A Comparative Review on Supply Chain Maturity Models

Munyaradzi Bvuchete
Department of Industrial Engineering
Stellenbosch University, South Africa
20574304@sun.ac.za

Sara S. (Saartjie) Grobbelaar
Department of Industrial Engineering
Stellenbosch University AND DST-NRF Center of Excellence in Scientometrics and Science, Technology and Innovation Policy (SciSTIP), Stellenbosch University, South Africa
ssgrobbelaar@sun.ac.za

Joubert van Eeden
Department of Industrial Engineering
Stellenbosch University, South Africa
jveeden@sun.ac.za

Abstract

In order to ascertain and measure supply chains, a wide range of supply chain maturity assessment models have been developed. Maturity models represent stages through which processes and organisations progress as they are defined, implemented and improved. The purpose of maturity models is to assist organisations to compare the maturity of their processes against best practices and further guide in the development of an improvement roadmap. Despite the proliferation maturity models, the maturity models have been troubled by criticism such as; maturity models lack strong theoretical foundation and empirical validity. It is however the primary objective of this study to investigate this claim by performing a comparative analysis of supply chain maturity models. The results of this paper are meant to serve as a manual for a detailed understanding of the documented supply chain maturity models.

Keywords
Supply chain, maturity models, assessment models, design requirements

1.1. Introduction and problem statement

The notion of evolution from an initial state to some more advanced state is called maturity (Fraser, Moultrie and Gregory, 2002). Maturity consist of stages that form a desired path towards a goal (Pöppelbuß and Röglinger, 2011). In an organisation, process maturity implies that processes are well comprehended, supported, monitored, documented and there is continuous training and improvement throughout the organisation (Fraser, Moultrie and Gregory, 2002).

The concept of maturity models represent the stages through which processes and organisations progress as they are defined, implemented and improved (Clark and Jones, 1999). This can be achieved through institutionalization, policies and corporate culture (Paulk *et al.*, 1993). Pöppelbuß and Röglinger (2011) pointed out an interesting view that maturity models should not only focus on stages of development but should put emphasis on the elements that drive the evolution process towards a better state. The purpose of a maturity model is to assist companies to compare the maturity of their processes against best practice (Netland and Alfnes, 2008) and further provides a roadmap for improvement (Battista, Fumi and Schiraldi, 2012).

Despite the proliferation maturity models, the maturity models have been troubled by criticism such as; maturity models lack strong theoretical foundation and empirical validity (Mettler, 2011). It is also noted that procedures and

methods that led to the development of these maturity models have not been documented clearly (Becker, Knackstedt and Pöppelbuß, 2009).

1.2. A literature review on maturity models

Several maturity models have been developed for different disciplines such as innovation, quality management, research and development, product and software development, supplier relationships and SCM (Fraser, Moultrie and Gregory, 2002). However, the origins of maturity models can be traced back to the work of Crosby (1979) who developed a quality maturity grid (Fraser, Moultrie and Gregory, 2002). The maturity model provides a way of measuring and managing organisational processes according to five maturity stages; uncertainty, awakening, enlightenment, wisdom and certainty (Crosby, 1979). In a quality maturity model, an organisation can be situated at any level in the continuum. The first stages of the maturity model outline poor knowledge about quality and successive stages represent the transformation of attitude and understanding of quality as a management tool (Garcia, 2008).

The quality management model inspired the development of a capability maturity model (CMM) by the United States of America Defence Software Engineering Institute. This is the most popular maturity model concept representation (Netland and Alfnes, 2008).The CMM provides a continuous software improvement path towards process capability (Paulk *et al.*, 1993). The CMM consist of five evolutionary levels; initial, repeatable, defined, managed, and optimising (Paulk *et al.*, 1993). The difference of the CMM and quality maturity grid is that the CMM further identifies key process areas (KPA) that need to be performed at each maturity level before going to the next level. It is postulated that CMM was the trigger to the development of a numerous number of maturity models (Van Dyk, 2013).

1.3. Characteristics of maturity models

The concept of process maturity proposes that a process has a lifecycle that can be assessed by the extent to which the process is defined, managed, measured and controlled (Reyes and Giachetti, 2010). Pöppelbuß and Röglinger (2011) postulated that a maturity model can be used as a tool to assess the as-is situation (descriptive maturity model), so as to guide an improvement and control roadmap (prescriptive maturity model) (Van Dyk, 2013). Furthermore, a maturity model can be used as a benchmarking model for similar processes with other industries (comparative)(Pöppelbuß and Röglinger, 2011). Descriptive, prescriptive and comparative perspectives reflect the purpose of the maturity model, what the maturity intends to achieve. Detailed description of the characteristics of maturity models is shown in Figure 1.

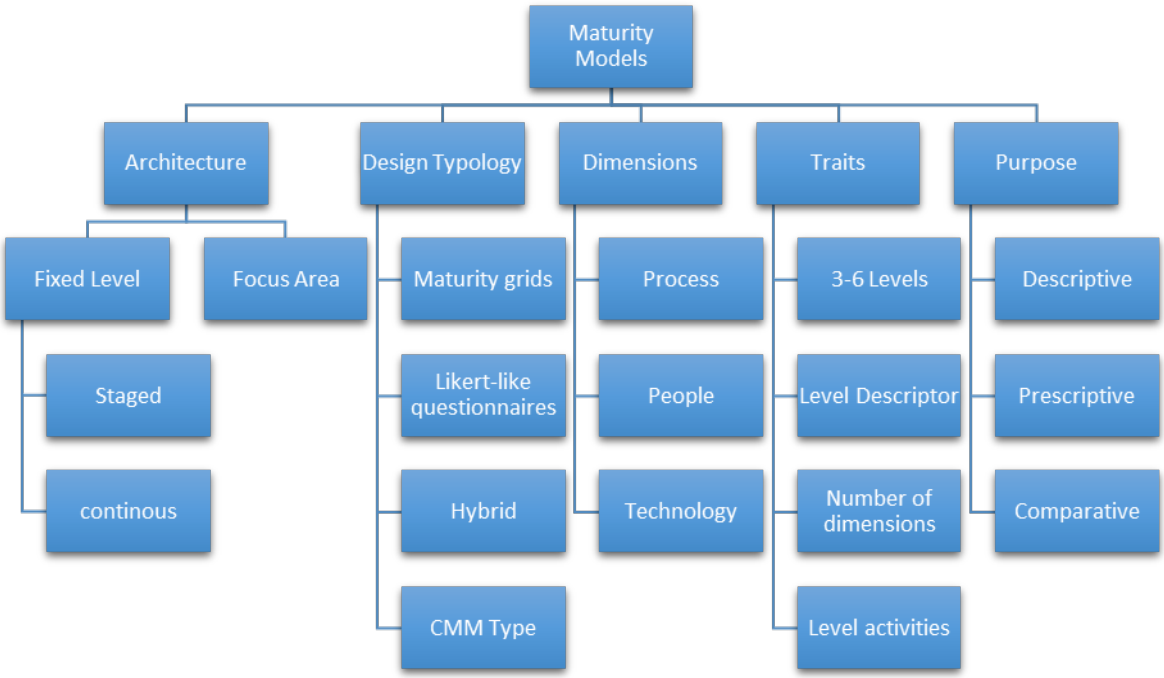

Figure 1: Maturity model characteristics

Source (Fraser et al., 2002; Steenbergen, 2011; Mettler, 2011; Pöppelbuß and Röglinger 2011)

Fraser et al., (2002) provided a framework for designing maturity models. The framework outlines the necessary traits that a maturity model must possess. Maturity models usually have typically three to six maturity levels, a generic level descriptor, number of dimensions; and each level is described based upon the activities associated with it.

Fraser et al., (2002) framework further classified maturity models into four maturity model types; maturity grids, Likert-like questionnaires, hybrid maturity model and capability maturity model type. Maturity grids consist of concise descriptions of each activity for each maturity level. The textual descriptions outline all activities and capability of that maturity level. Likert-like questionnaires consist of a question or statement of best practices and the respondents are supposed to score on a scale from 1 to n. The scale 1 to n represents the respondent's preferences. A hybrid maturity model combines questionnaires with definitions of maturity. The maturity levels in a hybrid maturity model are described and a respondent is supposed to score a preference based on the questions asked regarding that maturity level. Capability maturity model type contain both generic and specific goals and key practices for each process area and maturity level (Mendes, Leal and Thome, 2016).

Mettler (2011) also developed a framework of classifying maturity model dimensions. The framework outlines whether a maturity model addresses dimensions such as process, technology, people or all the three, for example the capability maturity (CMM) model addresses the process dimension only (Paulk et al., 1993). Process maturity represents the extent to which a process is explicitly defined, managed, measured, and controlled. People maturity provides an overview of the extent to which people can develop knowledge and improve proficiency. Technology maturity defines the extent to which a technology reaches a threshold level.

Steenbergen, (2011) classified maturity models according to the architecture of the maturity models. There are two types of maturity models architectures; fixed level maturity model and focus area maturity model. Fixed level maturity models are further classified into staged maturity models and continuous maturity models. In staged maturity models the achievement of a level is measured by having a key process area fully implemented. A staged maturity model contains fixed number of levels usually between three and six (Steenbergen, 2011). Each maturity level contains a number of key process areas that have to be satisfied for the firm to achieve that specific level. Conversely, continuous maturity model requires having the key process area implemented to an extent required by the maturity level. It contains fixed number of levels usually between three and six (Steenbergen, 2011). Continuous maturity models allows evaluation to be done for each dimension (Brooks, El-Gayar and Sarnikar, 2013). Key process areas are not attributed to a level, but the generic maturity levels are distinguished within each key process area.

For focus area maturity model, maturity levels are distinguished that are specific to a specific focus area and the number of levels differ depending on the focus area (Steenbergen, 2011). There is no fixed number of maturity levels, but instead the maturity models define specific maturity levels for each focus area. The overall maturity of an organization is expressed as a combination of the specific maturity level.

1.4. Methods

Using a systematic literature review, Scopus, Web of Science and Science Direct databases were searched with the following key words: "*supply chain management" AND "maturity models*" as shown in Table 1. The motivation of using systematic literature review (SLR) method is that it is an evidence based process intended to explicitly evaluate all published and unpublished literature. It is highly replicable (Bryman *et al.*, 2014) and transparent thereby minimizes bias (Jackson, 2004; Petticrew *et al.*, 2006; Keele and Staffs, 2007)**.**

Table 1: Search terms

Search terms	Scopus	Web of Science	Science Direct
Supply chain management" AND "maturity models	58	11	204

Papers were selected based on the topic and abstract. Furthermore, papers that were excluded from this study did not address the following attributes (Fraser, Moultrie and Gregory, 2002): (1) they did not define the traits of maturity models as discussed in section IV (dimensions, activities, levels), (2) did not present a new model but quote an existing model, (3) only presented assessment methodology not a holistic maturity model and (4) they only focused on specific supply chain aspects such as supply chain human resources or supply chain risk. The study also

obtained other additional papers from references of the papers extracted earlier. Only 13 relevant papers are used for the comparative analysis of supply chain maturity models.

1.5. Comparative Analysis Framework for Supply Chain Maturity

A framework for comparative analysis of the maturity models is developed from the literature searched. The comparative analysis framework that is used for this study is shown in Figure 2. The comparative analysis framework combines the maturity model design requirements (Rosemann and Bruin, 2005; Becker, Knackstedt and Pöppelbuß, 2009; Mettler, 2011) and maturity model characteristics (Fraser, Moultrie and Gregory, 2002; Mettler, 2011; Steenbergen, 2011).

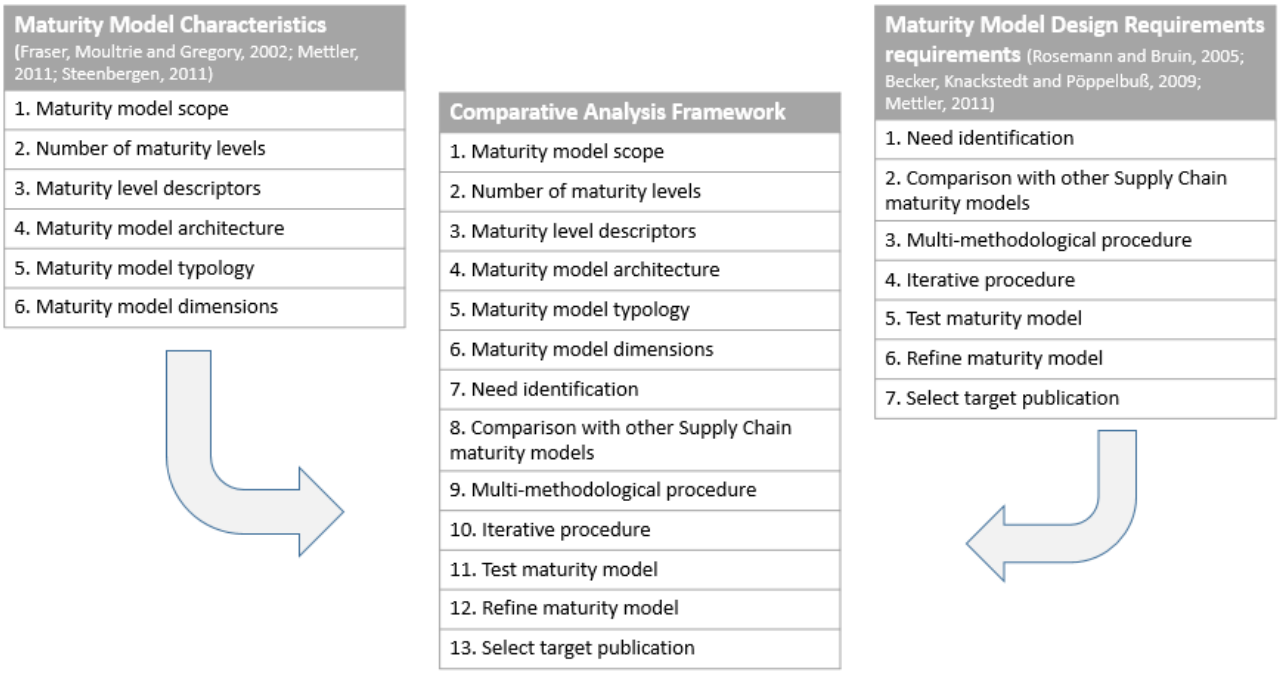

Figure 2: Comparative Analysis Framework
Source: (Rosemann and Bruin, 2005; Becker, Knackstedt and Pöppelbuß, 2009; Mettler, 2011; Fraser, Moultrie and Gregory, 2002; Mettler, 2011; Steenbergen, 2011)

1.1. Maturity model design requirements

It appears that few publications explicitly discuss the methodology that they used in the development of their maturity model. The following are a set of maturity model design requirements:

i. Need identification and problem relevance:
Outline the application domain and the benefits of developing the maturity model. It also identifies the gap that can be filled by the maturity model.

ii. Compare with existing supply chain maturity models
The development of a maturity model should be substantiated by comparison with previous maturity models. The new maturity model can be an improvement of an existing maturity model.

iii. Multi-methodological procedure
Several research methods should be applied during the development of the maturity model such as case studies, literature reviews, surveys and interviews.

iv. Iterative procedure
The development of a maturity model should be a step by step process.

v. Test and Evaluate Model
The testing and evaluation of the developed maturity model is based on the review of the maturity model in terms of its ability to satisfy all the design requirements as well as to evaluate the usefulness and effectiveness of the maturity model.

vi. Refine Model

Using the results and feedback from the maturity model testing and evaluation, refine the maturity model so as to improve its usefulness.

vii. Target publication

Decide the mechanisms in which you will communicate the refined maturity model either through journal articles or conference publications or reports.

1.2. Maturity model characteristics

The maturity model characteristics contained in the comparative analysis framework consist of scope, maturity levels, maturity model architecture, maturity model typology, and level descriptors. Fraser et al., (2002) claims that these maturity model characteristics guide researchers understand maturity models much better. The scope outline the supply chain area covered by the maturity model, while maturity levels represent the progressive evolutionary steps of the maturity model with each step outlining enhanced capabilities. Maturity model architecture presents whether a maturity model is staged, continuous or focuses area. The typology of the maturity model is the maturity model design, hybrid, grid or CMM-type. Finally the level descriptor represents a maturity level name.

1.3. Comparative analysis of supply chain maturity models

Using our comparative analysis framework in Figure 2; Table 2 and Table 3 provides a comparative analysis of supply chain maturity models based on the design requirements of maturity models. Also Table 4 provides a comparative analysis of supply chain maturity models based on characteristics of maturity models

It appears that prior to the development of many supply chain maturity models searched in literature, a comparison of existing maturity models is done. A number of maturity models followed an iterative way of developing a maturity model. Literature review, experts, Delphi, case studies and surveys are predominate methods that are used. Notably, there are few studies that attempt to evaluate the maturity models and only a few maturity models were evaluated through the use of case studies (Lahti, Shamsuzzoha and Helo, 2009), interviews, experts (Garcia Reyes and Giachetti, 2010) and surveys (Lockamy and McCormack, 2004). Other maturity models were only developed using extensive literature review (Vaidyanathan and Howell, 2007).

The comparative analysis of supply chain maturity models based of maturity model characteristics is shown in Table 4. The scope for the supply chain maturity models covers supply chain management (SCM), demand driven supply chain (DDSC), supply chain (SC), supply chain flexibility, supply chain integration (SCI), logistics and supply chain collaboration (SCC). The maturity levels of the supply chain maturity models range between three and six and have different descriptors depending on the scope of the maturity model, with initial maturity reflecting processes that are ill-defined and high maturity representing a level where processes are measured and managed. Also staged models are predominating under the maturity model architecture classification. This imply that maturity models require all key process areas in a maturity level to be accomplished before progressing to the next level as opposed to the incremental approach reflected by continuous maturity models. Furthermore, with regards to maturity models typology, maturity grids have a higher frequency, followed by hybrids and lastly the CMM-type due to their complexity nature. Maturity grids consist of the descriptor of the maturity level followed by little expression describing the maturity level. The hybrid maturity models consist of both maturity model description and a checklist to assess the maturity of an organisation. Lastly the dimensions of the maturity levels varied significantly between three to fifteen key process areas. The dimensions that were most common across most supply chain maturity models include information flow, information technology, collaboration, organisational roles and responsibilities.

Table 2: Comparative analysis of supply chain maturity models based on design requirements

Design Requirements	Stevens, (1989)	Stonich and Moncrieff, (2001)	Ayers and Malmberg, (2002)	Lockamy and McCormack, (2004)	McLaren, (2006)	Vaidyanathan and Howell, (2007)	IBM, (2007)
Compare with other maturity models	No comparison with other existing maturity models. Model developed by consultancy firm.	Not specified	No comparison with other MM	Transfer of Business Process Orientation (BPO) MM to SCM and adoption of SCOR Processes	Comparison of existing supply chain models. The model integrate two dominant supply chain maturity models	Review of SCM MM, CMM and other maturity models	No comparison with other MM. IBM also looks at management consultancy
Iterative Procedure	No methodology specified for the development of the MM.	Not specified	No complete description of how the dimensions and stages of MM are chosen	Development of model from the principles of business process orientation	Integration of two maturity models into one	Conceptual model developed based on the concepts of process maturity.	Survey instrument used to collect data on what leading companies are doing
Evaluation	The model is not applied	Applied in a discrete electronic equipment sector	MM is not tested	Survey instrument to investigate SCM process maturity and overall supply chain performance	Case company	No validation	Application of model in a manufacturing organization and logistics , customer order management as well
Multi-methodological approach	Literature review	Case study	Literature search	Literature Search, survey instrument	Case study, interviews and questionnaires	Only Literature review	Only experts through a survey instrument
Problem Relevance	Supply chain issues such as lead-time, inventory levels, availability caused by conflicting functional goals and attitudes can be resolved by an integrated supply chain, therefore there is need of a supply chain strategy to ensure a structured approach to supply chain integration	It is vital that organizations determine their strategic intent in leveraging their supply chain and implement best practices to enable improvements	Many obstacles to complex Supply chains Improvements and some initiatives fall short of objectives	No published studies which examine the concept of process maturity relative to SCM	Despite apparent benefit of web-enabled supply chain integration , its further study and application is hindered by the lack of empirically supported model for classifying the varying levels of supply chain integration that are now possible using e-business technologies	Construction industry is still in infancy but however other maturity models such as CMM cannot be applied directly to guide in the development of the industry	As supply chains evolve from static to demand driven other companies are striving to meet their objectives and there is room for improvement but developing top supply chains is hard
Problem definition	Model to guide organizations towards an integrated supply chain	Model describing stages of operational capabilities within a supply chain and providing a roadmap for improvement	Framework showing how supply chain organization and demand driven supply chain can support the introduction of information technology to SC	SC process MM that can be used to help facilitate enhanced SC performance	Framework to assess the level and integration dimensions including supply chain strategy ,performance management and decision making	Framework to be used to assess processes, technologies, strategy and value in construction industry and provide a roadmap towards operational excellence.	Framework for describing how different supply chains for organizations address challenges for different supply chain process areas
Publication	Journal Paper	Report	Journal Paper	Journal Paper	Conference Paper	Conference Paper	Report

Table 3: Comparative analysis of supply chain maturity models based on design requirements (continued)

Design Requirements (DR)	Lahti, Shamsuzzoha and Helo, (2009)	Garcia Reyes and Giachetti, (2010)	Battista, Fumi and Schiraldi, (2012)	Fischer *et al.*, (2016)	Ho, Kumar and Shiwakoti, (2016)	Mendes, Leal and Thome, (2016)
Compare with other maturity models	Comparison with SC and logistics MM	Evaluation of enterprise reference frameworks, SCOR, and CMM	Stages of the logistics maturity model are developed from the Capability maturity model integration	Recognizes MM such as quality maturity grid, CMM, BPO, SCOR, SCM	Model developed based on capability maturity model integration approach	Comparison with other SCM maturity models
Iterative Procedure	Development of a new model using a model developed by PMG and PRT management consultants as a development guideline	Literature search to determine structure of a MM then use of Delphi study to identify dimension, stages, improvement tools and factors	No clear methodology explained that was used to develop the logistics maturity model	No complete description of methodology used for the development of the MM and how the dimensions and stages are derived	Only adopted the CMMI approach and used literature search on collaboration to populate the model	Dimensions and stages adopted from literature search. Then SC executives applied Analytical hierarchy process to assign priorities and rank the actual and desired dimensions
Evaluation	Application of model in a case company	Validation with experts	The model is not applied in any supply chain settings	The model is applied in a toy case in the automotive supply chain	The MM is not tested	Tested in a large beverage company in three different countries
Multi-methodological approach	Literature search, case study	Literature search, Delphi method, experts, case study	Literature review only	Literature review and case study in a toy case automotive supply chain	Literature review only	Literature search, experts, case study
Problem Relevance	A supply chain strategy for the visibility of supply and demand collaboration determines the success of a firm	Lack of guidelines in SC assessment and improvement. Also existing models are theoretical constructs and not tested with actual Supply chains	There is lack of an easy to use framework, hard criterion of process modelling and evaluation of maturity and lack of framework that in cooperate global vision of business logistics processes	Currently, there is a gap in literature for models that measure the maturity of supply chain flexibility	There is lack of clear theoretical framework which guides organizations in implementing or improving the collaboration maturity level for a supply chain	No framework that combine dimensions of demand driven supply chain of Ayers (2002) and Lambert (2008) supply chain processes
Problem definition	A framework for organizing disparate supply chain efforts around business processes, tools and standards	Framework that can evaluate their current supply chains and develop an improvement roadmap. Highlights the best practices that a company should focus on in improving.	Model to support the enterprises to understand immature processes, improvement actions.	Model to measure the maturity of flexibility in inter-organizational supply chains	Framework to analyze collaboration practices in organizations and develop a roadmap towards advanced collaboration in supply chain	Frame work for assessment of organization current DDSC maturity levels and helps in the development of a roadmap to set SC strategies
Publication	Journal Paper	Journal Paper	Conference paper	Conference paper	Conference Paper	Journal Paper

Table 4: Comparative analysis of supply chain maturity models based on maturity model characteristics

Reference	***Scope***	***No. of levels***	***Level Descriptors***	***Architecture***	***Typology***	***Dimensions***
Stevens (1989)	SCI	4	Baseline, functional, internal integration, external integration	Continuous	Grid	7 focus areas; Supply chain planning, organisational structure, customers, information flow, performance metrics, planning technologies and collaboration
Moncrieff and Stonich (2001)	SCM	4	Functional focus, internal integration, external integration, cross enterprise collaboration	Staged	Grid	11 focus areas; plan, source, make, deliver, overall, information flow, information sharing, information technology, resources, performance measurements, partnerships and collaboration
Ayers (2002)	SC	4	Infrastructure, cost reduction, collaboration, strategic	Staged	Grid	4 focus areas; supply chain organisation, demand driven supply chain, supply chain systems, stage challenges
Lockamy & McCormack (2004)	SCM	5	Ad hoc, Defined, Linked, Integrated, Extended	Staged	CMM	6 Focus Areas; suppliers, customers, source, make, deliver, plan
Mc Laren (2006)	SCI	5	Functional focus, internal integration, linked network, integrated network, optimised network	Continuous	Grid	4 focus areas; Organisation structure, performance measurement, collaboration
IBM (2007)	SCM	5	Static, functional, horizontal integration, external collaboration, demand driven	Staged	Grid	3 key areas; Information flow, organisational structure, order management
Vaidyanathan & Howell (2007)	CSCM	4	Ad hoc, defined, managed, controlled	Staged	Hybrid	5 key areas: Project management, collaboration, information flow, planning , automation
Lahti et al., (2009)	SCM	4	Functional focus, internal integration, external integration, cross enterprise collaboration	Staged	Hybrid	7 focus areas; Supply chain processes, information flow, organisational roles and responsibilities, supplier and customer partnerships, performance measurements, resources
Reyes and Giachetti (2010)	SC	5	Undefined, defined, manageable, collaborative, leading	Continuous	Hybrid	7 Focus areas; suppliers, customers, production, inventories, human resources, information systems and technology, performance measurement systems
Battista et al. (2012)	LMM	5	Start-up, managed, defined, measured, optimised	Continuous	Grid	4 focus areas; procurement, plan, distribute, storage
Mendes et al., (2016)	DDSC	5	Basic push, optimised push, hybrid push-pull, advanced demand driven, optimised demand driven	Continuous	CMM	3 main focus areas: Demand management, Supply and operations management, Product Lifecycle management
Fischer et al., (2016)	SC Flexibility	5	No flexibility, intra-firm flexibility, reactive flexibility, proactive flexibility, paradigmatic flexibility	Continuous	Grid	5 focus areas; collaboration, information flow, information technology, internal flexibility types, performance measurement
Ho et al., (2016)	SCC	5	Initial, managed, defined, quantitatively managed, optimizing	Staged	Grid	15 focus areas including, Information sharing, goal congruence, decision synchronization, incentive alignment, resource sharing, collaborative communication, managerial support, internal alignment, relationships

2. Conclusions and discussion

This study aimed at performing a comparative analysis of supply chain maturity models. The results of this paper are meant to serve as a manual for a detailed understanding of the documented supply chain maturity models with regards to how they were developed and implemented.

Stevens, (1989) developed a four level supply chain integration maturity model. The motivation for developing this model was based on solving supply chain issues such as inventory levels, availability and lead-time which are a result of conflicting functional goals and objectives. Stevens, (1989) argues that there is need for a supply chain strategy that supports a structured supply chain integration approach. The maturity model is a guide to organisations towards an integrated supply chain (Stevens, 1989). Stevens, (1989) concludes that supply chain integration initially start as level one which the author named "baseline" and the advanced level is termed "external integration." However, Stevens, (1989) does not first do a comparative analysis to understand if there is already an existing supply chain integration maturity model. This would have created a foundation on which the supply chain maturity model was developed. It appears that the maturity model was developed only from extensive literature review and the maturity model was not tested empirically through a case study or supply chain experts. In this sense, we argue that the maturity model is incomplete and requires rigorous testing for it to be a valuable tool that can inform supply chain improvements with regards to supply chain integration.

Stonich and Moncrieff, (2001) developed a four stage supply chain management maturity model. The maturity model define enabling practices that will drive performance improvements (Stonich and Moncrieff, 2001). The dimensions of the supply chain management maturity model are derived from the SCOR model (plan, source, make, deliver and overall) and the model is tested in an electronic equipment sector. However, it appears that this model is similar to Stevens (1989) supply chain integration maturity model in the sense that it emphasizes functional focus in an organisation as immature practice and cross enterprise collaboration as the advanced state of supply chain management maturity. It is also important to note that the maturity development methodology is also not outlined.

Ayers and Malmberg, (2002) argue that there are many obstacles to complex supply chain improvements and some initiatives fall short of objectives. Thereby they developed a maturity framework showing how supply chain organisation and demand driven supply chain can support the introduction of information technology (IT) to supply chain. However the four-level maturity framework is not tested and evaluated.

A near complete maturity model is one that was developed by Lockamy and McCormack, (2004). They argue that there have never been studies that have attempted to explore the concept of process maturity relative to supply chain management. Therefore they developed a five-level maturity model from principles of business process orientation through an extensive literature review and a survey instrument aiming to establish the relationship between higher levels of maturity and performance. They also adopted SCOR model business processes as dimensions (Lockamy and McCormack, 2004).

McLaren, (2006) consolidated two maturity models into a maturity model for classifying the varying levels of supply chain integration that are now a reality using e – business technologies. They argue that there is no web integration maturity model that has been tested empirically. In their study they use extensive literature review, caste studies and questionnaires (McLaren, 2006).

IBM, (2007) postulate that as supply chain evolve from static to demand driven, other organisations are striving to meet their goals and there is room for improvement but developing top supply chains is hard. Therefore there is need of a framework for describing how different supply chains for organizations address challenges for different supply chain process areas. However this framework was tested in a manufacturing organization. Prior to the development of this framework, it appears there was no attempt to compare existing maturity model to get a foundation if there is an already existing maturity model that can address such challenges.

Vaidyanathan and Howell, (2007) constructed a four level construction supply chain management maturity model to assess processes, technologies, strategies and value in construction and guide performance improvements. This conceptual model is developed from literature after recognising that the construction industry was still immature and many existing maturity models such as CMM cannot be applied directly to guide the development of the construction industry (Vaidyanathan and Howell, 2007).

Using literature and reference models developed by consultants as a guideline, Lahti, Shamsuzzoha and Helo, (2009) developed their supply chain management maturity model and tested it in a case company. The purpose of the maturity model is for organising disparate supply chain efforts around business processes, standards and tools (Lahti, Shamsuzzoha and Helo, 2009).

Garcia Reyes and Giachetti, (2010) developed a much comprehensive supply chain maturity model using a Delphi study and supply chain experts. They argue that there is lack of guidelines in supply chain assessment and improvement. Existing maturity models are theoretical constructs. Therefore they developed an evaluation tool to

assess current supply chain and guide improvements and also highlight best practices (Garcia Reyes and Giachetti, 2010).

Battista, Fumi and Schiraldi, (2012) constructed a five level logistics maturity model. Their motivation is that from the literature that they searched, there exists no easy to use framework. Therefore they developed a maturity model to support an organisation's understanding of logistics processes that are immature and guide in the implementation of improvement initiatives in the logistics processes (Battista, Fumi and Schiraldi, 2012). This logistics maturity model was not empirically tested.

Fischer *et al.*, (2016) also developed a five stage supply chain flexibility maturity model. This maturity model is developed because there is no maturity model in the literature searched that measures the maturity of supply chain flexibility in different organisations (Fischer *et al.*, 2016). The supply chain flexibility maturity model is tested in a toy manufacturing company.

Ho, Kumar and Shiwakoti, (2016) also argue that there is lack of clear theoretical framework which guides organizations in implementing or improving the collaboration maturity level for a supply chain. Therefore, using CMM as a reference model, they developed a framework to analyze collaboration practices in organizations and develop a roadmap towards advanced collaboration in supply chain (Ho, Kumar and Shiwakoti, 2016). However this maturity model is not empirically tested.

Mendes, Leal and Thome, (2016) developed the only demand driven supply chain maturity model for manufacturing. This model can be adapted in manufacturing organizations. The maturity mode was developed because it appears like there was no framework that combines dimensions of demand driven supply chain of Ayers (2002) and Lambert (2008) supply chain processes. The Frame work is for assessment of organization current DDSC maturity levels and helps in the development of a roadmap to set supply chain strategies (Mendes, Leal and Thome, 2016).

It appears that supply chain related maturity models suggest that maturity starts at a basic level and progresses to a higher level of maturity. However, little emphasis is placed on the design of the ready-to-use and adaptable tools for maturity assessment and improvement. Notably, the dimensions of these maturity models can be integrated to produce a more consolidated maturity model.

Only one model proposed a demand driven supply chain maturity model for consumable movable goods. This model adopted the supply chain processes proposed by Lambert (2008) as dimensions. The only weakness is that it only focuses on only how manufacturing companies can become demand driven and does not give guidance for other industries such as healthcare and retail. Another study by Ayers (2002) outline a maturity model that has demand driven supply chain being conceptualised as an enabler to implementation of information technology to support supply chain.

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Biographies

Munyaradzi Bvuchete is a masters' student in the Department of Industrial Engineering at Stellenbosch University, South Africa.

Sara S. (Saartjie) Grobbelaar is an Associate Professor, Department of Industrial Engineering Stellenbosch University AND DST-NRF Center of Excellence in Scientometrics and Science, Technology and Innovation Policy (SciSTIP), Stellenbosch University, South Africa.

Joubert van Eeden is a Senior Lecturer in the Department of Industrial Engineering Stellenbosch University, South Africa.