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ENGINEERING PATTERNS OF SUPPLY CHAIN OPTIMIZATION TO MANAGE OSCILLATION EFFECT

Abstract

The cascading order variability from downstream trumping up the upstream site of the supply chain network indicates the deleterious effect to the performance of the fast moving consumer goods industry. The fundamental likelihood to optimization in this industry requires dexterous flows of quasi-real-time information, as well as reliable product availability. In this context, this study analyzes the challenges of bullwhip effect on the perspective of ingenious optimization strategies, and further contemplates to establish the engineering patterns of interrelationships on the magnitude of pooling the resources to advance supply chain capabilities. The suppression of bullwhip effect on underlying optimization strategies is sought to elevate accelerated responsiveness, improve network demand visibility and reduce volatility in frequencies to inventory replenishment. A rigorous and disciplined quantitative approach afforded the tentatively development of pattern of interrelated supply chain dimensions. The factor analysis method was used on 448 responses and insightful findings were produced from the compelling purposive sampling technique. The findings indicate that the magnitude of better ameliorating bullwhip effect, the value of competitive economic information and strength of selected optimization strategies depend on the model of unified engineering patterns. This paper provides insights to FMCG industry on using innovative strategies and modern technology to enhance supply chain visibility through integrated systems networks.

Keywords bullwhip effect, agility, inventory, risk pooling, and distribution systems

JEL Classification M21, M29

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INTRODUCTION

Supply chain management as a matter of integrated coordination in a competitive environment has become a eulogised impetus value-adding strategic processes to match demand and supply. The degree of market uncertainty, limited supply chain visibility and template-based information sharing systems in the business environment challenge the competence of supply chain performance on responsiveness, connectivity and agility to ameliorate phenomenon of bullwhip effect (BWE) (Mbhele, 2014, p. 72). The fast moving consumer retail industry seeks the competence to manage demand-supply network through better supply visibility in a volatile marketplace to satisfy customers. The fast moving consumer goods (FMCG) (also known as Consumer Packaged Goods) have the main characteristic of having a high turnover and relatively low cost, and "the retail low-cost leadership earmarks to achieve maximum value as perceived by the customer" (Heizer and Render, 2014, p. 72). The supply chain partners leverage upstream and downstream interdependent relationships and interconnected nature of modern supply chains to create key performance outcomes for sustainable revenues.

This brief background provides a thematic framework on the following problem statement: The effect of global optimization strategies remains the central hypothesis for inducing pernicious effect of bullwhip effect and attempting to improve profitability on underlying cascading demand order variability (DoV) roaming upstream supply chain network. Research objectives of the study aim, firstly, to analyze the challenges of bullwhip effect from the perspective global optimization strategies on selected fast moving consumer goods (FMCG) industry; secondly, to establish the engineering patterns of interrelationships on the extent to which the phenomenon of bullwhip effect can be suppressed by global optimization strategies. The complexity and interconnected nature of modern supply chains, which remain embedded in rapidly changing environments, makes supply chain network functionality difficult with retailer's supply chain performance affected (Ganesan, George, Palmatier, and Weitz, 2009, p. 88). The desideratum open real time information sharing seems to ignite the starting point to underpin the synchronization of extended enterprise network and incentive alignments towards better interconnectivity (Bowersox, Closs, Cooper, and Bowersox, 2013, p. 351). The main aim of this study is to develop the dimensional patterns from the supply chain optimization strategies in managing the oscillation effect within the FMCG industry.

A vacillation in orders increases as one moves up the supply chain from retailers to distributors to manufacturers to suppliers is interpreted as the bullwhip effect. A high degree of variability results in an increase in all costs in the supply chain and a decrease in customer service levels (Mbhele, 2014). Eventually, it moves all parties in the supply chain away from the efficient frontier and results in a decrease of both customer satisfaction and profitability within the supply chain (Chopra and Meindl, 2007, p. 525). Tanweer, Li, Duan and Song (2014, p. 289) describe BWE as 'a continuous conundrum, addressing the shift of a seemingly steady inventory demand into enhancing demand fluctuation in upstream supply chain'. The BWE manifests a phenomenon colligated with inadequate competitive information flows normally ruminates on silo-oriented collaborator and is an upshot of rational reaction by the participants through dearth of coordination. Fu, Ionescu, Aghezzaf and Keyser (2014, p. 21) describe supply chain optimization as "set of approaches utilized to efficiently integrate supply chain partners for lean-based transformation process and efficient distribution in the right quantities, locations and time in order to minimize system-wide costs while satisfying service level requirements". Global optimization aims to "coordinate supply chain activities, so as to maximize supply chain performance" (Simchi-Levi, Kaminsky, and Simchi-Levi, 2008, p. 166). An optimized supply chain simply means an integrated collection of organizations that manage information, product and cash flows from a point of origin to a point of consumption with the goals of maximizing consumption satisfaction while minimizing the total costs of the organizations involved (Kiefer and Novack, 1999; Wright and Lund, 2003).

1. THEORETICAL FRAMEWORK

The integrated activities, as the supply chain network in this study, are associated with highly interconnected value-adding processes of sourcing, transformation, and effectively distributing to final consumer with echelon participants of supplier as vendor, distributor (either manufacturer- or retailer-based) and retailer. Supply chain network optimization refers to "the models supporting strategic and tactical planning across the geographically dispersed network of facilities operated by the company and those facilities operated by the company's vendors and customers" (Shapiro, 2004, p. 4). In understanding the connectivity across extended enterprises, the social network theory emphasizes that a supplier's economic actions are embedded in a network and that their outcomes are substantially influenced by an ongoing pattern of intra- and inter-organizational relationship (Gulati, 1998; Granovetter, 2005; Galaskiewicz, 2011). The word embeddedness implies on nature of the reliance on a network and the influence of social relations. Notably, the better positioning of the supplier and other partners on the underlying architecture of the supply network provides "access to novel information and inno-

vative ideas embedded in a network" (Kim, 2014), while reciprocally enhancing the performance of a buying firm, often the retailer. This networking involves "information and resources sharing, reduction of costs and social interactions that exist between individuals and organizations" (Watson, 2007; Machirori and Fatoki, 2013). Claro (2004) asserts that the roots of the networking theory can be traced from organizational behavior, management and sociology.

Kwon and Suh (2005, p. 26-33) postulate that commitment and trustworthiness play an important role in supply chain networking. Theory of relationship commitment states that "commitment develops as result of direct and mediating variables only" (Morgan and Hunt, 1994, pp. 20-38). In the context of supply chain, "a supplier makes a contribution to its manufacturer via their partnership policies and an expectation from its manufacturer forms for the return of a contribution at a later time" (Narasimhan and Nair, 2009, pp. 301-313). This study seeks to establish the engineering patterns of interrelationships to mitigate the challenges of bullwhip effect.

In the same light, Watson (2007) and Yu and Chiu (2010) caution that networking beyond some level when becomes too high, starts having negative impacts on firm performance. Nevertheless, Zhang and Fung (2006), Thrikawala (2011), and Machirori and Fatoki (2013) advocate that networking can positively impact on firm performance. The positive interrelationship between networking of optimization strategies in this study is anticipated to impact on performance with synchronized activities. Broadly, this study contemplates to develop patterns of dimensions systems to suppress bullwhip effect under optimization approach to increase accelerated speed of responsiveness to visible demand, and to decrease volatility in frequencies to inventory replenishment. According to Li and Liu (2013, p. 707) this endeavor should "ensure stability of supply chains by using inventory position information and allowable vendor order placement lead time for supplier managed inventory (SMI)" to maximize efficiency of entire supply chain network through customer's demand and inventory management entrusted with supplier.

2. LITERATURE REVIEW

2.1. Supplier-managed inventory (VMI)

The ideal partnership should mean achieving a level of information sharing and active collaboration. Normally, vendors are heavily involved in forecasting and planning, as well as performing functions, such as inventory management, data analysis, and order replenishment. The retailer is seen as the sole custodian of information about the consumer demand and there is limited chance of sharing information without greater amplification effect roaming upstream. Supply chain collaborative initiatives, such as supplier-managed inventory seem to improve supply chain efficiency and responsiveness to counter the phenomena of bullwhip effect (BWE) (Dominguez, Cannella, and Framinan, 2014, p. 85). The supplier is basically responsible for managing inventory levels at the retail store by determining the right timing and size of the orders. The timing of placing goods at the proximity of customer location by the supplier requires a better visibility (Cardi, Moretto, Perego, and Tumino, 2014) about the final customer demand and access to real-time demand information to improve product availability.

The manufacturer or supplier instead of the retailer is found to be better positioned to control the replenishment decision with real-time information in the supply chain (Hopp and Spearman, 2009). In forecasting South African fast moving consumer goods (FMCG) retail product sales, the product sales are promotion-driven to boost the sales of the focal products using competitive marketing activities, such as prices and promotions of competitive products (Mbhele, 2014). Rad, Razmi, Sangari, and Ebrahimi (2014, p. 295) underpin that SMI provides a comprehensive insight into selection of inventory policies for reduction in total cost of supply chain to improve commercial business and supply chain performance. As the architecture of the supply network provides access to economic information embedded in a network (Kim, 2014), the networking can positively impact on firm performance (Thrikawala, 2011; Machirori and Fatoki, 2013).

2.2. Build-to-order supply chain management (BOSC)

Supply chains are required to elevate their competitive levels locally and globally on responsiveness and low-cost-driven structures. As such mass customization has become a major objective with the development of build-to-order supply chain to enforce flexibility and responsiveness (Mbhele, 2014). If market environment is characterized by diverse customer tastes and preferences, rapid developments in technology and the globalization of management, the electronically-enabled mass customization should address the lead times and optimize the responsiveness and production schedules under BOSC (whereby the components and parts are ready for assembly) (Simchi-Levi, Kaminsky, and Simchi-Levi, 2008; Fu, Ionescu, Aghezzaf, and Keyser, 2014).

Gunasekaran and Ngai (2009, p. 319) define BOSC as "a strategy of value chain that manufactures quality products or services based on the requirements of an individual customer or a group of customers at competitive prices, within a short span of time by leveraging the core competencies of partnering firms or suppliers and information technologies, such as Internet and World Wide Web (WWW) to integrate such a value chain". This strategy attempts to provide a level of responsiveness, and flexibility; suppress the dependence on forecasts and anticipatory practices (Bowersox, Closs, Cooper, and Bowersox, 2013); to achieve lowest cost leadership allow a manufacturer to react on time with the market and even shape the behavior of the market. The build-to-order (BTO) concept as "a production strategy attempts to fulfill customer orders in short lead times through responsive manufacturing and information exchange" (Miemczyk, Howard and Graves, 2004; Lyons, Coronado, and Michaelides, 2006). BOSC paradigm as the knowledge-driven and centred on customer requires real-time information flow and responsiveness among supply chain partners in order to achieve whole system of value-based optimization and customer-aligned collaboration value chain system (Mbhele, 2014). The production network focuses on the mutual use of resources and the joint planning of the value-added process to access additional options within the network (Wiendahl and Lutz, 2002, pp. 573-586).

Central to the framework by Nohria and Garcia-Pont (1991, pp. 105-124) describing networks as "two strategic blocks based on the structure on the network of partners' capabilities, where the complimentary block composes of firms with different capabilities and pooling block composes of firms with similar capabilities". The production network holds a significant potential to cope with change drivers and enable agility in manufacturing by reduced market dependency, informational advantages, collective risk pooling, and the in-/outsourcing of production processes within the network (Monauni and Foschiani, 2013). The production networks benefit from resource pooling as an agility enabling concept to meet environmental turbulences, and this market volatility that creates oscillation effect is reduced by "the consolidation of companies to form production networks in order to shape their competitive market" (Monuani, 2014, pp. 657-662).

2.3. Collaboration planning forecasting and replenishment (CPFR) model

Supply chain collaboration focuses on coordinating activities between the network partners for improved supply chain performance, such as increasing excellence in service level and effectively responding to changes in the market place. Spekman, Kamauff and Myhr (1998, pp. 630-650) highlight that full collaboration includes a high level of trust and a common vision of the future, while cooperation gives visibility of essential information for the performance of the entire supply chain (Choi and Sethi, 2010) and coordination implements visibility mechanisms. Supply chain visibility improves supply chain performance by underpinning the decision-making process (Kulp, Lee and Ofek, 2004). It relates to "the ability of the focal company (the supply chain leader) to access and share information related to the supply chain strategy and the operations of supply chain partners" (Cardi, Moretto, Perego, and Tumino, 2014, p. 2). Although the supply chain members can manage their inventory on the basis of customers' demands using information sharing (Cho and Lee, 2011), the context of supply chain visibility entrenches the degree of collaboration in divergent supply chain networks that ameliorates the harmful conundrum of bullwhip effect (Dominguez, Cannella, and Framinan, 2014,

p. 85). In inducing BWE, optimized collaboration should relate to visibility in the sense that it includes an organization's willingness to share competitive information.

The Voluntary Inter-industry Commerce Standard (VICS) (1998) proposed a model entitled "Collaborative, planning, forecasting and replenishment" (CPFR), with a view to integrating the supply-side and the demand-side, thus enabling the collective creation of an effective environment to meet consumer demands. Chang, Fu, Lee, Lin, and Hsueh (2007, pp. 200-209) suggest that "many enterprises have implemented cross-enterprise operational models, such as JIT, VMI and CPFR", however, the CPFR represents "the paradigm-breaking business model, that extends VMI principles by taking a holistic approach to supply chain management". CPFR has evolved into a Web-based tool used to coordinate demand forecasting, production and purchase planning, and inventory replenishment between supply chain trading partners and further used as a means of integrating all members of a multi-tier supply chain (Mbhele, 2014). Although optimized supply chain collaboration and integration were used interchangeably as "tight coupling process between supply chain partners" (Cao and Zhang, 2011, pp. 163-180), supply chain integration means "the unified control (or ownership) of several successive or similar process formerly carried on independently" (Flynn, Huo and Zhao, 2010, pp. 58-71).

2.4. Strategic supply chain leagility

Supply chain agility as an operational strategy focuses on inducing velocity and flexibility in the supply chain. In a nutshell, a supply chain is the process of moving goods from the customer order through the raw materials stage, supply, production, and distribution of products to the customer. The agility of a supply chain is a measure of how well the relationship involved in the processes (of series of linked activities amongst firms) enhances the pivotal objectives of agile manufacturing (Mbhele, 2014). The competitive and successful companies require to be agile in their response to market demand, and the capabilities of the whole supply chain must be leveraged to satisfy customer demand (Naim and Gosling, 2011). Christopher and Towill (2005, pp. 206-213) propose that "a framework for agility that is contingent upon the context, in which the business operates, and thus sought to bring together the lean and agile philosophies". Yusuf, Musa, Dauda, El-Berishy, Kovvuri, and Abubakar (2014, p. 500) advocate that "agile supply chain competitiveness depends on the accelerated speed of responsiveness, degree of resilience, level of reliability and strength of relationships amongst SC partners to improve supply chain performance". Qrunfleh and Tarafdar (2014, p. 345) interpret supply chain performance in terms of SC flexibility as the extent to which SC partners effectively and quickly adapt to changes in the market (Vickery, Calantone, and Droge, 1999); SC integration as the extent to which activities, communication and decision-making in the SC are coordinated together (Stock, Greis, and Kasarda, 2000); and responsiveness to customers as the extent, to which SC partners respond in a timely manner to customers' needs and wants (Chen, Paulraj, and Lado, 2004). Seemingly, the suppression of BWE under agile SC strategy requires flexibility and adaptability on dynamic customer needs and highly competitive environment through continuously accelerated clock-speed responsive approach.

2.5. Central supply chain system

The CscD system diffusion transcends the traditional silo-orientation and legal contractual boundaries of entities along the supply chain and instead views the entire chain as a single entity (Mbhele, 2014). The centralized supply chain distribution centre (CscDC) or warehouse in this context is the facility in the supply chain network that receives goods from the upstream side, stores them in the centre, and ships them to the downstream individual retail stores. The study findings revealed that "the CscD system makes quasi-real-time products availability in the supply chain network using integrated information sharing and technology systems to improve business efficiency. It is also noted that the agile CscD system with advanced supply chain technology needs to be supported by a fully integrated information system that provides visibility of the whole supply chain for fast replenishment of goods in stores customized precisely to the needs of individual retail stores" (Mbhele, 2013, p. 139). The CscD system recognizes "the customer-supplier duality, where suppliers deal with a retailer's central distribution centre in an inherently bidirectional way, with few echelon-levels of interaction" (Fitzsimmons and Fitzsimmons, 2006, p. 478). Notably, information technology is the driving force

behind the CscD system's ability to coordinate the many interrelated activities commonly performed by upstream independent companies (Mbhele, 2014). It is understood that the CscD system assists the retail stores to make up for the lower margins through a higher volume throughput, higher overall volume of sales, the sale of higher-margin items, giving each product section a sense of individual difference and altering customer's perceptions of the atmosphere (Gajanayake, Gajanayake, and Surangi, 2011; and Browne, 2010). The central repository synergy synchronizes the individual retail outlets' changes on planograms, and emergency and planned promotions while allowing for a continuous flow of information and customer behavior with no artificial barriers to impede the reaction time (Vendrig, 2008).

3. RESEARCH METHODOLOGY

3.1. Research design

The exploratory research design framework constitutes the blueprint (Cooper and Schindler, 2008, p. 140) for the data sources, data collection, data sampling methods and measurement, and statistical analysis of data. Blumberg, Cooper and Schindler (2008, p. 195) cited Kerlinger (1986, p. 279) that "a research design expresses both the structure of the research problem and the plan of investigation used to obtain empirical evidence on relation of the problem". This study used cross-sectional quantitative approach in the FMCG industry to analyze data on the phenomenon of bullwhip effect, and the self-administered questionnaire survey instrument was used for the data collection. The organizations in retail sales, logistics, warehousing, marketing, manufacturing and information technology hubs were the units of analysis in this study, as such the managers (senior and functional levels) including supervisory level (nonmanagerial) are the subjects within the organizations (FMCG retail stores). The pre-formulated thematic instrument (bullwhip effect, information sharing, inventory positioning and optimization strategies) was pre-tested for suitability to enhance face and content validity. The anonymity and confidentiality of the respondents from an ethical point of view tend to yield confidence and create avidity around participation in a research study.

3.2. Data sampling methods and measurement

Nonprobability sampling has some compelling practical advantages to meet the sampling objectives of the study (Blumberg, Cooper, and Schindler, 2008, p. 235), purposive sampling was adopted to select sample members to conform to some criterion (Cooper and Schindler, 2008, p. 397). It was also necessary to approach few individuals from the relevant population "act as informants and identify other members from the same population for inclusion in the sample" using snowball sampling (Welman, Kruger, and Mitchell, 2005, p. 69). The retailers (downstream supply chain) and capacitated suppliers (mid and upstream supply chain) in the selected FMCG industry constituted the population of 800 proportionate representative within five major retail chain stores with 300 selective suppliers in eThekwini Metro, South Africa. According to Sekaran (2003, p. 294) and Bartlett, Kotrlik, and Higgins (2001, p. 48) the representative population size of 800 (retailers) and 300 (suppliers) in determining minimum returned sample size is 260 and 196 sample size respectively with an alpha of 0.05 and a degree of accuracy of 0.05 (Mbhele, 2014). The alpha value or level of significance (0.05) would become enshrined as the threshold value for declaring statistical significance in this study. This study has produced a sample size of 448 respondents with return rate of 98% [(448/456) 100]. The relevant letters (gatekeeper's letter, ethical clearance certificate, and consent letter to ensure confidentiality and anonymity) were constantly depicted to the gatekeepers, where the researcher was given a permission to enchroach their domain (Mbhele, 2014).

3.3. Data and statistical analysis

The summarized univariate technique examined the distribution of cases on one variable at a time using frequencies and descriptive statistics (mean and standard deviation). The multivariate analysis as statistical technique was organized around a scheme on interdependence (factor analysis) procedures for underlying objective to develop models and dimensions that best describe the population as a whole.

3.4. Frequency distribution

According to Cai and Du (2009, p. 709) "the strategy of risk pooling is designed to bring about demand aggregation across locations and time in order to reduce the demand order variability". Seventy five percent overwhelming majority of the respondents agree that the pooling and sharing of resources and information in the supply chain by modeling central supply chain distribution (CscD) system (71%) avert the risks in supply disruptions. By the same token, risk pooling and CscD system guard against stock outs and reduce the consumer order variability by aggregating demand across locations. Although the South African FMCG industry espouses the customer-supplier duality through modeled CscD system, a considerable percent (36%) of the respondents believe that decentralized supply chain distribution (DscD) system keeps the optimal stock level. 'The retail store chains seem to converge towards the shared business solutions of CscD system as consolidated hub systems that service a number of retail consumers' (Mbhele, 2014). The CscD system seems to display the potential to allow upstream partners (suppliers or manufacturers) to plan their capacity and demand forecast, and sixty three percent of the respondents agree that accurate forecasting models interlink the inventory positioning and order replenishment decisions among supply chain members. However, it is noted that around 42% of the respondents did not affirm that DscD system retains an optimal stock level to circumvent the phenomenon of bullwhip effect, while 22% of the respondents shows neutrality to a less consolidated system.

The respondents agree that a vendor managed inventory model (62%) allows the manufacturer to control demand order replenishment over the entire supply chain to mitigate bullwhip effect, while the CPFR model (64%) is recommended to

Source: Mbhele (2014)

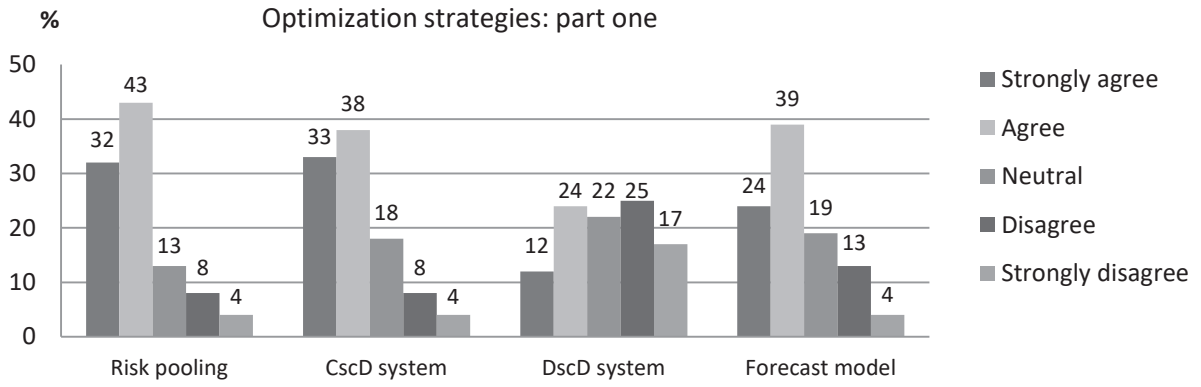

Figure 1. Global optimization strategies on bullwhip effect – part one

Source: Mbhele (2014)

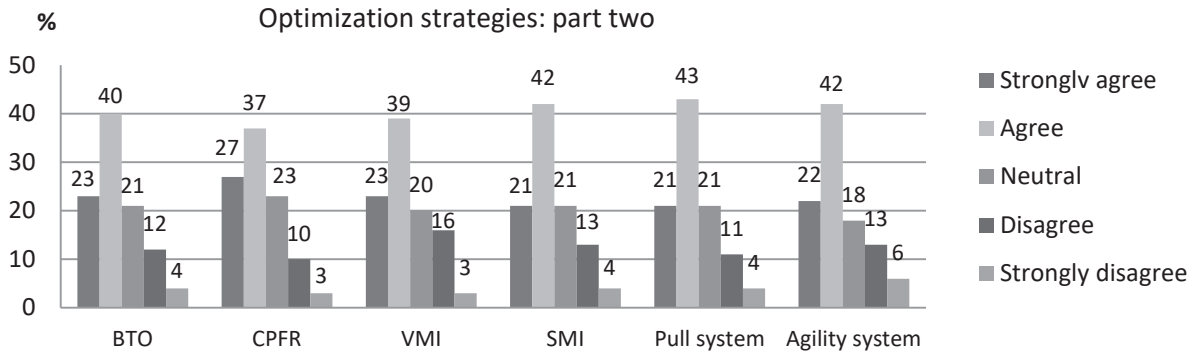

Figure 2. Global Optimization strategies on bullwhip effect – part two

provide unlimited access to the retail store's replenishment system. Sixty three percent of the respondents underpinned a build-to-order (BTO) system on order replenishment flexibility and responsiveness, and sixty four percent of the respondents believed that an agile supply chain further induces velocity and flexibility in a supply chain. A demand-driven strategy (pull-based supply chain) is supported by 64% of the respondents as the production and distribution coordination improvement mechanism. Sixty three percent of the respondents found supplier managed inventory system as "a shift of responsibility for inventory planning from manufacturer to supplier" as an attempt to mitigate demand order variability.

3.4.1. Descriptive Statistics.

Measures of dispersion and central tendency give a summary indication of the distribution of cases and an average value by describing single variable within the exploratory study. Descriptive statistics relating to the research findings are presented in this table to assess each of the strategic optimization items in an attempt to manage the phenomenon of bullwhip effect. The average response of this study indicates that risk pooling (M = 3.90) is the most significant global optimizing and cost-effective strategy to reduce the consumer order variability by aggregating demand across locations. The consolidated distribution strategy for either lead time pooling or location pooling keeps inventory close to customers, while hedging against certain form of uncertainty (Mbhele, 2014). The central inventory location within supply chain can exploit lead time pooling to provide some of the benefits of location pooling without moving inventory far away from customers. The respondents underpin the central supply chain distribution system (M = 3.86) as global optimization model to suit the individual retail facility and enhance the integration of stock ordering, buying systems and store replenishment systems. This collaborative supply chain system focuses on directly involving suppliers in its initiative to realize high levels of product availability, service levels and stock runs. Interestingly, collaboration, planning, forecasting and replenishment (CPFR) model (M = 3.74) with a standard deviation of 1.069 being perceived as the most important model to provide unlimited access to the retail store's replenishment system to ameliorate and manage demand order variability.

Table 1. Descriptive and factor analysis on KMO and Bartlett's test rotated components

Source: Mbhele (2014), Compiled by the researcher from the SPSS statistical results.

KMO and Bartlett's test		
Kaiser-Meyer-Olkin measure of sampling adequacy		0.832
Bartlett's test of sphericity	Approx. Chi-square	3662.946
	Df	465
	Sig.	0.000

Supply chain optimization factors	Factorial components			Descriptive statistics		Sigma
	Factor load	Eigenvalue	Com extra	Mean	S/D	Sigma BWE
Pull-based system	.781	1.942	.660	3.6696	1.0396	.092
Supplier managed inventory (SMI)	.747		.642	3.6384	1.0738	.595
Agility supply chain system	.709		.628	3.6295	1.1257	.002
Collaboration (CPFR)	.723	1.409	.713	3.7388	1.0686	.153
Build-to-order system (BTO SCM)	.679		.578	3.6696	1.0797	.938
Accurate forecasting models	.658		.669	3.6496	1.1192	.899
Risk pooling	.810	1.274	.736	3.8973	1.0778	.000
CscD system	.805		.766	3.8616	1.0903	.000
DscD system	.768	1.034	.658	2.8795	1.2792	.075

Notes: (Overall Cronbach's Alpha = 0.842) SD/σ = Std deviation, Med = Median. M = Mean, Overall Alpha = 0.701.

This model is most suitable for the build-to-order supply chain (BTOSC) system (M = 3.67) to allow the creation of the greatest degree of order replenishment flexibility and responsiveness on the bases of market sensitivity, leveraged information technology and tactical postponement agility. The BTOSC system requires the decoupling point (boundary) to describe forecast-driven and demand-driven elements with real-time information flow to achieve the whole system optimization. The demand-driven strategy, also known as pull-based supply chain (M = 3.67) with standard deviation of 1.039 is the better ranked strategy to improve production leagility and distribution coordination with the customer demand.

The system optimizes the processes and customer demand-driven for enrichment of customer with clear understanding of demand order variation and oscillation. The forecast-driven model with accurate forecasting (M = 3.65 and SD/σ = 1.119) is supported by the respondents to control bullwhip effect in linking the inventory positioning and order replenishment decisions among supply chain trading members. The order replenishment decisions allow supplier managed inventory (SMI) system (M = 3.64) with standard deviation of 1.074 "to shift responsibility for inventory planning from manufacturer to supplier" with oriented paradigm on customer services and proximity to the downstream customers. The respondents also agreed that vendor managed inventory (VMI) system (M = 3.63) with standard deviation of 1.087 allows real-time inventory level information. The leagility system provides a level of order replenishment responsiveness and flexibility (M = 3.63) and decentralized supply chain distribution (DscD) system (M = 2.88) seems "to keep the optimal stocked level to avoid bullwhip effect". All variables with the exception of the DscD system (M = 3.00, mode = 2.00 and median = 3.00) are symmetrical by located on same centre point (4.00), and the distributions have scores that cluster heavily in the centre.

3.4.2. Factor analysis

The purpose of factor analysis is to discover discrete dimensions in the pattern of relationships among the variables in the survey instrument. This study provides four reduced number of different factors that are explaining the pattern of relationships among the variables. Nevertheless, its major objective is to reduce a number of observed variables into small number of underlying grouped factors in order to enhance interpretability and detect hidden structures in the data (Treiblmaier and Filzmoser, 2010, p. 198). This study uses exploratory factor analysis as an attempt to discover the nature of the constructs influencing a set of responses on the basis of a common factor model. This model proposes that each observed response is influenced partially by underlying common factors and partially by underlying unique factors. The KMO value as the tests of appropriateness in this study is 0.832, which indicates a meritorious degree of common variance above the normally acceptable threshold of 0.50 for a satisfactory factor analysis to persist with analysis. Kaiser (1970) further stresses that a cut-off value is 0.50 and a desirable value of 0.80 is meritorious in order to proceed with a factor analysis (Hair, Anderson, Tatham, and Black, 1998, p. 99). This desirable value suggests that patterns of correlations are relatively compact and factor analysis would give distinct and reliable individual factors. The value of the test of statistic for Barlett's sphericity is large (3662.946) and the associated significance level is small (p-value = 0.000), suggesting that the data matrix has sufficient correlation to factor analysis. In terms of moderate to moderate-high intercorrelations without multicollinearity, there was no violation of assumption with KMO revealed 0.832 as good factorability. The assumptions of both sphericity and adequate sample size were met with Barlett's test of sphericity significant at 0.000 and more cases than factors on adequate sample size. According to Garson (2012, p. 55) there is near universal agreement that factor analysis is inappropriate, when the sample size is below 50. This study agrees with the suggested general rule of thumb that recommends at least 300 cases for factor analysis (Tabachnick and Fidell, 2007, p. 613), while Sapnas and Zeller (2002) and Zeller (2005) recommend cases of 100 or even 50 under some circumstances. Nonetheless, normality is not considered to be a critical assumption of factor analysis as intercorrelation methods.

The purpose is to seek the rotated loadings that maximize the variance of the squared loadings for each, with the goal of making some of these loadings as large as possible, and the rest as small as possible in absolute value (Garson, 2012; Costello and Osborne, 2005). Eigenvalues (characteristic roots) measure the amount of variation in the total sample accounted for by each factor. Kaiser rule (Kaiser, 1970) recommends a drop of all components with eigenvalues under 1.0. In the extraction sums of squared loadings in this study, all eigenvalues are greater than 1.0 from factor one (1.942), factor two (1.409), factor three (1.274) and factor four 91.034), and associated with percentage of the variance in the original data of 6.265%, 4.544%, 4.110% and 3.336% respectively. The proposition of each variance that can be explained by the factors is noted as h^2, and Tabachnick and Fidell (2007, p. 621) define communality (h^2) as "the sum of squared loadings (SSL) for a variable across factors". This study reveals that the variance with highest value 76.6% of variance in CscD system is accounted for by sum of $(a)^2$, and lowest value 57.8% of variance in build-to-order (BTO SCM) is accounted for by sum of a^2 or (Sum (factor loadings)^2. In this regard, variables with high values (CscD = 0.766) are well represented in the common factor space with higher loading on each factor between 0.7 and 0.8, while variables with low values (0.578 = BTO SCM) are not well represented in the common factor space or not well explained by the factor model. In the real data, Costello & Osborne (2005, p. 4) suggest that the more common magnitudes in the social sciences are low to moderate communalities of 0.40 to 0.70. The factor interpretations and labels confine to the assumption of face valid imputation of factor label (face validity) that is rooted in theory. The factors were interpreted as dimensions of supply chain optimization strategies to suppress BWE and individually labeled as 'Demand-driven supply chain system, Knowledge-driven supply chain system, Central risk pooling system and Decentralized supply chain system'. The following figure (1) presents the above mentioned dimensions:

Source: Developed by the researcher from contextual, conceptual and reflective supply chain learning approach

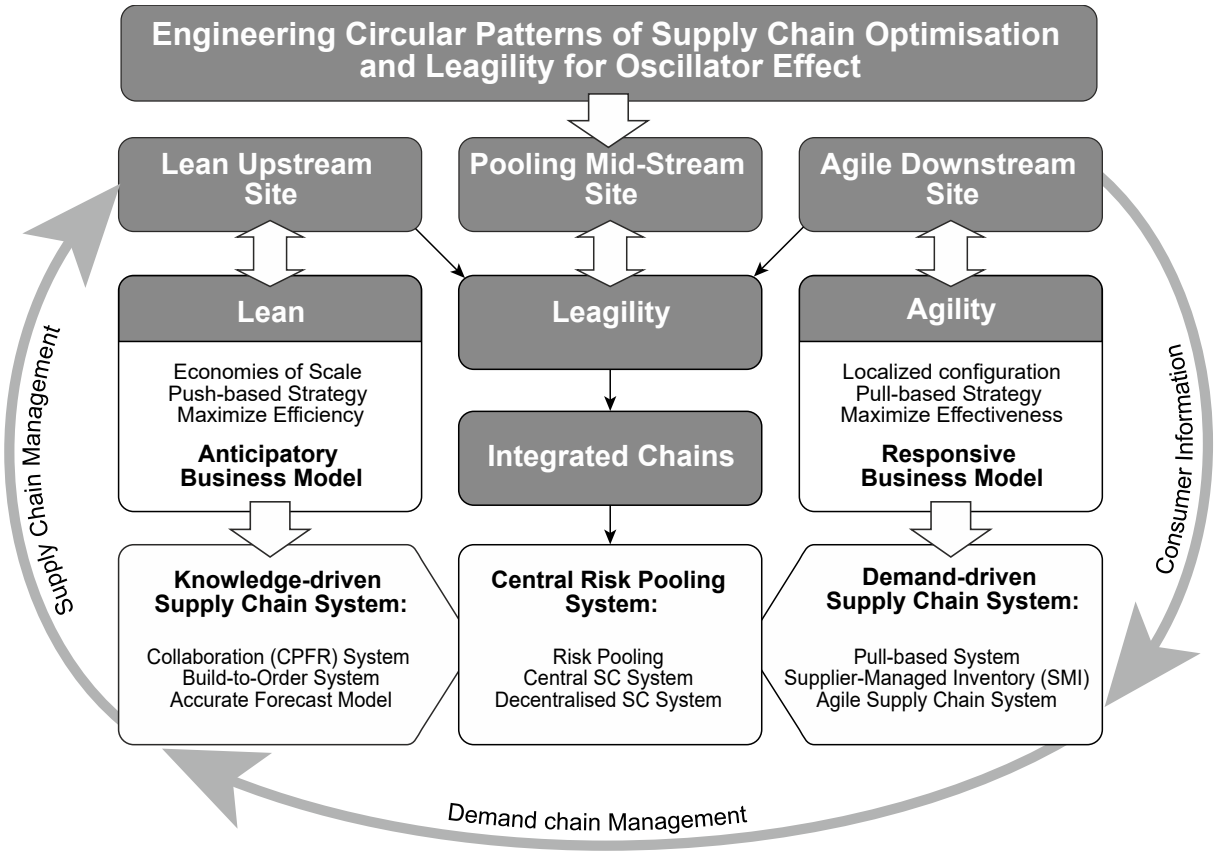

Figure 3. Engineering circular patterns of supply chain optimization strategies and leagility system

3.5. Engineering patterns phase one: dimensions of supply chain optimization strategies

3.5.1. Demand-driven supply chain system

Tentatively, the manufacturer has limited access to real-time inventory level information, if the retailer relishes a sole custody of information about the consumer demand. This factor describes the demand-driven, supplier managed inventory and agility supply chain systems that yield the upstream site instead of the retailer a better inventory positioning to control the demand order replenishment decision with real-time information in the supply chain. The principle of agile supply chains in particular, allow the enrichment of customers through optimum processes and customer driven-demand from pull-based supply chain as orders move upstream on real-time information sharing systems (Cachon and Terwiesch, 2009; Simchi-Levi et al., 2008; Mason-Jones, Naylor, and Towill, 2000).

3.5.2. Knowledge-driven supply chain system

While these factor items recognize the advanced collaboration that deals with synchronizing the supply chain processes within forecasting, replenishment and planning, the knowledge-driven paradigm has cluster of components 'where materials and products are pulled through the system based on customer orders. With regard to the integrated cross-enterprise model (CPFR model), responses suggested that the model provides unlimited access to the retail store's replenishment system to manage demand order variability. Apart from collaboration, planning and replenishment components of CPFR model, accurate forecasting eliminates bullwhip effect by linking the inventory positioning and order replenishment decisions among supply chain members (Simchi-Levi et al., 2008). The market-driven system (Build-to-order supply chain) moves the boundary between push-based and pull-based systems close to customers, allowing order replenishment flexibility and responsiveness to reduce order variability.

3.5.3. Central supply chain pooling system

This factor describes the aggregation of demand orders across locations wherein the high demand from one customer will be offset by low demand from another customer. The higher the coefficient of variation, the greater the benefit obtained from centralized systems, that is, the greater the benefit of risk pooling (Mbhele, 2014).

3.5.4. Decentralized supply chain system

A decentralized supply chain allows the manufacturer to have "better demand information because of proximity to consumers" (Simchi-Levi et al., 2008). Cachon and Terwiesch (2009) and Schroeder (2008) stress that self-interest and decentralized decision making do not lead to supply chain efficiency without integrated electronically-enabled supply chain management systems and profound reciprocal interdependence among echelon stream sitesEngineering patterns on phase two: dimensions of leagility systems

The second phase of the figure shows the hybrid system on 'leagile' strategy that should build an agile response upon a lean platform by seeking to follow lean principles up to the de-coupling point and agile practices after that point. Christopher (2011, p. 100) recommends "lean on high volume, low variety and predictable environment and agility on less predictable environments, where the demand for variety is high". Bowersox et al. (2013, p. 12) interpret an anticipatory business model as push system (produce product based upon a market forecast while responsive business model is associated with pull system (relies on timing and agility) on reducing forecast reliance and improving joint planning and real-time information exchange. Van Hoek (2000, p. 196) describes postponement as "the basic thesis of leagility, the delaying of operational activities in a system until customer orders are received rather than completing activities in advance and then waiting for orders. The lean processes on the upstream side of the decoupling point are associated with knowledge-driven supply chain system, and the agile processes on the downstream side are associated with demand-driven supply chain system. An increase in product mix, variability in demand and fluctuating volume would drive the decoupling point to move upstream to maximize efficiency, making the supply chain system more agile to maximize effectiveness while ameliorating the magnified oscillations upstream.

DISCUSSION OF RESULTS

The global optimization strategies attempt to manage the phenomenon of bullwhip effect. Interestingly, risk pooling is the most significant global optimising (synchronize and coordinate supply chain activities so as to maximize supply chain performance) and cost-effective strategy to abate the consumer demand order variability by aggregating demand across locations. The respondents confirmed that a central supply chain distribution system is more suitable for the individual retail facility and enhances the integration of stock ordering, buying network systems and frequencies to store replenishment systems. The CPFR strategy seems to provide unlimited access to the retail store's replenishment system to manage demand order variability. The magnitude of supply chain coordination and collaboration between the supplier as vendor and buyer, often as retailer (offering and tendering retailing space to the supplier) improve the better insight of the customer demand network to avoid the conundrum of multifarious demand order amplification moving upstream supply chain network. Ryu, Moon, Oh, and Jung (2013, pp. 316-326) astutely point out that SMI program offers a competitive advantage for retailers with respect to higher product availability through replenishment frequencies at reduced inventory level (Chen and Chang, 2010); and provides the supplier with opportunities to improve flexibility in production network scheduling and marketing network efficiency through improved customer service level (Kang and Kim, 2012) and extended consumer and society benefit from low prices and increased overall channel (Chen, 2013, p. 518). The network theory views any system as a set of interrelated actors or nodes (Tate, Ellram, and Golgeci, 2013, p. 266), whereby the actors can represent entities at various levels of collectivity, such as persons, firms, countries and other participants in the network (Borgatti and Li, 2009, p. 2). According to Watson (2007, pp. 852-874) networking involves "information and resources sharing, reduction of costs and social interactions that exist between individuals and organizations".

However, it is most important to underpin the CscD system that focuses on directly involving suppliers in their initiatives to realize high levels of product availability, service levels and stock runs. The central repository synergy synchronizes the individual retail outlets' changes on planograms, and emergency and planned promotions, while allowing for a continuous flow of information and customer behavior with no artificial barriers to impede the reaction time (Vendrig, 2008). In terms of supply chain order processes and suppliers' involvement, BTO, agile, pull-based and SMI supply chain system allow the creation of the greatest degree of frequencies of order replenishment flexibility and responsiveness. These further entrust to improve production leagility and distribution coordination within the consumer demand complexities, while the oriented paradigm on customer services enhances the proximity to the downstream customers. Lean and agile systems share some interface with several other types of performance improvement, including flexible, adaptable, and mass customization to overcome the rippling oscillator effect in the supply chain. As customers becoming more and more aggressive in demanding new products and services within a short period of time, the conjoint of agile and lean (leagile supply chain) presents an interesting attempt to tame and manage consumer order demand variability in the supply chain (as an extension to the four dimensional patterns of supply chain optimization strategies). Although the appropriate degree of availability varies with the characteristics of the product and the target customers, Mullins and Walker (2010, p. 313) suggest that the market and competitive factors in the FMCG influence a firm's ability to achieve a desired level of product availability through effective use of e-SCM systems and functional CscD systems to enhance customer service.

Managerial implications

The typical South African retail supply chain network has an obligatory mandate to retail for continuously improving levels of customer service network while concurrently reducing costs of inventory, distribution and transportation to maintain profit margins. In a reengineering network in retail industry, a coordinated supply chain network should consolidate distribution of strategic locations in a viable national geographic imperatives underpinning the principles of risk pooling and regional decentralizing

the system to achieve proximity to customers. The national geographic imperatives points should coincide with broader infrastructural development plans for efficient logistical performance to entrench risk pooling by aggregating production, distribution and demand networks to improve the overall supply chain performance network. Lee and Knon (2010, p. 94) interpret a supply chain network as "the logistic network, which consists of facilities, customers, products in the procedure of the planning, coordination, controlling inventory and distribution". In decelerating the pernicious effect of consumer demand variability, supply chain consolidated inventory from several locations (inventory pooling) takes advantage of the risk pooling on consumer demand orders to control variability. Eventually, this could reduce inventory costs, improve supply chain performance and enhance product availability within the FMCG industry.

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