the number of altered deliveries by client also hit the top.

Finally, the context analysis closes with the simple question: "Is there any need to improve?" As an answer, the problems are summarised: i. Business is growing faster than the SC maturation; ii. SWEETs' clients are facing many market problems which causes demand volatility and hostile marketing strategies; iii. Soon the installed capacity will not be able to bear the present variability;

Following the context analysis and major issues identification, follows the portfolio breakdown. This because segmentation relies on entities and its attributes, thus, it is critical to understand what the company is dealing with.

4.3.2 Step 2 – Portfolio Analysis

Before performing the analytical approach on the data, different products must be treated differently as for example B2C segment have a much greater time window for delivery than the B2B. The reason for prior portfolio segmentation is that many errors and misinterpretations might occur when we analyse quantitatively too heterogeneous products, mostly evident through some nonsense correlations between different variables.

The given portfolio had almost one thousands of different SKUs, each SKU was assigned to only one client and each client usually had more than one SKU.

The requested data contained the SKU characteristics, e.g. the assigned client, kind of business segment, its final application, key composition, price, storage and transport particularities as well as other. Following a preliminary descriptive statistical analysis, the key segment came up. The major business segment of the focus company is business to business, fruit composites for dairy product application. (Figure 27)

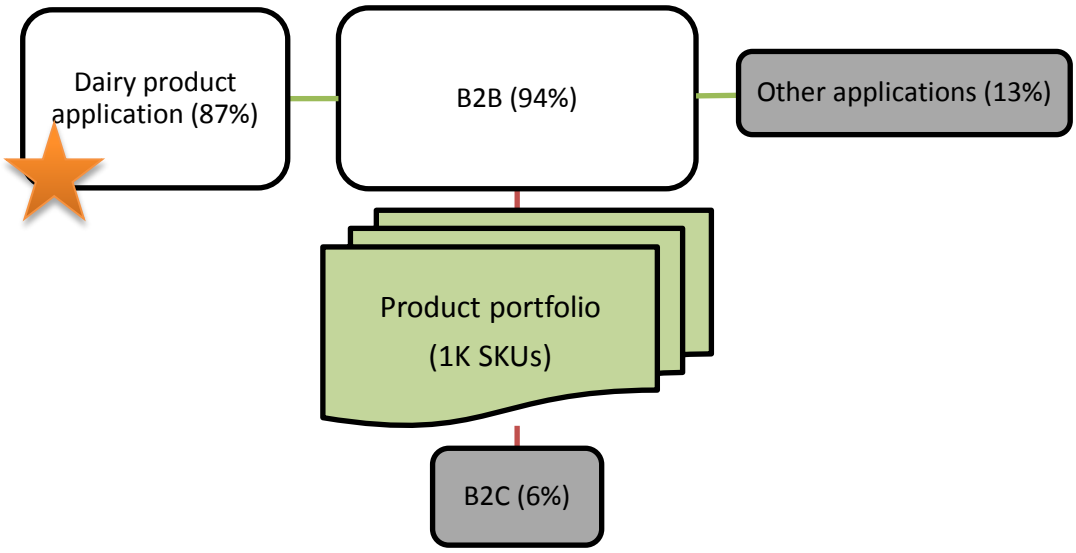


Figure 27: Portfolio organization and the selected segment of products

Due to the very high variety of SKUs, for better understanding of how different are the products, the following analysis relied on a visual statistical technique named Multidimensional Scaling (MDS). MDS is a powerful approach for information visualization for exploring similarities or dissimilarities in data. It starts with a square matrix of item similarities which is transformed into special N dimensional coordinates by means of MDS algorithms. This work used the classical MDS algorithm also known as Torgerson Scaling, which seeks a configuration which minimizes the loss function (strain). Once attained the SKU bill of materials (BOM), it were transformed into a global Boolean list where rows contained all the raw components and columns the SKUs. Cells held values 1 or 0 which showed if that component was part of the composition of some particular SKU. Next, the above mentioned SKU-BOM Boolean matrix was transformed into a proximity matrix (Appendix 1). All the SKUs formed square symmetrical matrix and the cells represented the number of common components between each pair of SKUs. The application of MDS for product analysis is so far unknown and was considered to be very suitable by the managers because it shows graphically how similar different products are, based on the number of common components, delivering solid arguments to assist strategic decisions. Recognised its utility, further application of this method is justified.

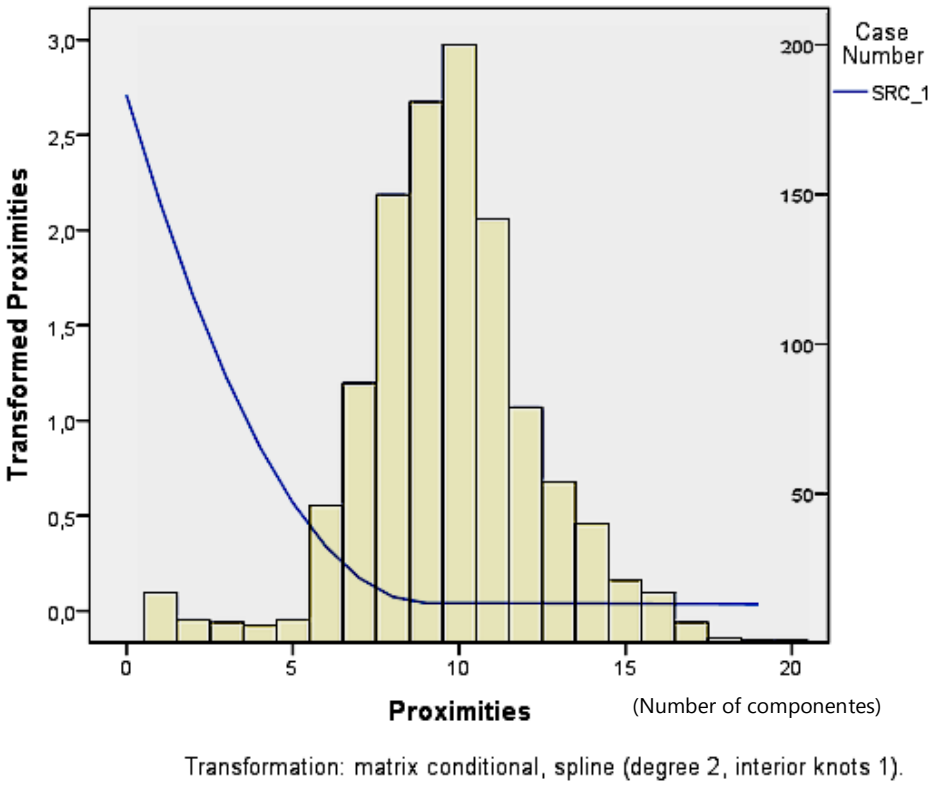


Figure 28: Proximities transformation plot and number of components histogram

The attained proximity matrix of 1074x1074 SKUs and the respective similarities was transformed by means of the spline (second degree, one interior knots), a thousand random starts seeking for the lowest stress and ten thousand iterations. The proximities transformation plot can be observed in Figure 28, which interpretation is that products with less than about eight common components are widely spaced while those with more than eight common are very close. The limit about nine common components was established mostly because the number of components in each SKU ranges between two and twenty and the average is between nine and ten (standard deviation of 2,77 components), which indicates that 50% of the SKUs have from eight to eleven components, for a boxplot and histogram regard Appendix 6 & Appendix 7.

The use of multidimensional scaling methods, namely ProxScale routine in IBM SPSS resulted in the output of Figure 29 where the SKU final application is highlighted. As the figure suggest, most of the SKU's are proximate (common components). Another interesting feature of the MDS output is the emergence of natural clusters of common application SKUs, e.g., application in "sweets" is concentrated in the bottom of the main cluster as well as the agglomerates of "bakery" and "drinks".

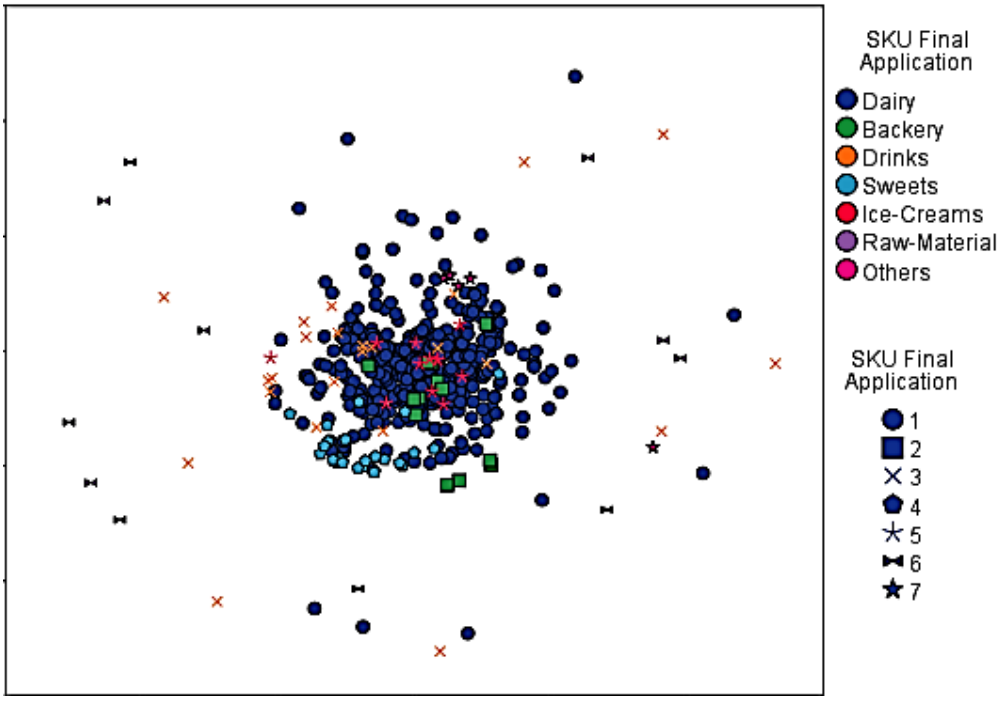


Figure 29: Portfolio representation and its final application

As an answer to "which is the core business", it is clear that this particular analysis and further work focuses on the B2B segment, specifically on the dairy application products as they represent the greatest portfolio share (87%), thus, considered to be the core business of the company.

4.3.3 Step 3 – Demand and product segmentation

The third step of the roadmap concerns the demand and product segmentation. Once the portfolio is understood and the key segments identified, follows its analysis. Cluster analysis is the process of assigning set of objects into groups regarding its similarities. It is not an automatic task, thus the best method and number of clusters is achieved through an iterative process of knowledge discovery involving trial and failure. It is critical to realise what is the desired outcome of such analysis as there is no "right" or "wrong" result. Initial approach towards this technique, requires the careful selection of possible discriminative variables. During this phase, the involvement of practitioners is crucial, so it is possible to speed up and direct the trials towards a more logical way.

The chosen clustering method was Ward's Method measuring the Squared Euclidean Distance between elements. The first approach on clustering, once the variables are selected, should be hierarchical so it can be decided the best number of cluster. There are many methods of

deciding on the best number of clusters; however, this analysis focused on the dendrogram[3] representative of the distance between items.

It is also important to keep the number of clusters as low as reasonable. The suggested number of clusters should vary from 1 to the number of classification given by the factorial of the number of variables, to allow the maximum number of combinations, i.e.:

$$Number\_of\_Clusters = Number\_of\_Variables!$$

The selection of classification variables started from the full pool of variables. Some variables did not apply at all; others held a lower importance, while some was considered to be critical. Due to the business particularities, it was considered to add new variables to describe on of the previously identified problems: the order changing which causes production peaks and disruptions.

The best way of understanding why order changing is important is to imagine the simple flow of delivery: Sixty days before the delivery, the client orders a one tonne of product to be delivered in a specific moment, the company starts the planning, assures that every component is available, orders what is missing, as soon as the delivery date is coming closer, the production plan is scheduled and meantime, for some unknown, the client wants to postpone the delivery by, for example, five days (company's full working week). This causes waste and disturbs other SKU production planning (keep in mind the big picture: almost one thousand active SKUs in the portfolio), while each setup requires the complete line cleaning, fresh raw components and other particularities which are critical in food SCs for best quality and norm compliance. In the end, the client's demand variability might be low, yet, this "good" variability hides a unsettled demand which probably causes more SC disturbance rather than need variability, in some cases.

Order Corrections (OC_{ratio}), or unsettledness can be expressed through the number of corrected orders divided by the total number of orders for some specific SKU:

$$OC_{ratio} = \frac{\#\ Corrected\ Orders}{\#\ Orders}$$

When the OC_{ratio} is greater than one, it suggests that the client changed the same order more than once. Yet, it is important to note, that SC agility is the best way of dealing with the negative impact of the order unsettledness. However, it might be less expensive to address

[3] A dendrogram is a tree diagram used to represent the arrangement of clusters produced by hierarchical clustering methods.

the problem source on the client's side rather than adapting the whole SC to meet the client's problem.

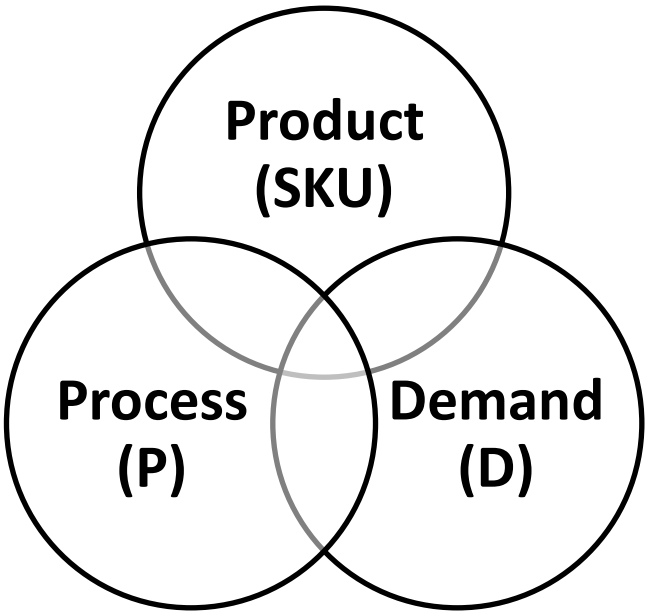


Figure 30: Categorisation of the classification variables

Each variable group is further organised accordingly to the proposed categorisation represented in Figure 30 as being product, process and demand, as well as the intersections, which is discriminated in the "domain" column. In addition, each variable is referred the classification (quantity or quality) and its units (when applicable). The importance gradation, although it is not analytically validated, is considered as the most important categories are those which company cannot control nor have significant influence. This because process, for example, is (or should be) managed in spite of the demand needs and product characteristics, as well as product is what the demand needs, thus its characteristics are derived from the demand. Finally, demand is the most independent domain due to the fact that the client's needs are based not in the supply but in his clients, SWEET's client's clients. In contrast, while it is possible to create and boost the need through marketing strategy in the B2C segment, in B2B segment it is very unlikely to happen.

The initial variable triage was performed in an open interview with the company's SC management team. After the preliminary selection, the selected segment of the portfolio was analysed. During the first runs, some variables showed less discriminative, thus discarded further.

Demand domain concerns the clients' characteristics listed in Table 8. One of the most important categories as it is out of the company's control. A client is characterised by the

number of different products he is buying (variety), the global volume (either kilograms or currency), demand behaviour which is the average variability as a way of characterising the flow "turbulence", and the order changeability which accounts for the client's planning and inventory management performance.

Classification variable	Classification (units)	Domain	Observations	Importance
Variety	123 (# products)	D	Property such as variety, is useful for both segment and client characterization. High variability often means more setups, lower volumes, higher variability, less economies of scale. Its reduction is critical.	**High**
Global Volume	123 (Kilograms)	D	The global volume per client indicated its strategic importance. Similar to pareto analysis, when the price of products is homogeneous, this can be used for client characterization.	**High**
Global Variability	123	D	This dimension reflects the clients' inventory management capacity. Low global variability means that the client has an efficient inventory management system. In contrast, high value can justify companies' involvement with clients and implementation of measures such as information sharing, direct replenishment, forecast sharing, etc.	**High**
Global Ratio of Order Corrections*	123	D	This characteristic weights the clients overall performance for planning and inventory management. It was found to be critical for production flow stability.	**High**
Impact/ Demand pareto analysis	123 (Currency)	D	Just like global volume, this is price related and reflects the strategic share of business addressing some particular client. This can be used to access the client importance.	**High**
Customer Expectations	ABC	D	All the clients expect to be served on time, with the right quantity, on the right place with the highest service level possible as we are his strategic supplier. There are no other options.	**Low**
Nature of demand	ABC	D	This dimension encompasses all the previous on a more generalise level. When we are able to gather information concerning the previous, this dimension loses importance.	**Low**
123: Quantitative **ABC: Quantitative**			**D: Demand** *** New case specific variables**	

Table 8: Classification variable selection – Demand

Next, follows the intersection zone of product and demand domains seen in Table 9. It is the insight on the discrete demand on the SKU level. It is the starting point for some of the clients' global characteristics. Here, besides the already mentioned volume, variability and

order changeability goes ordering frequency along with SKU life cycle phase (might be also considered as duration). Ordering frequency is strongly related to the finished product delivery frequency (Table 11), which was considered a more important classification variable. Regarding life cycle phase or duration, in this particular case, is inconclusive as after a number of demand series through time, showed that new products often started at the average demand level and were discontinued abruptly, fact that might be related to being B2B.

Classification variable	Classification (units)	Domain	Observations	Importance
SKU Volume	123 (Kilograms)	D/SKU	This is the monthly average volume in kilograms of some specific SKU. High volumes mean higher production capacity usage, thus better production scheduling and levelling, allowing make-to-forecast strategies. Low volumes mean more frequent setups. This variable, most of the times show a negative correlation with the respective variability.	**Very High**
SKU Variability	123 (no units)	D/SKU	Variability is a measure of instability. Does not reflect the volume as it is obtained through the standard deviation divided by the mean. High variability mean less predictability while low variability the opposite. Normally it presents a negative correlation with volume. Spikes affect capacity utilisation and the production techniques.	**Very High**
Order Frequency	123 (# order/year)	D/SKU	The number of orders per year or per month indicates how often the client orders some specific SKU. High rate of orders mean more setups thus more waste.	**Low**
Ratio of order corrections*	123	D/SKU	This particular variable, reflects the how efficient is the clients planning of his needs. Order changes cause a negative impact in the operations management because it disturbs the production scheduling, purchasing and distribution causing risks of running out of capacity.	**Very High**
SKU Life cycle phase	ABC	D/SKU	Given the fact that it is mostly B2B, there is no explicit product lifecycle phasing.	**Very Low**
123: Quantitative **ABC: Quantitative**			**SKU: Stock Keeping Unit** **D: Demand**	

Table 9: Classification variable selection - Demand & SKU

As far as products (SKUs) are concerned, classification variables listed in Table 10, SKU price and complexity were considered having a low importance, this because of the global portfolio homogeneity concerning that characteristic. As already mentioned in the context and portfolio segmentation above most of the product had a similar price as well as complexity.

Additionally, life cycle duration was not considered relevant by the practitioners due to the fact that is was believed to be almost random. However, its characteristic needs further development and validation. However, SKU final application was considered of primary importance, mostly because after analysing each of the segments, they revealed very different demand patterns, thus, it is used to perform the initial triage of products prior to any demand segmentation.

Classification variable	Classification (units)	Domain	Observations	Importance
SKU Impact (Price)	123 (Currency)	SKU	This is the unitary price of an SKU. Given the fact that the price of SKUs is similar, its volume is more important because it is more important in the operations and management planning rather than the price.	**Low**
SKU Complexity	123 (# components)	SKU	The complexity of a SKU can be expressed through its number of components and recipe steps quantity. In this particular case, the selected segment show a homogeneous number of components and the recipe was unknown.	**Low**
SKU Final application*	ABC	SKU	Different SKUs require different variables and cannot be compared all together. This classification variable is important as a starting point to make the triage of items.	**Primary**
SKU Life cycle duration	ABC	SKU	The SKU lifecycle is considered homogeneous but impossible to predict accurately. Given the fact that each SKU have only one client, it is fully dependent on one particular client what makes this kind of predictions useless for the case.	**Low**
123: Quantitative **ABC: Quantitative**			**SKU: Stock Keeping Unit** *** New case specific variables**	

Table 10: Classification variable selection – SKU

Regarding Table 11, it is the intersection of both process and products. Time window for delivery, in this particular case, was pre-defined by the client in the supply contract, thus it usually followed a pre-set duration which is inconclusive for segmentation. About minimum run size, it would make sense in this particular case, however, one of the company's key particularities is total responsiveness and is part of the organisational culture: "to satisfy any client's need" – thus, there is no limits on the minimum run-size, if the client orders only one kilogram, he gets it anyway. Finally, point of product configuration is not applicable for the case, as the whole process right from the beginning differentiates the product, and there is no postponement or late differentiation, what means that almost everything is runs on demand.

Classification variable	Classification (units)	Domain	Observations	Importance
Time window for delivery	123 (days)	P/SKU	The time window for delivery after manufacturing is agreed with the client concerning the specific SKU. Thus, it depends on the supply agreement and not on the client behaviour, so does not discriminate SKUs.	**Low**
Minimum run size	123 (Kilograms)	P/SKU	One of the key characteristics is the extraordinary responsiveness of the company which works on MTO basis, thus there is no constraints concerning the minimum run size. If the client wants, the company delivers.	**Low**
Point of Product configuration	ABC	P/SKU	Due to the absence of any postponement or late differentiation, each SKU demand flow is independent since the very beginning.	**N.A.**
123: Quantitative ABC: Quantitative SKU: Stock Keeping Unit			**P: Process N.A.: Not Applicable**	

Table 11: Classification variable selection - Process & SKU

Finally, Table 12 regards the process domain. It is hard to name this domain's ownership, due to the fact that it is mostly a compromise between the client and the company. Thus, variables that are set up by means of agreement are partly controllable due to the fact that the company is a strategic supplier what grants the bargain power balance between both parties (Kraljic, 1983). Flexibility, which is in this case, is understood as the time window to produce the good and deliver it is controversial. On one hand, as the actual process logic is MTO, the company is allowed a fair degree of flexibility to perform sourcing and to deliver. On the other hand, those time windows are defined by very strict food industry requirements, the shelf life is limited and clients expect the delivery in a pre-set time window in very special shipping conditions (Labuza, 1982). This leads to the idea that the agreements and process characteristics can be used to segment different clients. However, the company follows a standardised protocol which is similar to most of the products but a few. The suggestion, however, is to reconsider the above variables when the business logic changes, as different segments are likely to benefit from different protocols. For example, in the highly variable, very varied segment, of unpredictable and badly behaved client (poor inventory management), it would be wise to demand for a greater time window for deliver, assuring greater flexibility allowing better planning and production scheduling. This would certainly benefit the company and its SC performance, as combined deliveries and better manufacturing capacity utilisation is likely to reduce SC global costs. The other dimension of flexibility is related to the stock capacity. The amount of raw components and product that

can be stocked allows greater flexibility, because it buffers the demand variability. However, the company does not produce to stock, and everything that is produced, is dispatched as soon as possible to the client. The SC response time was not considered in the analysis because the process times for different SKU production was homogeneous, thus useless to segment. The same applies to change over time, which is standard. Finally, reliability of both supply and delivery, was considered as qualitative, and ignored in this case study because both activities are outsourced.

Classification variable	Classification (units)	Domain	Observations	Importance
Flexibility (Time windows)	123 (Days)	P	The flexibility in food industry is dictated by regulations and supply agreements. There is very low control over flexibility and most is standard for all SKUs.	**Low**
Flexibility (Stock capacity)	123 (Kilograms)	P	There is no make to stock to the moment, so, the stock capacity is useless for the analysis. However, the company can stock products.	**N.A.**
Lead Times	123 (Days)	P	All the lead times are process dependent and kept at the minimum. Due to the lack of information this was not considered in the analysis.	**Unknown**
Frequency of delivery	123 (# deliveries /year)	P	The annual number of deliveries is critical as the formula for variability is strongly dependent on the continuity of demand. There is no point segmenting rarely ordered SKUs. Those are improper for this kind of analysis side by side with other frequently ordered.	**Primary**
Supply chain response time	123 (Days)	P	Working on an MTO basis, the SC response time is an outcome rather than a principle. It is always kept at the minimum and does not change for different SKUs. The delivery date is part of the order which is launched before the real need.	**Low**
Change over time	123 (Hours)	P	The change over time is standard for all SKUs, covering full line cleaning.	**Low**
Reliability of supply	ABC	P	The supply or raw materials is most of the times done in advance and there are no delays due to the lack of raw materials.	**Unknown**
Reliability of delivery	ABC	P	The task of delivering is outsourced. The service level is excellent.	**Low**
	123: Quantitative **ABC: Quantitative**		**P: Process** **N.A.: Not Applicable**	

Table 12: Classification variable selection – Process

Firstly, once the classification variables were critically selected by means of experimentation, groups of variables arose. Those considered as "primary", are variables that are used in the

analysis start-up, as they allow the segmentation of SKUs for segment selection. In this particular case, SKU final application was used to discriminate the core business segment while the frequency of delivery, being the number of deliveries per year, the second condition for selection. Those SKUs ordered less than three times per year were ignored.

Secondly, variables considered such as "very high" importance. These are the main drivers for the first approach towards the issue: The usually applied variables such as "Volume" and "Variability" as well as the case specific "Ratio of order corrections" (also called OC_{ratio}). Those characterise the flux, its stability (uncertainty) and the client's behaviour, which is ultimately related to his capacity to plan the needs and manage his own stocks of raw components.

Thirdly, part of the variables was attributed "high" importance for segmentation. On a higher degree of fragmentation, these focus on the demand looking at the client and its family of products. The first variable, variety, characterizes how much different SKUs are assigned to a specific client of cluster. It is needed to make the further decision on segmentation (mass approach) vs. individual profiling (in cases where the business volumes justify). Global volume represents the volume assigned to a specific client, which is important to assess the client's impact (when affected by the SKU prices). Further, the global variability is an indicator of the clients demand pattern. Steady clients usually are better patterns in the SC as they are predictable while instable ones cause many problems and inefficiency. Following the same logic, there is the case specific variable "Global ratio of order corrections" which expresses the client's performance in planning and inventory management. This group of variables considered as highly important is used in a separate analysis.

Finally, both products and clients are analysed accordingly to its degree of uncertainty (Lee, 2002), reflected through the variability value. All the other non-considered variables presented low importance (as well as the ones which did not applied for this case). The main criterion for its selection was the portfolio/client homogeneity as there is no point in discriminating equal elements. Product complexity (Lamming, et al., 2000) is not important for the case as most of the products are similar in both number of components and manufacturing processes. Concerning product uniqueness (Lamming, et al., 2000), due to the fact that each product is engineered exclusively for each client; they all can be considered as being unique.

There are many different examples, like the Figure 31, of segmentation initially based on the volume and variability (Vitasek, et al., 2003; Wedgwood, 2006; Payne & Peters, 2004; Godsell, et al., 2011; Christopher, 2011). However, a third important classification variable is likely to

influence the first approach on segmentation, the order changeability which is partly responsible for disruptions and lack of production levelling.

First analysis only on volume and variability shown in the Figure 31, suggests that the company can apply lean flows on the high volume with variability below 0.5, leaving the rest as agile and responsive (Bumpy & Crazy Peanuts) as already suggested in the literature (Godsell, et al., 2011; Christopher, 2011). The higher volume with low variability seems to be stable and predictable (Cash Cows) and the mass of SKUs can be regarded as being smooth, thus also predictable. However, segmentation is meant to align demand with best matching SC strategies, and the already discussed variable such is the order correction ratio which expresses the client's stock management and planning performance. Considering that variability is amplified because of the bullwhip effect, the clients management is something that the company can influence, working on clients integration, improving SC visibility and for example, take that particular SKU management under control, granting better availability and smoother flow. Focusing only on volume and variability, managers may be overlooking the real demand behaviour pattern.

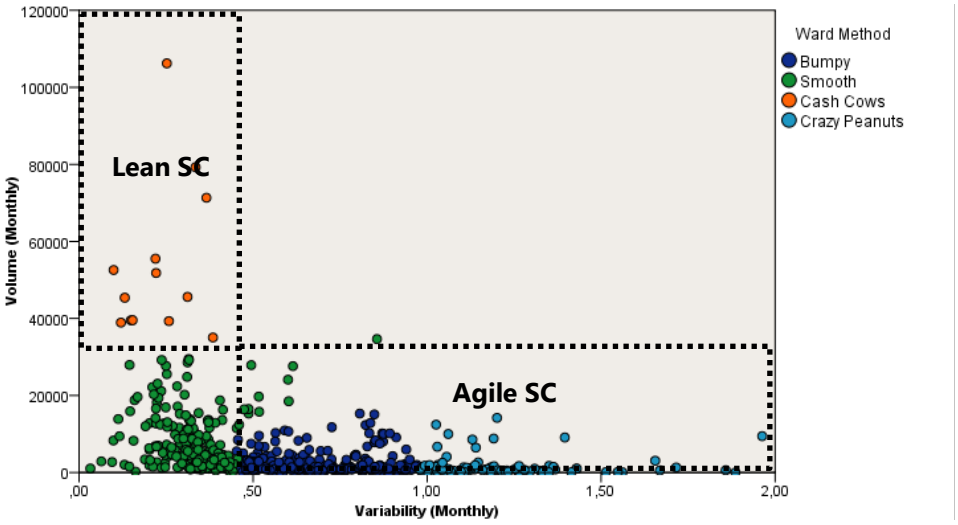


Figure 31: SKU volume & variability plot

In contrast, from a slightly different perspective, the relation between demand stability and client's inventory management performance reveals a hidden characteristic. Client might be causing a greater hassle and waste because of the various order changes, which in the end might be even considered stable by variability alone, regard Figure 32, in particular the low variability and high order changeability ratio.

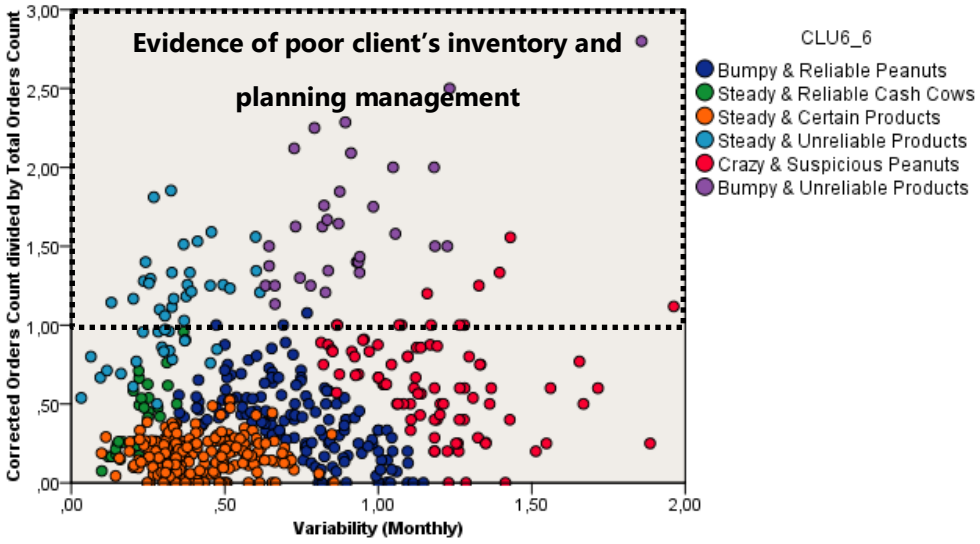


Figure 32: SKU Order correction ratio & Variability

The above mentioned, suggests that plotting a three dimensional plot (Figure 33 and Figure 34) for better observation of volume, variability, order changeability and finally variety which is visible by the number of entities in each group (explained further).

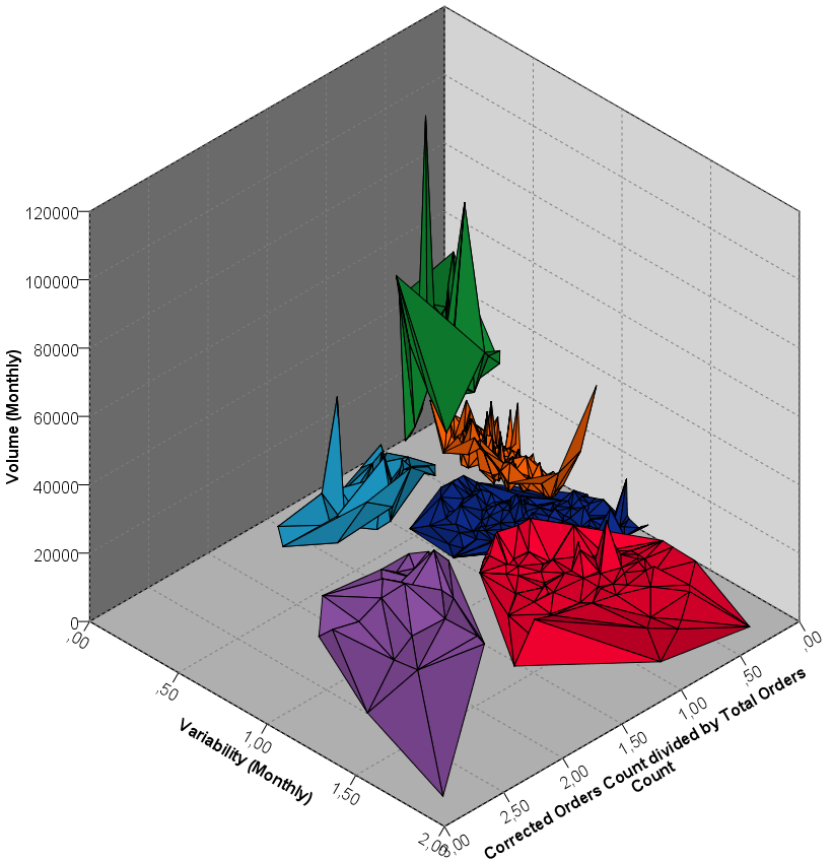


Figure 33: SKU segmentation 3D plot

After the initial filtering using the "primary variables", using the hierarchical clustering method (ward method on the squared Euclidean distances), the three variables (ranked as very high

importance) were normalised (only for the clustering). The selection of the best number of clusters was done critically backed up by the distance dendrogram (Appendix 8), starting at two clusters, we gradually increased the fragmentation until eleven clusters. Mostly because this is a pilot exploratory application, the criterion for cluster number selection was simplicity, so the selected number of clusters was six.

The fact that there were three variables, it allowed spatial representation. This kind of methods was considered as a powerful way of abstraction towards large variety of different SKUs, allowing the human pattern recognition which is by far more powerful than any computational approach. The three dimensional scatter plot (Figure 34) show the output of the above described. Note the six clusters and its position in the space (colour coded) and the variety in each one. For better visualisation the dots in each cluster were used to form a surface (Figure 33), which eases the perception on the position of the different clusters.

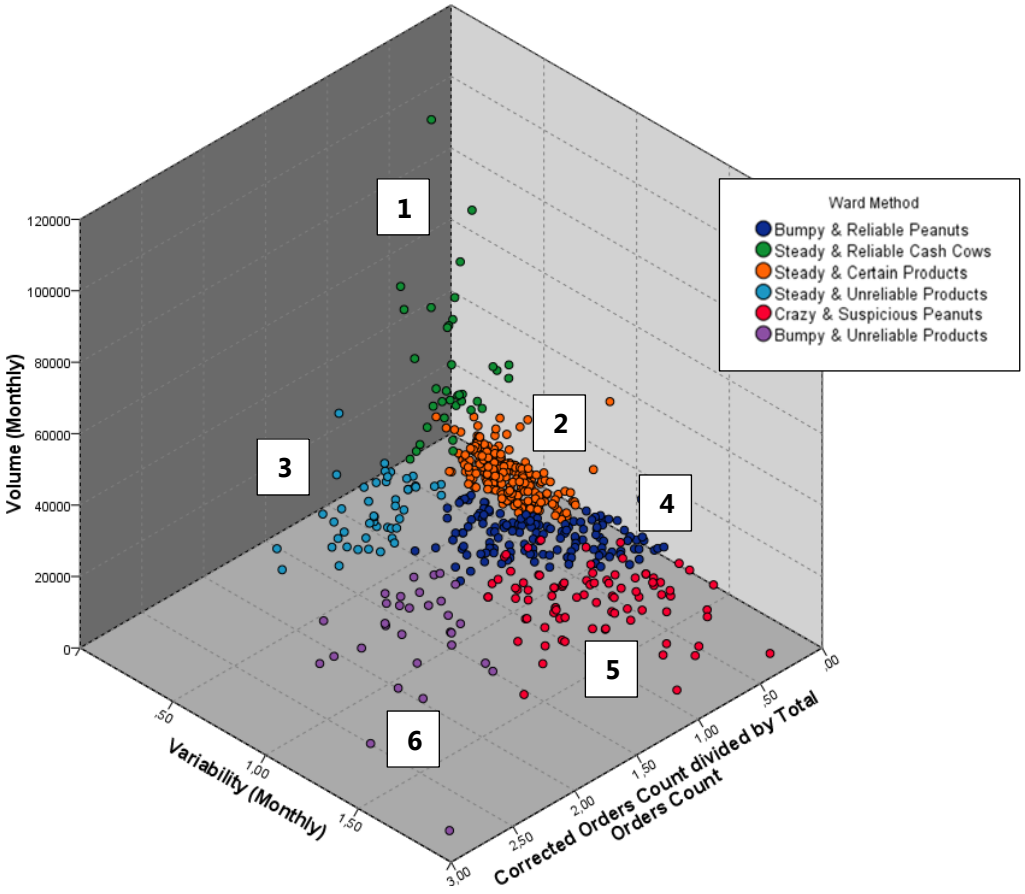


Figure 34: SKU segmentation doted scatter plot

Each cluster has a centroid, which is the average characteristic of the included elements (Table 13). The "revenue" of each cluster was measured as the sum of volume multiplied for the respective unitary price while the "portfolio representation" considered the variety in each cluster (number of SKUs).

	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6
Average Volume (Kg)	Cash Cows	Regular	Regular	Peanuts	Peanuts	Regular
	32.581	4.790	10.046	1.524	1.763	4.201
Average Variability	Steady	Steady	Steady	Bumpy	Crazy	Bumpy
	0,24	0,42	0,32	0,74	1,19	0,91
Order Changeability	Reliable	Certain	Unreliable	Reliable	Suspicious	Unreliable
	0,36	0,18	1,09	0,39	0,63	1,67
Portfolio representation	6%	38%	8%	26%	16%	6%
Revenue	35%	34%	16%	8%	4%	4%

Table 13: Segment characteristics

The first cluster, "Steady and reliable cash cows" represent 35% of the segment sales with only 6% of the portfolio. It holds the highest volume of more than 32 tonnes per month, its average variability is very low and the order changeability (OC_{ratio}) is one of the best which can be considered as a "reliable" pattern.

The second cluster, "Steady and certain products" has a regular average monthly volume and also fairly steady demand patter hitting the impressive OC_{ratio} of 0.18, the lowest of all; it is a proportional cluster as 38% of the SKU's represent 34% of the sales and almost five monthly tonnes per SKU.

The third cluster, "Steady and unreliable products" have twice the volume of the previous, being only 8% of the portfolio which accounts for 16% of the sales. Its key feature is the controversial relation between steady demand pattern and high order changeability of more than one which can be interpreted as each order is corrected at least once.

The fourth cluster, "Bumpy and reliable peanuts" is one of those with high variety and low business impact with an average volume of about 1.5 tonnes. It accounts for only 8% of the sales with 26% of the SKUs. In contrast to the previous cluster, it has a high variability but reliable ordering.

The fifth cluster, "Crazy and suspicious peanuts" regards one of the most problematic clusters. It represents 16% of the SKUs, only 8% of the revenue while the average volume per month is less than two tonnes. The demand is highly erratic and the order reliability is suspicious as the ratio indicates that more than six in ten orders are corrected.

Finally, the sixth cluster, "Bumpy and unreliable products" is the smallest cluster. It accounts for 4% of the sales with about 6% of the portfolio. The average volume is regular with about four tonnes monthly. Its key feature is the highest of six order changeability which suggest that each order is corrected more than once (1.67 order corrections) while the average

variability is also irregular. Ignoring its low revenue, this can be considered as the "worse" cluster.

Despite the fact that flows of products are represented by volumes, it is critical to assign a value to each cluster so managers can prioritise actions. Analysis on the number of SKUs and the respective sales volume is a powerful visual approach towards this concept. As Figure 35 shows, the cluster variety is not proportional to the containing number of SKUs. Quick gains are more likely when improvement is done on the less busy clusters yet with great revenue. In this case, as each product have only one assigned client, it is obvious that the first cluster "Steady and reliable cash cows" are the most suitable for improvement implementations.

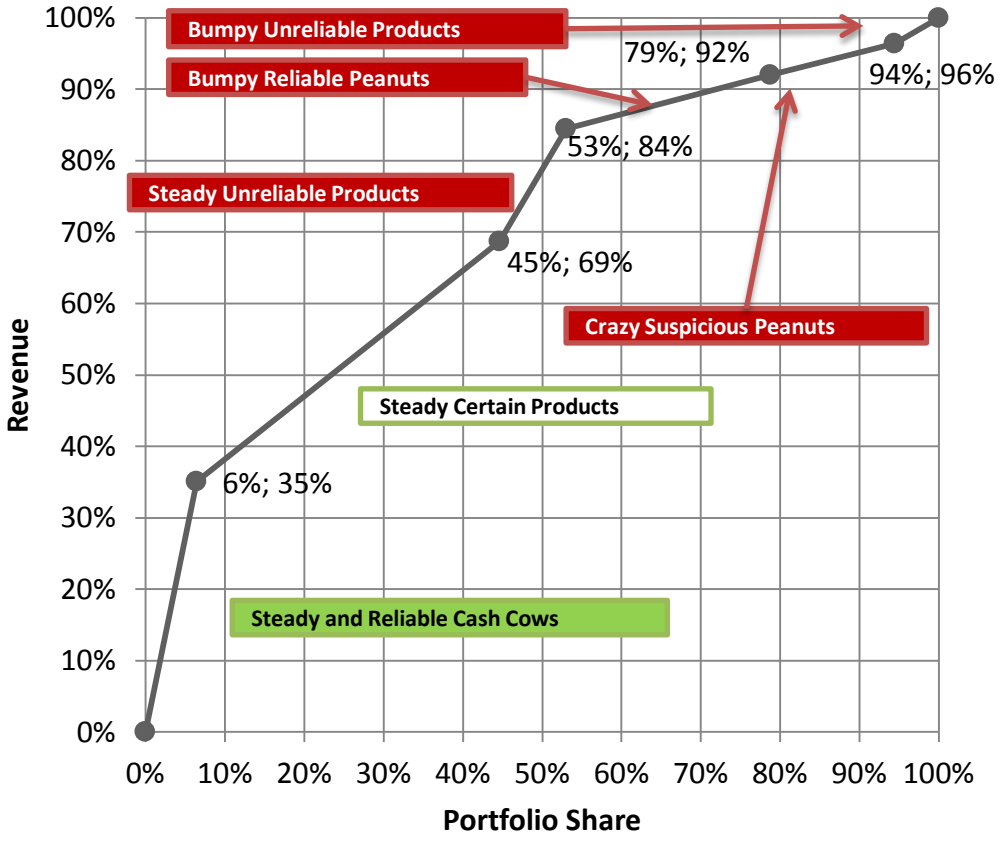


Figure 35: Revenue of each cluster

Extending the focus to raw components, which later enables strategic decisions for procurement, the demand characteristics of each SKU, affect the need for raw materials. Analysing first SKUs, its characteristic inheritably succeeds to the components which form two main groups: key and specific. On one hand, key components are those that are common to many products, such is sugar, used in 97% of SKUs. On the other hand, specific components are used to differentiate products. (Table 14)

Raw Component	Percentage of SKUs with that component
MP1	97%
MP7	94%
MP10	86%
MP6	75%
MP14	67%
MP67	39%
MP11	29%
MP27	29%
MP20	28%
MP12	27%
MP8	25%

Table 14: Key components

Consequently, suggesting a totally new insight on procurement, purchasing strategies could be developed towards the direct demand characteristics which are volume and stability as illustrated in the Figure 36. Key segment of highly demanded components are prone to have efficient supply while specific segment is more affected by demand patterns. Specific components subdivide into two groups regarding variability of the use flow.

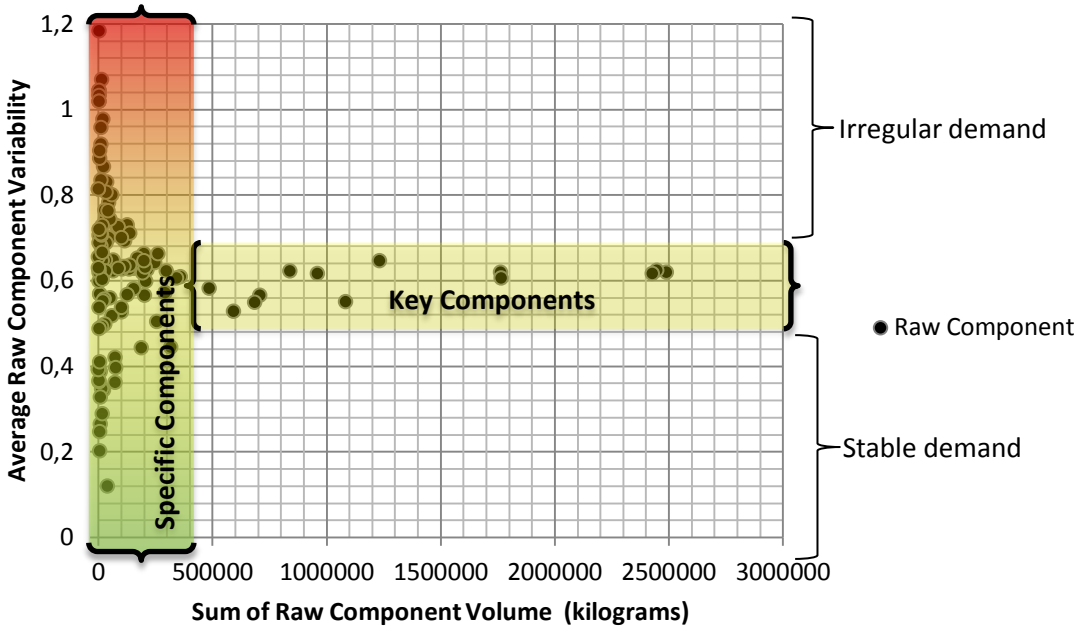


Figure 36: Raw material Variability/Volume plot

For the key component segment, the number of related products is very high, which makes the average variety low. Its high volume and stability make it a proper segment for supplier development programs and strategic partnerships as the company is likely to have the leverage and the bargain power on his side.

Those of irregular demand zone are likely to form bottlenecks. Thus, safety stocks are highly recommended. In contrast, stable demand is predictable which enables more efficient sourcing and minor safety stocks.

4.3.4 Step 4 – Client analysis and segmentation

Each SKU is assigned to only one client (further analysis discarded clients that are out of the dairy segment, dumping twenty clients), thus, the client characteristic is affected by SKU individual characteristics. Despite the Pareto analysis, client characterization should regard its behavioural characteristics such as the demand volume, global variability and the case specific global ratio of order corrections which represent how efficient is the clients planning and inventory management.

Classification variable	Classification (units)	Domain	Observations
Variety	123 (# products)	D	Property such as variety, is useful for both segment and client characterization. High variability often means more setups, lower volumes, higher variability, less economies of scale. Its reduction is critical.
Global Volume	(Kilograms)	D	The global volume per client indicated its strategic importance. Similar to Pareto analysis, when the price of products is homogeneous, this can be used for client characterization.
Global Variability	123	D	This dimension reflects the clients' inventory management capacity. Low global variability means that the client has an efficient inventory management system. In contrast, high value can justify companies' involvement with clients and implementation of measures such as information sharing, direct replenishment, forecast sharing, etc.
Global Ratio of Order Corrections*	123	D	This characteristic weights the clients overall performance for planning and inventory management.
Impact/ Demand Pareto analysis	123 (Currency)	D	Just like global volume, this is price related and reflects the strategic share of business addressing some particular client. This can be used to access the client importance.
123: Quantitative			**D: Demand**
ABC: Quantitative			*** New case specific variables**

Table 15: Demand classification variables

Concerning client complexity, variety was considered as one of the main drivers, it was a clear indicator of how many different products the clients has assigned. Which is a topic of great concern as the variety is generally considered negative due to the sub consequent need for frequent setups, lower volumes, higher number of different components and other operational drawbacks. As previously referred in the context analysis, clients are very heterogeneous as only five out of 83 clients represent 80% of the business. (Figure 37) For the

client analysis, similarly to the previous SKU analysis, global volume, global variety and global ratio or order corrections constitute the three dimensions of the plot while variety and Pareto analysis goes separated. This separation is important as it allows comparing and contrasting the different approaches towards clients. Pareto analysis is a very common way of identifying the key clients and priorities (Christopher, 2011), it is often stated that 80% of the sales comes from only 20% customers (80-20 rule)[4]. While this kind of information is useful as a starting point, it is not enough.

In this particular case, Table 15 shows the selected variables for client analysis. Firstly, we accomplished a Pareto analysis to understand how different are our clients concerning revenue[5]. In Figure 37 it is clear that the classic rule of 80-20 does not apply, the reality is much more extreme as 80% of sales are held by only 6% of the clients (type A).

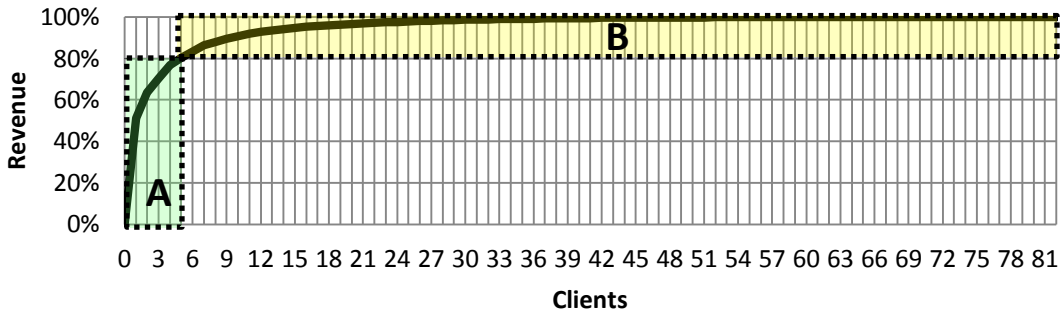


Figure 37: Demand Pareto analysis: Type A & Type B clients

Strategically, such panorama can be considered both positive and negative. On one hand, it is positive because quick gains are much more likely to get when we integrate large customers into the system. However, on the other hand, such situation is dangerous as the failure of the strategic clients can result in serious business damages.

Management must be concerned about the clients differences and inevitable set priorities (Christopher, 2011), thus behavioural variables such as demand volume, its variability and the case specific number of order corrections are important to profile and/or segment clients, enabling this way better match between the client needs and supply. For segmentation and profiling, Hierarchical clustering Ward's Method was applied. Using the three behavioural

[4] Pareto analysis as well as the Pareto Principle was introduced by the Italian economist Vilfredo Pareto in the 19th century. Is has been widely applied in business.

[5] The appropriate measure should be profit rather sales revenue or volume (Christopher, 2011). However, that information was not available from the case study.

variables, normalized between 0 and 1, we first produced a dendrogram to ground the decision on the best number of clusters (Appendix 9). As seen in Figure 38 (see Appendix 11 without the variety), the decided number of clusters was seven: Resulting in two individual profiles and five other segments.

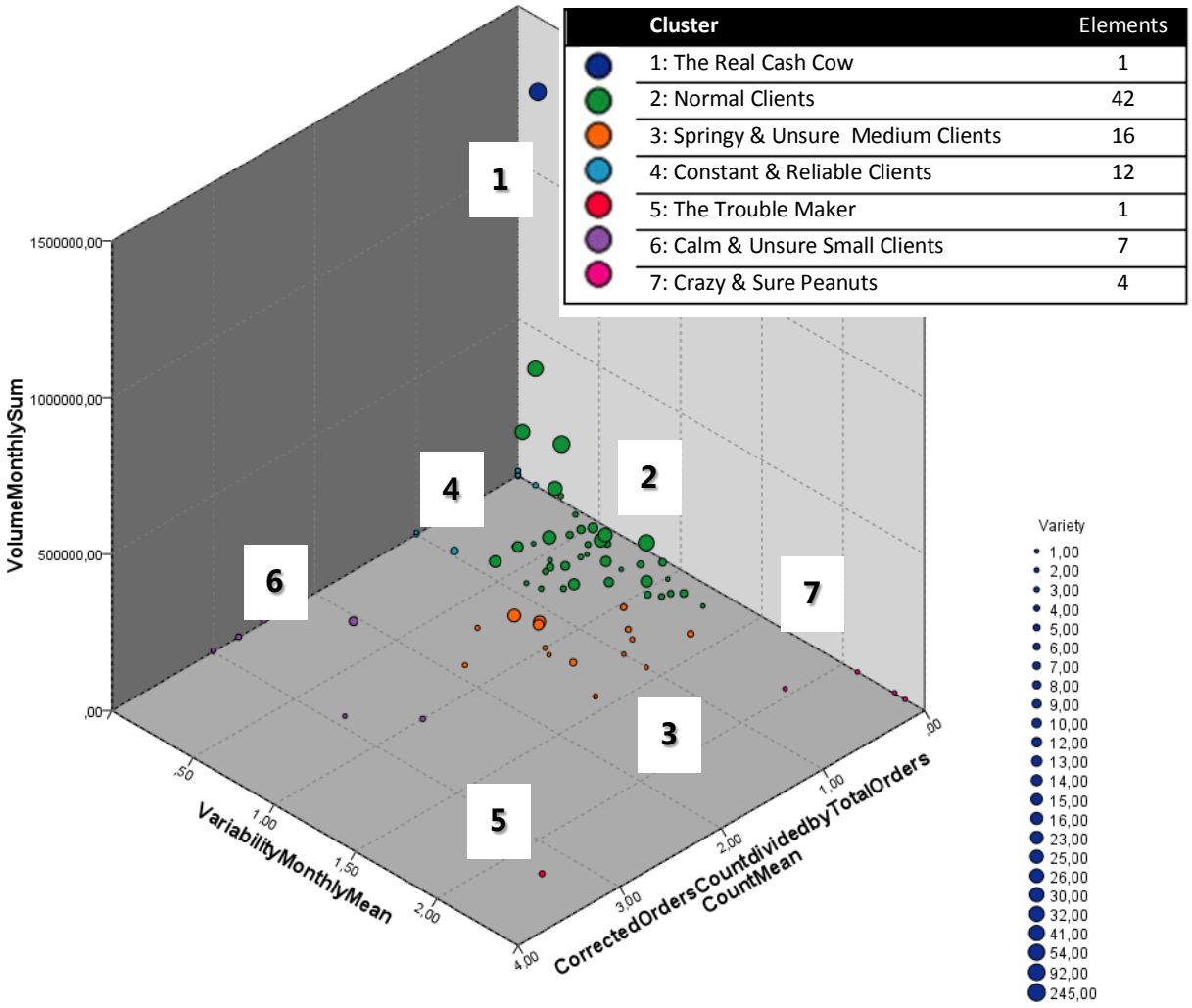


Figure 38: Client Clustering: Bubble size proportional to variety of SKU per client

	Number of Clients	Order Correction Racio	Monthly Volume Sum		Monthly Variability Mean
Cluster	**Count**	**Mean**	**Mean**	**Sum**	**Mean**
1: The Real Cash Cow	1	0,62	1.493.250	1.493.250	0,51
2: Normal Clients	42	0,40	45.891	1.927.430	0,67
3: Springy & Unsure Medium Clients	16	1,19	10.333	165.325	1,11
4: Constant & Reliable Clients	12	0,34	4.229	50.743	0,03
5: The Troublemaker	1	3,31	15.727	15.727	2,22
6: Calm & Unsure Small Clients	7	2,68	3.798	26.585	0,29
7: Crazy & Sure Peanuts	4	0,12	778	3.112	2,18

Table 16: Clients' clusters centroids

Each group has its individual centroid which represents its overall characteristic (based on the last year of activity), thus, each member of the cluster is expected to have a similar behaviour in future, e.g., very unstable clients are likely to remain inconstant while those who bought large volumes over the year, are likely to keep buying large volumes of products. The Table 16 and more detailed Appendix 10 shows the characteristics of each cluster.

The analysis resulted in two main groups: Two profiles and five segments. The criterion for profile/segment is the simple number of entities in each cluster. Those isolated clients are likely to form profiles while groups of proximate ones form segments. Concerning the first two profiles, "the real cash cow" and "the troublemakers" are very distinct types of clients. The first, is a certain and steady client which usually does not correct his orders. He can be considered as the best business partner as he represents more than 50% of the sales. In contrast, "the troublemaker" client, have a fair quantity of sales volume and the behaviour pattern is the worst of all. Its order changeability scores 3.31 which can be interpreted as each order is changed more than twice. Concerning the demand flow, its volume is almost 16 tonnes and the pattern is very unstable (variability about 2.22). In this particular case, this client can be considered as the worse business partner due to its negative features regarding its inventory management, planning and manufacturing flow. Finally, considering revenue, Figure 39 shows that 95% of the revenue regards 43 clients while the other 40 clients represent only 5%. This regards the Pareto simplicity, by exposing the most profitable segments first enritched by its behavioural characteristic.

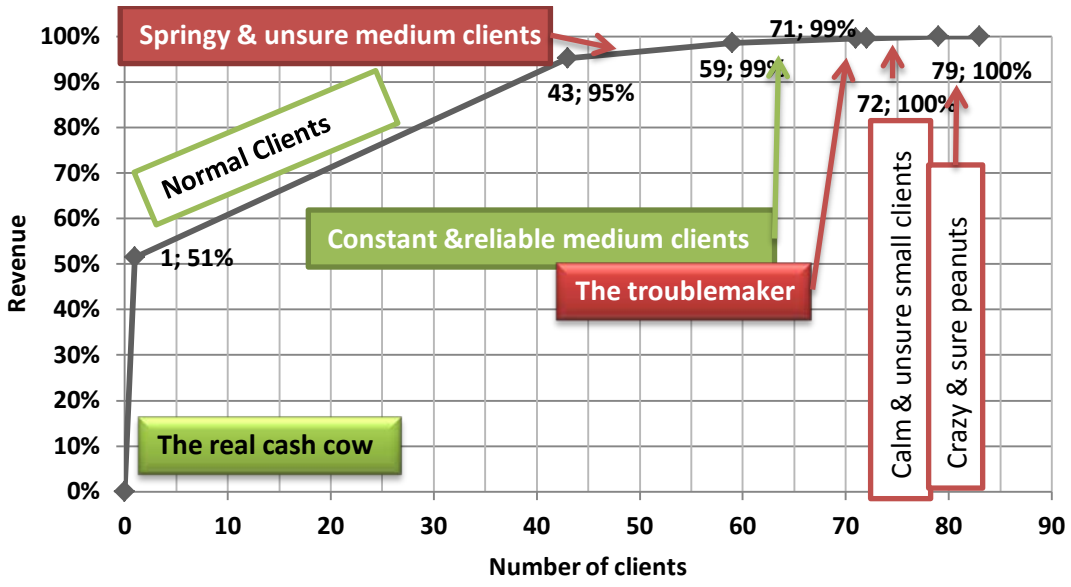


Figure 39: Revenue by client's segment - #clients vs. %sales

As far as segments are concerned, besides the "normal clients", which are 42, there are other four segments with individual features. Normal clients are the vast majority, the total monthly volume is almost 46 tonnes per client while the total cluster accounts for almost two thousand tonnes and it is the greatest cluster regarding its monthly volume. Then, follows the second biggest groups of clients: "Springy and unsure medium clients" are 16 which hold an average about 10 tonnes per month each one. Its demand flow is unstable and the order correction ratio indicates that each order is corrected at least once which cause many inherit problems in the operations management. Next, follows "good" groups of clients, the "constant and reliable clients". These are twelve clients, their demand is extremely steady (lowest variability of all) and order corrections are low. Despite the fact that they order a low monthly volume when compared with the real cash cow, they can be considered great business partners. Succeeding goes "calm and unsure small clients" which main feature is very high order changeability. This is a controversial situation as a steady flow of demand is usually associated with clients' good operations management and planning, however, its variability is very low yet the order corrections is about 2.68 which can mean that each order is adjusted several times after the order placement. This group of clients require careful managerial approach, and there are several ways of approach the issue, e.g., client's forecast sharing. Finally, there are four "crazy and sure peanuts". These clients' orders are very unpredictable and low volume. However, once again, against the expectations the order high variability does not mean high rate of order changes which is an extraordinary ratio of only 0.12.

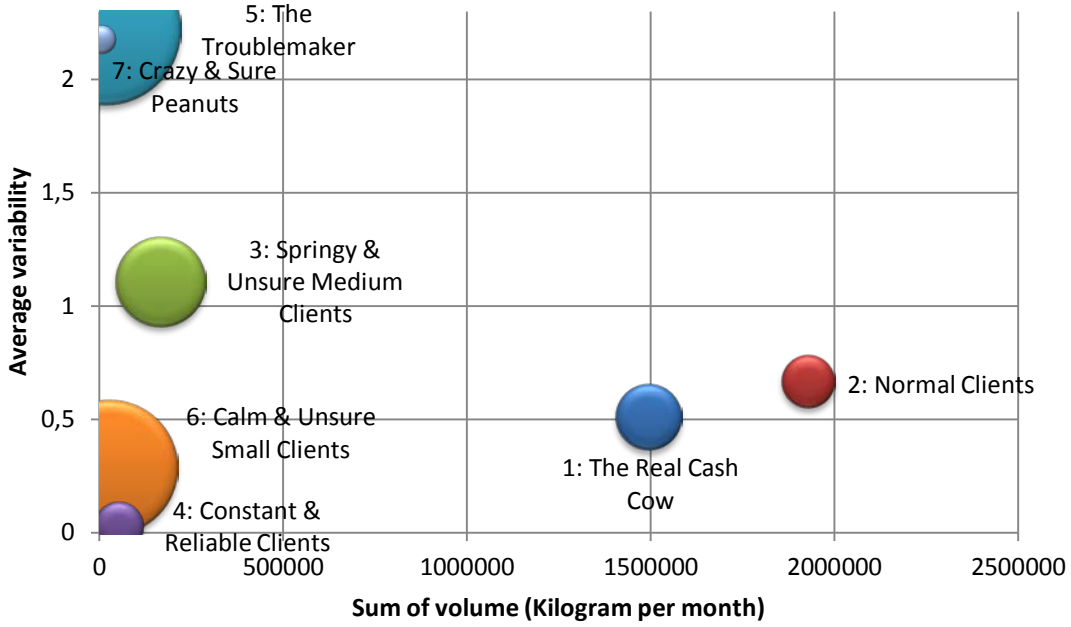


Figure 40: Sum of volume & variability plot for client clusters (bubble - order changeability)

Finally, client segmentation's outcome is a number of segments and profiles which must be dealt differently. In Figure 40, bigger bubbles mean problematic client which will mostly benefit with integration; average demand variability represent the segment steadiness while it's the sum of clients and the respective average monthly volumes regard the impact of those clients to our business. Volume can be changed by the sales value, however, in this particular case and considering that the majority of SKU's cost the same, volume is more important.

4.3.5 Step 5 – Conceptual Strategy building

Strategy must be matched with the context, resources, demand and products what is possible by means of segmentation. The suggested approach is that management concern strategy regarding each product and client segment. On one hand, product and client analysis can be dealt with independently which allows a greater degree of flexibility. On the other hand, they can be matched and each cluster combination analysed. We considered that there is no great interest in listing all the possible combinations of product and client segments as they account for about 42 possibilities. Thus, it is considered to be much more appropriate discuss major segments and allow management to decide whether to look at only client segment or product segments; or both.

This methodology is founded on the logic of groups containing similar elements and its discrete historic data. The premise is that objects which present similarity in the recent past, are expected to maintain a similar behaviour and each groups characteristic can be generalised which enables managerial approach. These approach is a compromise between the "one size fits all" strategy and the individual, elementary approach when each element of the system is managed separately (with is inherit costs and resource), which is only possible on very basic systems, such as small mono-product manufacturing.

One of the main features of such approach is that this does not rely on forecasting, as forecasting are prone to fail (Makridakis, et al., 2010). Its objective is to better match strategies so it can maintain its agility and responsiveness minimising waste. As a compromise between lean and agile paradigms, the suggestion is to build the strategy from a pool of 'tailored practices' (Lapide, 2006) rather than relying on pre-determined paradigms.

The strategy main target should be the suppression of production peaks, enabling a flawless and adapted flow of goods based on the clients' needs. Such approach makes visible some behavioural issues such as bad planning of inventory management on the client's side which might be used as an argument for joint actions and SC integration. As well as revealing

internal issues, such as variety and product complexity which negatively affect sourcing and operations planning.

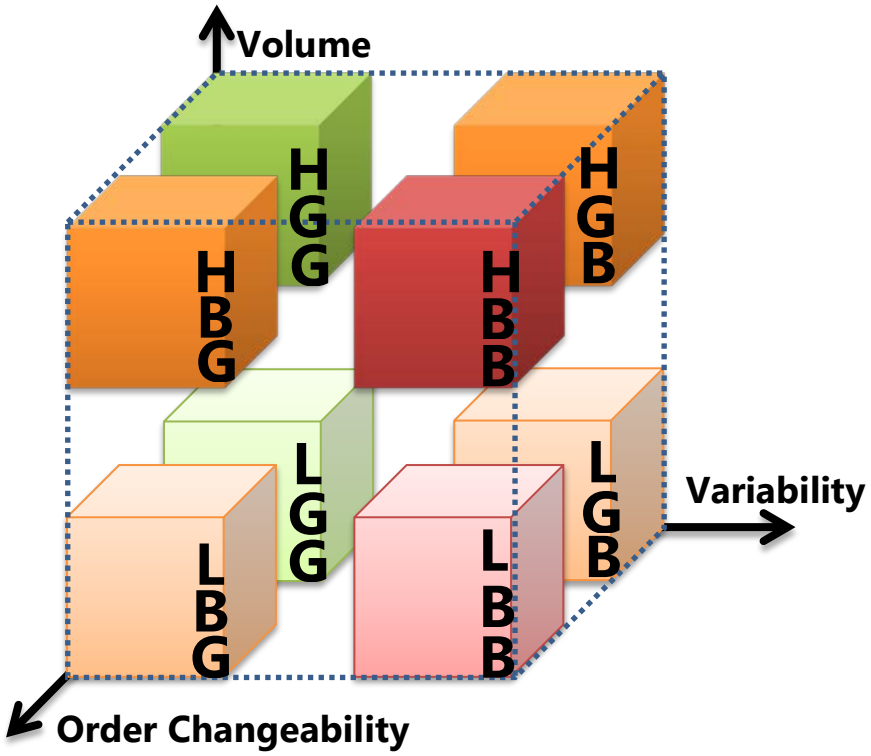


Figure 41: Strategic Cube (H: High; G: Good; B: Bad)

There is no one universal solution, thus, the current case focused on three key classification variables. Concerning the demand, from a more simplified point of view, further strategic discussion on different segments will address a simplified cube of volume-variability-changeability constructed with eight generic sections represented in Figure 41. Each section or group of sectors (sub-cubes) has a number of recommended managerial practices which were collected during open interviews and literature review. This step of the roadmap is the bridge between strategy and tactics, as it enables the definition of tactics which best suit particular elements. It is important to understand, that the strategic cube is a conceptual tool which does not rely on different combinations of sub-cubes as there are 24 different combinations of sub-cubes and analysing each combination alone would be unpractical. The main purpose of the strategic cube is to give guidelines for segment and strategic recommendations matching. Thus, it is not a recipe and segments may not fit perfectly into only one sub-section. The essence of the cube is to assist strategy building.

Each sub-cube of the strategic cube is the combinations the three key variables: Volume, Variability and Order Changeability both for product and client. Variety is an indicative classification variable that defines whether it is profiling (multiple entities) or segmentation

(single entity). In this particular case, the variety is one of the major concerns as the portfolio holds more than one thousand products.

The cube logic is simple: there are "good" sectors such as the steady and certain high volume zone, which allows more efficient management, and "bad" sectors where there is also high volume demand, but it is unstable and the client constantly changes the order properties, thus, disrupting the system.

The priorities should concern the greatest revenue which can be defined, in a simplified view as the volume. However, in cases when the price per unit varies significantly, volume must be affected by price for more efficient view on the portfolio its associated demand. Following the revenue logic, which in this case was considered as volume, the first concern should look for worse position, the HBB sector (red), following by secondary which are HGB & HBG (orange).

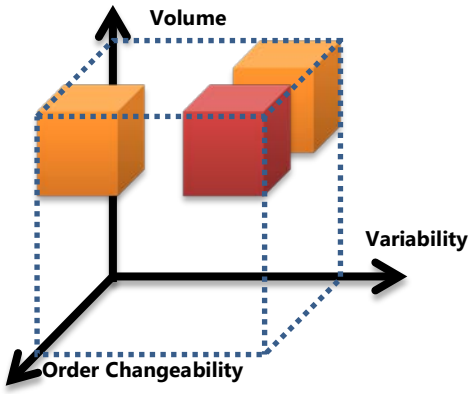


Figure 42: Strategic Cube - The most critical sectors: Unpredictable high volume

As the Figure 42 shows the most critical sector (HBB) has very large and erratic volumes demanded by poorly managed clients. This should be the number one concern and all the primary managerial efforts must address this category. The second most critical sectors are those which volume is also high and either variability or order changeability is high. In both cases, it is recommended that the company establish strategic partnerships so these issues may be addressed. In the case on high variability, client should allow better visibility of his needs. Demand instability might be lowered if the company can know any earlier clients' real needs, or marketing plans which likely will affect the demand volumes (e.g. promotions). Better client's inventory visibility may also increase the demand predictability as the company will be more aware of the coming needs. Due to its criticality, there should be very few entities in this zone as it is unlikely that any SC survives long enough to be analysed with such combination of elements, fact which eases custom approaches and individual profiling instead

of segmentation. In this case, none of the clusters or clients entered the above mentioned critical zones.

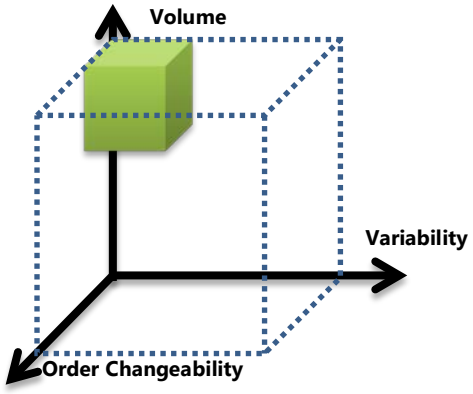


Figure 43: Strategic Cube - The best sector: Steady and certain high volume

The best position (Figure 43), of high volumes with low variability and efficient purchasing mechanism and need planning on the client's side (HGG) are of those products which demand is so smooth that it is almost certain that if the company produce it, it will be purchased by the client, which enables a lean logic. The stability allows make-to-stock and make to forecast practices, allowing better production planning. Products could be delivered on a rate-based system directly to the point of use. Despite the stability, this segment benefit from small buffers of finished products at the end of the supplying process. Concerning production scheduling, repetitive flow of entity types that have a large, smooth demand do not need individual scheduling as they can be rate-based, so that each time-period a consistent quantity of product is processed (knowing a priori the clients' average needs), while slight variations in demand are compensated by small inventory buffers. Segments in this zone are likely to have a reasonable margin and business volume which can justify a dedicated group for its management. For the case, the cash cow segment accounts for 6% of SKUs which represent 35% of the total sales, thus the variety is very low. Similarly, concerning client segmentation, "The real cash cow" is an individual client which holds 51% of the business. It is recommended an individual approach on each element of these segments, performing demand profiling looking for opportunities. For these segments, it is worthwhile to perform value stream mapping for the customer ordering process and work on client integration towards information sharing and closer cooperation as both parties are likely to benefit from the partnership.

Concerning the "smoothness" of demand, customer demand rates are normally much smoother than they seem while its real usage rates are even smoother because internally, and

mostly in the B2B segment, entities are batched for large lot processing, thus clients should be encouraged not to batch their demand and spread it instead. This causes flow irregularities, making the variation much higher than it actually is. To perform profiling, it is essential to analyse the demand patterns (demand pattern recognition models) through time and not the production output, as it is the company plan and not the client's need. In addition, demand quantities and frequency should be optimised. It is suitable to install "blanket orders" and "call off" whereby customers agree to order a large amount over a long period of time taking the delivery in regular, smaller quantities and paying as they go. Finally, the organization should look for triggers in the process to find options of earlier warnings of demand. In this case, the company is likely to benefit from make to forecast whenever possible, which solves most of the capacity peaks. In the previous segmentation and profiling step, both "Cash Cows" product's segment and "The real cash cow" profile fell into this sector.

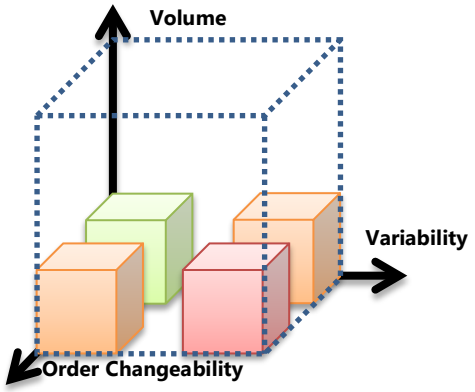


Figure 44: Strategic Cube - More common sectors: Low volume

For segmentation, that is likely to happen into the lower section of the strategic cube (Figure 44) low volume, high-low variability and high-low order changeability (Figure 41: LGG; LGB; LBG; LBB) there might be less beneficial to perform forecasting as the variety is great, the demand might be discontinuous and erroneous, at least for this case and likely to many others. High variation, low volume gives such unpredictable demand that it forces the Supplier to deliver only when there is an order. So the company's current manufacturing logic fits it flawlessly: pure Make-To-Order (MTO). The first question that must be asked is: "Should these products be offered at all?" – Managerial efforts should focus on the variety reduction, thus, in this case, clients should be persuaded to accept already existing products of agree on common components rather than totally new recipes, e.g., there is more than a thousand strawberry flavours in the warehouse, while only 10 are noticeable different. In order to deal with these low volume products, lead times should be reduced as much as possible so the work is done quickly reducing the capacity usage and time windows for delivery extension is

likely to add some flexibility allowing better operations planning. Finally, reducing customisation helps to reduce variety which consequently reduces variability and increases volumes. And finally, postponement, however, technological constraint on whether it is possible to pre-prepare any part or use modules of the product arises.

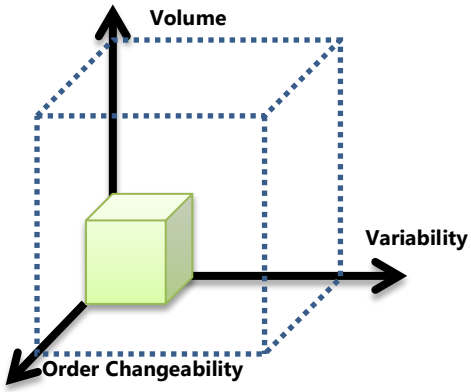


Figure 45: Strategic Cube - The 2nd best sector: Steady and well managed

The second best sector with low variability, low volume and low order changeability (Figure 45) is of the least concern. It allows efficient flows, good production scheduling and usually does not cause capacity peaks as the volumes are low. For the case, both "normal clients" and "steady and certain products" segments occupied this position. However, despite the positive perspective, SC flow must be adapted towards its steady and certain behavioural characteristics. Variety reduction is still a concern as this kind of segments usually holds great numbers of different entities, e.g., the segmentation resulted in 42 clients and almost 400 SKUs respectively. While it is unreasonable to reduce the number of clients, the 400 different SKUs should be.

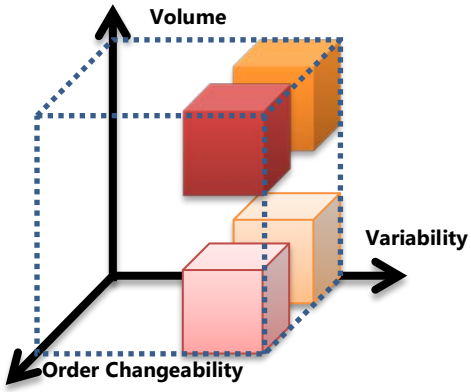


Figure 46: Strategic Cube - High variability demand

Regarding Figure 46, demand irregularity is one of the greatest problems for situations such as forecasting. While it is easy to predict stable demand some weeks further, erratic demand

patterns are not. Agility and responsiveness are the bottom line of such sectors. As the case company works on a pure MTO basis, it approaches all the products as being unpredictable, even those stable ones. Thus, the current situation and manufacturing logic suits well the high variability sectors as the production only fires to meet the delivery date of the client order which is placed long before the real need.

However, in spite of meeting better the clients' needs, irregularity should be addressed. Management should work towards increasing warning time or other triggers from the downstream customer, as knowing earlier allows the company to work as a buffer, absorbing the irregularities. Looking at individual demand profiles might also help to identify possible opportunities and is a powerful support to discuss strategic decisions with customers as often, clients are not aware of his own need pattern. Additionally, this approaches towards closer partnerships only work if the client is willing to hear the company, i.e. is we are his strategic supplier, which is the case as the pilot case is always a strategic supplier due to its uniqueness and lack of alternatives in the geographical area.

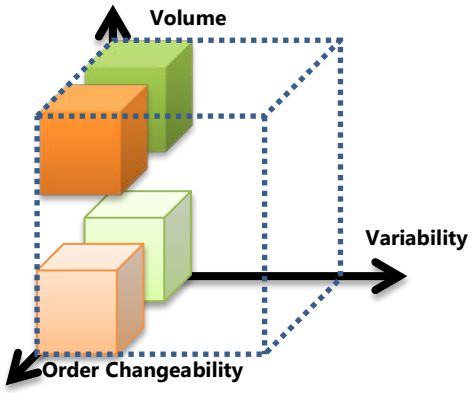


Figure 47: Strategic Cube - Predictable demand

In opposition to the previous strategic cube sectors, the stable demand (low variability) allows predictability, which consequently enables forecasting (Figure 47). Generally, the proper manufacturing strategy for these segments is Make-to-Stock and on a SC perspective, lean SCs. There are several stable examples in the case. For the cash cow segment for example, it is important to analyse each of the demand profiles seeking for the current level (the mean value at the current time), the trend, as being the rate of systematic increase or decrease in the mean value, as well as its seasonal pattern and finally the random component, However, simple forecast models such as the moving average solves much of the current needs.

There are many different demand patterns. Next, follows some different types as well as examples from the case for each one on a weekly basis during one year (2011). Firstly, it can

be a large demand which rarely drops to zero with no significant spikes or with great irregularity (Appendix 13). Secondly, it can also be small demand with no significant spikes which rarely drops to zero or irregular which frequently drops to zero (Appendix 12). Finally, long seasonal behaviour, such as summer higher consumption of liquids or show a short term special cause of demand variability, such as the early summer special promotions (Appendix 14).

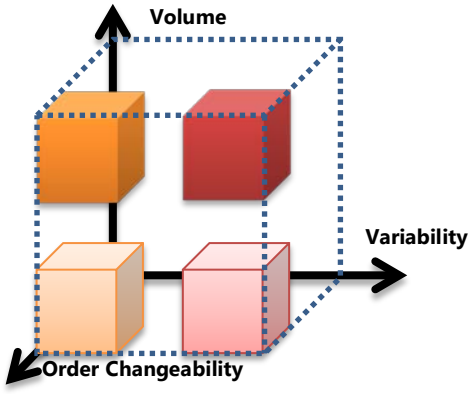


Figure 48: Strategic Cube - High order changeability

Finally, the case specific order changeability classification variable is an additional problem in the specific context Figure 48. As previously identified in the context analysis, demand peaks tend to happen in times when the order changeability ratio is higher. The client's marketing department induces internal conflicts, which affect the internal planning or resources, thus forcing the inventory managers to correct orders. The top 3 reasons for order corrections are: firstly the delay of the delivery date (about 32%), secondly anticipation of the delivery date (about 19%) and thirdly production planning (13%). Worth noting that the production planning is dependent on orders, so this is directly related to the client demand behaviour rather than internal constraint. This variable reflects the client's ability to know his own needs, its inventory management efficiency and operation excellence. Thus, it is highly recommended that the company work with its client's procurement department and marketing to develop better visibility of the chain. For example, white brand clients are fall most into this sector as the numerous promotions and lack of client fidelity causes opportunistic demand which turns into inefficient planning. This same problem affects order stability (variability); however, there is a difference between steady demand which is stable by means of multiple adjustments opposed to steady demand which is well aligned with the clients perception of his future needs. Consequently, is requires different approaches towards clients.

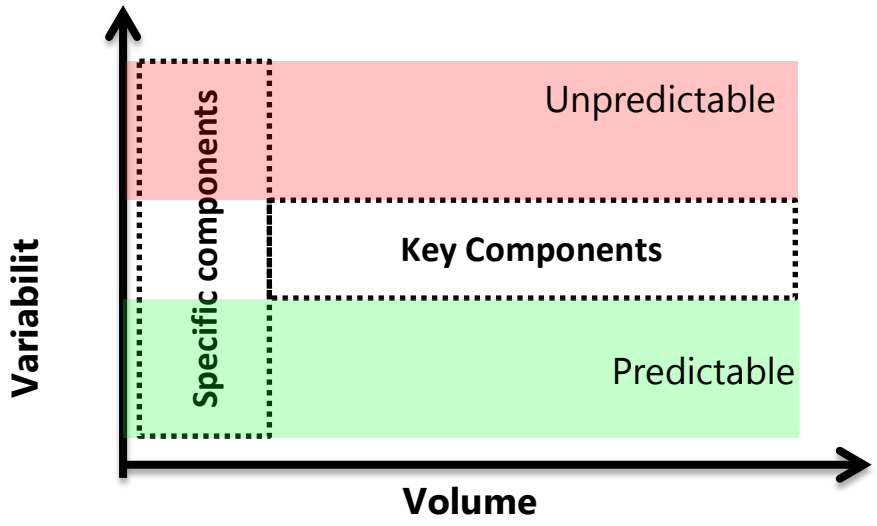


Figure 49: Raw component portfolio segmentation concept

Management should focus on the strategic alignment along the SC (Gattorna, 1998). Once the products and clients are segmented, and each segment gets its own set of strategic recommendations, it is possible to achieve alignment on the sourcing side. Clients' needs should shape our manufacturing and supply strategy, and also, our own resource management: procurement strategy development. Portfolio approaches on procurement such as Kraljic's matrix (Kraljic, 1983) are often criticised due to its focus on price and aggressive focus on suppliers, seeking not only for opportunities, but also for leverage as the bargain power is one of its main foundations (Gelderman & Van Weele, 2005). As a possible shift away of the price, the present work suggests the raw material segmentation into two distinct categories: Key components and specific components (Figure 49). Thus, it is possible to identify stable needs and highly variable ones. Key components are demanded in higher volumes/quantities and due to its universal application, have an average stability which reflects the global demand variability. Key components, despite its price, are surely needed and its stability allows lean sourcing strategy, what is consequently an argument towards a leagile supply configuration, which is basically lean upstream and agile downstream breaking in the decoupling point (Naylor, et al., 1999). In contrast, need for specific components can either be predictable or unpredictable as it is totally dependent on client's ultimate demand. Thus, procurement of these entities must be matched with its characteristics which are set by the clients' needs. This way, it is possible to achieve a continuous driver for strategy building through the immediate tiers of SC. (Figure 50)

The final conceptual model illustrated in Figure 50 is meant to allow strategy building based on segmentation. The management process description adopted was the: plan, source, make,

& deliver by SCOR® (SCOR, 2010). This description of the SC processes is one of the most developed and mature, allowing virtually any SC to be modelled. The logic behind the concept is the total chain to answer to the real demand data based on the most recent history. When the company already runs various value streams entity permutation to other segments is possible in the real time, allowing an adaptable, aligned and agile SC. This is possibly a practical answer for the triple-A SC proposed by Lee (2004).

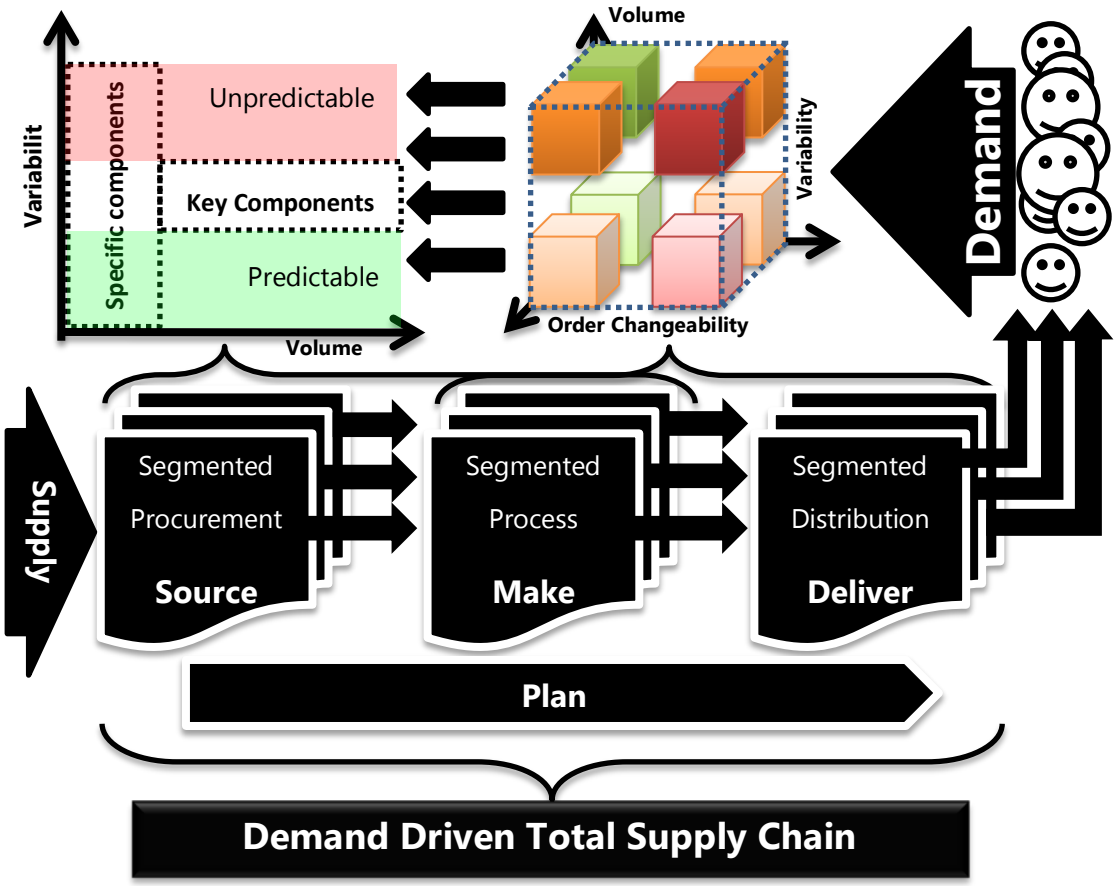


Figure 50: Demand driven total supply chain concept

Finally, SC strategy requires tactics which are case specific, enabling operational planning and control. Its operational control is possible through specific metrics: Key performance indicators (KPI's).

Plan	Source	Make	Deliver
# of change orders	Supplier performance	Setup times	Carrier utilization
On-time plan	Contract compliance	Capacity utilisation	Inventory turns
Doc. accuracy	Cost/unit purchased	Waste and scrap	Express freight %
Supply chain cost			
		Perfect order rate	
	Forecast accuracy		

Table 17: Process-based metrics (SAP AG) (adapted)

Such SC metrics are a mature field of studies and many SC models such is the Supply Chain Operation Reference Model (SCOR®) offer a wide range of different indicators which can be used as KPI's for SC performance assessment after the strategy implementation. Different SC strategies require adapted operations management, thus, the need is to define different targets for different segments. Table 17 is an example of KPIs within one silo of operations, i.e. just related to Design, Procurement, Production or Distribution which are suitable for segment performance assessment.

Finally, it is important to underline that SC segmentation success converges on one master key performance indicator: Cost-to-serve – which expresses the SC cost to meet the demand which is highest on the individual stream extreme and high at the "one-size" stream for all entities. Thus, SC segmentation is the compromise between those two extremes seeking for the best match between segments and the respective demand characteristic.

4.3.6 Step 6 – Matching segments with supply chain 'tailored practices'

Finally, after segmentation and conceptual strategy building steps, portfolio and client segments/profiles must be matched to the proper place in the conceptual model for SC 'tailored practices' (Lapide, 2006).

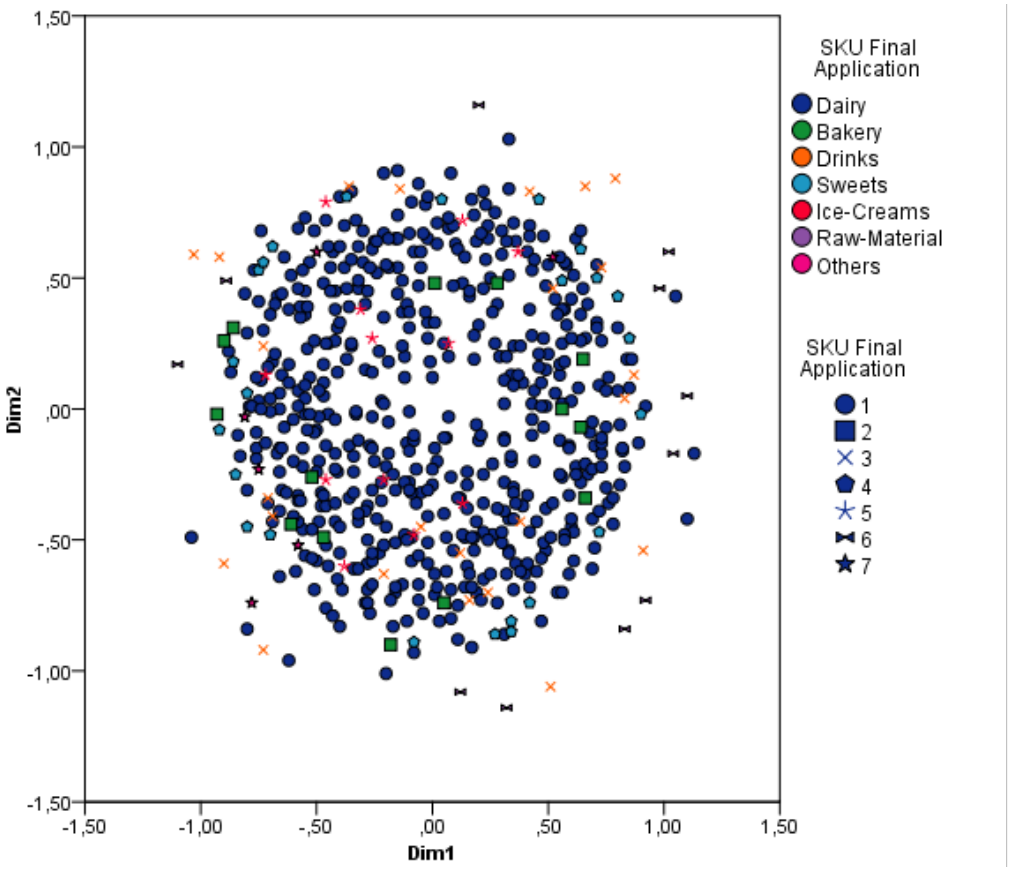


Figure 51: Portfolio MDS plot of SKUs using a linear proximity transformation

From an internal perspective, the high portfolio variety should be reduced. The compromise of customisation vs. standardisation is a two-side discussion in the SWEET's context. However, high variety can be addressed by different strategies. Late product differentiation (postponement strategy) is one of the most effective ways of reducing the number of products. MDS plot is an effective visual way of identifying similarity between products. Figure 51 illustrates that the portfolio contain many products with common elements which could be grouped.

Concerning SKU segmentation represented in Figure 52, products affected by demand characteristics allow its position inside the strategic cube as a segment. Ward's clustering using the square of the distance between entities is based on similarities and not predefined boundaries, allowing neutral grouping. It is manager's concern to decide on the best matching position in the conceptual model for strategy building which purpose is to provide guidelines.

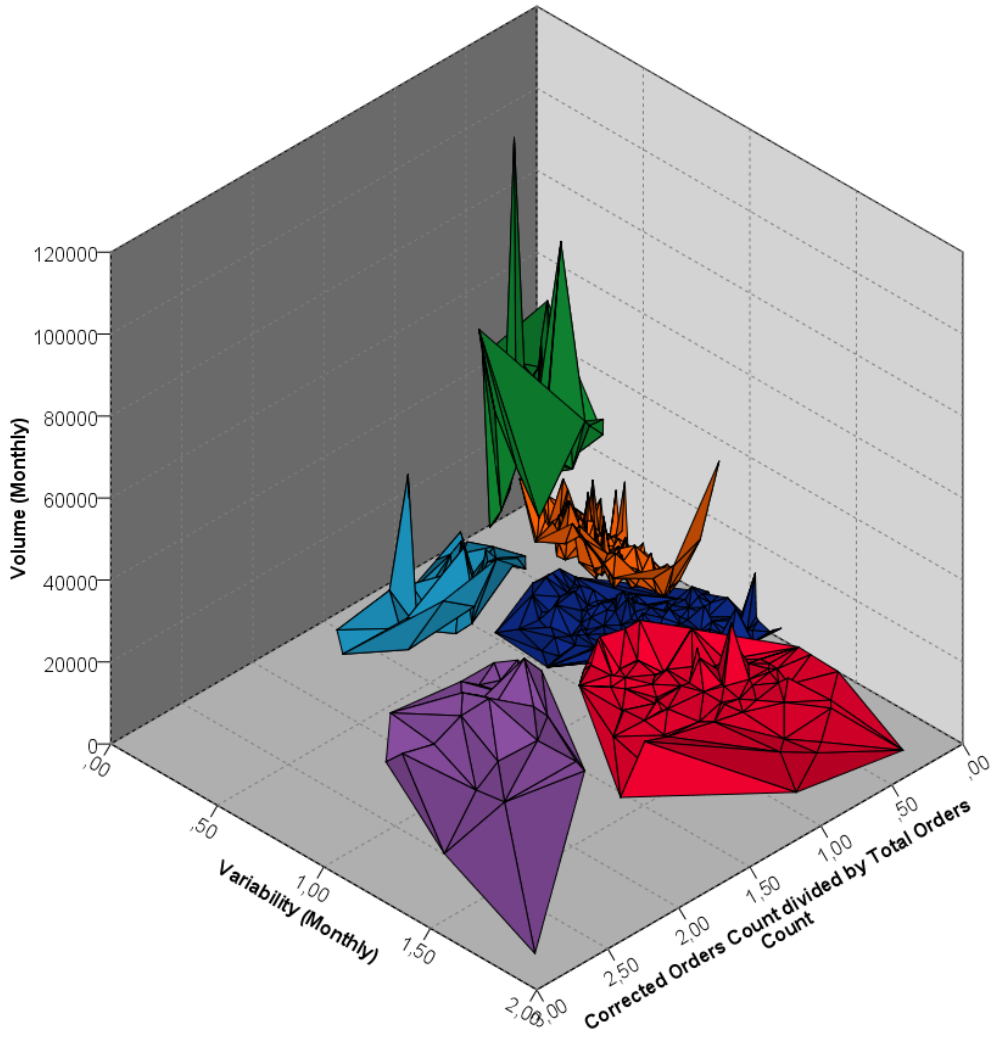


Figure 52: SKU Segments obtained

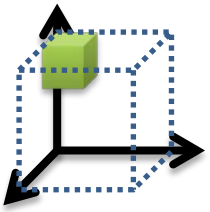
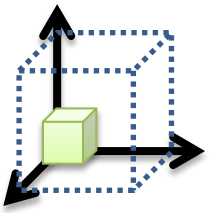
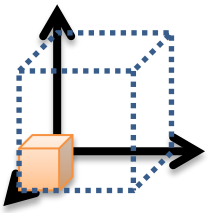
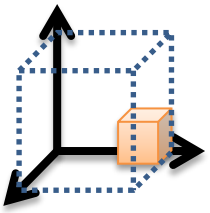
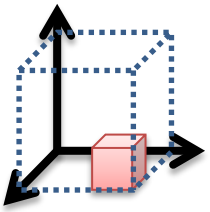
Product Segment	Observations	Position in the strategic cube
Steady & reliable cash cows	This product segment has high volume demand and can be considered both stable and reliable. This segment is likely to benefit from some lean principles, and make-to-forecast manufacturing making use of the great stock capacity, the inventory turn is expected to be high. Its low variety is beneficial allowing individual forecasting and small buffers of finished product at the end of the supplying process are likely to absorb all the demand improving the capacity utilisation. It might be worthwhile to profile each of the entities in this segment. Providing high availability and excellent service level is recommended as these entities are few.	
Steady & Certain Products	Low volume yet stable and reliable segment allowing lean principles. Its predictability and extreme order reliability can be considered non critical and its management can be automatized as much as possible. Management should try to reduce this segment variety offering less customisation. Thus, it is likely that lower variety enable economies of scale and lower cost to serve.	
Steady & Unreliable Products	SKUs showing stable demand allowing accurate forecasting (MTF) but high order correction ratio. This can mean problems on the client's side regarding inventory management and operations planning. It is mostly beneficial to work on client integration, e.g. proposing direct replenishment or vendor managed inventory (VMI).	
Bumpy & Reliable Peanuts	This segment requires agile SCs as the demand is unstable and low. Make-to-order, ensuring the availability of the specific components is crucial to meet the demand in an agile manner. It is critical to reduce the segment variety, what is likely to augment the overall demand volume and demand stability reducing the setups and the inherit wastes.	
Crazy & Suspicious Peanuts & Bumpy and Unreliable Products	Extremely variable demand best matched by agile manufacturing. However, client's order corrections are frequent thus client integration and SC visibility improvements are likely to benefit the segment moving the contained entities to better zones. It is critical to reduce the variety, the question is "should these SKUs should be offered at all?"	

Table 18: Product segment strategy matching

On the other hand, focusing on clients, those can be segmented (or profiled) using the averages of the assigned SKU characteristics allowing the identification of good strategic partners and problematic clients. That way management can decide on the best approach on each client (or group of clients) accordingly to its behavioural characteristic and strategic importance. That approach can differ on the kind of contracts agreed, using the company's

leverage or dependency, it is important to negotiate for example the most suitable time windows for delivery, quantities, minimum run-sizes and/or product recipes. It is critical to address the most problematic clients seeking for improvement measures over the identified problems.

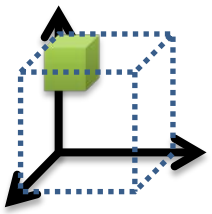
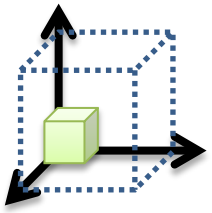
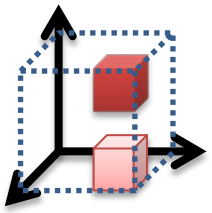
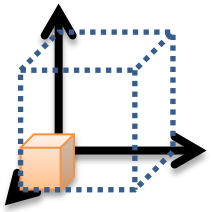
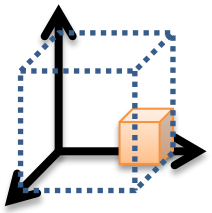
Client Segment	Observations	Position in the strategic cube
1: The Real Cash Cow (Individual profile)	The most important client. Responsible for the greatest share of annual business, client integration, information sharing, VIM or DRP, and small buffers of finished product at the end of the supplying process are highly recommended. However, he has assigned many different SKUs with different demand patterns. Strategic partnership with this client benefits the whole company.	
2: Normal Clients & 4: Constant & Reliable Clients	In sum this holds an equivalent sales share to "the real cash cow" profile, yet it encompasses 42 clients which require a more systematic approach. Overall stability and reliability suggests that there are no major issues about these clients.	
3: Springy & Unsure Medium Clients & 5: The Troublemaker (Individual profile)	These two segments require special attention. It indicates both high variability and poor client's inventory management. These clients should be approached for problem sources identification, taking appropriate measures. Vendor inventory management or direct replenishment might solve partly the issue. Wise to consider stopping business with those clients unless he changes.	
6: Calm & Unsure Small Clients	SKUs showing stable demand allowing accurate forecasting (MTF) but high order correction ratio. This can mean problems on the client's side regarding inventory management and operations planning. It is mostly beneficial to work on client integration, e.g. proposing direct replenishment or vendor managed inventory (VMI).	
7: Crazy & Sure Peanuts	This segment requires agile manufacturing as the demand is unstable and extremely low. Make-from-stock (MFS), ensuring the availability of the specific components is crucial to meet the demand. Expanding time-windows for delivery allowing more flexibility is also likely to benefit this segment.	

Table 19: Client segment strategy matching

Finally, sourcing which is affected by company's own need to meet the clients demand. First, it is essential to try restricting the various options of components which integrate the final SKU. Total customisation may not be appropriate for low volume clients and some restrictive measures are likely to benefit processes and sourcing which ultimately benefit the whole SC e.g. SKU price may be lower due to the economies of scale.

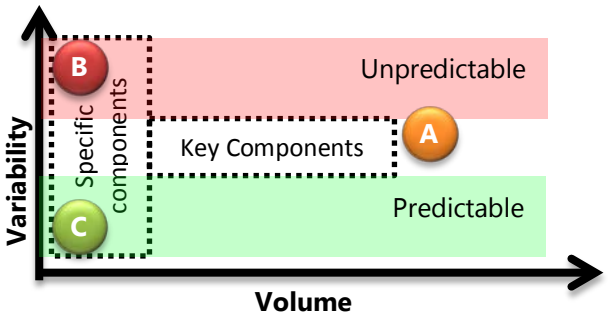
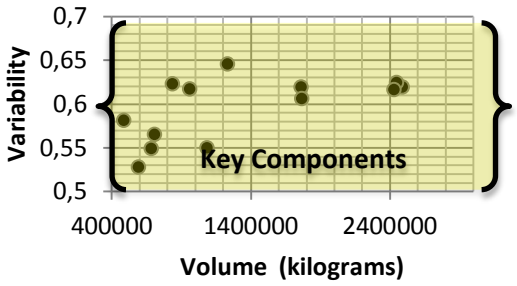
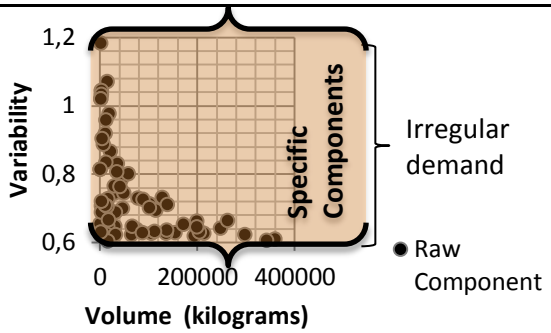
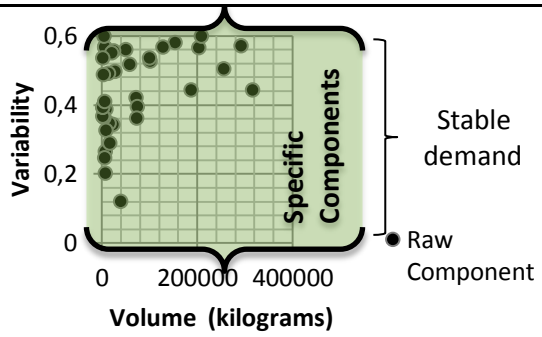
Observations	Component segments
Using the final demand characteristics, raw components tend to take an inverted T shape distribution which can be divided into three main zones: A; B; and C.	
Zone A: Key components are needed in high-volumes as it integrates many different SKU's. The fact that it is needed in many different SKU's places about the average variability measure. Low variety, high volume and predictability allow lean sourcing, opening ground for leagile configurations. Long-term supply agreements and strategic partnerships with suppliers reduce supply risk	
Zone B: Specific components normally have low-volume. Its distinctive feature is high demand variability what requires agile sourcing, stocks and product availability. It is recommended to have multi-sourcing to meet the demand peaks. Unpredictable demand is challenging for suppliers, thus providing information in advance is likely to benefit the whole SC.	
Zone C: Similar to the above described specific components with low-volume, but are distinguished by stable demand. Predictability allows less waste, lean sourcing giving the suppliers the opportunity to deliver more efficiently. By allowing inventory visibility and more information sharing, VMI is possible.	

Table 20: Source segment strategy matching

Management must set priorities (Christopher, 2011), thus, once each segment gets its own set of recommendation, segmentation using profit/revenue enable the definition of priorities underlining quick wins. Either on the SKU perspective or client's, the analysis reveal segments which are responsible for high percentages of revenue, i.e. the "steady and reliable cash cows" products as well as "the real cash cow" client, with 35% and 51% of the previous year revenue

respectively. Those should be addressed first, as its low variety and high impact is likely to provide quick wins, justifying the exercise of segmentation.

The logic for prioritisation is simple: the revenue share divided by the variety of entities in each segment is the priority ratio; high ratio means that high revenue share is represented by few entities. Low variety means that it is easier to implement changes. Thus, high ratios should be addressed first.

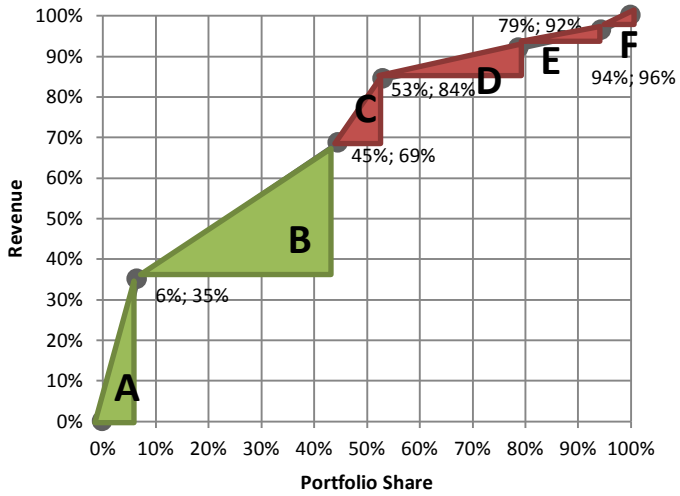


Figure 53: SKU segment - revenue vs. variety

A first insight on SKU segments represented in Figure 53 enable to detect that either segments A – Steady & Reliable Cash cows and C – Steady Unreliable Products hold high revenue against few entities, with 5.83 and 2.00 ratios respectively (Table 21). This suggests that these two segments should be addressed first. Working towards segment "A" optimisation and efficiency as it is steady and reliable, while lowering the unreliability of the segment "C". To address the unreliability further attention must be paid to probable reasons for those particular products to suffer changes, e.g. high number of promotions, while-label products, or other possible reasons. Closer collaboration might bring positive outcomes.

Segment	Importance (I= Revenue)	Ease of implementation (E=Variety)	Priority (P=I/E)
A – Steady & Reliable Cash Cows	35%	6%	5.83*
B – Steady & Certain Products	34%	38%	0.89
C – Steady Unreliable Products	16%	8%	2.00*
D –Bumpy Reliable Peanuts	8%	26%	0.31
E – Crazy Suspicious Peanuts	4%	16%	0.25
F – Bumpy unreliable products	4%	6%	0.67

Table 21: SKU Segment prioritisation

On the other hand, analysing clients' segments represented in Figure 54, shows clearly that segment A and B go up to 95% of the revenue. However, that is not enough for its prioritisation.

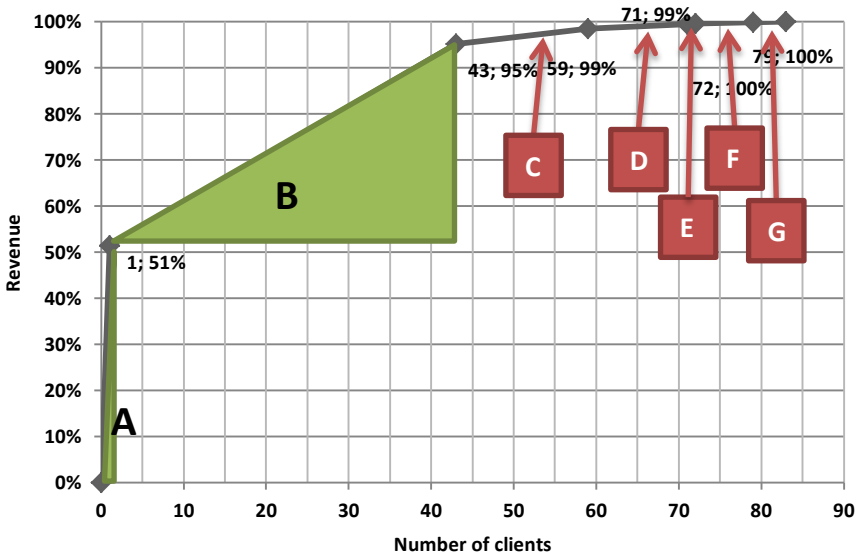


Figure 54: Client segment - revenue vs. variety

Regarding Table 22, priority ratios highlight two key segments, which in this case are profiles (single clients). A – The real cash cow, holding a great revenue share as well as E – The troublemaker. The first, should be addressed with extra effort as SWEET Company is highly dependent on him, close collaboration towards efficiency is likely to bring positive outcomes. On the other hand, the troublemaker should be either discarded or its high variability and order changeability resolved. Due to the low annual revenue share, it would be better not to waste resources with that client and simply stop business relationship with him.

Segment	Importance (I= Revenue)	Ease of implementation (E=Variety)	Priority (P=I/E)
A – The real cash cow	51%	<1%	42.00*
B – Normal Clients	44%	51%	0.86
C – Springy & unsure medium clients	4%	19%	0.21
D – Constant & Reliable medium clients	<1%	14%	0.07
E – The troublemaker	<1%	<1%	1.00*
F – Calm & unsure small clients	<1%	8%	0.13
G – Crazy & sure peanuts	<1%	5%	0.21

Table 22: Clients' segment prioritisation

The priority order, gives a support for decision on which segments must be addressed first. However, its results should be only taken as decision support and never as a definite order

due to the fact that it only accounts for revenue and variety, and is taking the premise of: few entities are easier to manage.

4.4 Chapter summary

The present chapter contains the practical walkthrough of the previously defined roadmap. First it regards the context, which is essential for SCs. Next, the portfolio characteristics as the SC characteristics are highly dependent on product characteristics. In this section, the application of multidimensional scaling on products is believed to be novel and recognized as useful by the practitioners as an argument towards postponement strategies. Is then performed SKU and later Client segmentation, after careful selection of classification variables.

In order to achieve better understanding, the conceptual strategy blocks are separated from the real segments, and each segmentation tool gets its own insights on what are the proper ways of addressing each segment. The chapter closes with matching the obtained segments with the previously defined conceptual strategy blocks, as well as segment prioritisation based on the revenue/variety ratio. That way, segments that can bring quick gains are highlighted.

Next chapter brings in the conclusion and highlights the probable contributions of this thesis. Its limitations are discussed and future research recommendations are given.

5 Conclusion and Future Research

"Conventional people are roused to fury by departure from convention, largely because they regard such departure as a criticism of themselves."

– Bertrand Russell (1930) in *The Conquest of Happiness*

5.1 Chapter outline

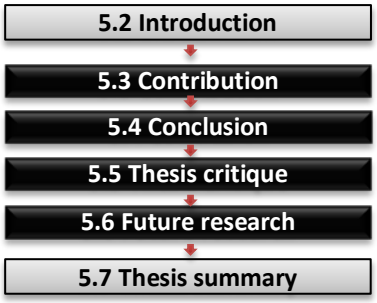


Figure 55: Chapter 5 structure

Finally, the last chapter concludes the thesis regarding several ends. Following a brief introduction about the context of this work (5.2), the key contributions are discussed (5.3). Next a general 5.4 conclusion is made, followed by a critique on the advantages and limitations of this study. Finally, a set of future research insights are presented (5.6), closing with a thesis general summary (5.7) highlighting the main points and conclusions.

5.2 Introduction

Times are changing, markets are evolving and people are offered more and more technological tools which should, or even must be used for its advantage. Everything must be related to the context and it is suggested, that tactics change, but strategies remain as they reflect the most basic rules of nature and particularly men.

Segmented SC strategy is becoming an eminent topic, as "one size does not fit all" (Shewchuck, 1998). Consequently, in order to achieve sustainable competitive advantage, companies must select the best matching SC strategy concerning product and demand characteristics. The need for context specific strategies is not new, however, due to many constraints and technological limitations, grasping the SC entities on a unitary level was difficult and facing the already mature field of qualitative approaches, it remained in the background, sometimes even related to pure operations research which most of the times remained on paper. However, social sciences offer us a wide range of different approaches

towards either number or qualities, and as every entity has a set of attributes, it enables many statistical studies which can be linked with the management research.

Next sections, discuss the possible contributions of the thesis, as well as the final conclusions and future research.

5.3 Contribution

This work is meant to approach the problem of:

"What is the most appropriate approach for implementing supply chain segmentation to enable better alignment of demand and supply in a FMCG context?"

This work review objective was to outline the so far evolution of this topic, highlighting the main stream, the key research gaps and further research insights.

The essence behind this approach is different from demand driven SCs as it proposes a combination of push (which is mostly based on forecasts) and pull which is based on real customer demand, suggesting that companies may have many different SCs in it depending on product and market characteristics

It gathers the latest, major contributions on this topic backed up by a bibliometric approach using citation and co-citation analysis, discussing its similarities and differences. The literature review takes the bibliometric approach using citation and co-citation analysis on two independent sets of papers. First set is broad and neutral, explicitly referring to SC strategy, and the second core set of references handpicked as considered relevant. The key-findings are the similarity and compatibility of several different approaches, the lack of quantitative empirical research as well as the absence of classification variable categorization and metrics. This work identifies the main stream in the research of differentiated SCs, its gaps and suggests further directions based on a bibliometric analysis. It also proposes a categorization scheme of the pool of classification variables into quantitative and qualitative groups, easing further quantitative approach.

A new roadmap is outlined, which can support further development, as well as the pool of classification variables and its categorization which enhances its compatibility with different sectors and industries.

The instrumental case can also support cross application to similar industries, as its application faces some interesting problems and the way they were handled might be useful for other cases. Moreover, the use of multidimensional scaling was recognised to be useful for product characteristic analysis, as it is based on common components and can be used as an

argument towards postponement strategy implementations. Additionally, a new dimension is defined which in this case is an evidence of clients inventory management and planning problems. It is believed that such variable use can be extended to other sectors.

The benefits of this research are: In general, that it shrinks the distance between academics and practitioners. Concerning the theoretical relevance it is a contribution towards the lack of the empirical quantitative approaches on this problem. Concerning industrial marketing segmentation, it is a contribution which addresses its immature state especially in the business to business segment (Blocker & Flint, 2007; Steenkamp, 2005) and allows a possible approach on the problem of segment instability by considering behavioural patterns such as the variability and order corrections. Managerial relevance is the enhancement of cross application of the body of works already existing, making the current state of the academic research more usable for practitioners from different sectors and finally, this research address the creation of a practical roadmap for segmented SC definition and its integration with both process and overall company strategy. The case study which enabled the practical walk-through the roadmap can be used as a support for further applications. Thus, it is likely that this study will bring benefits to the case company as each step and outputs were discussed and validated with practitioners and most of the managerial recommendations are currently in implementation.

The use of clustering methods, in particular Ward's method by means of the squared distance between entities showed to be successful for the identification of either profiles and segments. The decision on the number of cluster is also efficiently obtained by means of dendrograms, which are a powerful visual tool for the assessment of how similar different entities are. Concerning the application of multidimensional scaling on products, its application is likely to be novel as none similar applications were found in the literature. The approach towards supply strategy (procurement) using directly the demand characteristic (volume-variability affected through the bill of materials) is also unknown in the literature, which establishes fertile ground for further research and validation. Practical application of the roadmap, also suggested that visual approaches are most welcomed by practitioners as it allow visualisation of so far invisible realities. For example, just like the demand volume sequence charts are a useful tool for pattern/problem identification, two or three dimensional representation of entities (clients/products) in a relative position to each other, using different classification variables, is also a powerful way of comparing different products, clients and components. Thus, this is a great step further from the widely used Pareto charts or pie-

charts. As the human capability for visual patter recognition is, regarding the actual technological state, unmatched.

In particular regarding segmentation through the empirical research, several hypotheses arise. First, segmentation enables better setting of service standards as different segments require different targets and require different management addressing the cost to serve. Second, it enables better match between customer expectations and what company is willing and capable of providing. Third, it provides ground for negotiation of service standards with customers. Fourth, it is also found to be an enriched alternative to the Pareto tool for client prioritisation, reflecting not only profitability, but reducing the client variety making management easier. Finally, it is proposed a new segmentation concept on procurement based on the client's demand which segments the components as key and specific, either stable or variable, suggesting different SC 'tailored practices' (Lapide, 2006) for each segment which is an alternative to the price driven portfolio approaches focused on the bargain power balance described by Kraljic (1983). It is suggested that SC segmentation is essential for agile, aligned, and adaptable SCs described by Lee (2004) due to its extension through the whole SC, possibility of re-segmentation enabling real-time adaptability retaining the needed level of agility by not falling into strict paradigms. As well as, it is a move towards the merging of system 1 (qualitative) and system 2 (quantitative) thinking (Stanovich & West, 2000), thus enabling more rational managerial decisions.

In conclusion, segmented approach on SC strategy building enables better match between customers demand and company's supply, which may be extended to company's procurement strategy as well. Better matched streams, with segment individual strategy and KPI's with specific targets, are likely to deliver better service levels, less costs, less waste, reduced demand risk and competitive advantage enhancement. However, it remains as a preposition as to the moment of this writing, there is not enough data to validate it.

5.4 Conclusion

First of all, it is worth noting that management stands between the exact science and art. As science, is capable of accurate quantitative expression and rigorous methods of testing hypotheses. In contrast, art accounts for the skill in conducting any human activity. Thus, there is no right or wrong in different approaches, and due to the fact that the total complexity of systems is unbearable, they are just worse or better in different situations and, every result, belief or method linked to positive results will remain alive while people simply believe in them.

This work approached the problem by first identifying a possible research problem, followed by a literature review which indicated possible research gaps in the field. Next, it is proposed first approach, as a SC strategy building model which is applied on a case study. The application process was described by steps and discussed.

RQ1. What are the main supply chain strategy paradigms?
RQ2. What is the main stream of research on differentiated supply chain strategies?
RQ3. Which classification variables are used for supply chain segmentation?

First, concerning the main SC strategy paradigms the answer turns out to be evident. The big-picture analysis on the keyword "supply chain strategy" revealed a cluster of both more cited and more dense contributions, mostly by management schools located in UK. The individual analysis of that cluster revealed that most of the authors regard the lean-agile paradigms, as well as the hybrid leagile. Another strong focus of that contributions is the market orientation, building a solid bridge between process, marketing and SC management which tends to be customer centric, also named demand driven SCs, demand chain management or slightly different, yet focused on the client, the responsive SC. Thus, the main SC strategy paradigms are lean, agile and leagile applied on the total SC.

Secondly, the main stream of research on differentiated SC strategies converges on segmentation. This segmentation, just like used in marketing, provides management with solid support to match the SC segment with the ultimate customer demand characteristic, expressed for example through volume and variability.

Thirdly, a list of classification variables is collected and categorised. The most recurrent set of variables is DWV^3 (Christopher & Towill, 2002), containing product lifecycle duration, time window for delivery, volume, variety, and variability. The author suggests, based on the empirical segmentation application, that classification variables should be those which the company cannot control. Demand volumes, patterns, and other characteristics which are external because the focal firm can be both absorber and amplifier. All the incontrollable factors (external) are of primary concern while all the controllable ones are secondary.

The conclusion is that SC segmentation is the balance between the "one-size-fits-all" and "individual-size-for-each-one", i.e., one general stream vs. individual streams, seeking for the best compromise between resources spent on management (cost to serve), and the best way of delivering the right product, on the right moment, and in the right place. And it is likely to be the essential element for agile, aligned, and adaptable SCs described by Lee (2004).

To address the SC segmentation immaturity, this study focuses on an empirical exploratory case study. However, the main limitation is that it lacks of any critique on the success of the

proposed strategy implementation which is still in progress. Thus, the empirical confirmation of the validity and fitness of the study are so far unknown and the overall value of the work could be enhanced by future follow-up and assessment of the effect of the proposed approach.

5.5 Thesis critique

This thesis's main strength is the fact that the subject of supply chain segmentation is new. There are few studies concerning this particular topic and either conceptual or empirical contributions are necessary. This thesis provides the foundation for segmented approach on supply chains, presenting its rationale and highlights how supply chain management converges on segmentation. The empirical exploratory study of a case is also an advantage, as it covers the dearth of practical descriptions. It is believed to be due to the dominant system 1 thinking, which is mostly intuitive lacking of analytical support. This study, regards statistical methods, contributing to a hybrid system 1-system 2 decision support presenting a set of analytical tools addressing both ends of supply chain, i.e., the segmented total supply chain based on customer demand characteristics. For example, the new insight on procurement, segmenting the raw components based on the direct customer behaviour is also unique, what does add value to this work.

In contrast, the probable limitations of this thesis are the number of case studies, a single very specific company in this case. Mostly because of several constraints on data acquisition, some analyses were impossible. Thus, further research must address new dimensions by trial and failure seeking for new possible classification variables which somehow differentiate products and can support differentiated SC strategies.

As well as all the conclusions drawn out are be based on beliefs, which might, in some way open ground for criticism regarding the model generalization, mostly because the suggested SC recommendations and practices as still in process of implementation. However, these limitations are likely to be diminished due to the large pool of initial classification variables as well as future studies comparing before and after SC performance indicators.

5.6 Future research

This thesis raised more questions than it answered. However, it is a fertile ground for further research as many questions still unanswered and the existing answers lack of better validation.

Following the literature review on this topic, some possible specific research gaps arose. The key findings reveal that there are many different conceptual approaches on the problematic.

However, empirical studies are mostly qualitative which cause many different constraints when we try to apply it into practice (integrating them with processes). In contrast, the efficient match between SC segmentation and processes is possible through quantitative studies (which are scarce and by far immature). Yet, there is a lot of literature that can support the further research, as the problematic have been winning importance. The present work examines only part of the identified intellectual segments opening new ground for further research.

It is now clear, that more work must be done to group a comprehensive pool of SC 'tailored practices' (Lapide, 2006); collect more possible classification variables, perform its categorization and metrics definition; set up a wider set of tools for its analysis; to study when quantitative research is better than qualitative for the case, or maybe both are reasonable; and finally, which are the classification variables that discriminate products and in which sectors, making inevitable the empirical application of the model on a number of different case studies.

In detail, concerning the quantitative vs. qualitative approach, there is also no clear evidence on whether it is better or not. It is probable that quantitative models are more prone to generalisation and cross applicability; however, it must be proved.

Secondly, as far as classification variables are concerned, there are also numerous references on it, as well as its applications description and critique. Most of them are applied in a qualitative way, however, majority can be quantified and measured accurately which enables data analysis, leading to replicable, neutral and probably cross applicable outputs; this eases the following definition of key performance indicators and its future targets accordingly to the new strategy.

Thirdly, data collection should be done through direct interaction with companies. As the research will be grounded on both quantitative and qualitative empirical analysis, on one hand, the model validation will rely on data from companies in different sectors. The data will comprehend mostly data logs at both SKU and order level, and portfolio discrimination. On the other hand, along with objective data, the research will need subjective data such as open interviews with practitioners, surveys and observation to outline the context and specifics. Meantime, comprehensive literature review supported by bibliometric approach (citation and co-citation analysis) for intellectual structure building as well as classical review. The collected information can be analysed using simple statistical methods: mainly cluster analysis, descriptive statistics and model building (IBM SPSS, MS Excel and Mathworks Matlab).

Finally, strategic alignment is also a fertile ground for discussion as there is no practical evidence of whether the direct transfer of client demand characteristics benefit, in some degree, the proper sourcing strategies.

This suggest, that further research must address the perfection and fine tuning of the presented roadmap, developing it into a solid framework, its empirical application and most important of all, its follow up and assessment, as it will likely highlight its disadvantages, errors and efficiency for strategy development. And in the end, if the model survives the proof of time, it can be considered successful.

In conclusion, besides product SCs, service SCs segmentation is necessary as there are barely any studies regarding that matter. In the service context, classification variables are likely to be different and the proposed volume-variability is believed to be insufficient. However, further study must be done in order to draw out any conclusions and advances. Thus, due to the fact that this is a novel field of studies, it is essential that researchers dare to be wrong, because sometimes they might be right, and it is the key for pushing the boundaries.

5.7 Thesis summary

Facing the world changes, competitive advantage comes from well managed systems rather than isolated firms, what leads towards the need for proper supply chain management, as being the essential element to achieve and sustain competitive advantage. Thus, it is essential to choose the right SC strategies what consequently brings in the need for tools and practical studies on how to do it. Facing the dominant system 1 thinking, based mostly on intuition and qualitative approaches, managers must change towards a more analytical and quantitative base, enabling system 2 decisions.

Using the plethora of already developed studies, as well as wide range of statistical methods and tools, this thesis proposes several novel applications for segmentation, enabling practical support for managers and further research on SC segmentation.

Finally, it is believed that segmented supply chains are the key towards dynamic (adaptable) SCs by means of re-segmentation on a regular basis, allowing quicker recovery after disruptions as well as better match between the real customer needs and supply as it will automatically give measurable signs of the new, altered needs.

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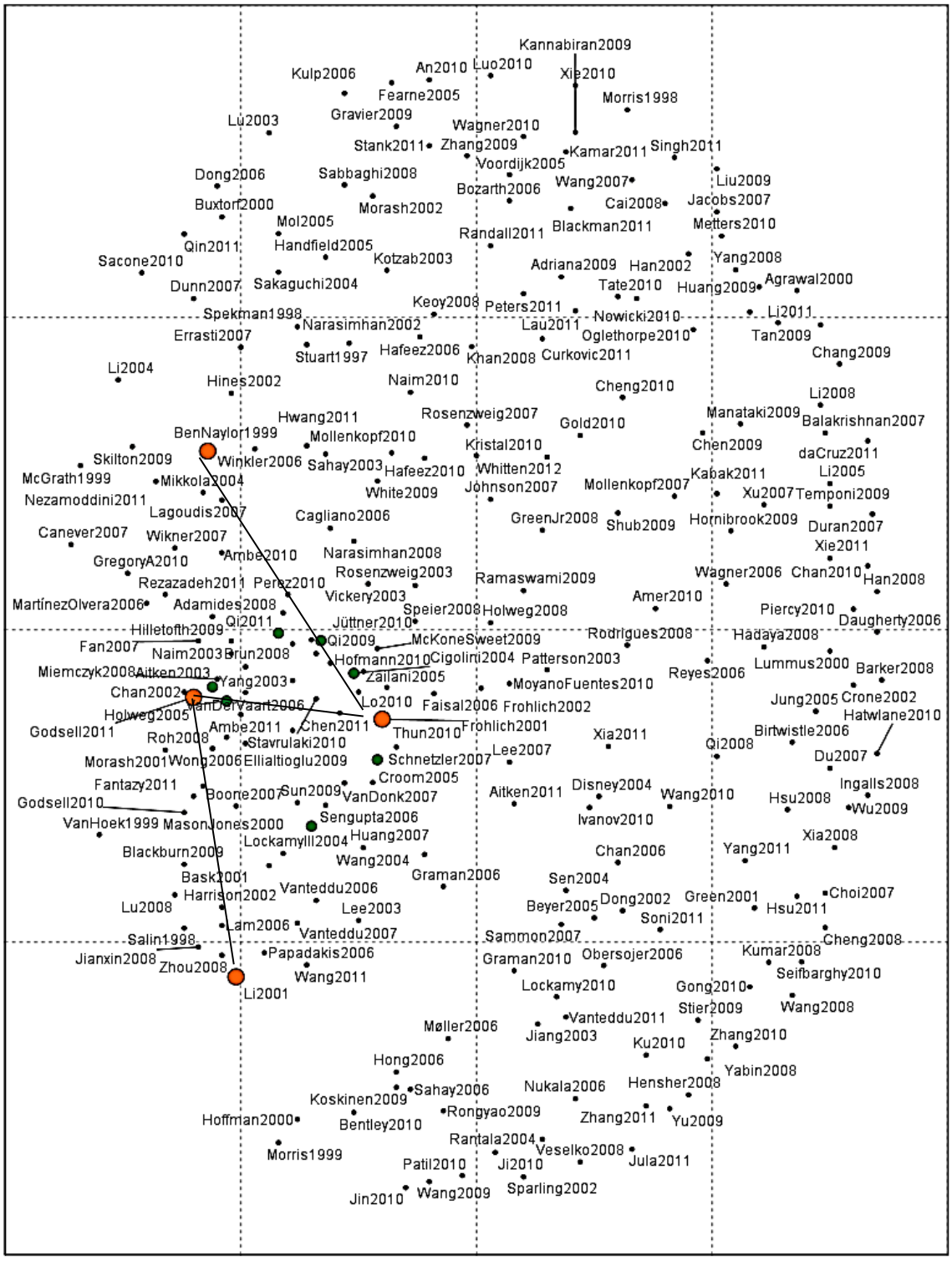
7 Appendix

Appendix 1: Matlab script for proximity matrix building

```
%
%###### Proximities matrix building script ######
%
% Copyright Alexander Kharlamov 2012
%
%###### Glossary: #######
% SKU: Stock Keeping Unit
% RM: Raw Material
% BOM: Bill Of Materials

% ####Read from excel file the Boolean BOM matrix where SKU = COLS &
RM = LINES ####
BOM = xlsread('BOM_raw.xlsx');

%##### Proximity size definition (LinesBOM, ColsBOM)

SIZE = size(BOM);
% Control vars
LinesBOM = SIZE(1,1);
ColsBOM = SIZE(1,2);

% Proximity Matrix initiation: Square matrix (#SKU's)
Prox = zeros(ColsBOM);

% Building cycles
for i=1:ColsBOM % Proximity matrix column cell advance
    for j=1:ColsBOM % Proximity matrix row cell advance
        BOMcolSUM = 0;% BOMcolSUM count reset
        for k=1:LinesBOM % Repeat until the end of the RM's in the
BOM

        % Cumulative advance of SKU comparison
        % SKU comparison 0*1=0 (dissimilar) OR 1*1=1 (similar)
        BOMcolSUM = BOMcolSUM + (BOM(k,i)* BOM(k,j));

        end % BOM column advance
        Prox(i,j) = BOMcolSUM;
    end % proximity row advance
end % proximity col advance

%End of script
```

Appendix 2: Plot of the references on the keyword "supply chain strategy/strategies"[6]



[6] Medium-size dots are some of the cited articles in the present work and the bigger dots are the core papers cited.

Appendix 3: The 244 references of the "big picture" on the subject of "SC strategy"

Author	Title	Year	Journal	Citations
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Ambe, I.M., Badenhorst-Weiss, J.A.	Strategic supply chain framework for the automotive industry	2010	African Journal of Business Management	10
Ambe, I.M., Badenhorst-Weiss, J.A.	Framework for choosing supply chain strategies	2011	African Journal of Business Management	0
Amer, Y., Luong, L., Ashraf, M.A., Lee, S.-H.	A systems approach to order fulfilment	2010	International Journal of Operational Research	0
An, T., Zhao, D.-Z.	A supply chain model of vendor managed inventory with fuzzy demand	2010	Proceedings - 2010 International Conference on System Science	0
Balakrishnan, K., Seshadri, S., Sheopuri, A., Iyer, A.	Indian auto-component supply chain at the crossroads	2007	Interfaces	2
Barker, R., Naim, M.M.	Is supply chain thinking permeating the UK housebuilding industry? Findings from a survey of UK housebuilders	2008	International Journal of Logistics Research and Applications	1
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Beyer, J., Gmilkowsky, P.	Approach to modelling and control of supply chains	2005	Proceedings of the 14th IASTED International Conference on Applied Simulation and Modelling	1
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Blackman, I.D., Holland, C.P., Westcott, T.	The evolution of motorola's global financial supply chain strategy	2011	Proceedings of the Annual Hawaii International Conference on System Sciences	0
Boone, C.A., Craighead, C.W., Hanna, J.B.	Postponement: An evolving supply chain concept	2007	International Journal of Physical Distribution and Logistics Management	18
Borgström, B., Hertz, S.	Supply chain strategies: Changes in customer order-based production	2011	Journal of Business Logistics	0
Bozarth, C.	ERP implementation efforts at three firms: Integrating lessons from the SISP and IT-enabled change literature	2006	International Journal of Operations and Production Management	12
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Caniato, F., Caridi, M., Castelli, C.M., Golini, R.	A contingency approach for SC strategy in the Italian luxury industry: Do consolidated models fit?	2009	International Journal of Production Economics	3
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Chan, F.T.S., Chan, H.K.	An AHP model for selection of suppliers in the fast changing fashion market	2010	International Journal of Advanced Manufacturing Technology	1
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Chen, H.-J., Ma, F.	Model for ranking green supply chain strategies based on MDEA	2009	IE and EM 2009 - Proceedings 2009 IEEE 16th International Conference on Industrial Engineering and Engineering Management	0
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Jula, P., Leachman, R.C.	Long- and Short-Run supply-chain optimization models for the allocation and congestion management of containerized imports from Asia to the United States	2011	Transportation Research Part E: Logistics and Transportation Review	3
Jung, S., Chang, T.-W., Sim, E., Park, J.	Vendor managed inventory and its effect in the supply chain	2005	Lecture Notes in Artificial Intelligence (Subseries of Lecture Notes in	2

			Computer Science)	
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Kabak, O., Ülengin, F.	Possibilistic linear-programming approach for supply chain networking decisions	2011	European Journal of Operational Research	3
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Ku, C.-Y., Chang, C.-T., Ho, H.-P.	Global supplier selection using fuzzy analytic hierarchy process and fuzzy goal programming	2010	Quality and Quantity	1
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Li, P.-Q.	Rethinking "sanlu" supply chain strategy dilemma	2011	2011 International Conference on Computer Science and Service System	0
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Mason-Jones, R., Naylor, B., Towill, D.R.	Lean, agile or league? Matching your supply chain to the marketplace	2000	International Journal of Production Research	92
McGrath, R.N.	Maintenance: The missing link in supply chain strategy	1999	Industrial Management (Norcross	0
McKone-Sweet, K., Lee, Y.-T.	Development and analysis of a supply chain strategy taxonomy	2009	Journal of Supply Chain Management	9
Metters, R., Zhao, X., Bendoly, E., Jiang, B., Young, S.	"The way that can be told of is not an unvarying way": Cultural impacts on Operations Management in Asia	2010	Journal of Operations Management	1
Miemczyk, J., Howard, M.	Supply strategies for build-to-order: Managing global auto operations	2008	Supply Chain Management	6
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Vanteddu, G., Chinnam, R.B., Yang, K., Gushikin, O.	Supply chain focus dependent safety stock placement	2007	International Journal of Flexible Manufacturing Systems	5
Vanteddu, G., Chinnam, R.B., Gushikin, O.	Supply chain focus dependent supplier selection problem	2011	International Journal of Production Economics	2
Veselko, G., Jakomin, I.	Coordinating supply chain management strategy with corporate strategy	2008	Promet - Traffic - Traffico	0
Vickery, S.K., Jayaram, J., Droge, C., Calantone, R.	The effects of an integrative supply chain strategy on customer service and financial performance: An analysis of direct versus indirect relationships	2003	Journal of Operations Management	180
Voordijk, H., Meijboom, B.	Dominant supply chain co-ordination strategies in the Dutch aerospace industry	2005	Aircraft Engineering and Aerospace Technology	1
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Wang, C., Fergusson, C.	A conceptual case based model supporting a SME's strategic supply chain decision	2007	IET Conference Publications	0
Wang, S., Song, H.	A multi-agent based combinational auction model for Collaborative e-procurement	2008	2008 IEEE International Conference on Industrial Engineering and Engineering Management	1
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Wang, X.	Research on information sharing platform of supply chain under regional economies environment	2010	Proceedings - 3rd International Conference on Information Management	0
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Wikner, J., Naim, M.M., Rudberg, M.	Exploiting the order book for mass customized manufacturing control systems with capacity limitations	2007	IEEE Transactions on Engineering Management	14
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Xia, G.H., Hui, L.	Study on logistic service supply chain task allocation based on MAS	2008	Proceedings of 2008 IEEE International Conference on Service Operations and Logistics	0
Xia, Y., Tang, T.L.-P.	Sustainability in supply chain management: Suggestions for the auto industry	2011	Management Decision	0
Xie, G., Yue, W., Wang, S.	Quality decision in a make-to-order supply chain with uncertain demand	2010	2010 7th International Conference on Service Systems and Service Management	0
Xie, G., Yue, W., Wang, S., Lai, K.K.	Quality investment and price decision in a risk-averse supply chain	2011	European Journal of Operational Research	2
Xu, L.X.X., Ma, B., Lim, R.	AHP based supply chain performance measurement system	2007	IEEE Symposium on Emerging Technologies and Factory Automation	0
Yabin, L., Tiejun, C.	Research on the power plant coal-fired supply chain based on witness software	2008	2008 International Conference on Wireless Communications	0
Yang, B., Burns, N.	Implications of postponement for the supply chain	2003	International Journal of Production Research	57
Yang, L., Su, Y., Zhao, J.	System dynamics modeling for green supply-chain strategies	2008	Journal of Beijing Institute of Technology (English Edition)	0
Yang, T., Wen, Y.-F., Wang, F.-F.	Evaluation of robustness of supply chain information-sharing strategies using a hybrid Taguchi and multiple criteria decision-making method	2011	International Journal of Production Economics	1
Yu, B., Liu, H.	E-commerce in international trade and performance evaluation of supply chain strategic alliance	2009	Proceedings - International Conference on Management and Service Science	0
Zailani, S., Rajagopal, P.	Supply chain integration and performance: US versus East Asian companies	2005	Supply Chain Management	36
Zhang, S.	Research on the readiness evaluation index system of green supply chain management based on RBV	2009	2009 1st International Conference on Information Science and Engineering	0
Zhang, J., Liu, X.	A capacitated production planning problem for closed-loop supply chain	2010	Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	0
Zhang, J., Liu, X., Tu, Y.L.	A capacitated production planning problem for closed-loop supply chain with remanufacturing	2011	International Journal of Advanced Manufacturing Technology	0
Zhou, M., Huo, J.-Z.	Measure product-driven supply chain performance using MEOWA	2008	2008 International Conference on Wireless Communications	0

Appendix 4: Research focus contributions

Code	Citations	Coordinates		Reference
Aitken2003	46	-0,0600	0,0748	Aitken, J., Childerhouse, P. & Towill, D., 2003. The impact of product life cycle on supply chain strategy. *International Journal of Production Economics,* 85(2), p. 127–140.
Bruce2004	78	0,0579	-0,1541	Bruce, M., Daly, L. & Towers, N., 2004. Lean or agile - A solution for supply chain management in the textile and clothing industry?. *International Journal of Operations and Production Management,* 24(2), p. 151–170.
Childerhouse2002	62	-0,0369	0,0809	Childerhouse, P., Aitken, J. & Towill, D., 2002. Analysis and design of focused demand chains. *Journal of Operations Management,* 20(6), p. 675–689.
Christopher2001	25	-0,3174	0,1510	Christopher, M. & Towill, D., 2001. An integrated model for the design of agile supply chains. *International Journal of Physical Distribution & Logistics Management,* 31(4), pp. 435-246.
Christopher2004	7	-0,6217	-0,6791	Christopher, M., Lowson, R. & Peck, H., 2004. Creating agile supply chains in the fashion industry. *International Journal of Retail and Distribution Management,* 32(8), p. 367–376.
Christopher2009	2	-0,2599	0,0342	Christopher, M., Towill, D. R., Aitken, J. & Childerhouse, P., 2009. Value stream classification. *Journal of Manufacturing Technology Management,* 20(4), pp. 460 - 474.
Cigolini2004	53	0,1960	0,1457	Cigolini, R., Cozzi, M. & Perona, M., 2004. A new framework for supply chain management: conceptual model and empirical test. *International Journal of Operations and Production Management,* 24(1), p. 7–41.
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DeToni1995	7	0,8739	0,4107	de Toni, A. & Nassimbeni, G., 1995. Supply Networks: Genesis, Stability and Logistics Implications. A Comparative Analysis of Two Districts. *International Journal of Management Science,* 22(4), pp. 403-418.
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Giannakis2006	23	0,5530	-0,6499	Giannakis, M. & Croom, S., 2004. Toward the development of a supply chain management paradigm: a conceptual framework. *Journal of Supply Chain Management,* 40(2), p. 27–37.
Godsell2011	37	-0,3757	-0,0085	Godsell, J. et al., 2011. Enabling supply chain segmentation through demand profiling. *International Journal of Physical Distribution & Logistics Management,* 41(3), pp. 296-314.
Grandori1995	186	0,9056	0,0943	Grandori, A. & Soda, G., 1995. Inter-firm Networks: Antecedents Mechanisms and Forms. *Organisation Studies,* 16(2), pp. 183-214.
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Li2001	32	-0,4204	-0,6915	Li, D. & O'Brien, C., 2001. A quantitative analysis between product types and SC strategies. *International Journal of Production Economics,* 73(1), p. 29–39.
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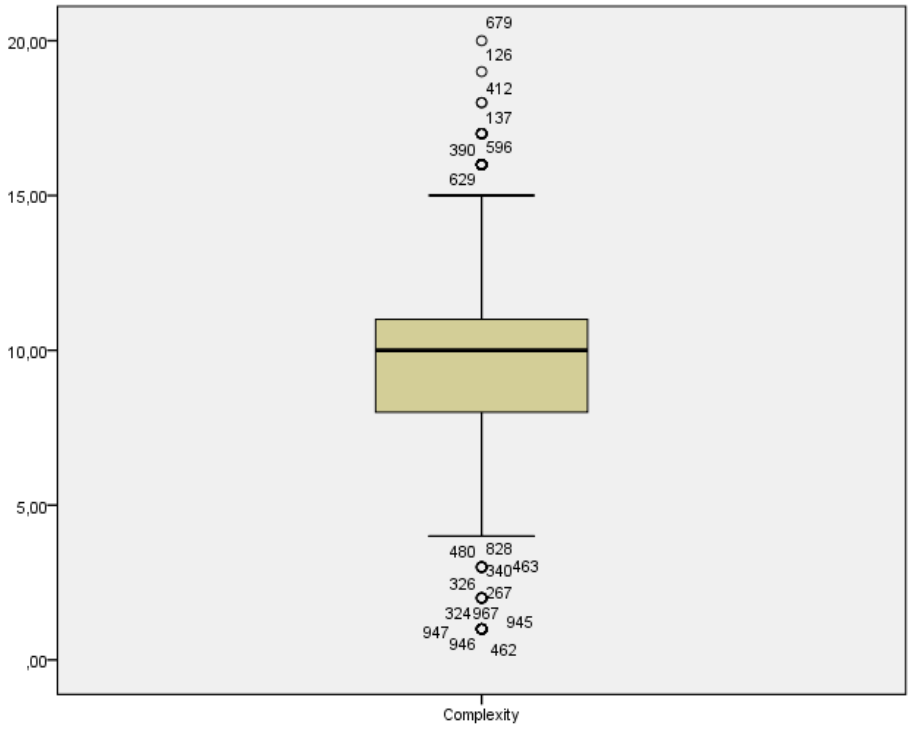
Qi2011	1	-0,1651	-0,3274	Qi, Y., Zhao, X. & Sheu, C., 2011. The Impact of Competitive Strategy and Supply Chain Strategy on Business Performance: The Role of Environmental Uncertainty. *Decision Science,* 42(2), pp. 371-389.
Schnetzler2007	16	-0,0659	-0,6404	Schnetzler, M., Sennheiser, A. & Schonsleben, P., 2007. A decomposition-based approach for the development of a supply chain strategy. *International Journal of Production Economics,* 105(1), p. 21–42.
Selldin2007	17	-0,2562	-0,2346	Selldin, E. & Olhager, J., 2007. Linking products with supply chains: testing Fisher's model. *Supply Chain Management: An International Journal,* 12(1), pp. 42 - 51.
VanHoek2000	7	-0,8343	-0,0492	Van Hoek, R. I., 2000. The thesis of leagility revisited. *International Journal of Agile Management Systems,* 2(3), pp. 196-201.
Vitasek2003	2	0,3956	1,0771	Vitasek, K., Manrodt, K. & Kelly, M., 2003. Solving the supply-demand mismatch. *Supply Chain Management Review,* p. 58–64.
Whitten2012	1	0,2548	-0,9854	Whitten, G. D., Green Jr, K. W. & Zelbst, P., 2012. Triple-A supply chain performance. *International Journal of Operations & Production Management,* 32(1), pp. 28-48.

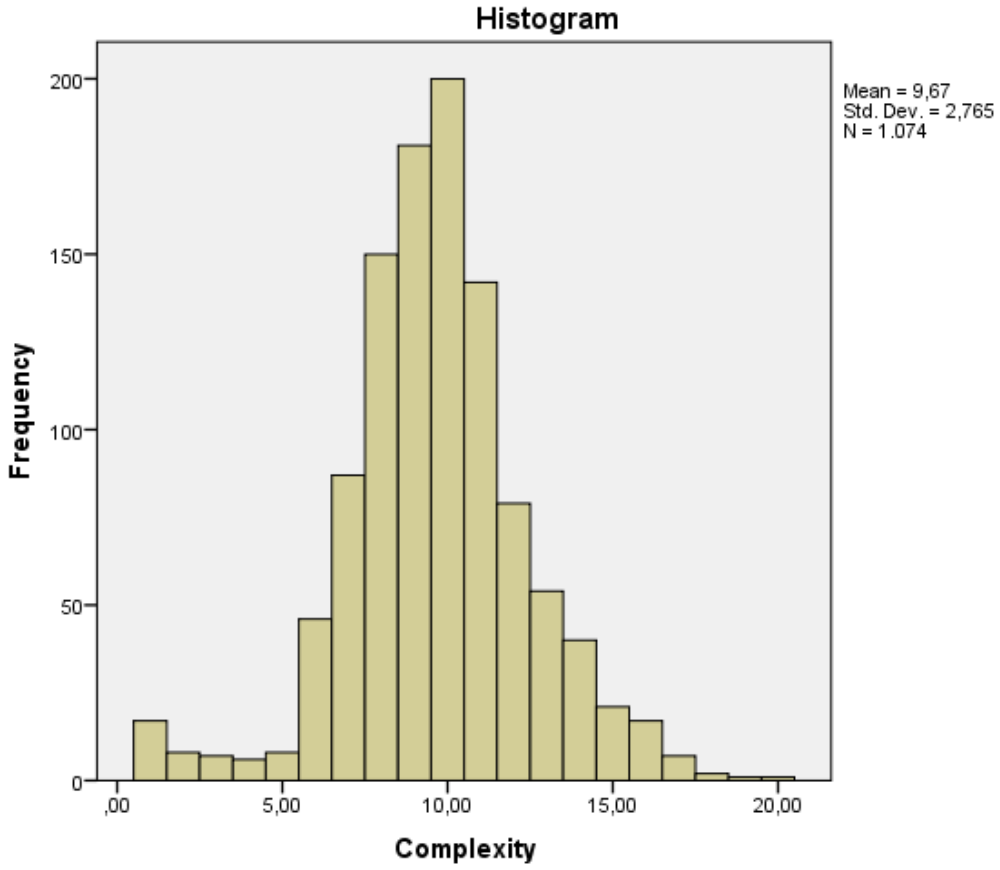
Appendix 5: Research focus proximity matrix

	Aitken2003	Bruce2004	Childerhouse2002	Christopher2001	Christopher2004	Christopher2009	Cigolini2004	Demeter2006	DeToni1995	Fisher1997	Frohlich2001	Giannakis2006	Godsell2011	Grandori1995	Harland1999	Harland2004	Holweg2005	Lamming2000	Lee2002	Lee2004	Li2001	MasonJones2000	MasonJonesB2000	Nassimbeni1998	Naylor1999	Qi2009	Qi2011	Schnetzler2007	Selldin2007	VanHoek2000	Vitasek2003	Whitten2012
Aitken2003	46	7	22	12	1	11	6	1	1	0	1	0	10	1	5	5	6	5	1	0	1	4	4	0	6	4	4	2	5	2	0	0
Bruce2004	7	74	5	7	2	3	3	2	0	0	2	3	4	2	3	4	5	4	1	0	1	2	2	0	1	5	6	2	3	1	0	0
Childerhouse2002	22	5	37	9	1	12	6	3	1	0	1	1	8	0	5	5	9	4	1	0	1	4	6	1	8	3	5	2	5	3	0	0
Christopher2001	12	7	9	38	3	9	5	2	0	1	0	0	10	0	3	3	10	4	2	1	1	7	8	0	6	5	6	1	4	3	0	0
Christopher2004	1	2	1	3	11	1	0	0	0	0	0	0	2	0	0	0	4	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0
Christopher2009	11	3	12	9	1	34	3	3	0	0	0	1	7	0	1	3	4	2	1	0	1	4	4	0	4	4	3	1	3	2	0	0
Cigolini2004	6	3	6	5	0	3	77	1	2	1	2	5	1	1	6	10	6	4	1	0	1	3	5	1	7	1	1	3	3	2	0	0
Demeter2006	1	2	3	2	0	3	1	33	0	0	1	3	1	0	0	4	1	3	1	0	1	2	2	1	1	3	3	1	1	0	0	2
DeToni1995	1	0	1	0	0	0	2	0	38	0	0	0	0	7	2	5	0	1	0	0	0	0	0	14	0	0	0	0	0	0	0	0
Fisher1997	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0
Frohlich2001	1	2	1	0	0	0	2	1	0	0	44	1	0	1	1	2	3	0	0	0	0	0	0	0	0	2	1	0	2	0	0	0
Giannakis2006	0	3	1	0	0	1	5	3	0	0	1	31	1	0	1	3	0	1	0	0	0	0	0	0	0	3	0	1	0	0	0	2
Godsell2011	10	4	8	10	2	7	1	1	0	0	0	1	37	0	0	1	7	2	1	0	1	4	4	0	3	6	6	1	4	2	0	0
Grandori1995	1	2	0	0	0	0	1	0	7	0	1	0	0	168	6	12	0	2	0	0	0	0	0	10	0	1	0	0	0	0	0	0
Harland1999	5	3	5	3	0	1	6	0	2	0	1	1	0	6	85	21	3	13	0	0	0	0	1	7	2	0	1	1	1	0	0	0
Harland2004	5	4	5	3	0	3	10	4	5	0	2	3	1	12	21	105	2	18	1	0	1	2	1	9	2	1	2	2	1	0	0	1
Holweg2005	6	5	9	10	4	4	6	1	0	1	3	0	7	0	3	2	83	4	2	1	1	7	6	0	4	5	6	2	5	4	0	0
Lamming2000	5	4	4	4	0	2	4	3	1	0	0	1	2	2	13	18	4	51	1	0	1	1	2	5	3	1	2	1	1	0	0	0
Lee2002	1	1	1	2	0	1	1	1	0	0	0	0	1	0	0	1	2	1	17	1	1	2	1	0	0	1	1	2	1	1	0	0
Lee2004	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0
Li2001	1	1	1	1	0	1	1	1	0	0	0	0	1	0	0	1	1	1	1	0	4	1	1	0	0	1	1	1	1	0	0	0
MasonJones2000	4	2	4	7	0	4	3	2	0	0	0	0	4	0	0	2	7	1	2	0	1	17	6	0	3	2	2	2	2	1	0	0
MasonJonesB2000	4	2	6	8	0	4	5	2	0	1	0	0	4	0	1	1	6	2	1	0	1	6	16	0	9	1	2	1	2	0	0	0
Nassimbeni1998	0	0	1	0	0	0	1	1	14	0	0	0	0	10	7	9	0	5	0	0	0	0	0	50	0	1	0	0	0	0	0	0
Naylor1999	6	1	8	6	0	4	7	1	0	1	0	0	3	0	2	2	4	3	0	0	0	3	9	0	29	0	1	1	1	0	0	0
Qi2009	4	5	3	5	1	4	1	3	0	0	2	3	6	1	0	1	5	1	1	0	1	2	1	1	0	59	22	2	6	2	0	4
Qi2011	4	6	5	6	2	3	1	3	0	0	1	0	6	0	1	2	6	2	1	0	1	2	2	0	1	22	55	2	3	2	0	4
Schnetzler2007	2	2	2	1	0	1	3	1	0	0	0	1	1	0	1	2	2	1	2	0	1	2	1	0	1	2	2	59	1	0	0	1
Selldin2007	5	3	5	4	0	3	3	1	0	1	2	0	4	0	1	1	5	1	1	0	1	2	2	0	1	6	3	1	30	1	0	1
VanHoek2000	2	1	3	3	0	2	2	0	0	0	0	0	2	0	0	0	4	0	1	1	0	1	0	0	0	2	2	0	1	10	0	0
Vitasek2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Whitten2012	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	4	4	1	1	0	0	62

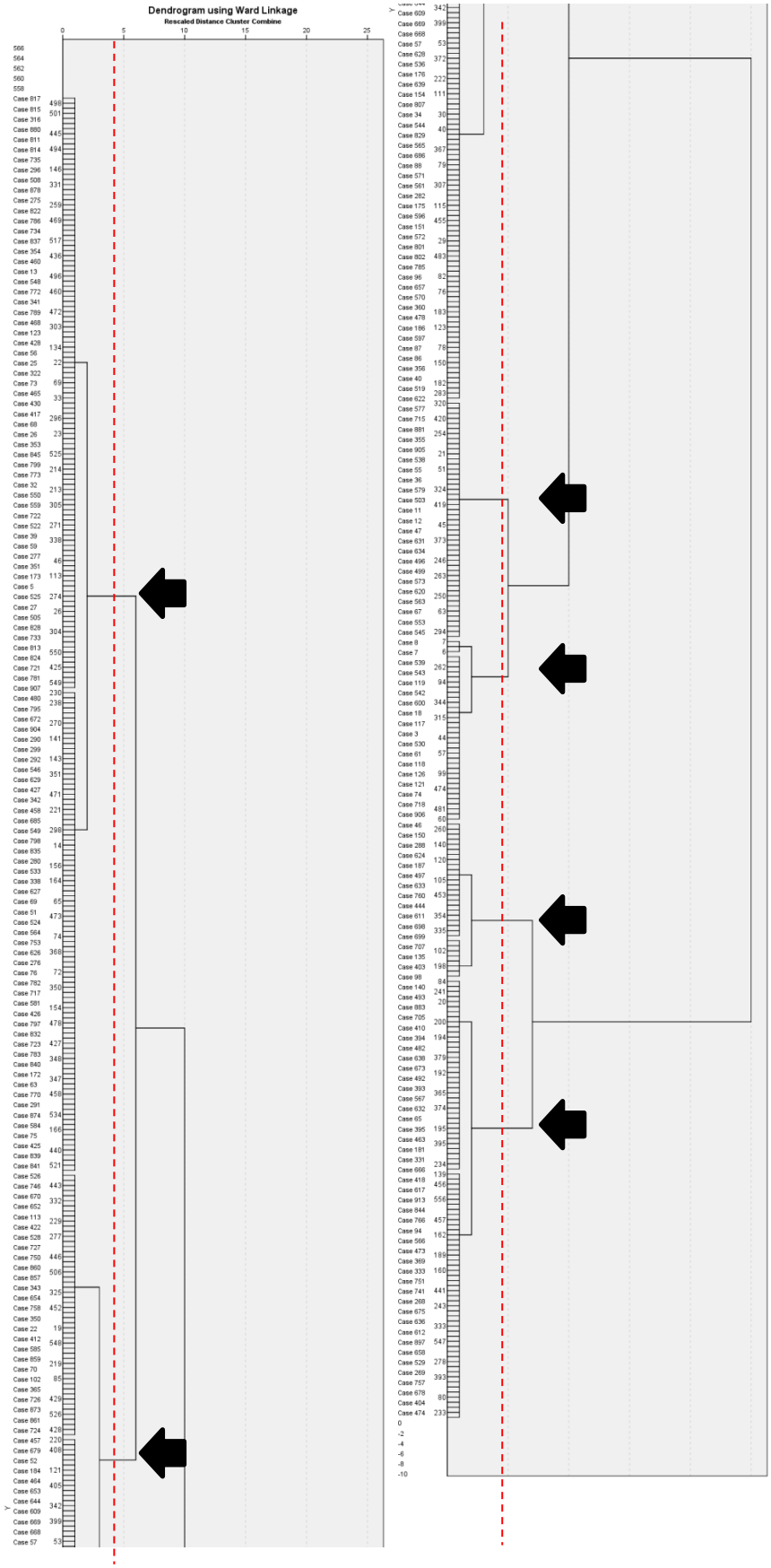
Appendix 6: Box plot for the complexity of SKUs (number of components)



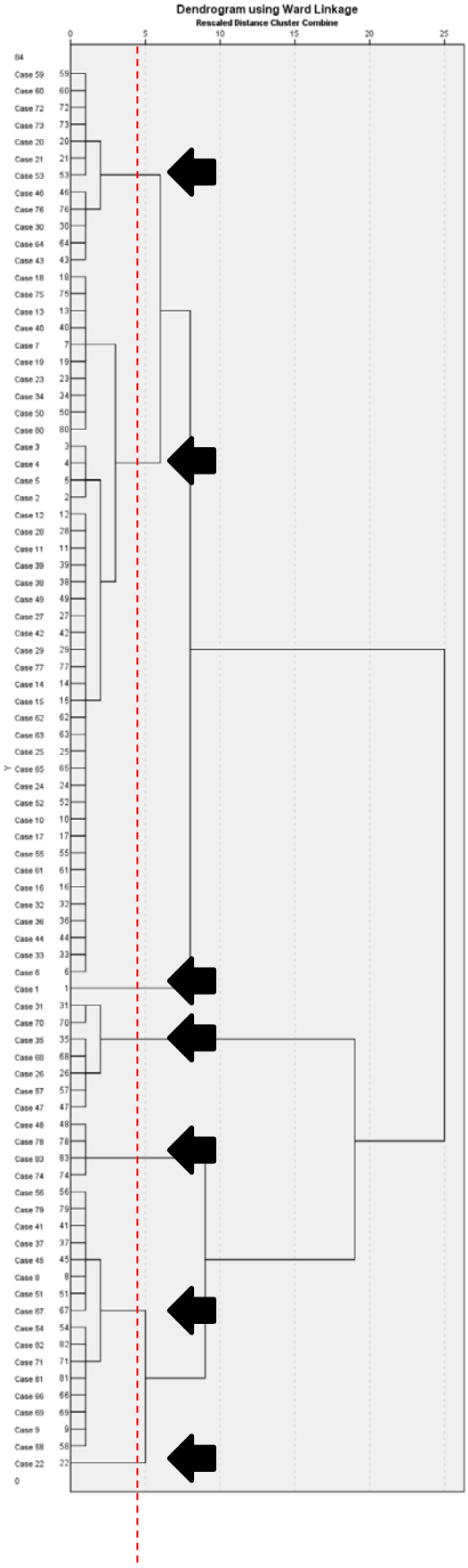
Appendix 7: Histogram of the SKU number of components



Appendix 8: Ward's method dendrogram on the SKU's clustering



Appendix 9: Dendrogram for client clustering

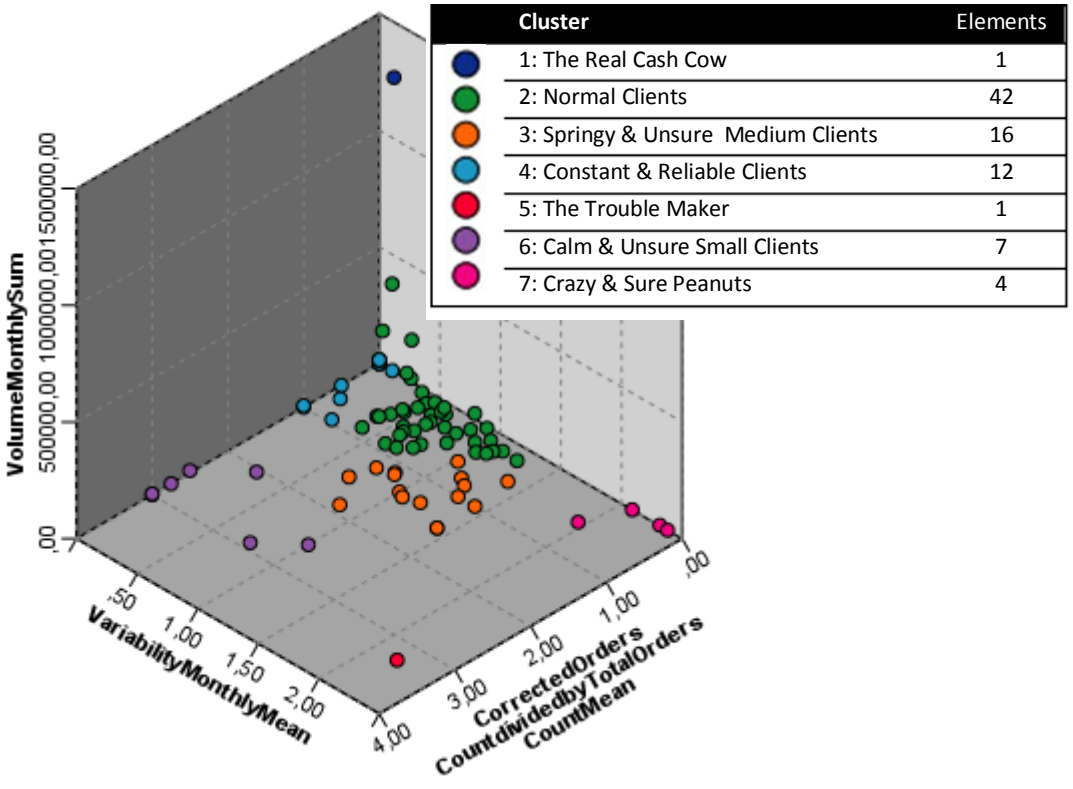


Appendix 10: Detailed clustering client list

Cluster	ClientID	Order correction ratio	Monthly Vol. Sum	Monthly Var. Sum
1	Client2	0,62	1493250	0,51
2	Client1	0,48	39919	0,49
	Client10	0,71	22495	0,79
	Client86	0,4	4409	0,46
	Client11	0,65	9422	0,6
	Client12	0,14	255	1,01
	Client14	0,48	5858	0,86
	Client15	0,26	39260	0,91
	Client16	0,37	111933	0,77
	Client17	0,26	5897	0,59
	Client19	0,41	303265	0,29
	Client21	0,3	3627	0,82
	Client23	0,3	16840	1,12
	Client3	0,28	132789	0,4
	Client30	0,87	9341	0,4
	Client32	0,3	20189	0,51
	Client36	0,15	554	0,48
	Client4	0,8	25535	0,78
	Client46	0,36	14792	1,11
	Client47	0,31	4708	0,73
	Client5	0,55	579783	0,45
	Client51	0,2	198	1,26
	Client53	0,85	752	0,67
	Client55	0,39	1423	0,63
	Client57	0,71	39782	0,44
	Client60	0,11	10920	0,53
	Client63	0	14444	0,26
	Client64	0,56	233	0,55
	Client65	0,3	291914	0,45
	Client66	0,69	4035	0,6
	Client67	0,27	46622	0,68
	Client7	0,51	4484	0,42
	Client70	0,28	4170	0,96
	Client72	0,19	18320	0,67
	Client74	0,88	837	0,6
	Client8	0,56	7390	0,64
	Client81	0,33	1000	0,63
	Client83	0,21	101582	0,92
	Client86	0,05	1777	0,39
	Client88	0,19	1945	1,14
	Client89	0,07	16925	0,93
	Client90	0,63	2408	0,37
	Client99	0,39	5400	1,04
3	Client13	0,77	540	1,16
	Client18	1,5	1669	1,41
	Client20	1,15	3203	0,85
	Client24	0,5	1020	1,37
	Client27	1	124	1,28
	Client28	1,88	453	0,85
	Client49	1,38	1293	1,05
	Client6	1,33	4149	1,17
	Client62	1,5	1900	0,69
	Client69	1,18	4530	0,86
	Client71	1,33	200	1
	Client73	0,77	63402	1,13
	Client76	1,5	107	1,41
	Client84	1,43	82054	0,87
	Client85	0,83	362	1,22
	Client87	1	320	1,41
4	Client10	0,5	250	0
	Client26	1	600	0

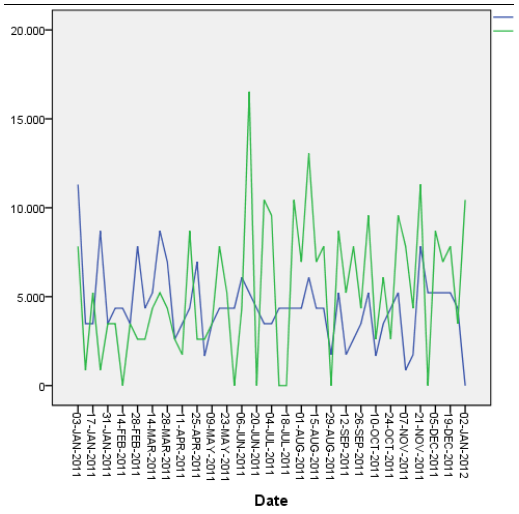
	Client29	0	1000	0
	Client31	0,96	3721	0,21
	Client50	0	315	0
	Client52	1	7200	0
	Client56	0	1674	0,11
	Client61	0	16000	0
	Client75	0,67	2713	0,09
	Client79	0	1012	0
	Client80	0	299	0
	Client98	0	15960	0
5	Client10	3,31	15727	2,22
6	Client10	2,56	6631	1,01
	Client22	2,75	1158	0
	Client33	2,06	2641	0,27
	Client58	3	400	0
	Client82	2,9	325	0,75
	Client9	3	4720	0
	Client91	2,5	10710	0
7	Client25	0	2520	2,32
	Client34	0	225	2,38
	Client77	0,5	285	1,95
	Client97	0	82	2,09

Appendix 11: Client clustering plot



Appendix 12: Example of high volume demand - Low and high variability

Appendix 13: Example of low volume demand - Low & high variability



Appendix 14: Example of Long term seasonal demand & special cause (promotion)