



SUPPLY CHAIN MATURITY MODELS: A COMPARATIVE REVIEW

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ABSTRACT. Background: Due to the high potential to gain competitive advantage in today's global market, supply chains play a critical role in the current industry. Understanding maturity and its features in the context of the supply chain can help companies achieve higher levels of performance. To assess and measure supply chains, a wide variety of supply chain maturity models have been developed to help companies analyze the existing state in the supply chain, allowing for the achievement of higher levels of maturity and providing guidance in the development of an improvement roadmap.

Methods: The review spans from the early 1990s to 2021 and examines research carried out and published in the literature, including papers on conference proceedings, articles in journals, and technical reports. The previous models, stages, dimensions (areas/elements), and methods are included in this review. Research gaps are also noted, analyzed, and discussed.

Results: The purpose of this study is to perform a comparative analysis of supply chain maturity models to explore the special characteristics of the studied models, which help to identify the differences and similarities between each other, and also to present the various focus areas related to the supply chain. The results show the existence of a large variety of models with a trend to the customs of models for specific area of supply chain. We also identified that most of the models have similar maturity level names and number since they are developed based on previously existing maturity models. The results of this paper are meant to serve as a reference guide for a detailed understanding of documented supply chain maturity models and help practitioners to seek better alignment in regards to supply chain maturity models characteristics.

Conclusions: Supply chains play an important role in the market rivalry nowadays. Understanding maturity and its components in the context of supply chain management can help companies perform at higher levels. Despite the high number of maturity models developed in the field of supply chain, the result of this review shows that there is a need for new studies to fill the gaps in the existing work and to take into consideration the complexity faced in the management of supply chain networks.

Keywords: supply chain management; SCM; maturity models; performance

INTRODUCTION

Today, supply chain is becoming a crucial component of the organization's performance measurement and has attracted considerable interest from academics and professionals [Azman Daud and Suhaiza Zailani 2011]. Gunasekaran, Patel [2001] and McGaughy [2004] have discussed the critical role of metrics and measures in an organization's success due to direct impact on strategic, tactical, and operational planning and control [Azman Daud and Suhaiza Zailani 2011]. In addition, "the revolution of SCM in the last decade has proved that an increasing number of companies seek to enhance performance beyond their own

boundaries" [Azman Daud and Suhaiza Zailani 2011].

"Maturity model aims to aid companies to benchmark the maturity of their operations and assumes that companies pass through a number of maturity levels before reaching high stages" [Nentland 2008]. "Maturity models have been developed within a wide range of disciplines. However, only a few models are targeting supply chain management" [Nentland 2008, Lockamy and McCormack 2004, Netland et al. 2007, Srai and Gregory 2005]. "The concept of maturity in supply chain network derives from the understanding that networks have life cycles that can be clearly defined, managed, measured and controlled throughout the time" [Fraser et

al. 2002]. When there is a high level of maturity, it leads to high performance, costs saving, and increased efficiency in achieving outlined objectives [Fraser et al. 2002, Lockamy and McCormack 2004, McCormack et al. 2008]. Companies are better prepared to deal with changes in the supply chain environment by developing mature supply chain operations. [Lahti et al. 2008]. SCM processes are evaluated using maturity models, which also help businesses in identifying areas for improvement. [McCormack et al. 2003, Lahti et al. 2008]. In recent years, more studies have focused on examining supply chain management procedures and trying to enhance their effectiveness using supply chain maturity methodologies [Cheshmberah and Beheshtikia 2020]. By responding to the following research question, our objective is to gain an overview of existing supply chain maturity models: – “What kind of maturity models has already been developed to assess the maturity of supply chain?” and “How the supply chain maturity models differ from each other?” To answer these questions, this article reviews what kind of supply chain maturity models are currently offered in the literature by conducting a literature review on supply chain maturity models.

This paper is structured as follows: in Section 2, we present the research methodology, in Section 3 we highlight the theoretical background of supply chain maturity models, then in Section 4 we discuss the summary of different developed supply chain maturity models, including an overview of the characteristics of the main model. The supply chain maturity discussion is covered in Section 5, and the study is concluded in Section 6.

RESEARCH METHODOLOGY

Using a systematic review of the literature, we searched in several databases with the following key words: “supply chain management” AND “maturity models”. The papers were selected based on the topic and abstract. Furthermore, papers that were excluded from this study did not address the following attributes: they did not define the traits of maturity models (dimensions, scope, levels), (2) did not present a new model but quote an existing model. The study also obtained other additional papers from references from the earlier articles extracted. Only 49 relevant papers are used for the comparative analysis of supply chain maturity models. Figure 1 shows the distribution of selected articles by database and publication type.

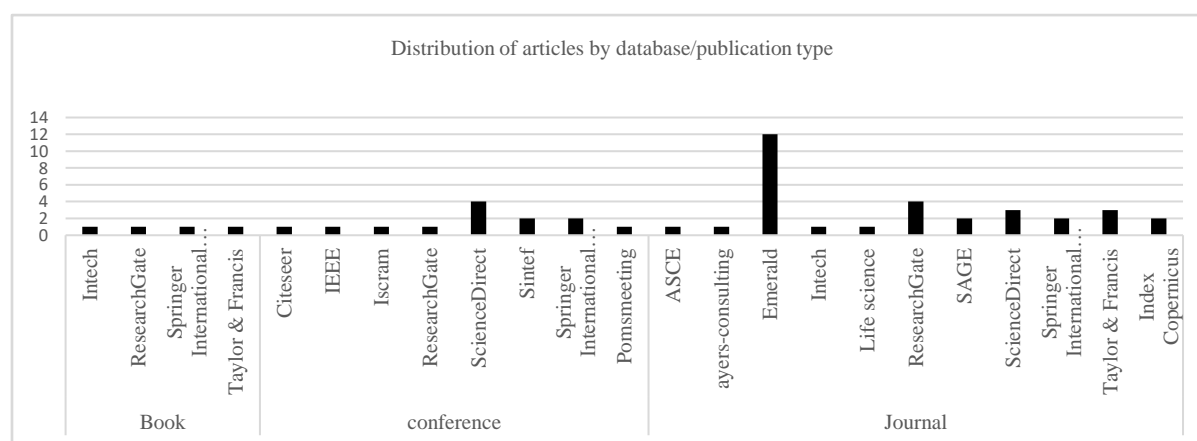


Fig.1. Distribution of articles by database/publication type.

The majority of the articles were found in the Emerald database (24%, 12 articles), Science direct (14%, 7 articles) and ResearchGate (12%,

6 articles), with the remainder being split between 19 different databases. In relation to the breakdown of the papers reviewed by publishing type, as shown the articles were drawn from a

variety of publications, with published journals accounting for the majority (64%, 32 articles), 26% from conference proceeding (13 articles), with the remainder 10% (5 articles) from books and other sources (technical report, unpublished theses).

THEORETICAL BACKGROUND

“The literal meaning of the word maturity is ripeness, which means the evolution from initial to more advanced state” [Lahti et al. 2009]. “The basic idea behind this is that the subject may pass through several intermediate states on the way to maturity” [Lahti et al. 2009]. Furthermore, “maturity implies that the processes are well understood, supported by documentation and training, is consistently applied in projects throughout the organization and is continually being monitored and improved by its users” [Lahti et al. 2009, Fraser et al. 2002].

“Maturity models are rooted in the field of quality management, where Crosby’s Quality Management Maturity Grid was a pioneering work” [Fraser et al. 2002]. Since then, numerous different forms of maturity models have been created within various fields. The Capability Maturity Model (CMM), which depicts stages in the usage of information technology, is the most well-known use of the maturity model concept in information technology and software development. “Technology, innovation, R&D effectiveness, collaboration, dependability, quality management, product design, knowledge management, and service operations are more examples of disciplines where maturity models have been developed” [Netland et al. 2007]. Later, in 2000, the CMM was upgraded to Capability Maturity Model Integration (CMMI).

“The CMMI is a process improvement approach that provides organizations with the essential elements of effective processes” [Lahti et al. 2009]. “It can be used to guide process improvement across a project, a division, or an entire organization” [Lahti et al. 2009]. Although several types of maturity model of SCM have been published, they all have in common the fact that they define a number of dimensions or process areas at various stages of maturity and provide a description of typical performance. When a maturity level is reached, it is expressed at that level. While the number of levels varies depending on the maturity model, the most immature state is represented by the lowest level, and the highest level represents the completely developed state. Dimensions illustrate various aspects of maturity and subdimensions give a deeper view. Furthermore, different typologies were proposed by Fraser et al. [2002]. First, the activities requested for each level are described in maturity grids. Second, in Likert-like questionnaires, respondents must rate the organization's performance across multiple dimensions to assess maturity. The hybrid category combines answers with maturity descriptions [Lahti et al. 2009].

OVERVIEW OF SUPPLY CHAIN MATURITY MODELS

Continuous improvement is acknowledged as a key element for firms to flourish in today's competitive business environment. “Flexible, efficient and matured supply chains guide the business to maintain competitiveness and maximize customer and shareholder value” [Lahti et al. 2009]. In this section, we present an overview of supply chain maturity models. The descriptions of the models are presented in chronological order:

Table 1. Overview of the supply chain maturity models.

Reserachers	Year	Approach
Stevens	1989	Management of material flow must be evaluated from three perspectives: strategic, tactical, and operational—in order for an integrated supply chain. At all levels, it is necessary to coordinate and harmonize the utilization of resources such as people, facilities, money, and systems.
Poirier	1999	Based on a thorough model with four levels of maturity that a company develops through as it works to advance to the advanced stages of supply chain optimization, the company evaluates its current maturity stage.
McCormack	2001	This model states that supply chain management maturity progresses through five stages, with the ultimate objective of having a fully expanded organization with complete integration of operations between businesses, their clients and their trading partners. Within a specific supply chain, more functions and businesses are included with each additional step.
Poirier and Bauer	2001	A corporation increases its supply chain effort to a position where e-commerce features are introduced, absorbed, and advantageously used as a full network communication system is described by the proposed model, which is made up of five levels.
Stonich and Moncrieff	2001	The enabling practices that will lead to performance gains are defined by the maturity model. The SCOR model serves as the basis for the supply chain management maturity model's dimensions (plan, source, make, deliver and overall)
Ayers and Malmberg	2002	a four-stage model for reevaluating your supply chain's capacity to provide affordable customer service and competitive advantage
Ayers	2004	Based on a thorough model with five stages and the operational dimensions organization, process, and systems, the company evaluates its current maturity stage.
Handfield and straight	2004	Using a paradigm that ranges from Ad Hoc through Defined, Linked, Integrated, and Extended to gauge the maturity of procurement practices. Each of these components is evaluated at the level of the business process, categorizing it as a strategic, team-based, or operational (daily) process.
Lockamy and McCormack	2004	The "business process maturity" of a supply chain is described in the model. utilizes the Supply Chain Council's SCOR framework and, like the majority of other maturity models, draws inspiration from the Quality Maturity Grid and the Capability Maturity Model. The maturity of the supply chain management process is provided by the model for improved supply chain performance.
Leem and Yoon	2004	Because customer satisfaction is based on how a software product and its service are perceived collectively, the maturity model of software customer satisfaction takes into account both software products and related services. The degree to which customer opinions regarding software products and services are gathered and reflected determines the maturity levels of software customer satisfaction.
IBM	2005	The model that was created, which is in line with the degree of supply chain integration, served as a foundation for maturity level assessments and the goal of creating an "On Demand Supply Chain". Static supply chain, functional excellence, horizontal integration, external participation, and demand-based supply chain are the five tiers that make up the model.
Lapide	2005	This model should be used as a diagnostic tool for helping a company improve its sales and operation planning processes based on four defined maturity stages
PRTM management consultant	2005	The four processes of the Supply Chain Operations Reference model: plan, source, make, and deliver—as well as what is referred to as "overall" SCM practices, which direct the strategy and connect the processes, are individually evaluated according to their level of capability using this model.
Aberdeen Group	2006	presented an approach for determining the level of supply chain visibility under the name "Roadmap for the Visibility of Supply Chain." "Shipment tracking capabilities," "supply chain disruption management," and "supply chain improvement" are the three levels at which this model evaluates the supply chain maturity level.
Jaklic et al.	2006	presented a supply chain maturity model with five levels. In this model, the SCOR framework and the Lockamy and McCormack model are combined in this model. This paradigm has the following levels: Ad hoc, Defined, Linked, Integrated, and Extended.
Netland et al.	2007	The author recommended using the EFQM Excellence Model to assess the level of supply chain maturity. The SCM-CMM model is defined as having

		five maturity levels: the following: primary, defined, extended, networked, and ad hoc (contingency)
Pache and Spalanzani	2007	Five maturity levels—intra-organizational, inter-organizational, extended inter-organizational, multi-chain, and social—have been proposed as influencing interorganizational connections.
McCormack et al.	2008	The approach uses the business process maturity model and the supply chain operation reference model to identify the supply chain management actions that could enhance a company's competitive supply chain performance.
Garcia Reyes and Giachetti	2008	The various dimensions of the supply chain (suppliers, production, inventories, customers, human resources, information systems, and performance measurement systems), as well as different abstraction levels, are all covered by the model, which offers a roadmap for business improvement. In general, it offers practical techniques to improve enterprises.
Lahti	2009	Functional emphasis, internal integration, external integration, and cross-enterprise collaboration were the four stages of the model. This study created a questionnaire to evaluate the practices of the supply chain players, as well as the maturity of various sectors of the supply chain process.
Vics	2010	The CPFR business model is made up of 4 maturity stages namely: Unlinked- Basic- Collaborative- Strategic aims to reach integrated business planning.
Gupta and Handfield	2011	Model based on 5 maturity levels : Ad-hoc- Defined -Managed -Leveraged Optimized
Meng et al.	2011	The model follows the capability maturity principle and defines four maturity levels of the relationships in the construction supply chain. It is composed of 24 assessment criteria in eight categories at each of the four maturity levels. The maturity is evaluated through a series of expert interviews.
Accenture Company	2012	Set of the four supply chain maturity stages, from discrete decision making along the chain to a value-driven supply chain. These actions include demand-driven supply chains, value-driven supply chains, supply chains focused on tasks and business units, and supply chains focused on efficiency and cost.
Hameri et al.	2013	Six steps form the concept, the first three of which are regional and deal with initial sourcing, chain organization, and expansion. The following three steps deal with global and multinational operations, chain redesign, and lean supply chain management.
Reefke et al.	2014	The "SSCM maturity model," which has six maturity stages, offers guidance for the growth of more advanced SC sustainability. A description, set of objectives, and prerequisites are given for each level. A cyclical, multistep method to maturity advancement is used to support this paradigm.
Wagner et al.	2014	Creates a comprehensive S&OP maturity model that companies can use to evaluate their internal S&OP procedures and outlines the steps necessary to adopt an integrated S&OP strategy in order to achieve a more aligned company.
Fischer et al.	2016	This approach has been designed to assess the supply chain flexibility's maturity (SCF). Each of the five (5) maturity levels—collaboration, information technology, information flow, internal flexibility, and performance measurement, that the researchers found incorporates these five (5) characteristics.
Ho et al.	2016	Considered a framework built on the Capability Maturity Model Integration (CMMI) methodology as a diagnostic tool to assess current organizational collaboration practices, as well as a road map for directing enterprises to higher degrees of supply chain collaboration.
Mendes JR et al.	2016	Framework to help businesses evaluate their current demand-driven process maturity level and provide a road map for setting SC plans to advance to higher degrees of maturity
Tontini et al.	2016	Small and medium-sized businesses can use this useful tool to evaluate their own maturity in procurement and supply management. The maturity of the following four macroprocesses is assessed by this instrument: (1) Materials management, (2) Purchase process, (3) Supplier evaluation process, and (4) Procurement planning process.

Rudnicka	2017	The major objective of the proposed maturity model is to help companies self-evaluate their current strategy and identify any potential gaps that need to be filled to support sustainability.
Sartori and Frederico	2017	Taking into account the maturity of supply chain management, three categories were discussed and determined. These include the supply chain structure (collaboration, strategic focus, responsiveness, and environmental resources), the business process and management components (process management, technology and tools, performance assessment, and risk and project management).
Asdecker and Felch	2018	The concept consists of five maturation stages that are applied to three dimensions: basic digitization, cross-departmental digitization, horizontal and vertical digitization, full digitization, and optimal full digitization (order processing, warehousing and shipping). Three to seven elements make up each dimension. The high degree of information makes it easier to create a particular development path for a supply chain and allows for detailed evaluations of the maturity outcomes.
Szlapka and Stachowiak	2018	In order to categorize businesses into five types, criteria were defined using the Logistics 4.0 Model. The three aspects of logistics1 listed below serve as the basis for this classification: (1) Management; (2) Material Flow; (3) Information Flow
Gustafsson et al.	2019	a maturity model for product fitting in retail supply chains has been developed, with three levels of digitization and potential results for each level being stated. In fact, digital product fitting is a growing operational approach in the retail industry that uses digital models of both customers and products to match product supply to customer needs. The three levels mentioned are volumenta, virtusize, and corpus.
Yahyaoui et al.	2019	The suggested model's goals are to first determine the SC maturity level of SMEs in the automotive industry and then to provide them with assistance in creating a roadmap for supply chain progress.
Grest et al.	2020	recommending a supply chain maturity model tailored especially for the humanitarian industry. The model, which takes the shape of a two-dimensional matrix, intends to: 1) objectify one organization's situation with respect to its transformation journey; and 2) provide a roadmap for the subsequent improvement areas to focus on.
Caiado et al.	2021	a fresh methodology that takes into account the intricacy of how OSCM perceives the extent of digitalization is proposed to evaluate the I4.0 maturity of manufacturing organizations. The main focus is on determining the best way to gauge the readiness of manufacturing enterprises for digitalization.

All of the models described are essentially similar, with the exception of the observed supply chain subject areas and number of maturity stages. It is critical to remember that

companies should move through the stages of those models in order, building on the practices they have built at each level. To be considered mature for a specific maturity level, a corporation must be effectively implementing most of the practices of that stage.

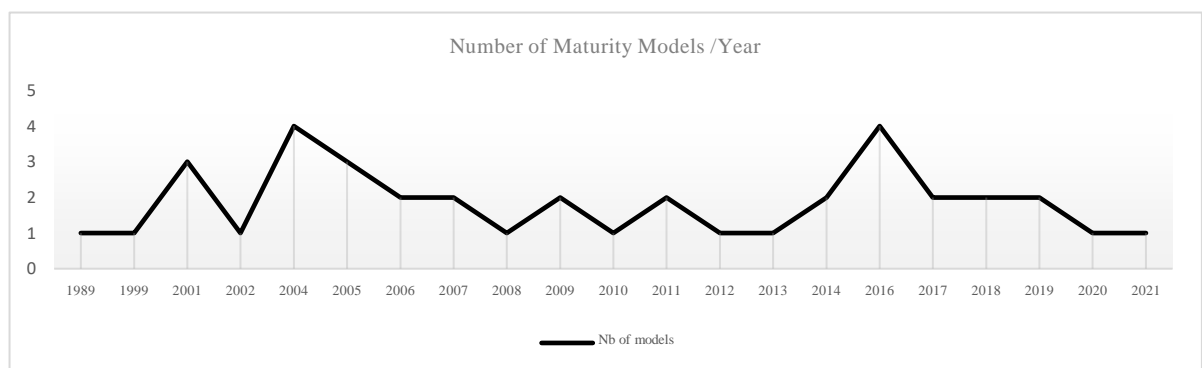


Fig.2. Number of SCMM developed per year.

Supply Chain Maturity Levels

Figure 2 shows the distribution of supply chain maturity models obtained by publication year. The number of models remains steady, except for two noticeable peaks in 2004 and 2016. We were unable to pinpoint the main cause of this study's findings in 2004 and 2016.

One of the main criteria of the listed models is maturity levels, which differ from model to another. In the table below, we identified for each model the number and name of maturity levels.

Table 2. Supply chain maturity levels.

Author's	Year	Number of maturity levels	1	2	3	4	5	6
Stevens	1989	4	Baseline	Functional	Internal Integration	External integration		
Poirier	1999	4	sourcing & logistics	internal excellence	network construction	industry leader		
Poirier and Bauer	2001	5	Enterprise integration	corporate excellence	partner collaboration	Value chain collaboration	Full network connectivity	
Stonich and Moncrieff	2001	4	Functional focus	Internal integration	External integration	Cross Enterprise collaboration		
McCormack	2001	5	Ad hoc	Defined	Linked	Integrated	Extended	
Ayers and Malmberg	2002	4	Infrastructure	Cost Reduction	Collaboration	Strategic		
Handfield and straight	2004	4	Basic Beginnings	Moderate Development	Limited Integration	Fully Integrated Supply Chains		
Ayers	2004	5	Dysfunctional	Infrastructure	Cost reduction	Collaboration	Strategic Contribution	
Lockamy and McCormack	2004	5	Ad hoc	Defined	Linked	Integrated	Extended	
Leem and Yoon	2004	4	Initial	Ready-made	Tailored	Customer oriented		
PRTM management consultant	2005	4	Functional focus	Internal integration	External integration	Cross Enterprise collaboration		
IBM	2005	5	Static	Functional	Horizontal Integration	External collaboration	On-Demand SC	
Lapide	2005	4	Marginal	Rudimentary	Classic	Ideal		
The Aberdeen Group	2006	3	Shipment tracking capability	supply chain disruption management	supply chain improvement			
Jaklic et al	2006	5	Ad hoc	Defined	Linked	Integrated	Extended	
Pache and Spalanzani	2007	5	Intra-organizational	Inter-organizational	Extended inter-organizational	Multichain Maturity	Social Maturity	
Netland et al	2007	5	Ad hoc (contingency)	Primary	defined	Extended	Networked	
McCormack et al	2008	5	Ad hoc	Defined	Linked	Integrated	Extended	
Garcia Reyes and Giachetti	2008	5	Undefined	Defined	Manageable	Collaborative	Leading	
Lahti	2009	4	functional focus	internal integration	external integration	cross-enterprise collaboration		
Vics	2010	4	Unlinked	Basic	Collaborative	Strategic		

Meng et al	2011	4	Price competition	Quality competition	Project partnering	Strategic partnering/alliance		
Gupta and Handfield	2011	5	Ad-hoc	Defined	Managed	Leveraged	Optimized	
Accenture Company	2012	4	Focused on function	focused on efficiency	demand driven supply	Value driven supply		
Hameri et al	2013	6	Startup	systemization	Explosion	Restructuring	Integration	Focused chains
Reefke et al	2014	6	Unaware & non-compliant	ad hoc & basic compliance	Defined & compliance	Linked & exceeds compliance	Integrated & proactive	extended & sustainability leadership
Wagner et al	2014	6	Undeveloped	Rudimentary	Reactive	Consistent	Integrated	Proactive
Ho et al	2016	5	Initial	managed	defined	quantitatively managed	Optimizing	
Tontini et al	2016	4	Level 1	Level 2	Level 3	Level 4		
Fischer et al	2016	5	No flexibility	Intra-firm flexibility	Reactive flexibility	Proactive flexibility	Paradigmatic flexibility	
Mendes JR et al	2016	5	Basic Push Operation	Optimized push	Hybrid push-pull	Advanced demand driven pull	Optimized demand-driven pull	
Rudnicka	2017	5	Poor	Sufficient	Good	Very good	Excellent	
Sartori and Frederico	2017	3	Initial	Intermediate	Advanced			
Szlapka and Stachowiak	2018	5	Ignoring	Defining	Adopting	Managing	Integrated	
Asdecker and Felch	2018	5	basic digitization	cross department digitization	horizontal and vertical digitization	full digitization	optimized full digitization	
Yahyaoui et al	2019	3	Effective	efficiency SC	excellence SC			
Gustafsson et al	2019	3	Corpus	virtusize	volumenta			
Grest et al	2020	4	Elementary	Intermediate	advanced	Proficient		
Caiado et al	2021	5	Nonexistent	Conceptual	Managed	Advanced	Self-optimized)	

Maturity models use a variety of terms to describe different stages of maturity. The various terminologies for maturity levels are shown in Table 2. Regarding the number of maturity levels, we observed that the majority of models are based on five levels (46%), followed by the usage of four levels (36%) and by the usage of three levels (10%) and only few models used six levels (8%).

Supply Chain Maturity Dimensions

The most important dimensions mentioned in the published studies are shown in Figure 3. The dimensions highlighted in the following picture can serve as a basis for the creation of supply chain management maturity models.

These dimensions provide a global perspective for supply chain management.

- The characteristics of each of the dimensions are as follows:
- Planning is related to multiple steps including demand planning, supply planning and operation planning.
- Costs are affected by the level of costs and inventory in the supply chain.
- Customers are related to the level of customer satisfaction as well as the attention provided to customers within the chain management.
- Processes deal with formalizing, integrating, and structuring the chain's processes.

- Technology and tools are highly supporting supply chain management, for example, information systems and statistical techniques for demand forecasting.
- Collaboration refers to communication and other joint chain endeavors, such as product creation and planning, as well as the sharing of information, profits, and resources among chain participants.
- Management is related to the quality of supply chain project management, risk management, and supply chain management training and awareness.
- Performance: The extent of performance measures in the supply chain is related to performance measurement.
- Strategic focus is the term used to describe the strategic objectives set for supply chain management by the focal company and its other participants.
- Resources are linked to the types of resources used in the supply chain, being they common (needed for execution of processes within the chain) and competitive (generate competitive advantage and are difficult to be employed by competing chains due to their differential);
- Environment refers to refers to legal concerns and credit incentives that promote the supply chain's optimal performance.
- Supply involves sourcing raw materials, services, managing contracts, and relationships with suppliers.
- Demand seeks to balance meeting client demands with maintaining adequate inventory levels.
- The organization outlines how certain activities are directed to achieve the goals of an organization.
- Storage and distribution cover a wide range of tasks and procedures, including inventory management, warehousing, supply chain management, and logistics.

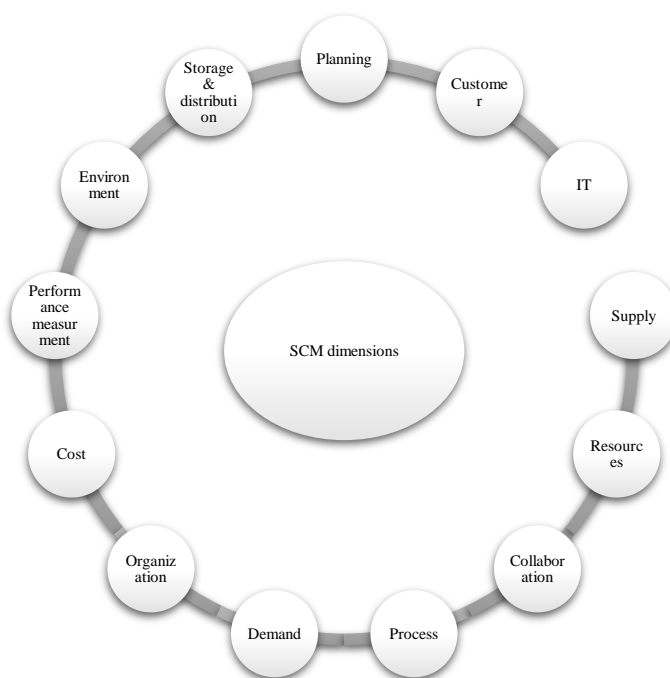


Fig. 3. Supply chain maturity dimensions.

Supply Chain Maturity Focus Areas

The review of the literature reveals that there are various methods for evaluating the maturity of SCM. Table 3 shows the focus area on SCM maturity issues based on the maturity models.

The scope of supply chain maturity models covers various areas of the supply chain; some models have contemplated supply chain management (SCM), demand driven supply chain (DDSC), supply chain optimization, supply chain integration (SCI), supply chain collaboration (SCC), and supply chain process management. In certain studies, the supply chain's flexibility, sustainability, visibility, and leanness were given special consideration; other models place a premium on the customer and the cost.

DISCUSSION

Reviewing the available supply chain models in the literature shows that the number of maturity levels varies from model to model. For most of these models, the number of levels is determined at random and is dependent on the author's ability to locate the appropriate labels or illustrative language that distinguishes the levels. Some of the studies models are basically similar, only the name of maturity levels and subject area of supply chain are varying, this can be explained by the fact that these models were created by adapting or enhancing previous maturity models.

The literature review provides evidence that most maturity models offer little guidance on particular actions that should be taken to raise maturity levels. The absence of orientation and information in the majority maturity models was emphasized by [Poepplbuss et al. 2011] (p. 519): "academic articles often present new MMs as a rough sketch that would not suffice for practical application. Thus far, academics often fall short in providing detailed guidelines and helpful (software-based or on-line) toolkits to support the practical adoption of models developed in academia", this can be improved by

establishing precise criteria that enable users to identify their present maturity stage and recognize a roadmap to the next stage.

We also noticed that some models were developed to serve specific type of organizations; therefore, their application in different organizations or industries is not as successful. Furthermore, only a few models used scientific guidelines to develop maturity models, implying that most of the models studied were developed based on the author's practical experience of the author. As a result, most models lack a theoretical foundation.

CONCLUSION

Supply chains play an important role in the market rivalry nowadays. Understanding maturity and its components in the context of supply chain management can help companies perform at higher levels. A supply chain maturity model is a methodology for the definition, measurement, management, and control of business processes. A higher level of maturity denotes an organization's superior performance [Poirier 2006].

It is acknowledged that continual monitoring and improvement are necessary for a company to succeed in the cutting-edge business world of today. Supply chains that are adaptable, effective, and mature help businesses stay competitive and maximize customer and shareholder value [Lalwani and Mason 2006].

Table 3. Supply chain maturity areas.

Reseracher/Focus area	Cost	Customer satisfaction	Demand driven supply chain	Lean supply chain	Procurement and supply manamegent	Delivery process	S&OP	Supply chain 4.0	Supply chain collaboration	Supply chain flexibility	Supply chain integration	Supply chain managment	supply chain management	supply chain optimization	supply chain process management	supply chain sustainability	supply chain visibility
Stevens 1989											*						
Poirier 1999														*			
McCormack 2001													*				
Poirier and Bauer 2001													*	*			
Stonich and Moncrieff 2001													*				
Ayers and Malmberg 2002	*	*											*				
Ayers 2004												*					
Handfield and straight 2004					*												
Leem and Yoon 2004		*															
Lockamy and McCormack 2004															*		
IBM 2005			*														
Lapide 2005							*										
PRTM management consultant 2005												*					
Aberdeen Group 2006																	*
Jaklic et al 2006															*		
Netland et al 2007													*				
Pache and Spalanzani 2007																*	
McCormack et al 2008															*		
Garcia Reyes and Giachetti 2008															*		
Lahti 2009												*					
Vics 2010									*								
Gupta and Handfield 2011															*		
Meng et al 2011												*					
Accenture Company 2012	*																
Hameri et al 2013				*													
Reefke et al 2014																*	
Wagner et al 2014							*										
Fischer et al 2016										*							
Ho et al 2016									*								
Mendes JR et al 2016			*														
Tontini et al 2016					*												
Rudnicka 2017																*	
Sartori and Frederico 2017													*				
Asdecker and Felch 2018						*											
Szlapka and Stachowiak 2018								*									
Gustafsson et al 2019												*					
Yahyaoui et al 2019												*					
Grest et al 2020												*					
Caiado et al 2021								*									

The state of the art maturity models in supply chain was analyzed. 49 articles (published from 1998 to 2021) were selected from the Science direct, Emerald Insight, and Research Gate databases. Despite the growing interest in supply chain maturity models as evidenced by the number of recently published, efforts to summarize the state-of-the-art in Supply chain maturity models have so far been rather limited, which emphasizes the importance of investigating this research area. This research contributes to a comprehensive review, analysis, and synthesis of the MM literature. Various issues associated with MMs (i.e., research objectives, maturity levels, and focus/scope of models) are explored to reveal the differences and similarities between each model and to contribute to the evolution and significance of this multidimensional area. The results of this paper are meant to serve as a reference guide for a detailed understanding of documented supply chain maturity models and help practitioners to seek better alignment in regards to supply chain maturity models characteristics.

The present study has some limitations, considering that maturity models developed by practitioners and consultants are often difficult to access using scientific databases, the art of state was performed through various databases to identify all possible relevant papers, but it is certain that some research papers were missed. To fill this gap, more comprehensive research is required using other sources of information, such as magazines and organizations' internal documents.

Organizations seek models and tools to help improve their supply chain operations. There are numerous models that might be used to achieve the required benefits. Despite numerous attempts to enhance and broaden individual performance evaluation into firms' suppliers, distributors, and customers of firms, there is currently no supply chain maturity model capable of managing the normal complexity faced in the management of supply chain networks. Future research could be considered to expand the analysis of supply chain

maturity models including other characteristics such as the typology, architecture, and application area of the model.

ACKNOWLEDGMENTS

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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