

A Review on Integrated Supply Chain Performance Measurement System Concerning Industry 4.0: A developing world perspective

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Abstract

With regards to Industry 4.0, integrated supply chain performance measurement system (SCPMS) is paramount for an efficient supply chain management (SCM) at inter-organizational and beyond-the-boundary processes. The recent technological innovations (internet of things (IoTs), big data, and web-based communication systems) revamp the SCPMS through effective data collection, information sharing, and framework integration among the different SC partners in developed countries. However, the research addressing the obstacles facing by developing countries is limited. During this study, a systematic review of available academic literature about the SCPMS, framework approach/techniques, SCPMS and technology, and constraints faced during its adoption is performed. A set of 56 articles are selected spanning over one decade (2011-2020) to grasp the understanding of trends and recent developments in SCPMS globally. Moreover, future research areas are identified, and research agenda is presented for Pakistan industrial sector – a representation of an developing world.

Keywords

Integrated supply chain performance measurement system, Industry 4.0, IoTs, big data

1. Introduction

In the quest of achieving long-term performance goals, Industry 4.0 emphasizes the implementation of smart, intelligent, and integrated supply chain (SC) management in organizations. Integrated supply chain management (SCM) – an application of internet of things (IoTs), big data, and artificial intelligence (AI) – helps firms to focus primarily on improving their core competencies while effectively using external agencies for other capabilities and

resources, including human resource management, finance and accounting management, logistics, inventory management, supplier-customer relationship management, demand forecasting and information management, etc. (De Vass et al., 2018 and Yin et al., 2019). Conventional SCM is a systematic management of coordinated business functions between firms and their SC partners (Molamohamadi et al., 2013). As organizational performance in Industry 4.0 increasingly depends on the extended SC partnership, management's control at both the firm and the SC levels becomes paramount. While the conventional performance management system (PMS) is limited to one single organization (Doliński et al., 2011), the integrated supply chain performance measurement system (SCPMS) enables companies to adopt a set of performance metrics that extend to the various processes performed at different firms (Kisomi et al., 2016 and Zhu et al., 2016). As such, the SCPMS improves SC effectiveness through designing more strategic, responsive, and timely courses of actions. Although the SCPMS is advantageous, it is challenging in terms of consistency in data sharing and integration at both the inter-firm and partnered organizational levels. Improving the efficacy of integrated supply chain management in these areas concerning Industry 4.0 is the focus of the current research.

Recently, a growing trend in the use of SCPMS has been noted in the literature based on case studies from developed countries. However, the scope is mainly limited to partial SCPMS implementation in one functional area, such as vendor evaluation, inter-firm operations assessment, or buyer-supplier relationship management. Moreover, very little research is found concerning the issues faced by developing countries during SCPMS implementation. Therefore, the present study aspires to methodically review the literature to define and evaluate (concerning Industry 4.0) the maturity of SCPMS as a discipline in different industrial sectors within developed countries. It then highlights the recent advancements in literature for Pakistan, as a representation of the developing world. Finally, the study identifies potential gaps in the literature to provide a motive for future research.

The paper is organized as follows: Section 2 illustrates the methodology used to perform a systematic literature review. Section 3 comprises relevant literature selected from peer-reviewed journals to establish background knowledge regarding SCPMS and its utilization in developed countries. A conceptual interpretation related to the objectives of the paper is presented, including the type of subjected industry, tools and techniques employed, and challenges faced by the firms. Section 4 reports the articles specifically related to Pakistan's industrial sectors. Lastly, Section 5 concludes the results and suggests a way forward by indicating potential research gaps.

2. Research Methodology

The key purpose of this study is twofold: 1) to comprehensively review the approaches, models, and techniques used for the effective and efficient adoption of SCPMS in regards to Industry 4.0, and 2) to understand the role of various available technological solutions in revamping the SCPMS adoption, such as IoTs, big data, intelligent business analytical systems, and web-based communication platforms. The availability of IoTs and big data enable fast and reliable data collection, which drives business analytical solutions to perform robust data analysis, while the web-based communication portals provide a smooth and steady configuration of data sharing between internal and external SC partners. Figure 1 illustrates the research methodology (Maestrini et al., 2017) followed for the systematic literature review of this study.

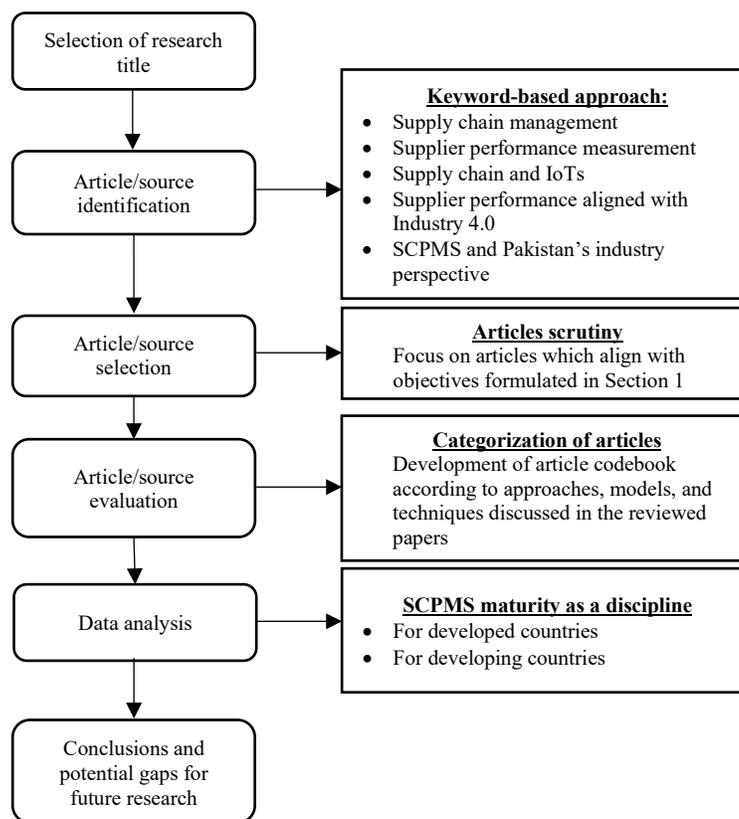


Figure 1. Research methodology

The article/source identification for SCPMS was performed through a keyword-based approach by using online search engines/forums. A set of five keyword phrases like “supply chain management,” “supplier performance measurement,” “supply chain and IoTs,” “supplier performance aligned with Industry 4.0,” and “SCPMS and Pakistan’s industry perspective” was used to increase the likelihood of obtaining all relevant articles from various online databases. Further, the article/source selection was accomplished by selecting the articles that were aligned with the defined scope of the current research. Research papers were selected if they addressed at least one component of SCPMS at both inter-organizational and across-the-boundaries supply chain levels. During the article/source evaluation, the articles were categorized according to their content, such as integrated SCM, SCPMS taxonomies, methodological approaches/techniques, and global SCPMS adoption. A codebook for the sake of paper classification was developed according to the guidelines defined by the Association of Business School, 2015 (Maestrini et al., 2017) and updated throughout the study. Table 1 represents the final version of the codebook used during the research. The data were then analyzed to extract relevant knowledge/information. The data analysis was conducted based on the qualitative/quantitative results of codebook entries using Microsoft Excel software. Consequently, a synthesized summary of information led to the identification of research gaps that require further attention.

Table 1. Codebook used for the paper classification

Topic	Entries	References
Article/source information	<ul style="list-style-type: none"> - Authors’ name - Publication year - Article title - Journal name - Journal domain 	

	- Journal impact factor (IF)/Scimago journal ranking (SJR)
Methodological approach	- Theoretical approach - Explorative approach - Case study-based empirical approach
SCPMS adoption inferences	- SCPMS impact on operational performance (internal and external SC players) - SCPMS impact on SC partners communication, trust, and collaborative relationship - Obstacles in SCPMS implementation

To review the lifecycle of SCPMS, the literature was distributed according to the content as shown in Fig. 2a. After excluding non-referred entries such as book reviews, notes, reports, and irrelevant content, a set of 56 articles relevant to the research area was identified. Almost 22% (12 out of 56 articles) were based on theoretical studies/review papers discussing the conceptual frameworks for SC performance measurement with regards to Industry 4.0. The frameworks entailed metrics (financial/non-financial and qualitative/quantitative) that were perceived through mathematical algorithms and techniques, such as balanced scorecard, analytical hierarchy process (AHP), Delphi/survey, fuzzy logic/simulation, categorical system, and sustainability. The 35% (19 out of 56) are exploratory studies providing an insight into SCPMS impact on SC partners communication, trust, and collaborative relationship through the application of IoTs, big data and web-based communication portals. These studies also identified future research gaps. While the 43% (25 out of 56 articles) consists of empirical work revolving around case studies that discuss SCPMS model development for general use as well as for a specific organization and list the barriers that encountered during the implementation. The concept of supplier performance assessment is nascent in organizations. Therefore, research articles spanning over a decade (2011-2020) are reported. For a comprehensive literature review, a cross-disciplinary approach is adopted to study various scientific domains of journals. Table 2 reports the article/source distribution for journal list and Fig. 2b illustrates the distribution of reviewed articles over time.

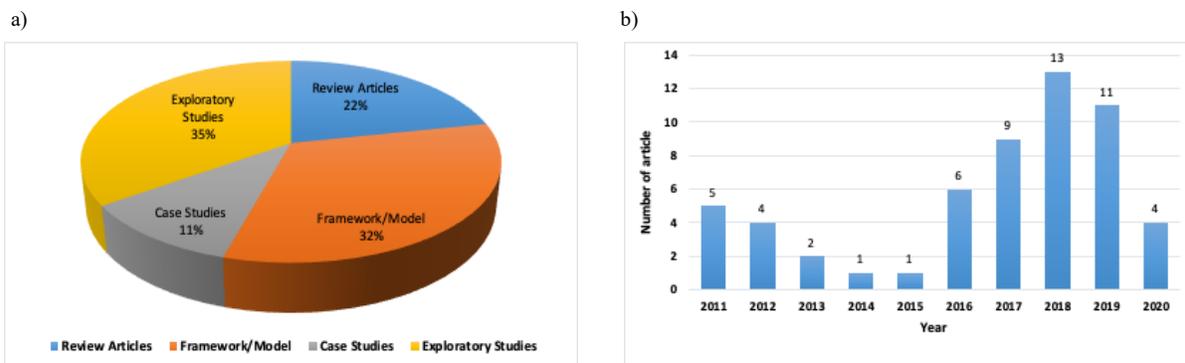


Figure 2. Literature review distribution, a) percentage based on the content, b) based on year of publication

Table 2. Journal-wise article distribution

Journal domain	Journal Name	No.	IF/SJR	References
Supply Chain Management	Supply Chain Management: An International Journal	1	4.39/0.19	Ashby et al., 2012
	Journal of Purchasing and Supply Management	1	3.47/1.47	Zhang et al., 2018,
	International Journal of Logistics Management	2	2.860/1.06	Zhu et al., 2016, Wu et al., 2016
	Scientific Journal of Logistics	3	0.24/0.11	Parkash and Kaushik, 2011, Doliński and Koliński, 2011, Parkash and Kaushik, 2011
	Benchmarking: An International Journal	1	2.60/0.55	Mishra et al., 2018
	International Journal of Retail and Distribution Management	1	2.93/0.73	Teller et al., 2016
	Uncertain Supply Chain Management	1	-/0.415	Lemghari et al., 2019
	International Journal of Logistics Systems and Management	1	-/0.37	Charkh and Jaju, 2014
Operations Management and Technology	Journal of Production Planning and Control	3	4.220/1.39	Alfalla-Luque et al., 2012, Dey and Cheffi, 2013, Li et al., 2017
	International Journal of Production Research	2	4.210/1.78	Xu et al., 2018, Ben-Daya et al., 2017
	International Journal of Operations and Production Management	1	2.955/2.19	Maestrini et al., 2018
	International Journal of Production Economics	5	5.134/2.38	Peng et al., 2019, Maestrini et al., 2018, Amoako-Gyampah et al., 2019, Maestrini et al., 2017, Mani et al., 2018
	International Journal of Quality and Reliability Management	1	2.16/0.57	Troung et al., 2016
	Business Process Management Journal	1	2.78/0.73	Bienhaus and Haddud, 2018
	International Journal of Applied Business and Economic Research	1	0.30/0.14	Suvittawat, 2017
	Journal of Quality and Technology Management	1	1.76/1.11	Abbasi and Afzal, 2011
	Advances in Mechanical Engineering	1	1.230/0.33	Yin and Qin, 2019
	Applied Mathematical Modelling	1	3.290/0.96	Kisomi et al., 2016
	Procedia Manufacturing	1	1.590/0.52	Accorsi et al., 2017
Information Technology and Management	Expert Systems with Applications	2	5.890/1.49	Ferreira and Borenstein, 2012, El-Baz, 2011
	Australasian Journal of Information Systems	1	1.00/0.3	De Vass et al., 2011
	Future Generation Computer Systems	1	7.010/1.22	Abdel-Basset et al., 2019
	Intelligent Information Management	1	2.190/0.59	Ganeshkumar et al., 2017
	Simulation Modelling Practice and Theory	1	3.270/0.61	Mokhtar et al., 2019
	Computers and Industrial Engineering	6	4.480/1.47	Chan et al., 2014, Manavalan and Jayakirishna, 2019, Addo-Tenkorang and Helo, 2016, Cho et al., 2012, Ghadimi et al., 2017, Torres-Ruiza and Ravindran, 2019
Environment/Sustainability	Journal of Applied Environment and Biological Sciences	1	0.06/0.11	Imam et al., 2017
	Sustainability	1	2.576	Shahid et al., 2020
	CenRaPS Journal of Social Sciences	1	-	Mansoor et al., 2020
	Journal of Commerce, Economics, and Social Sciences	1	0.159	Basheer et al., 2018
	Computational Intelligence and Sustainable Systems	1	Book	Khan et al., 2018
Management in General	International Strategic Management Review	1	6.67/8.835	Kumar and Rahman, 2015

Journal of Advanced Management Science	1	-	Molamohamadi et al., 2013
Industrial Marketing Management	2	4.695/2.084	Lee et al., 2019, Maestrini et al., 2018
Global Business Review	1	1.040/0.45	Bag S., 2018
International Journal of Management Processes	1	10.1471	Ahmed et al., 2020
Journal of Modelling in Management	1	2.753	Khokhar et al., 2020
Journal of Modelling in Management	1	1.86	Rehman et al., 2020
International Conference on Management Science and Engineering Management	2	2.06	Nazam et al., 2019, Hashim et al., 2019
Journal of Business Research	1	5.350/1.87	Li et al., 2017

3. Results and Discussion

This review of literature on integrated SCPMS regarding Industry 4.0 reveals that the topic is of a great deal of interest for both scholars and practitioners. The important results of the study are the identification of three main dimensions of integrated SCPMS discipline aligned with Industry 4.0 and are discussed in the subsequent sections.

3.1 Integrated SCPMS, Various Techniques/Approaches, and Performance Metrics Development

Integrated SCPMS and Techniques

Considering the integrated SCPMS where performance measurement process involves inter-firm and beyond-the-boundary levels, literature provides various framework techniques/approaches to design SCPMS such as balance score card system, categorical system, weighted point technique, analytic hierarchy process (AHP), delphi survey approach, and fuzzy logic technique. From the literature, it is revealed that integrated SCPMS is a multidimensional approach, that is developed by a focal organization and shared to all supply chain partners (Alfalla-Luque et al., 2012, Kisomi et al., 2016, Zhu et al., 2016, Abdel-Basset et al., 2019). Figure 3 illustrates various components of an integrated SCPMS. It is implemented through a common web-based tool designed by any third-party IT firm, which provides flexibility to a focal organization for many-to-many interactions. A set of metrics is shared among all to quantify the efficiency of inter-organization and beyond-the-boundary processes. These metrics can be designed using various techniques such as balance score card system. As SCPMS consists of multiple components, it provides a broader avenue for future research.

Performance Metrics

Successful adoption of SCPMS depends on designing the standard metrics and sharing them among all SC players. Doliński and Koliński (2011) defined nine criteria using the balanced score card technique (price, quality of raw material, punctuality of deliveries, terms of payments, discounts, terms of complains and returns, approach to client's demands, transport, and packaging) for the evaluation of suppliers. Parkash and Veerender (2011) developed a list of metrics (on-time delivery, rate of acceptance of goods, competitive pricing, and proper responsiveness) based on weighted point balanced scorecard method for the assessment of sports goods supplier's performance. Cho et al. (2012) presented a method to design performance attributes using AHP for the hotel industry supply chain. Dey and Cheffi (2013) proposed a performance management system to measure the efficiency of green SC using the AHP technique. Khan et al. (2018) applied an integrated SCPMS model designed by Fuzzy-Shannon Entropy and Fuzzy-Inference System in manufacturing organization to prioritize the suppliers based on sustainable dimensions perspective.

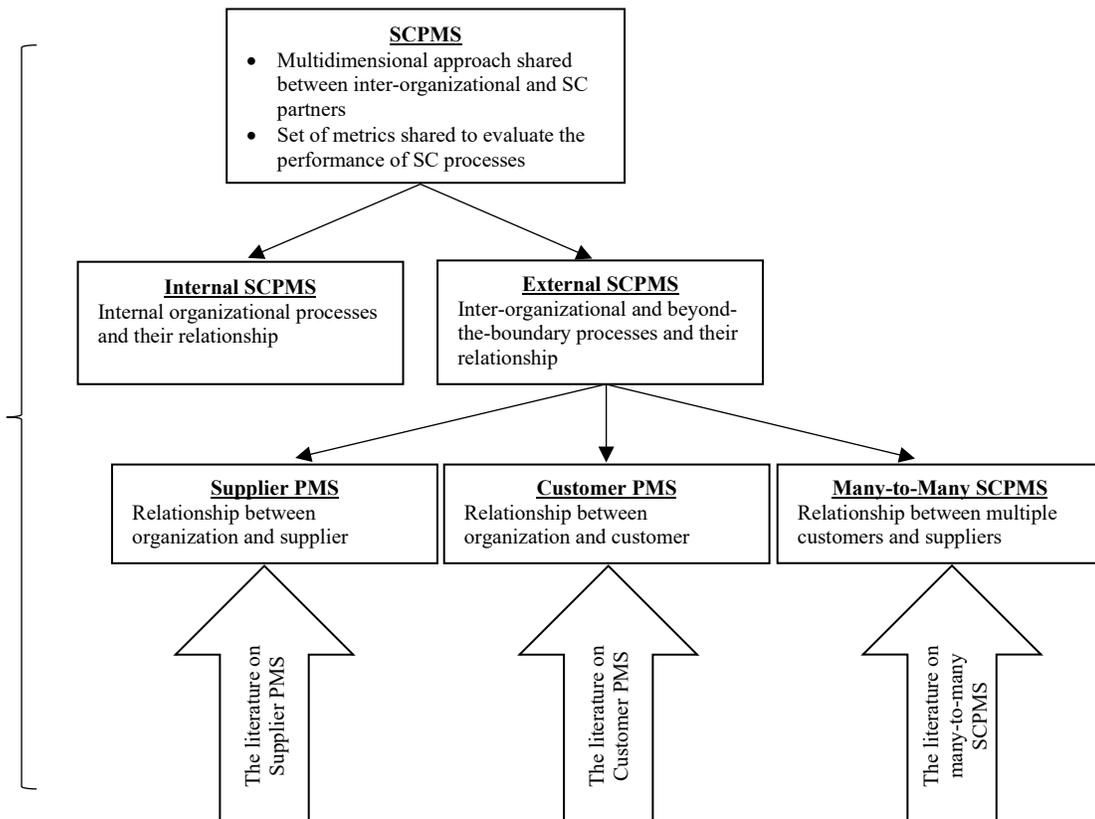


Figure 3. SCPMS components

3.2 Integrated SCPMS and Technology

Information System

Literature reveals that an efficient Supply Chain Performance Management System (SCPMS) design is not adequate to guarantee a successful adoption of the system (Maestrini et al., 2018). Failure during its implementation can occur due to the unavailability of an effective information system that comprises several attributes, such as sensitive information, data standardization, and data reliability. Inefficient information systems impede trust, communication, and collaboration among the SC partners. Innovations in information technology (IT), an essential component of supply chain management (SCM), have decreased its cost and enabled standardized communication (Ben-Daya et al., 2017).

Internet-of-Things (IoTs)

Several researchers have discussed the benefits of the internet of things (IoTs) for SCPMS implementation in various industrial sectors. For example, Accorsi et al. (2017) discussed the goals and strategies for designing and building an IoTs architecture to aid in the planning, management, and control of food supply chain (FSC) operations. Abdel-Basset et al. (2019) applied IoTs in supply chain management through building a smart and secure system of SCM which integrates the neutrosophic decision making trial and evaluation laboratory (N-DEMATEL) technique with analytic hierarchy process (AHP) to infer cause and effect interrelationships among criteria of smart supply chain security requirements. Addo-Tenkorang and Helo (2016) thoroughly investigated and analyzed big data and IoTs application in SCPM. Manavalan and Jayakirishna (2018) discussed sustainable SCPMS in manufacturing companies through the use of IoTs for industrial 4.0 transformation. Li et al. (2017) explained the conceptual distinctions between formal and informal IT-enabled interactions and their roles in supplier-buyer cooperation. Wu et al. (2016) explained the concepts of an e-supply chain, IoTs, smart factory, and industrial Internet for larger and complicated business systems to become part of the global supply chain network. Finally, Abbasi and Afzal (2011) examined benefits of

the e-sourcing achieved for four key business strategies, i.e., supply chain management, total quality management, time-based purchasing, and organizational integration for the automotive industry.

3.3 Implementation Barriers Faced by Developed and developing Countries

List of Barriers Faced by Researcher during SCPMS Implementation

Many barriers may result from the implementation of SCMPs. Table 3 lists the barriers encountered by developed and developing countries during the implementation phase.

Table 3. Implementation barriers faced by developed and developing countries

Developed countries perspective		Developing countries perspective	
Barriers	Authors	Barriers	Authors
Lack of knowledge regarding smart supply chain	Wu et al., 2016	Lack of awareness about the sustainable practices among SC partners	Kumar and Rehman, 2016
Lack of top management commitment	Bienhaus and Haddud, 2017; Wu et al., 2016	Employee's illiteracy rate in private industrial sector	Hashim et al., 2019
Opportunistic behaviour of suppliers	Maestrini et al., 2018	Organizational learning capabilities in private industrial sector	Basheer et al., 2018
Lack of technology and IT infrastructure	Abdel-Basset et al., 2019; Wu et al., 2016; Zhu et al., 2016; Kisomi et al., 2016; Charkh and Jaju, 2014	Lack of sustainability in following areas in private industrial sector:	Nazam et al., 2019
High computational processing time		- Outsourcing	
Poor skill level of employees	Bienhaus and Haddud, 2017; Zhu et al., 2016; Suvittawat, 2017; Charkh and Jaju, 2014	- Competitiveness and innovation	
Undeveloped suppliers	Bienhaus and Haddud, 2017	- Buyer-supplier relationship	
Lack of communication with SC partners	Mansavalan and Jayakrishnan, 2018	- Technology	
Lack of departmental support due to insufficient organizational structure	Abdel-Basset et al., 2019; Mansavalan and Jayakrishnan, 2018; Bienhaus and Haddud, 2017	- Knowledge sharing	
Lack of financial resources	Mansavalan and Jayakrishnan, 2018; Charkh and Jaju, 2014	- Marketing and organizational culture	
Uncertainty in production processes	Zhu et al., 2016	- Production and distribution	
Competitors	Zhu et al., 2016		
Environmental effects	Zhu et al., 2016		

Recent Trends in SCPMS Adoption Suggesting Future Research Areas

From Table 3, two main trends can be identified: i) the use of technology to integrate SCPMS into existing systems in developed countries, and ii) limited adoption of SCPMS in the developing world. Moreover, Pakistan - an emerging economy in the developing countries, has adopted integrated SCPMS on a small scale that is limited to private industrial sectors, such as the automobile and textile industries, but not (to best of our knowledge) public sector organizations (due to several governmental regulations).

4. Conclusions and Future Research

The present literature review is focused on two main objectives: 1) integrated supply chain performance management system (SCPMS) implementation constraints faced by developed countries with regards to Industry 4.0, and 2) recent SCPMS advancements in developing countries, with a specific focus on identifying the research gap for the industrial sector of Pakistan. The study is accomplished through a systematic review that is limited to the dimensions mentioned in the codebook (see Table 1). The review first defines the components and framework development of SCPMS by using different techniques/approaches. It then highlights the critical role of technology for the successful adoption and implementation of SCPMS in various industries. Finally, by listing constraints faced by developed countries, it provides guidelines for the integration of SCPMS into existing systems. Future work will aim to collect data and information to compare current practices being followed, if any, by government sector organizations in Pakistan to standard SCPMS practice. This gap analysis will provide necessary information that will then be used to develop an SCPMS framework for improvements to existing practices in Pakistan.

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