

Mitigation of the bullwhip effect considering trust and collaboration in supply chain management: a literature review

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Abstract The aim of this paper is to provide results of trust and collaboration that lead to the mitigation of the bullwhip effect in supply chain management through a systematic literature review. The criterion for its inclusion in the sample of papers was that at least two reviews of the respective subfields were published in peer-reviewed journals between 1990 and 2014. A total of 24 articles were selected. The analysis found that few studies focused on addressing behavioral aspects to reduce the bullwhip effect. Most of them focused on operational and quantitative aspects. These results indicate the need for studies on behavioral aspects in mitigating the bullwhip effect, where trust and collaboration among those involved in the supply chain need to be developed and organized.

Keywords Supply chain management · Bullwhip effect · Trust · Collaboration

1 Introduction

Mentzer et al. [1] define supply chain management (SCM) as a systemic, strategic coordination of traditional business functions

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and the tactics across these business functions within a particular company and across businesses within the supply chain (SC), for the purposes of improving the long-term performance of individual companies and the supply chain as a whole.

Fluctuations in demand constitute a problem for companies promoting irregular transactions for all members of the SC. They make it difficult to forecast sales and inventory management, reducing the service level [2].

These oscillations are known as the Bullwhip Effect (BWE), a phenomenon which was first studied by Forrester in 1958 [3]. The BWE occurs when the demand order variability in the supply chain are amplified as they moved up the supply chain from retailer to manufacturer, and is the subject of several studies [4–9]. Actually, in spite of SCM initiatives such as Collaborative Planning, Forecasting and Replenishment (CPFR), Vendor Managed Inventory (VMI), Sales and Operations Planning (S&OP), among other practices and developments in the field of Information and Communication Technology (ICT), the BWE is still present in the SC.

Thus, many academic papers have attributed operational causes to the BWE [8–12]. However, another group of studies have attributed behavioral causes to it [13–17].

These causes, given by academic literature findings, demonstrated a lack of communication, collaboration, and trust among members of the supply chain. Thus, there is no coordination between the partners, culminating in misinformation, opportunism, lack of knowledge and proper training, and lastly factors that lead participants to occupy different roles in the chain where they get economic advantages over others by opportunism, and do not have an overview of the business.

Ha et al. [18] point out to the need for research that examines trust in different cultures, assessing the constructs of different cultures that can provide an additional insight about trust in SCM. They also consider that there is a need

for research relating to trust, collaboration, and logistics in power relationships in SCM. Delbudalo [19] analyzed the results of interorganizational trust through a systematic literature review and meta-analysis. The articles selected in this study show an increasing interest on this topic. One of the aspects highlighted by Nold III [20] in relation to trust in interorganizational relationships is that it constitutes the essential element of organizational culture which is necessary for the individual to interact and share knowledge. Without trust, despite the level of technological sophistication and management efforts, initiatives related to knowledge management are not successful [21].

The aim of this paper is to provide results of trust and collaboration in SCM that lead to the mitigation of the bullwhip effect through results obtained by a systematic literature review. This critical literature review is a contribution because, despite the fact that there are already recent studies regarding trust and collaboration, and operational aspects of bullwhip in SCM, there is a gap in the fiercest and most vigorous debates about these two themes, with which this article proposes to contribute. The criterion for inclusion into the sample of papers was that at least two reviews of the according subfields were published in peer-reviewed journals between 1990 and 2014.

The paper is structured as follows: the “**Methodology**” section describes the adopted research methodology; the “**Descriptive analysis of the selected articles**” section provides statistics information of the selected articles and a descriptive evaluation of the body of literature; the “**Evaluating and discussing the findings**” section evaluates and discusses the findings obtained by the systematic literature review; and the “**Conclusions**” section contains the conclusions and suggestions for future research.

2 Methodology

This study adopts a systematic literature review as research methodology. It is characterized by being more systematic and explicit in the selection of studies from traditional narrative reviews, and by employing rigorous and reproducible methods of evaluation [22].

A systematic literature review allows analyzing the existing state of the art on a particular subject, developing a field of knowledge, identifying opportunities for further research, and preventing expensive and fruitless effort repetition [22, 23].

Therefore, it was directed to issues related to trust and collaboration in the SCM and the BWE. This review was divided into three stages [24]: planning the review (proposed revision, development of research protocol), conducting the review, and a presentation of results (identifying and selecting studies, summary of relevant articles).

2.1 The research protocol

The purpose of the review is to provide the results of trust and collaboration in SCM that lead to the mitigation of the BWE. The research protocol explains how the papers were found and the criteria for their inclusion. This procedure is outlined as follows:

- 1 The review was conducted by researching the Science Citation Index Expanded (Web of Science), SciVerse ScienceDirect (Elsevier), OneFile (GALE), Emerald Management eJournals, Social Sciences Citation Index (Web of Science), and SpringerLink. These databases were chosen due to having the greatest coverage coupled to functionality and access of full articles in the fields of Supply Chain and Operation Management, which are relevant for the present study.
- 2 The current literature sample comprises peer-reviewed journal articles on the bullwhip effect from 1990 to 2014. The review included only articles published in the English language.
- 3 A literature search was carried out based on the keyword *bullwhip effect* found in titles or abstracts.
- 4 The paper’s relevance was insured by requiring that the selected articles contained *bullwhip effect* as the primary keyword on their title or abstract.
- 5 The review’s relevance was enhanced by reading all abstracts.
- 6 Its relevance was finally ensured by reading the articles thoroughly. This enforced the alignment between the selected articles and the review objectives.

2.2 Database searching process and results

The literature search was performed using the keyword *bullwhip effect* resulting in 1228 peer-reviewed articles, whereas 108 articles were obtained containing the word *bullwhip effect* as primary keyword on their title or abstract. After reading the abstracts, 63 articles were selected.

From the result of these 63 articles, its empirical relevance was insured by reading the articles thoroughly, resulting in 24 articles characterized by being inside the scope of this review.

The steps for selecting articles on the bullwhip effect are summarized in Table 1.

3 Descriptive analysis of the selected articles

This section shows the analysis results without their discussion; this is carried out in the “**Evaluating and discussing the findings**” section. The descriptive analysis included:

Table 1 Summary of the results

Citations searches in the database	Results	Citations selected
Stage 1: Citation searches in databases considering peer-reviewed journal articles	Databases [6] Keywords used [1] Citations found (4.679)	(1228)
Stage 2: Exclusion analysis through keywords	Relevant (108)	(108)
Stage 3: Exclusion analysis by reading all abstracts for a substantive context	Relevant (63)	(63)
Stage 4: Full articles analyses	Relevant (24)	(24)

- 1 Analysis by journal
- 2 Analysis by research aim
- 3 Analysis by methodology
- 4 Analysis by method
- 5 Analysis by industry

The analysis by journal presents a total of 15 journals containing the selected publications. Table 2 shows the number of articles per journal.

Table 3 presents the distribution of papers across journals, and their research objectives, with the bullwhip effect as main topic.

The analysis by method shows that the majority of publications (67 %) use a theoretical analysis as methodological

Table 2 Number of articles per journal

Journal	No. of articles
Applied Mathematical Modeling	2
Computers & Industrial Engineering	1
Computers & Operations Research	1
European Journal of Operation Research	3
Expert Systems with Applications	2
International Journal of Advanced Manufacturing Technology	1
International Journal of Forecasting	1
International Journal of Operations & Production Management	1
International Journal of Production Economics	2
International Journal of Physical Distribution & Logistics Management	1
Journal of Operations Management	1
Management Science	4
Production and Operations Management Society	1
Omega	2
Sloan Management Review	1

approach. The remaining articles adopt different methods such as laboratory experiment (17 %), single case study (8 %), literature review (4 %), and survey (4 %).

The analysis method indicates the use of a structural equation model (21 %), a confirmatory factor analysis (21 %), a simulation model (21 %), simulation experiments (4 %), the transfer function method (4 %), minimum mean squared error (MMSE) (4 %), data envelopment analysis (DEA) model (4 %), Taguchi's design of experiments and simulation techniques (4 %), autoregressive integrated moving average (ARIMA) processes (8 %), and the optimization model (4 %). Only 9 % of the sample employs a combination of qualitative and quantitative methods and 9 % of the papers adopt a qualitative approach. The majority of publications (83 %) neither applies nor mentions samples and 83 % neither applies nor mention industries.

Table 4 presents the BWE descriptive analysis that included methodology, analysis method, and type of data analysis, sample, and industry.

4 Evaluating and discussing the findings

The findings on the bullwhip effect from a literature review are hereby evaluated and discussed.

4.1 Bullwhip effect

According to Chen, Drezner, and Ryan [27], the BWE occurs when the demand variability increases as it advances in the levels of the SC, from retailer to supplier.

The BWE causes numerous negative effects and significant inefficiencies in supply chains, but the main one is the excessive investment in inventories throughout the SC members who compose it and need to prevent themselves from fluctuations in demand [39].

The main characteristics of the BWE are:

- Amplification of demand variation across SC [25]
- Lack of coordination between companies of the chain (Bhattacharya and Bandyopadhyay [11])
- Lack of transparency in information [11]
- Formation of excess inventories throughout the supply chain aimed at preventing demand variation [39]
- Product unavailability [40]

The main addressed topics in academic literature referring to the BWE directed to operational causes are information sharing [5, 6, 10, 11, 25–27, 32, 38]; better demand forecasting [4, 6, 9, 27, 30, 33], replenishment policy [31, 34–36], and reduction of lead time [8, 27, 37].

Table 3 Distribution over journals and main topics of papers under review about the bullwhip effect

Reviewed papers	Journal	Aim/main topic
Lee et al. [25]	MS	Examining the information distortion in the supply chain and causes of the bullwhip effect
Lee et al. [26]	SMR	The bullwhip effect in supply chains
Chen et al. [27]	MS	Analyzing the impact of forecasting, lead times and information to reduce bullwhip effect
Disney and Towill [28]	O	The bullwhip effect and inventory variance produced by an ordering policy
Disney and Towill [29]	IJOPM	VMI offers a significant opportunity to reduce the bullwhip effect in real-world supply chains
Zhang [30]	IJPE	Considering the impact of forecasting methods on the bullwhip effect
Lee and Wu [31]	CIE	A study on inventory replenishment policies in a two-echelon supply chain system
Wu and Katok [16]	JOM	Investigating the effect of learning and communication on the bullwhip effect in supply chains
Croson and Donohue [15]	MS	Analyzing behavioral causes of the bullwhip effect and the observed value of inventory information
Ouyang [32]	EJOR	Examining the effect of information sharing on supply chain stability and the bullwhip effect
Wright and Yuan [33]	IJPE	Mitigating the bullwhip effect by ordering policies and forecasting methods
Jaksik and Rusjan [34]	EJOR	Examining the influence of different replenishment policies on the occurrence of the bullwhip effect
Kelepouris et al. [35]	COR	Studying the impact of replenishment parameters and information sharing on the bullwhip effect
Su and Wong [36]	ESA	Studying a stochastic dynamic lost-sizing problem under the bullwhip effect
Agrawal et al. [37]	EJOR	The impact of information sharing (IS) and lead time on bullwhip effect and on-hand inventory
Yu et al. [38]	ESA	Evaluating the cross-efficiency of information sharing in supply chains
Bhattacharya and Bandyopadhyay [11]	IJAMT	Overall research studies on the effect of both operational and behavioral factors on the bullwhip effect
Hussain et al. [10]	IJPDLM	Quantifying the impact of a supply chain's design parameters on the bullwhip effect using simulation and Taguchi design of experiments
Bray and Mendelson [5]	MS	Investigating information transmission and the bullwhip effect
Trapero et al. [6]	O	Impact of information exchange on supplier forecasting performance
Ali et al. [4]	IJF	Forecast errors and inventory performance under forecast information sharing
Li [7]	AMM	Exploring new ways to reduce the bullwhip effect in supply chain systems that face uncertainties with respect to information sharing
Li and Liu [8]	AMM	A robust optimization approach to reduce the bullwhip effect of supply chains with vendor order placement lead time delays in an uncertain environment
Croson et al. [17]	POMS	Examining the behavioral causes of the bullwhip effect, in particular the possible influence of coordination risk

MS Management Science=4, SMR Sloan Management Review=1, O Omega—The International Journal of Management Science=2, IJOPM International Journal of Operations & Production Management=1, IJPE International Journal of Production Economics=2, CIE Computers & Industrial Engineering=1, JOM Journal of Operations Management=1, EJOR European Journal of Operational Research=3, COR Computers & Operations Research=1, ESA Expert Systems with Applications=2, IJAMT International Journal Advanced Manufacturing Technology=1, IJF International Journal of Forecasting=1, IJPDLM International Journal of Physical Distribution & Logistics Management=1, AMM Applied Mathematical Modelling=2, POMS Production and Operations Management Society=1

Most studies involve a quantitative analysis including simulations and developing structural equations. Qualitative analyzes are restricted in laboratory experiments [15–17] and surveys [5].

According to Croson and Donohue [16], supply chain executives and academics have focused their attention on the operational causes of the BWE. In this first category most studies are directed to the problem of sharing information in supply chains.

Research aimed at mitigating the phenomenon often includes:

- Studying the relation between demand forecasts and implications in inventory through an ARIMA representation of the demand process [4, 9]
- Analyzing new ways to reduce the BWE in supply chain systems facing uncertainty regarding information sharing

through methods of inventory control that includes an optimization problem [7]

- The impact of replenishment parameters and information sharing on the BWE [35]
- A robust optimization approach to reduce the BWE of supply chains with lead time delays [8]
- Coordination [11]
- Vendor Managed Inventory (VMI) [29]

The second category of studies focuses on the behavioral causes of the BWE [15–17]. These are studied in laboratory by a “beer distribution game”, in order to eliminate operational causes, due to being difficult for them to be eliminated in field research.

In Croson's and Donohue's [15] research, the experiment revealed that even if the operational causes were eliminated

Table 4 Bullwhip effect descriptive analysis

Reviewed papers	Methodology	Analysis method	Type of data analysis	Sample	Industry
Lee et al. [25]	Theoretical analysis	Structural equation model	QAN	Not applicable	Not applicable
Lee et al. [26]	Theoretical analysis	Descriptive analysis	QAL	Not applicable	Not applicable
Chen et al. [27]	Theoretical analysis	Structural equation model	QAN	Not applicable	Not applicable
Disney and Towill [28]	Theoretical analysis	Mathematical model	QAN	Not applicable	Not applicable
Disney and Towill [29]	Theoretical analysis	Simulation model	QAN	Not applicable	Not applicable
Zhang [30]	Theoretical analysis	Structural equation model	QAN	Not applicable	Not applicable
Lee and Wu [31]	Theoretical analysis	Simulation model	QAN	Not applicable	Not applicable
Wu and Katok [16]	Laboratory experiment	Beer distribution game	QAN, QAL	192 undergraduate business students	Laboratory/college
Crosno and Donohue [15]	Laboratory experiment	Beer distribution game	QAN, QAL	Undergraduate business students	University of Minnesota
Ouyang [32]	Theoretical analysis	Structural equation model	QAN	Not applicable	Not applicable
Wright and Yuan [33]	Theoretical analysis	Simulation experiments	QAN	Not applicable	Not applicable
Jaksik and Rusjan [34]	Theoretical analysis	Transfer function method	QAN	Not applicable	Not applicable
Kelopoulos et al. [35]	Single case study	Simulation model	QAN	250 retail stores / 7 central warehouses	Grocery retail
Su and Wong [36]	Theoretical analysis	Simulation model	QAN	Not applicable	Not applicable
Agrawal et al. [37]	Theoretical analysis	Minimum mean squared error (MMSE)	QAN	Not applicable	Not applicable
Yu et al. [38]	Theoretical analysis	Data envelopment analysis (DEA) model	QAN	Not applicable	Not applicable
Bhattacharya and Bandyopadhyay [11]	Literature review	Content analysis	QAL	Not applicable	Not applicable
Hussain et al. [10]	Laboratory experiment	Taguchi design of experiments and simulation techniques	QAN	Not mentioned	Not applicable
Bray end mendelson [5]	Survey	Structural equation model	QAN	4689 questionnaires	Public companies
Trapero et al. [6]	Single case study	Nonlinear AR models, ARIMA, exponential smoothing, moving averages and neural networks	Univariate models / ARIMA processes	43 Stock keeping units (SKU) with 52 observations per SKU	Household products
Ali et al. [4]	Theoretical analysis	ARIMA processes; mean squared error (MSE)	QAN	1798 Stock keeping units (SKUs)	Supermarket
Li [7]	Theoretical analysis	Simulation model	QAN	Not applicable	Not applicable
Li and Liu [8]	Theoretical analysis	Optimization model	QAN	Not applicable	Not applicable
Crosno [17]	Laboratory experiment	Optimization model	QAN, QAL	Not mentioned	Public university

QAL qualitative analysis, QAN quantitative analysis

and the demand known to the participants of the game, the BWE would have persisted in occurring. According to the authors, an “irrational” behavior is related to behavioral causes [41–43], showing that individuals have a behavioral tendency in business settings. The participants have a tendency to place their orders at a time, but do not consider these applications in calculations of inventory when effecting orders for the next period. This requested, but not received, stock is not considered in the following order, and this occurs even when operational causes are removed.

In a second experiment, Croson and Donohue [15] found that the trend continues when information on inventory levels is shared. However, they noted that information about stocks assist in mitigating the BWE with upstream members of the chain, anticipating and preparing them for fluctuations in inventory needs at downstream in the chain. Upstream members of the SC are benefitted from initiatives of information sharing.

Wu and Katok [16] consider the supply chain as an integrated organization, and investigate the effect of learning, training and communication in mitigating the BWE. The study was conducted in the context of a “beer distribution game”. The results showed that demand variability significantly decreases in the environment which the participants have experience (knowledge) in order to formulate strategies collaboratively. The training improves the individual’s knowledge about the system, but it does not improve the performance of the SC, unless the partners share and communicate this knowledge.

According to Wu and Katok [16], programs that improve the performance of individual decisions and the coordination of SC partners are needed. They emphasize the need for studies that explore the impact of other practices alongside communication to facilitate coordination as CPFR to mitigate the BWE, and add that empirical studies are needed to test the applicability and accuracy of the experiment results.

Croson et al. [17] analyze, from laboratory experiments, the behavioral causes of the BWE, more specifically the possible influence of coordination risk. There is such coordination risk when individuals’ decisions contribute to a collective outcome and the decision rules followed by each individual are not assuredly known, for example, where managers may be unsure of how their supply chain partners will behave. The authors assumed that the existence of coordination risk may contribute to the BWE. Among these factors, there is the lack of experience from managers. But only lack of experience itself is not responsible for contributing to the BWE. Many managers are not reliable, dodging the “ideal game” in which it is built an inventory coordination to reduce the BWE. Croson et al. [17] point to the need for research on experience, learning, and decision-making in mitigating the BWE. Moreover, they claim that research that incorporates behavioral responses to the volatility of orders and supply

disruptions is needed. While SC agents seek to make decisions based on cost minimization, the authors direct their attention towards the need for research to examine the decision-making rules based on human behavior.

The work of Croson et al. [17] demonstrates that the BWE constitutes not only a behavioral, as well as operational one, and that methods for reducing instability in the SC may be addressed to behavioral and structural causes of the problem. Decision-makers have difficulties in controlling time, which include lack of experience and delays. Thus, training and guidance in making decisions that aid them are necessary for further development.

The notion of “optimal” behavior is contingent on people’s assumptions about the thinking and behavior of other agents with whom they interact. If a person believes that their colleagues will act in an unpredictable and capricious manner, it could lead to a greater instability in the supply chain. When managers can be sure of their partner’s knowledge in their SC in optimal decision-making and can be trusted to implement it, the performance can be improved even further.

Croson et al. [17] identify it as an effective mechanism for moderating the BWE in inventory coordination. The coordination of inventory in its turn depends on the risk coordination level, the cost of excess inventory, and thus the cost of not reducing the BWE. They point out to the need for research to better define the nature of these relations.

As previously discussed, information sharing is widely studied to mitigate both operational and behavioral causes of the phenomenon. However, the elements of trust and collaboration of the organizational culture of a company is not taken into account, which strongly influences the behavior of its employees and, consequently, improves information sharing.

As it was examined, the individual’s behavior influences the problems caused by the BWE, because such an effect persists only with the elimination of operational causes. The integration between members of a supply chain and its management constitutes a complex task, considering the different cultures that permeate the participating companies.

According to Croson et al. [17], the risk of coordination in SCM can lead to an increase in the BWE that is caused by lack of experience and trust in decision-making from managers.

Thus, it is found that there is a lack of studies directed at behavioral causes of the BWE. Bowersox and Closs [44] argued that to be fully effective in a competitive environment, firms must expand their integrated behavior to incorporate customers and suppliers. This extension of integrated behaviors, through external integration, is referred as SCM.

In this respect, the relationship among participants cannot only be summarized in process quantitative analyses. It involves people who exercise their functions in businesses and are responsible for these relationships. The organizational culture cannot be left untouched in this analysis, from the framework of studies on the mitigation of the BWE.

Thus, within the wide area of organizational culture, the development of trust and collaboration among SC partners constitute important elements for the mitigation of the BWE.

Results were observed with the development of trust and collaboration in the SC, such as information sharing, joint decision-making, encouraging knowledge management, learning and training that in turn constitute factors that promote the solution of problems which lead to mitigating the BWE in the SC.

4.2 Trust

Barrat [45] considers the elements of trust and collaboration as key factors to maintain a close relationship between the participants of the SC and improve their performance as well as customer satisfaction.

Collaboration among partners of a SC strengthens long-term relationships based on personal trust, bringing benefits such as the joint creation of knowledge, sharing expertise and understanding the intentions of the partner, reducing logistics costs, and creating values for a SC [46, 47].

Research conducted by the Great Place to Work Institute [48], which is comprised of large companies in the world considered as the best companies to work for, indicate elements in the dimensions of respect, fairness, credibility, pride, and camaraderie, which are identified as trust indices.

Nold III [20] adopted these elements to analyze the relation of knowledge management with the company's performance and the reference group had more intangibles than the other group, comprised of companies that are not part of the Great Place to Work Institute, under the form of patents, copyrights, branding, ability to innovate, strategic flexibility and secrets of business property. These intangible assets are created through processes of knowledge, which give the company a competitive advantage.

The reference group even outperformed itself regarding operational performance. This result suggests that firms with high levels of trust can be more effective in knowledge processing, and in converting into actions that improve operating results. In an environment where knowledge is shared, the learning process is accelerated and access to tacit knowledge of organizations is also obtained, which further accelerates this process. With an increase in the learning rate, one can respond more quickly when making decisions, thus, achieving better results.

Leading companies also showed a higher annual growth rate than that of the group which is not part of the Great Place to Work Institute. Nold III [20] concluded that companies in which individuals who rely on one another and take pride in the organization they work for often grow more efficiently than those who work for companies with lower levels of trust, e.g., cultural attributes that are favorable to knowledge sharing, facilitate effective knowledge processes, resulting in

innovation and flexibility which are manifested by higher growth rates.

Nold III [20] further indicated that future research can complement this work by identifying practical ways related to knowledge process that add value, operational performance, and growth to businesses.

Ha et al. [18] classify affective trust, as related to the dimensions of emotion and personality, often developed in a long-term relationship, and trust based on competence related to rationality. According to the authors, these two forms of trust in clients are present in suppliers to work collaboratively and increase work performance.

Affective trust has a significant influence on the cooperation of information sharing, and trust in competence is significant for collaboration in joint decision-making. If suppliers develop an affective trust with their partners, they will feel more comfortable to more frequent contact, leading to greater information sharing and communication. However, it does not necessarily mean that customers will participate in joint decision processes of suppliers. Decisions in many areas, especially strategic ones, must be shared with partners who have enough technical knowledge to contribute to the performance.

For this reason, trust in competence is significant in joint strategic decision-makings because wrong decisions often lead to an increase in costs and a drop in performance.

Fawcett et al. [49] argue that although trust is a subjacent affective personal relationship, it does not exist among companies. Trust in the supply chain is based on competence. For companies, ability in performance and capacity commitment in the relationship are needed.

The competence of the company is related to efficiency in relation to the material quality, cost, and fulfillment of delivery. The continuous search of product quality is an important requirement for companies, due to high competitiveness in the current scenario, market opening, and increasing consumer demand. The costs of product or services constitute monetary measures that portray the competence of the company to manage its budget control and important information for decision-making and planning.

Table 5 presents the main elements of trust.

On the whole, trust partly consists of a belief that the other part in the relationship will neither act opportunistically nor exploit their vulnerabilities. Thus, according to data from the view conducted in this work, trust may have honesty, credibility, respect, and mutual understanding as indices between the supplier and its customer. Indices or elements of trust must be present in the customer-supplier relationship.

These characteristics improve internal trust in the company, achieved in good relationship management with employees. This relationship will contribute to the training of employees and better internal organization of the company, which will provide the results expected by clients.

Table 5 Trust elements and according authors

Theoretical factors and their according elements	Authors
Affective trust	
Respect	Ha et al. [18], Nold III [20]
Honesty	Ha et al. [18], Chen et al. [50], Delbufalo [19], Nold III [20]
Credibility	Chen et al. [50], Delbufalo [19], Xiao et al. [51], Nold III [20]
Mutual understanding	Ha et al. [18], Nold III [20]
Trust in competence	
Knowledge/technique for performance	Ha et al. [18], Fawcett et al. [49]
Commitment in the relationship	Fawcett et al. [49]

Internal collaboration based on trust improves the performance of internal business processes related to, e.g., the fulfillment of delivery to customers. Delays in products delivery lead the client's need to have safety inventories to guard against the inefficiency of the supplier if delivery delays occur frequently.

The trust developed in the company's internal environment helps mitigate this phenomenon caused by the BWE, promoting collaboration among employees to improve the quality of the performed work, resulting in fulfillment of delivery and avoiding the formation of inventories throughout the supply chain.

Despite the competitive advantage generated by the customer-supplier relationship, developing trust is quite difficult. The people chosen to develop trust among members of a SC are of great importance. The establishment and maintenance of a trusting relationship depends on the work of individuals who regularly interact with one another in organizational boundaries. Buyers or customers are the ones who develop relationships with individuals from other companies, especially suppliers. These relationships provide the individual a broader communication portal among organizations that create familiarity and trust [52].

Among the factors or mechanisms that contribute to the development of trust, Zhang et al. [53] take the strategy of open communication with client and supplier into account. The client's knowledge increases the supplier's trust and the client's skill to fulfill commitments.

The strategy of client communication with the supplier has a positive and significant effect on developing the supplier's trust. This communication includes having knowledge on the client's future plans, which assists in the coordination of the SC and increases the supplier's trust in their customer. It is, however, addressed to purchasing agents than to the buyer company when the buyer agent demonstrates professional knowledge. Professional knowledge includes technical and

commercial knowledge related to products and supplier's capacity. It was also noted, according to Zhang et al. [53], that the buyer's skill to fulfill its commitments builds up the supplier's trust in the buyer, but not in the company.

Trust is developed within an individual's range before being transferred to the companies and it is important to maintain the continuity of interpersonal relationships to keep a long-term partnership with a particular company.

High levels of trust support interactions among firms in a SC, enhancing cooperation and communication, and also reducing uncertainties in the system [54].

Studies on trust in the context of SC indicate that trust is the key element for the development of relationships and also for operating joint activities among suppliers and clients in the SC [55].

The fulfillment of delivery directly impacts the inventory management of the company, which absorbs a substantial portion of its operating budget. As they do not add value to products, the lower inventory level, in which a productive system can work, promotes major efficiency. It helps maintain minimum inventory level, obtaining a satisfactory margin of costs in relation to storage and maintenance. It mitigates one of the main effects of the BWE, the accumulation of unnecessary inventory throughout the SC.

Thus, affective trust also affects trust in the competence that reaches the highest levels of product quality, cost, service level, and financial health.

Therefore, affective trust determines the development of relationship with the SC partners.

Figure 1 shows the relationship between affective trust, internal trust, trust in competence, and external trust.

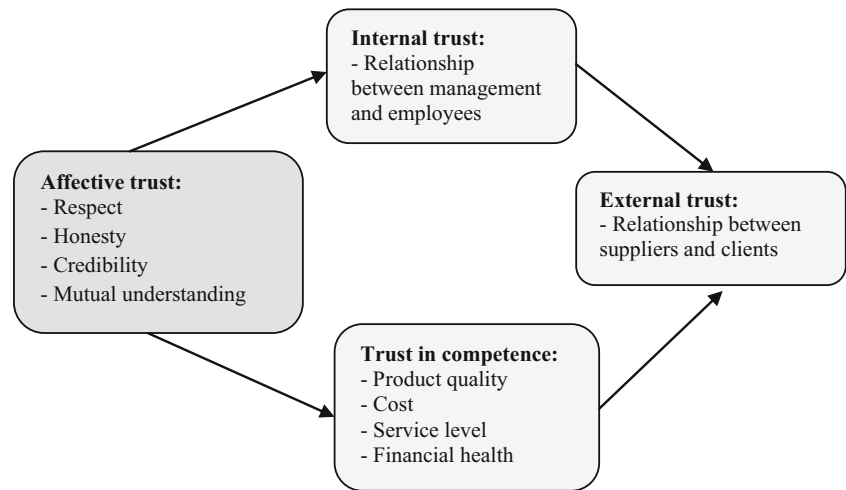
Affective trust in the company according to its organizational culture provides an open relationship between management and employees. This relationship will enable an efficient organization of internal business processes that will result in the generation of trust in the competence of this company by partners of the SC, and consequently the external trust with a long-term and open relationship between customers and suppliers.

Table 6 presents the main trust results.

Trust is an important success factor for collaborative relationships in supply chains. Studies clarify that the success of SCM is built on the foundation of trust [61]. The implementation of tools for electronic collaboration requires trust in trading partners, because they involve information exchange on projects, plans, and demand forecasts. It is important to build trust with business partners before implementing SCM integrated through electronic collaboration tools, and share important information in the SC [62].

Collaborative relationships in information sharing between members of a SC promote learning and produce new knowledge [63], but before initiating collaborative relationships, it is important to build up trust so that information sharing and

Fig. 1 Relation between affective, internal, external trust, and trust in competence



cooperation becomes more efficient. Thus, the environment is more conducive to product innovation projects and processes.

4.3 Collaboration

Collaboration in the context of supply chains is defined according to APICS [64], as the establishment of a working relationship with the supplier’s organization, in which the two organizations act as if they were one single organization.

Barrat [45] considers two potential forms of collaboration, dividing them into two categories: vertical, which includes collaboration with clients, internal which involves functions, and suppliers; and horizontal, which includes collaboration with competitors, internal, and with non-competitors sharing the manufacturing capacity.

Internal integration among the various functions of an organization (purchasing, manufacturing, logistics, and marketing) must be connected to external collaboration, developing relationships, integrating processes, and sharing information with suppliers and clients.

Vieira et al. [65] have identified interpersonal integration as consisting of trust, interdependence, flexibility, and reciprocity as key elements for the development of collaboration between retailers and suppliers of manufactured products in the Brazilian context, specifically in the retail chain. It was found that interpersonal relationships among agents directly influence interorganizational relationships.

Thus, if parties have a good social life, they are receptive and open to suggestions and criticisms, giving credence to the opposing party and belief in what was said. There is an enormous predisposition to collaboration (at all levels of integration—strategic, tactical, and interpersonal) and the consequences of this would be the following: greater agility in operations, greater transparency in communication, more information sharing, greater flexibility, lower costs seeking unnecessary information to other functional areas of business; greater willingness to resolve logistical contingencies, among other benefits.

Barrat [45] considers that most organizations cannot operate in a collaborative behavior and one of the main elements that support collaboration is the collaborative culture of the organization, which is composed of the following factors: trust and commitment in relationships established in internal and external environments of the organization; mutuality in the sense that all possible gains and risks arising from the collaboration will be shared among all collaborating agents; information exchange in supply chains in order to provide a transparent information flow, accuracy, and symmetry; communication and understanding of the information exchanged between agents, and sincerity and honesty in relationships.

In this study, collaboration is a process that promotes interorganizational cooperation, information sharing, and knowledge, in which two or more independent organizations work together to align the processes of the SC. Collaboration

Table 6 Trust results in the supply chain (SC)

Results	Articles
Information sharing	Chen et al. [50], Wei et al. [56], Özer et al. [57], Delbufalo [19]
Cooperation	Ha et al. [18], Wu et al.[54], Xiao et al. [51], Delbufalo [19]
Innovation	Panayides and Lun [58], Fawcett et al. [49], Delbufalo [19]
Learning and knowledge management	Mellat-Parast and Digman [59], Nold III [20]
Integration with suppliers	Laequuddin et al. [60], Delbufalo [19]

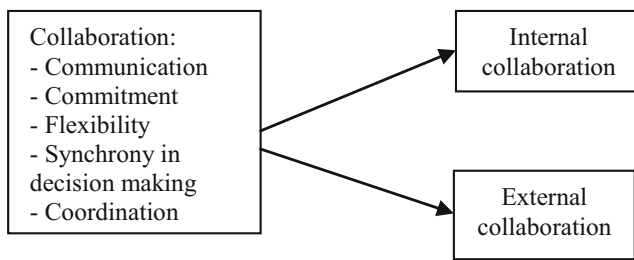


Fig. 2 Relation between internal and external collaboration

presents the following characteristics: communication [45, 66], commitment [45], flexibility [53], synchrony in decision-making [45, 66, 67], and coordination [68].

Communication characterizes the presence of collaboration when it is more transparent, in which more information is shared, promoting greater flexibility in operations. Information sharing associated with sales history, processing time (lead times) of purchase orders and/or manufacture of the product, demand forecasting, and product availability can eliminate any excess stock with the goal of synchronizing decision-making and coordinating the activities of organizations involved in planning [66], thus contributing to the mitigation of BWE.

Collaboration between customers and suppliers allows the organization to work with greater flexibility in purchase requests, enabling prompt response in cases of unexpected changes in demand or new requests from consumers [69].

According to Barrat [45], commitment is developed by sincerity and honesty. If the delivery of products to a particular customer is delayed, the supplier does not need to wait until the deadline has expired, otherwise it will warn you as soon as there is delivery delay to the customer to implement contingency plans, thus avoiding delay in decisions of managers, appointed by the literature as one of the behavioral causes of the BWE [15].

Internal collaboration involves the various functions of an organization and must be connected to external collaboration to develop relationships with process integration and information sharing between suppliers and customers [45].

Figure 2 shows the relation between internal and external collaboration.

Table 7 presents the main results of collaboration in academic literature studies.

Collaboration between participants of a SC requires practical and defined actions. The most in-depth method, known as CPFR, introduces a sequential approach that defines key actions to be undertaken during the formulation of collaborative initiatives. The VMI was designed to bring partners closer to the SC, but this practice does not focus on information exchange between partners.

CPFR captures the operational advantages of VMI and adds collaboration mechanisms to facilitate the exchange of information in different echelons of the SC [78]. The advantages of CPFR, according to Cassivi [78] are significant, and among them are increased sales, reduced inventory, and improved customer service.

The literature review focuses on a quantitative analysis to understand and provide a solution to mitigate the bullwhip effect. Among the causes of the BWE, the authors point out operational causes such as demand forecasting, rationing game, order processing, price changes, high lead times, lack of transparency, and replenishment policy [3, 6, 7, 10, 25, 26, 79].

However, another group of articles have attributed the triggering behavioral causes of this effect, as the negligence of the delay in decision-making, lack of learning and training, empty stock suspicion, and coordination risk [13, 15–17]. Few studies were identified in academic literature on the behavioral causes of BWE.

Table 8 presents the key elements addressed by reviewed papers to mitigate the BWE.

4.4 Relation between trust, collaboration, and BWE

Some studies consider trust as a defining characteristic of the presence of collaboration among members of a SC [45, 65]. According to Ha et al. [18], trust in a SC is considered as a parallel part of the collaboration. They are two closely related concepts.

Thus, the relation between trust, collaboration, and the BWE in SCM are described in the following subsections.

Table 7 Collaboration results in the supply chain (SC)

Results	Articles
Use of initiatives and practices of SCM (CPFR /VMI)	Disney and Towill [29], Danese [67], Kauremaa et al. [70], Danese [71], Ramanathan and Gunasekaran [72]
Information sharing	Barratt [45], Danese [67], Simatupang and Sridharan [73], Kim and Lee [74], Vieira et al. [65], Fawcett et al. [77], Danese [67], Ha et al. [18]
Joint planning (production, demand forecasts and replenishment products)	Danese [67], Kim and Lee [74], Olorunniwo and Li [75], Danese [71], Lehoux et al. [76]
Learning and training	Fawcett et al. [69]; Fawcett et al. [49]

Table 8 Mitigation of bullwhip effect key elements

Key elements	Reviewed papers
Information sharing	Lee et al. [25, 26], Chen et al. [27], Ouyang [32], Yu et al. [38], Bhattacharya and Bandyopadhyay [11], Hussain et al. [10], Bray and Mendelson [5], Trapero et al. [6], Li [7]
Improved demand forecasting	Chen et al. [27], Zhang [30], Wright and Yuan [33], Ali et al. [4], Trapero et al. [6]
Replenishment policy	Lee and Wu [31], Jaksik and Rusjan [34], Su and Wong [36], Kelepouris et al. [35]
Lead time reduction	Chen et al. [27], Agrawal et al. [37], Li and Liu [8]
Behavioral causes	Wu and Katok [16], Croson and Donohue [15], Croson et al. [17]
Coordination	Bhattacharya and Bandyopadhyay [11]
VMI	Disney and Towill [29]

4.4.1 Information sharing

Since 1997, academic literature has been attributing it to distortions of information, inefficiencies in SC and the BWE [25]. In reviewing BWE causes, Bhattacharya and Bandyopadhyay [11] point out to the need for information transparency and coordination between companies in SCM to reduce the BWE. Trapero et al. [6] conclude that information sharing improves the demand forecasts performance. Li [7] had used the simulation and indicated that sharing information is essential to reduce the fluctuations in inventories replenishment to improve the performance of the SC.

The amplification of demand variation occurs throughout the chain because of distortions, lack of transparency, and information sharing. This piece of information refers to the historical level of end-user demand, schedule requests from businesses downstream in the SC and inventory information, also downstream in the SC.

Inventory replenishment of companies depends on information of customers demand. To avoid the accumulation of inventories which generates costs and obsolescence, information about demand should be frequently updated and shared with transparency and credibility.

Distortion of demand information promotes the coordination risk between firms in a SC, pointed out by Croson et al. [17] as one of the behavioral causes of the BWE. The coordination risk and the uncertainties of the decision-makers' actions lead to instability and variability of orders, leading to the BWE.

Negligence or delay in decision-making [15] contributes to a delay in fulfilling order and delivery. Information distortion also leads to a behavioral cause of BWE which is related to stock suspicion [15], when companies request a surplus amount of orders due to being afraid of reaching an empty stock and lose customers.

Trust constitutes an important element for reducing the bullwhip effect, because it is related to the availability and quality of information in a supply chain [50]. Wei et al. [56] stated that information integration and the development of trust are important factors for collaboration among partners, moreover it improves logistics performance.

Özer et al. [57] consider the importance of the problem of information sharing among participants of a SC. Companies like General Motors and Procter & Gamble heavily invested in the implementation of information management in their global supply chain for better coordination with suppliers around the world. However, the values of these information systems depend on whether the information is shared with credibility. There are cases when the supplier requests information from demand forecasting to retailer that has the opportunity to manipulate the forecast to ensure an abundant supply.

The manipulation of excessively optimistic forecasts prevails in all sectors. The lack of suppliers' upstream trust against forecasts of demand from downstream buyers offers limits to a SC to meet the market demand. Özer et al. [57] highlight the importance of developing trust with suppliers to facilitate the sharing of demand forecasting between members of a SC.

Delbufalo [19], in her systematic literature review and meta-analysis, obtained information sharing as an outcome of interorganizational trust, which allows an open relationship and reduces information protection mechanisms.

Distortions, lack of transparency and information sharing require mutual understanding, in which the SC companies work as a team, developing affinities from the principles of justice and ethics among them.

Barrat [45] clarifies that information sharing is developed through collaboration between customers and suppliers where trust, openness in relationships, honesty, respect, and commitment are needed.

According to Kim and Lee [74], controlling the BWE requires collaboration and, consequently, the understanding that there is a need to formalize a policy of replenishment, which is possible through information sharing.

According to Ha et al. [18], the main areas of collaboration in SCM include joint decision-making, information sharing and risk/benefit sharing. According to the authors, collaborative behaviors are strengthened in long-term relationships based on personal trust. The collaboration between the partners of the SC results in benefits, such as the joint creation of knowledge, expertise sharing, understanding the intentions of the partner which, in turn, contribute to lower logistics costs and create values in the SC. Strategic collaboration involves the interdependence of relationships in which the partners mutually get beneficial results. Risk/benefit sharing refers to the willingness of both parties to accept short-term conflicts, considering that the opposing part does the same, resulting in long-term mutual benefits.

Trust and collaboration positively influence information sharing that is necessary to reduce the BWE in supply chains, reducing the incidence of opportunistic attitudes by the presence of respect, honesty, credibility (benevolence), and mutual understanding between the supplier and its customer (Fig. 3).

4.4.2 Innovation

Innovation can be defined as the adoption of an idea or behavior belonging to a system, process, policy, product, or service for a company. It implies the ability to break old habits and try to put forward new ideas. However, openness to new ideas is characteristic of the culture of each company [80–82].

Organizational culture is the key factor for innovation management and the ability to learn and innovate is essential in organizations [81]. Innovation enables the company to more efficiently meet customer's expectations, instead of having to compete with its rivals. The ability of firms to accumulate resources and capabilities that are rare, valuable, and difficult to be imitated are translated into an improved performance in relation to other firms [83].

Panayides and Lun [58] consider innovation, within the logistics context for example, as new processes that increase logistics performance. The introduction of new technologies, processes, systems, according to the authors, depends on the interorganizational relationships that would provide the opening of new behavioral patterns and new ideas as an aspect of culture.

These relationships facilitate innovation within an organization. In their research, the authors find positive effects of trust, and identify trust and innovation as background of high-performance supply chain. Trust between organizations

creates an environment where companies strive to exceed the minimum requirements of a relationship to increase the probability of mutual benefits.

According to Daugherty et al. [84], initiatives and practices of supply chain management such as CPFR and VMI will bring benefits for the chain if each partner trusts the other one in interorganizational collaboration. It is necessary to invest in initiatives to develop a learning culture that encourages innovation within modern organizations [85].

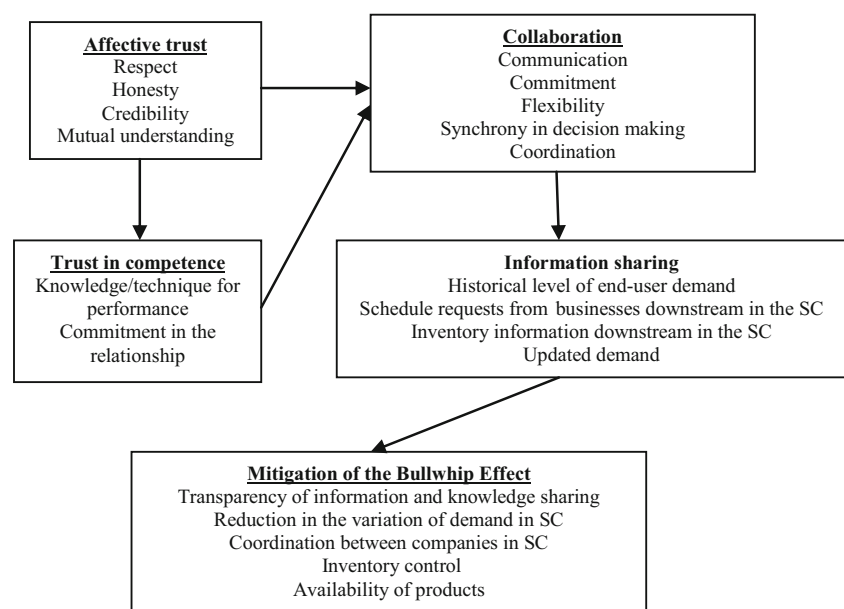
Supply chain management initiatives and practices constitute innovation, and trust presents a positive relation in supply chains innovation [58]. Manufacturers with a high level of trust towards their suppliers are more likely to adopt such innovation and in the context of a trusting relationship. These innovations provide performance improvements for the chain.

Manufacturers can be assured to obtain high returns to promote and encourage innovation. The authors consider that directing a company's culture for innovation can increase the performance of the supply chain, but this requires investments in resources, especially time management, in which the results may not be readily apparent.

The development of collaborative relationships where the element of trust is present between customers and suppliers promotes gains in the SC such as punctuality, reduced lead time, reliability, responsiveness, and accuracy.

Innovation in products and processes is important for a company in maintaining its market competitiveness. Regarding the BWE, innovation in processes between companies of a SC supports the mitigation of its undesirable effects. This innovation process requires trust and collaboration among partners for its development.

Fig. 3 Trust and collaboration in information sharing for mitigating the BWE



Innovative processes require an efficient exchange of information to achieve business objectives with the implementation of these new processes. Among the innovative processes, practices and supply chain initiatives can be considered, more specifically the VMI and CPFR that aim to provide a more efficient replenishment policy for companies. The replenishment policy is a major cause of the BWE [11].

The inventory policy specifies inventory decision rules regarding the time when the inventory replenishment should be initiated and the replenishment quantity that should be ordered from the supplier in the supply network. The ordering and inventory policy are interrelated, since the order, quantity, and time of the order depend on inventory level.

Through partnerships, developing practices such as VMI and CPFR, companies can align inventory policy, avoiding the accumulation of unnecessary inventory that generates costs and obsolescence, mitigating this effect arising from the BWE.

Inventory replenishment depends on the sort of purchase orders, inventory policy, and customer demand. Thus, VMI and CPFR can establish a policy of adequate replacement for various combinations of ordering.

The innovation that corresponds to the introduction of practices and initiatives such as VMI and CPFR in the SCM requires trust and collaboration to be developed with partners in the SC (Fig. 4).

Trust is necessary for effective sharing of knowledge and information, based on respect, honesty, credibility, and mutual understanding for collaboration in the sharing of risk and benefit of implementing VMI and CPFR processes in its entirety and original form.

4.4.3 Production, demand forecasting, and replenishment products

Collaboration along the SC has aroused the interest of practitioners of logistics and the number of models of cooperation and integration in the SC with different perspectives is increasing and being customized to facilitate relationships of each business.

VMI implementation eliminates a level of demand forecasting and ordering from the supply chain [29]. The obtained results benefits are the elimination of information delays and

material flow, source of uncertainty, and distorted decisions in the supply chain.

Suppliers will be able to more appropriately align their production processes with the customer's demand and provide information about the actual demand. Demand forecasting is available at the initial stage, and fluctuations can easily be smoothed over time where suppliers can proactively respond.

The benefits, opportunities and performance of a SC arising from VMI collaborative initiative for suppliers and customers have been researched and documented by analytical means, simulation, and case studies [28, 86, 87].

Studies indicate that the most important benefits of VMI are transparency and visibility of demand in a SC. Fundamental to achieving transparency and visibility of demand is the provision of customer data demand for the supplier. Likewise, the supplier must be able to apply these data for planning purposes. These two elements play a key role to the success of VMI [29].

Simchi-Levi et al. [88] consider that advanced information systems are important in VMI implementation. The electronic media for transmitting information reduces the time of transfer and input errors. Barcode scanners are essential. Inventory, production control, and planning systems must be online, integrated to take advantage of the available additional information.

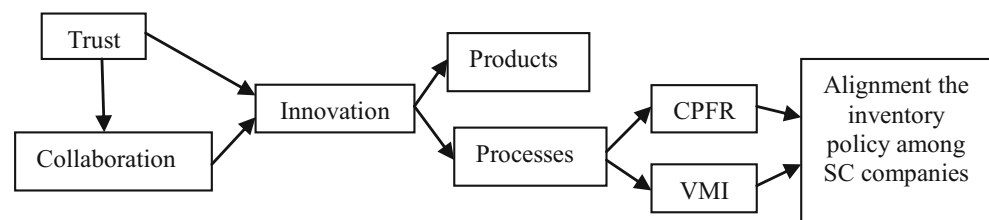
The availability of information allows the supplier to act proactively, also reducing lead time. Information on inventory levels, expected demand, promotional activities, and products cost should be made available to the customer, providing better decisions about replenishment.

The implementation of VMI eliminates a level of demand forecasting and ordering from the SC [29]. Removing a level of the SC can result in considerable benefits for the elimination of delays in information and material flow, and it removes a source of uncertainty and distortions of decisions in the SC.

Thus, suppliers will be able to align, more appropriately, their production processes with customer demand, and since the information about the current demand and demand forecasting are available at the initial stage, the fluctuations can be easily smoothed over time and providers can respond proactively and not reactively.

With the implementation of VMI on a large scale, flexibility in schedules replenishment allows the supplier to create full loads, resulting in reduced transportation costs [89].

Fig. 4 Trust and collaboration in the innovation process



With the initiative of VMI, communication and continuous exchange of information between suppliers and customers, according to Disney and Towill [29], result in a reduction of the BWE in a SC because the practice eliminates the main causes of the phenomenon.

The VMI can be developed only with chain companies in which your partner has to trust based on respect, honesty, credibility, and mutual understanding. The company will deliver replenishment control to the partner (supplier), which is done by regularly scheduled reviews of the local inventory, and has a greater dependence on the supplier with losing control of its supply.

Trust is one of the factors that interfere with the performance of VMI [86]. Information sharing must be credible for the success of its implementation.

The CPFR focuses on a strong link between business planning, forecasting and replenishment with wide information sharing. This SCM initiative provides a good alternative for collaboration, based on integration of internal and external activities of organizations [90].

Sari [91] suggests that the benefits of CPFR are superior to the practice of VMI. In the VMI program, retailers are excluded from the process of demand forecasting. Retailers share sales data and inventory. CPFR can solve most of the problems found in the VMI program, but it requires that all members of the SC jointly develop demand forecasts, production planning and purchasing, and inventory replenishment.

The CPFR initiative combines the intelligence of multiple trading partners and the planning and fulfillment of customer demand. It adds value to the SC in the form of reduced inventory, increased level of customer service, obtaining better matching of demand and supply. The successful implementation of CPFR is not an easy task.

The CPFR initiative involves strategy and planning among partner companies that establish goals for the relationship, defining rules and responsibilities. The activity requires trust among multiple trading partners motivated to seek joint gains and not acting opportunistically, but with mutual understanding and teamwork.

The development of a joint business plan identifies the significant events that affect the supply and demand in the planning period, as promotions and changing inventory policy, which are causes of the BWE.

The promotions interfere in sales forecast by masking the market in relation to anticipated sales. Companies increase production, believing in an increased demand, but as the goods are stranded and without buyers, it generates excess inventories. The identification of the aforementioned events allows companies of the SC to align policy with inventory, through collaborative activity strategy and planning the CPFR.

The initiative of the Sales and Operations Planning (S&OP) is another collaborative practice, which integrates different business plans into a set of integrated plans in order to balance supply and demand and relate strategic and operational plans of the company.

S&OP is characterized as a process of integrated and cross-functional tactical planning, concentrated in a intrafirm perspective [92]; integrates all business plans into a unified plan; involves a planning horizon of 18–24 months; reconciles the strategies and operations [93]; is responsible for creating value on company performance [94]; and aligns sales and production within the company and the supply chain [93, 94].

S&OP is an important process to mitigate the BWE. It acts on the internal collaboration of a company in which the integration between various departments as demand, supply chain, supply, sales, production, and marketing contributes to a more effective demand forecasting.

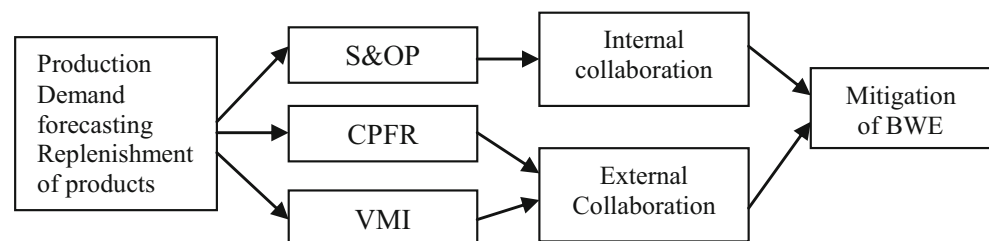
Joint planning involves issues of innovation, production, demand forecast, and products replenishment. It contributes to the reduction of the BWE. However, it requires the presence of trust and collaborative actions in the processes for the members of the SC to achieve better performances. These elements promote improved demand forecasting and production, better organization of replenishment policy, reduced lead time and improved coordination among the chain participants (Fig. 5).

4.4.4 Knowledge management, learning, and training

Technology, information, and measuring systems are the major barriers to collaboration in a SC. However, the issues that involve people—such as culture, trust, aversion to change and willingness to work are more difficult to be treated.

Misalignments in technology, information, and measurement systems have demonstrably corrected solutions, but

Fig. 5 Joint planning and mitigation of the BWE



when dealing with human barriers, such as lack of trust, unwillingness to abdicate control, and opportunism, the solutions become more of a judgment that an unresolved issue [79].

According to Fawcett et al. [79], the key to successful collaborative innovation are people. Companies continue to invest in technology, information, and measurement systems. However, managers should not ignore training, learning, and the union of the right people to work in the system and interact with one another. With the formation of certain teams assigned to certain tasks, the results will be well-defined projects and success stories that will influence members of other organizations and increase the commitment to collaboration in the SC.

Knowledge and learning are important mechanisms to maintain competitive advantage, especially during periods of rapid change. There is a clear need to manage knowledge upstream and downstream in the SC, and to train and manage human resources [95].

The leadership quality of companies involved in SC helps make the culture of their organizations and the perceptions of their staff in relation to alliances with other companies [96]. In this process, information sharing contributes for the development of new knowledge with benefits for the SC partners.

Robbins [97] describes knowledge management as the process of organizing and sharing knowledge to the right people at the right time throughout the organization.

According to Arnulf et al. [98], trust is the prerequisite to start interorganizational projects and must be present from the beginning of the relationship.

Wu and Katok [16] indicate that training and learning can improve individuals' knowledge and understanding of the system which, in turn, does not improve the performance of the supply chain, unless the supply chain allows participants to communicate and share knowledge.

According to the authors, the BWE is not mitigated by introducing information in the SC. Communication should be conducted through training. When training is combined with the opportunity of sharing knowledge and coordinated through communication, performance is reached at higher levels with reduced oscillations applications. This result indicates that the SC instability is partly caused by insufficient coordination among the participants of the SC. Training provides the knowledge for the individual, adding it to their

decision-making skill, while communication transfers the individual's learning into organizational and coordinated actions that lead to improved system performance.

According to Nold III [20], among the organizational culture elements, trust allows companies to turn knowledge and learning initiatives into tangible performance indicators recognized by the financial markets. Delfubalo [19] confirms the relation between trust and financial performance through sales growth, cash flow and increasing return on investment (ROI).

Politis [99] believes that knowledge is important but should be incorporated into the behavior set of members of a group, which is essential for acquiring and sharing knowledge. In this case, trust is essential to strengthen the collaboration and sharing of knowledge itself.

The relation between knowledge management, learning and training, and the BWE is depicted in Fig. 6.

4.4.5 Mitigation of the bullwhip effect

The literature review of this study indicated elements and their relation to the development of knowledge about the mitigation of the BWE, considering trust and collaboration in the SCM. The relation between these elements is shown in Fig. 7.

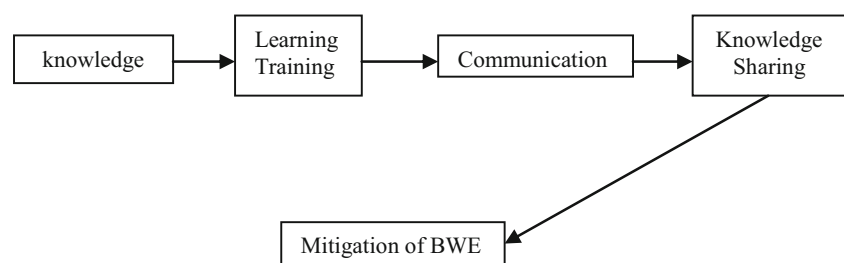
Behavioral causes are directed to the negligence of the delay in decision-making [15], lack of education or training [16]; empty stock suspicion [15] and risk of coordination in a SC [17].

These studies are related to the lack of coordination in decision-makers, the lack of learning, training, and knowledge sharing among participants of a SC. The formation of inventories throughout the SC, one of the main characteristics of the BWE, occurs when companies seek to be prevented because of the lack of trust in the decisions of SC partners.

The BWE can be mitigated when managers are assured of the knowledge of its partners in making optimal decision in the SC and trust when they can be trusted to apply this knowledge.

Thus, it is fundamental to have trust and collaboration in the internal activities of the companies, good relations between management and employees to improve the level of work and collaborative work in outside activities with SC companies towards innovation and technological improvement of products and processes.

Fig. 6 Relation between knowledge and the mitigation of the BWE



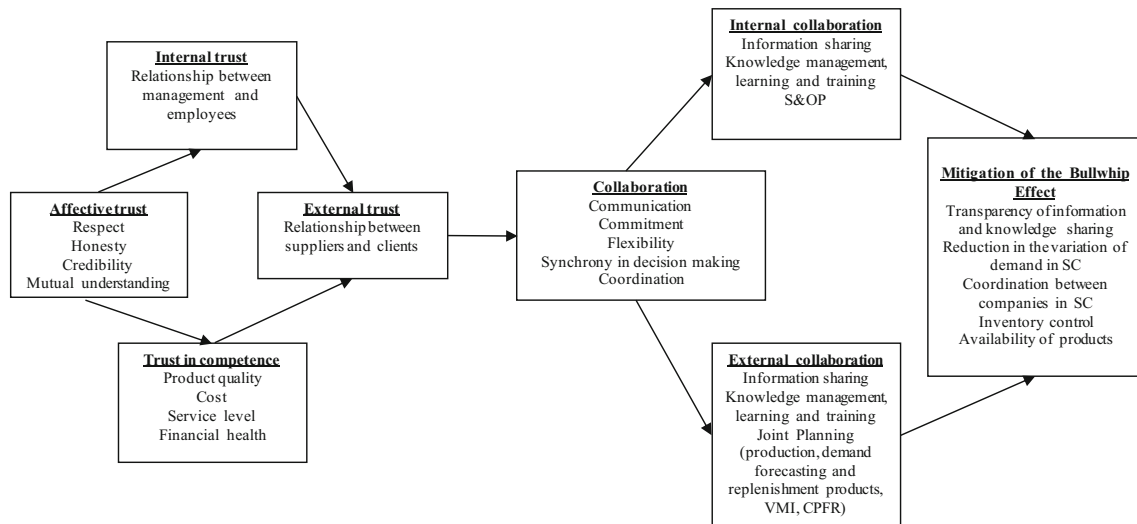


Fig. 7 Relation of trust and collaboration to mitigate the bullwhip effect

Internally, trust and collaboration influence the results of the S&OP practice, providing a more accurate demand forecasting because of sharing, transparency, and information between the company departments, mitigating one of the main characteristics of BWE, which is the amplification demand for the SC.

Externally, trust and collaboration influence the results of VMI and CPFR practices, providing greater visibility in the SC and contributing to a better coordination between companies, transparency and sharing of information with decreased levels of inventory and product availability.

These initiatives are practiced with SC partners who work with honesty, credibility, respect, and in mutual understanding. In VMI practice, the task of supplying and controlling the raw material on the client can only be done with a reliable partner, because a process of the company will be in their hands.

Regarding CPFR, communication of information planning, demand forecast, and replenishment of products should be transparent, with commitment of those involved in this practice. With the information coming from the two ends of the chain, customer and supplier, demand forecast becomes much more efficient. There is clarity and visibility of what is happening: if a problem is occurring, if sales are increasing or decreasing.

Flexibility, a characteristic of the collaboration, is necessary for possible problems or errors in the conduct of the CPFR practice or other processes, resulting in synchrony in decision-making and coordination between companies in the SC. As a consequence, the policy of replenishment is more efficient.

As regards knowledge management, learning and training, pointed as responsible for the lack of decision-makers' coordination in the SC, can achieve better results with trust and collaboration. It is possible to share knowledge between

companies in the SC if the relationship is based on trust and collaboration, achieving improvements related to reducing costs and inventory and process improvement.

The trust and collaboration between companies promote the exchange of knowledge and information transparency in the chain that can contribute to reducing inventory, improving demand forecasts and product availability with transparent communication and coordination between companies, thus mitigating the bullwhip effect.

5 Conclusions

The aim of this paper was to provide the results of trust and collaboration in the SCM that lead to the mitigation of the BWE through results obtained based on a systematic literature review. As recommended by Denyer and Tranfield [22], a more systematic and explicit research procedure in paper selection rather than the traditional narrative reviews was hereby adopted, and rigorous and reproducible methods of evaluation were employed.

The analysis found that few studies have focused on addressing behavioral aspects to reduce the bullwhip effect. Most of them in SCM have focused on operational and quantitative aspects, but problems in demand management and the occurrence of the BWE effect have persisted despite all these efforts. These results indicate the need for studies on behavioral aspects as a tool for mitigating the BWE, and the issues of trust and collaboration among SC's stakeholders need to be better developed and organized.

Behavioral causes of the BWE consider problems such as lack of experience of decision-makers, lack of training and learning, empty stock suspicion and the risk of coordination as triggering the BWE. However, it has not deeply addressed the

importance of the elements of organizational culture (trust and collaboration), to mitigate the BWE.

Many authors studied the results of trust between companies in the SC as the most effective information sharing, collaboration, innovation of products and processes, learning and knowledge management, and integration with suppliers. Regarding the collaboration results, the development of VMI and CPFR initiatives with integrity and in a primary way, the efficiency of information sharing, joint planning regarding production, demand forecast and replenishment of products and also learning and training were found. Through this study, a relationship between the results of trust and collaboration to mitigate the BWE in a SC was found.

Affective trust determines the relationship between companies in the SC. Trust in competence is important, but affective trust determines the transparency of information along the chain, problem solving, and collaboration between companies. It promotes a good relationship between management and employees who are responsible for the internal efficiency of the company.

Thus, affective trust also influences the development of the technical company's competence, providing external trust and relationships with partners of the SC.

This kind of relationship and collaboration is related to more efficient information sharing, development of VMI, CPFR, and S&OP (internal company level) initiatives, companies joint planning (production, demand forecast, and replenishment) providing transparency of information and sharing of knowledge throughout the SC, reducing demand variation, intercompany coordination, inventory control, and product availability.

Thus, the BWE can be mitigated considering trust and collaboration between companies in the SCM.

Future research may examine the relation between the variables of trust, collaboration, and the mitigation of BWE on field research in the same SC of companies.

Another relevant aspect to the behavioral causes of the BWE is the organizational cultural change of companies and performance implications. Future research can address this interesting research area.

Future research concerning the internal and external knowledge management of companies can also be developed, relating them to the performance impact in mitigating the BWE.

After the contribution of this article in terms of better understanding and providing qualitative systematization of behavioral aspects as a tool for mitigating the BWE, and the issues of trust and collaboration among SC's stakeholders, it is recommended that future studies take this understanding to an operational and quantitative level, seeking ways to better measure them, their occurrences, and effects of the BWE in SCM, quantitatively.

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