# Investigating The Mediating Impact of Supplier Quality Integration in Pharmaceutical Supply Chains


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## Abstract

**Purpose** –The study aims to investigate the mediating impact of supplier quality integration on the operational performance of the pharmaceutical supply chain (PSCs) by comparing mature and evolving PSCs.
**Methodology** – The study adopted a quantitative method where data was gathered through a survey instrument to identify the differentiators of dynamic capabilities and establish the extent of quality integration in PSCs. Thus, 310 questionnaires were collected from mature and evolving PSCs where the PROCESS technique was used to analyse the data.
**Findings**- The results demonstrate the significant paths that enable companies to create, extend, and modify the resources to develop their dynamic capabilities. The results reveal significant differences in internal and supplier quality implementation and their impact on operational performance between mature and evolving PSCs.
**Originality-** To the best of our knowledge, this is the first study to examine dynamic capabilities aspects of the pharmaceutical supply chain quality integration in mature and evolving PSCs, which extends the body of knowledge and makes a practical contribution.



**Keywords:** Supplier quality integration, Dynamic capability, Evolving and Mature pharmaceutical supply chain, Supply chain, quality management.


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## 1. Introduction

One of the fundamental challenges for pharmaceutical manufacturers is to ensure that their medicines and supporting products and services are fit for purpose for patient consumption, alongside the continual tasks of reducing costs and improving operational inefficiencies (Papalexi *et al*., 2020; Escudero, 2016). The number of quality problems in the pharmaceutical supply chain (PSC) has dramatically increased (Schleifenheimer and Ivanov, 2024). Such quality-associated problems resulted in costly litigation cases such as Novo Nordisk in 2009, where more than 120K insulin was illegally received by some diabetic patients and caused problems in blood sugar control (Hogerzeil and Recourt, 2017). Another example is when Pfizer paid $700K to the families who lost their children in the Trovan trials (Llamas,2022). These cases fall into the categories relating to operational performance in terms of product quality, cost, flexibility, and delivery problems (FDA,2020b). Such quality problems often arise due to inadequate implementation of quality throughout the PSC and a failure to fully leverage the suppliers' knowledge (Alkalha *et al*., 2019; Flynn *et al*., 2016). Suppliers' failure to provide quality materials, their weak compliance with regulations, and communication breakdowns cause quality problems for pharmaceutical companies (Schleifenheimer and Ivanov, 2024). Moreover, suppliers play an important role in dealing with quality issues through refining product designs, ensuring the seamless delivery of materials and minimising disruptions in the manufacturing process. Exploiting supplier knowledge proves beneficial across various facets, including material quality, product design, and development (Sheykhzadeh *et al*.,2024). Therefore, several studies considered expanding quality implementation across the PSC with the operational aim of reducing the level of quality problems and enhancing operation performance (Cohen and Lee, 2020; Soares *et al.*, 2017; Huo *et al.*, 2014). As a result, there is a growing need to examine the context of quality integration along with the PSC. Consequently, the supply chain quality integration (SCQI) concept has recently received considerable attention (Akhtar *et al*., 2024; Alkalha *et al*., 2019).

Supplier quality integration is an established component of SCQI thinking, and attention to it has increased since companies preferred to collaborate with a limited number of strategic suppliers to reduce the operational costs of their managed supplier chains (Yu and Huo, 2018). Internal quality integration supports supplier integration as an essential component for successful supplier quality integration (Huma *et al*.,2024). In addition, internal quality integration can improve operational performance if combined with external integration (Cheng *et al.*, 2016). Therefore, if companies need to implement SCQI, they need to have a good relationship with suppliers (Yu and Huo, 2018). However, it is not clear in the current studies what is the role of internal quality integration in developing supplier quality integration and which type of supplier quality integration improves operational performance (Abdallah *et al.,*2023; Zhang *et al*.,2019). Thus, recent studies concluded that numerous companies struggle to synchronise their resources with their existing supply chains, making high levels of collaboration difficult to achieve (Joel *et al*.,2024; Skipworth *et al*.,2023). This is because there are no precise established models and frameworks in the literature to help contextualise the key components of internal quality integration that enhance supplier quality integration in terms of operational performance (Sharma and Joshi,2023; Salimian *et al*.,2021).

While previous studies have explored aspects of supplier quality integration and operational performance, they have predominantly treated internal and supplier quality integration as a holistic construct (Sharma and Joshi, 2023, Zhang *et al*., 2019, Yu and Huo, 2018). Such approach neglects the more complicated relationship between the different internal and supplier quality integration components and how exactly they impact operational performance. Additionally, there is a notable lack of research that specifically focuses on the unique challenges and opportunities presented by evolving pharmaceutical supply chains. Evolving PSCs face more difficulties compared to mature PSCs in managing their quality (Saroha *et al.,*2022). However, evolving PSCs are attractive for investment due to the availability of human resources and low wages. Studies indicated that clinical trials in evolving PSC reduce drug development costs (Schleifenheimer and Ivanov,2023; Dutta *et al*.,2019). Thus, big companies in mature PSCs either moved the production of expired drugs or invested in developing new products for evolving PSCs (Ussai *et al*., 2022). Numerous studies have focused on the importance of improving the quality of products and the network of mature PSCs. Unfortunately, the number of studies focused on evolving PSCs remains somewhat limited, and the differences between evolving and evolved PSCs is not clear in the extant literature (Habib, 2024; Yu and Huo, 2018). Consequently, this gap highlights the need to understand the specific contributions of each internal and supplier quality integration component to operational outcomes. Additionally, the gap highlights a lack of comparative analysis between mature and evolving PSCs regarding key factors influencing supplier quality integration and operational performance. Thus, this study aims to investigate the mediating impact of supplier quality integration components on the operational performance of the pharmaceutical supply chain (PSCs) by comparing mature and evolving PSCs. This study aims to answer two fundamental research questions:

RQ.1 What is the mediating impact of supplier quality integration components in PSCs' operational performance?

RQ2. What are the differentiating factors between mature and evolving PSCs?

Based on dynamic capability theory, two fundamental activities are essential for creating new capabilities (Teece, 2019). The first is technical activities enabled by features such as internal quality integration (Chowdhury and Quaddus, 2017). The second is evolutionary activities, which refers to how well the capabilities enhance companies' abilities to create, extend, and adjust their resources (Teece, 2007). Supplier quality integration practices are example of activities that enable companies to create, extend, and adjust their resources (Alkalha *et al*., 2019; Huo *et al*., 2014). Thus, both technical and evolutionary activities sense, seize, and reconfigure companies' resources and create dynamic capabilities (Teece, 2019). The paper will be organised as follows: the literature review will discuss the supply chain quality integration, operational performance, and theoretical justification. Followed by hypotheses development. After that, the methodology section will explain the data selection, the analysis, and the techniques used to test mediation. After that, the result section, then the discussion and the conclusion.

## 2. Literature

### *2.1 Supply chain quality integration*

The concept of SCQI is rooted within the supply chain integration (SCI) literature. SCI posits that SC managers need to facilitate internal and external integration to achieve efficient, effective flows of products, services, information, and finances with the primary aim of customer satisfaction (Flynn *et al.*, 2010). Explicitly, SCQI combines internal and external integration to constantly enhance the quality of both products and processes (Zhang *et al.*, 2019). Flynn and Zhao (2014) viewed SCQI from a strategic partnership perception, in which they defined SCQI as the extent of the company's strategic collaboration with its SC network. SCQI is also concerned with coordinating intra and inter-organisational quality systems, often relating to the process design critical to producing high-quality products and services. Huo *et al.* (2014, p. 39) defined SCQI from both an operational and strategic perspective as *"the degree to which an organisation's internal functions and external supply chain partners strategically and operationally collaborate with each other to jointly manage intra- and inter-organisational quality-related relationships, communications and processes, with the objective* *to achieve high levels of quality-related performance at low costs".* Later, Abdallah *et al.* (2021) defined SCQI as expanding the quality of external companies' boundaries.

The consideration of SCQI often falls across three overlapping dimensions: internal, supplier and customer (Huo *et al.*, 2014), with the last two components of integration (relating to suppliers and customers) often referring to the external quality integration. In particular, external quality integration is the internal strategic, tactical, and operational integration with external partners through coordinating quality needed activities to meet customers' requirements (Alkalha *et al.*, 2019). On the other hand, internal quality integration represents the quality-interrelated processes within a company's internal functions by structuring and orchestrating the quality process to meet customer requirements (Alkalha *et al.*, 2019; Huo *et al.*, 2016). By studying the context of SCI and SCQI within the existing literature, it can be seen that internal quality integration revolves around two key practices: cross-functionality and problem-solving. Additionally, supplier quality integration revolves around three major practices: supplier involvement, supplier development and procurement (See Table 1).

*Table 1: A survey of previous literature regarding investigating the components of internal quality integration and supplier quality integration components*

| | **Supplier integration** | | | **Internal integration** | |
|---|---|---|---|---|---|
| Ref | Procurement | Involvement | Development | Cross-functional | Problem-solving |
| Huma et al.(2024) | X | X | X | X | X |
| Abdallah et al.(2023) | X | X | X | X | X |
| Escorcia-Caballero et al.(2022) | X | X | X | X | |
| Fernandes et al.(2022) | X | | | | |
| Salimian et al.(2021) | | | X | | |
| Zhang et al.(2020) | | X | | X | |
| Yu and Huo (2018) | | X | X | X | X |
| Golini *et al.* (2017) | | X | | X | |
| Ayoub *et al.* (2017) | | X | | X | |
| Tan *et al.* (2017) | | X | | | |
| Turkulainen *et al.* (2017) | | | | X | X |
| Yu *et al.* (2017) | | X | X | | |
| Qi *et al.* (2017) | | X | X | X | |

| | | | | | |
|---|---|---|---|---|---|
| Zhang *et al.* (2017) | | X | X | X | X |
| Huo *et al.* (2016) | | X | X | X | X |
| Flynn*et al.*, (2016) | | X | X | X | X |
| Cheng *et al.* (2016) | | X | | X | |

A series of studies emerged, each shedding new light on the nuanced relationships between SCQI components and supply chain outcomes. Lim *et al.*(2022) concluded that customer focus has the highest impact on sustianblity performance. Similarly, Ayaz (2022) demonstrated the importance of customer and supplier quality integration on environmental performance and highlighted that supplier quality integration practices support supply chain sustainability. Also, the study found that information sharing and transparency improved environmental performance. A study conducted by Abdallah *et al*. (2021) focused on the impact of SCQI on supply chain agility and innovation capabilities. The study revealed the mediator role of supplier quality integration in driving these enhancements. Huo *et al*. (2019) and Zhang *et al*. (2019) identified SCQI patterns and their relationships with quality-related performance. The studies concluded that the quality of raw materials from suppliers has more impact on product quality than the internal improvement process. However, companies need to deal with internal/external uncertainties and adopt a high level of SCQI to reduce the cost of production and improve delivery and flexibility (Zhang *et al*., 2019; Shahin *et al.,* 2018). This required change in employees culture and awareness (Van Nguyen *et al*.,2024)

Tran *et al*. (2020) and Akhtar *et al*. (2024) provided more focus on SCQI in improving economic outcomes. By highlighting the mediating role of supplier quality integration in driving financial performance through relational investments and leadership practices. Meanwhile, Huma *et al*. (2024) and Kabagambe *et al.* (2023) explored the intersections of SCQI with green supply chain practices and knowledge absorption, respectively, further clarifying the critical role of supplier quality integration in driving sustainability initiatives and knowledge management processes within supply chains. Huma *et al*. (2024) suggested that collaboration with eco-friendly suppliers and knowledge exchange with supply chain partners, drive improvements in sustainability and knowledge management. Likewise, Yu *et al*. (2019) focused on the relationships between supply chain quality integration in terms of supplier quality integration and customer quality integration, green supply chain management in terms of green purchasing and customer green cooperation and environmental performance.

Among the different supply chain management studies published, researchers conducted a joint investigation aiming to take apart the complexities of incorporating quality into supply chain processes and their impact on various performance dimensions. By studying the current literature through various lenses such as internal, customer and supplier quality integration, yet there was a notable gap in the comprehensive analysis of supplier quality integration practices. Although supposedly the studies recognised the overall benefits of SCQI, they failed to drill down to the specific mechanisms that constitute the favourable impact of supplier quality integration on the performance of supply chains that view this concept as an omnibus.

### *2.2 Operational Performance*

In the context of an open competitive market, manufacturing companies are facing challenges to achieve operational excellence and improve their performance from both a financial and operational perspective, to continually improve the quality of products and reduce costs and lead times (Pattanayak *et al*., 2019; Psomas *et al.*, 2016). Drawing on a number of SC studies that have explained the importance of integration in the pharmaceutical SC, it is intriguing to note that the concept of integration across the SC often reduces lead time for the production of medicines (Mehralian *et al.*, 2015), enhances SC capacities and reduces market uncertainty in pharmaceutical industry (Vann Yaroson *et al*., 2024). In addition, the integration helps improve customers' satisfaction and medicine quality (Hosseini-Motlagh *et al*.,2023). Table (2) summarises the studies that have discussed operational performance.

*Table 2: A literature survey of identified components of operational performance in the literature*

| Operational performance | Reference |
|---|---|
| Delivery | Abdallah et al.(2023), Garcia-Buendia et al.(2023), Xu et al.(2022),Alkalha et al.(2021), Yu et al. (2018), Yu and Huo (2018), Huo et al. (2016), Huo et al. (2014),Cheng et al. (2014), Flynn et al. (2010) |
| Product quality | Luo et al.(2023), Garcia-Buendia et al.(2023), Yang et al.(2022), Xu et al.(2022), Alkalha et al.(2021), Youssef and Youssef (2018), Yu and Huo (2018), Yuen and Thai (2017), Patyal and Koilakuntla (2017), Soares et al. (2017), , Zhang et al. (2017), Huo et al. (2016),Cheng et al. (2014), Huo et al. (2014) |
| Cost of production | Luo et al.(2023), ,Xu et al.(2022), Alkalha et al.(2021),Huo *et al.* (2016), Huo *et al.* (2014)Wiengarten and Longoni (2015), , |
| Flexibility | Abdallah et al.(2023), Garcia-Buendia et al.(2023), Yang et al.(2022), Xu et al.(2022), Alkalha et al.(2021), Yu and Huo (2018), Yu et al. (2018), Huo et al. (2016), Wiengarten and Longoni (2015), Huo et al. (2014),Flynn et al. (2010), |
| Inventory | Alfalla-Luque *et al.* (2015), Youssef and Youssef (2018) |

| | |
|---|---|
| Customer satisfaction/service | Yu and Huo (2018), Cheng *et al.* (2014), Flynn *et al.* (2010). |

Based on the previous literature, the following components of operational performance have been selected as the core focus of this study: quality, cost of production, delivery, and flexibility. These components are the generally agreed constructs to assess operational performance (Flynn *et al.,* 2010*;* Huo *et al.*, 2016).

The majority of the previous studies measured the impact of supply chain quality in general on overall operational performance such as Yu and Huo (2018) who demonstrated that supplier quality integration is the most important component of supply chain quality integration in improving the overall operational performance. Also, Abdallah *et al*. (2023) concluded that supply chain quality has a significant impact on the overall operational performance. However, the impact of supply chain quality on operational performance is not straightforward. For instance, Hong *et al.* (2019) found that supply chain quality does not impact the operational performance of Chinese manufacturing companies. Munir *et al.* (2020) highlighted that supplier integration does not have any impact on operational performance, but it has an indirect impact through risk management practices. Similarly, a study on manufacturing companies in Ghana showed that supplier integration does not impact the overall operational performance (Agyei-Owusu *et al.*, 2022).

To have a significant impact on operational performance companies are required to build a suitable infrastructure in terms of chain practices like supplier partnership, purchasing management practices, inventory management, Information sharing, and Quality (Sharma and Modgil, 2020). Moreover, companies need quality information and security to enhance operational performance (Vafaei-Zadeh *et al*., 2020). The quality of information leads to technological development that improves the lean ability of the supply chain which enhances the overall operational performance (Garcia-Buendia *et al*., 2023). Lee *et al*. (2023) concluded companies that can create a coordinating culture are able to have supportive supply chain partners as a result achieve a higher level of operational performance. This will build external supply chain integration with suppliers and customers which in turn improves the overall operational performance (Cheng *et al*., 2021).

Nevertheless, few studies measured the impact of supply chain quality on separate operational performance indicators for example, Soares *et al*. (2017) measured the impact of supply chain quality on quality performance. Phan *et al*. (2019) classified supply chain quality into upstream, downstream, and internal quality management. The study found that upstream quality management only improves the cost performance but it does not affect the quality and delivery performance (Phan *et al.,* 2019). Ganbold *et al.* (2021) concluded that supply chain integration has only a significant impact on the delivery and inventory level of operational performance in Japanese manufacturing companies.

The previous studies either focused on evaluating supply chain quality integration in general or on studying the impact of internal, supplier and customer quality integration on particular operational performance indicators. While these studies provide valuable insights into the relationship between supply chain quality and operational performance, they fail to identify the specific pathways through which supplier quality integration influences operational performance indicators. Consequently, the practices within supplier quality integration that improve operational performance remain unclear. This gap highlights the need for studies that not only explore the broader relationship between supply chain quality integration and operational performance but also investigate the specific practices within supplier quality integration that improve operational performance indicators.

### *2.3 The pharmaceutical supply chains*

The quality problems in the pharmaceutical industry influence companies' reputations and human health (Blanco-Gonzalez *et al*.,2023). The pharmaceutical industry struggles to maintain the quality of its products across its supply chain (Escudero, 2016). The evolving PSC face more challenges in managing quality due to a lack of quality awareness. For instance, Kuwaiti hospitals do not have sufficient knowledge on how to deal with pharmaceutical disposals (Alshemari *et al.,* 2020; Abahussain *et al*., 2012). Moreover, most logistics companies in Nigeria cannot transfer medicines that need low temperatures (Chukwu *et al.,* 2018).

The reports showed that the global production and trade of medicines are shifting towards developing markets, which are expected to contribute to a third of the global pharmaceutical ecosystem (FDA, 2020a ; Buente *et al.*, 2013). It is critical to shedding light on evolving supply chain practices and enables some knowledge transfer from the more mature PSCs. Jakovljevic *et al*.(2021) highlighted that evolving PSCs account for almost 50% of the global pharmaceutical sector market share. Moreover, the Middle East and North Africa region largely remain somewhat unexploited in advancing pharmaceutical production and manufacturing through foreign direct investment in the region (CPhI, 2019).

### *2.4 Theoretical framework, a dynamic capability perspective*

The underpinning theory of dynamic capability focuses on improving companies' capabilities to adapt to environmental change through interacting with the SC (Junaid *et al*., 2023). As such, dynamic capability can create and associate internal and external activities with managing environmental changes and sustaining competitive advantage (Eisenhardt and Santos, 2002). Lai *et al.* (2012) defined capabilities as factors that transform input into output, such as managerial capabilities, system development and integration. Teece (2019) stated that both learning and transforming are required to close the capability gap of a company.

In early work, Teece *et al.* (1997) argued that competencies improve the routine organisational process, with dynamic capability developing the organisational ability to adapt to changes. Keeping in mind Teece's (2007) argument that the main pillars of dynamic capability are technical and evolutionary activities. For instance, Huo *et al.* (2014) demonstrated that internal quality integration is a technical activity that focuses on cross-functional collaboration and on-time processes achieved by organisational routine following specific standards. On the other hand, Alkalha *et al*. (2019) argued that capability through evolutionary activities can be realised by reconfiguring firms' resources through cooperation with suppliers and customers in relation to quality issues using technical. Therefore, in this study, we have argued that companies can create their dynamic capabilities through internal and supplier quality integration by sensing, seizing and reconfiguring resources (Teece, 2019). Similar research highlights that companies' dynamic capabilities from internal and supplier quality integration need to be synchronised with their internal quality activities, in terms of cross-functional integration and problem-solving, with supplier quality activities (Junaid *et al*.,2023; Alkalha *et al.,* 2019; Chowdhury and Quaddus, 2017). This is achieved via suppliers' development, supplier involvement and procurement policies (Herold *et al*.,2023; Alkalha *et al.*, 2019; Sampaio *et al.*, 2016; Mellat-Parast, 2013).

#### *2.4.1 Mediating role of supplier involvement*

Previous studies have identified the importance of external integration in enhancing the impact of internal integration on the firm's operational performance. For example, Huo *et al.* (2014) found that a company's integration with its suppliers can reduce lead time and improve inventory management, quality, delivery, reliability, and product customisation. Furthermore, Cheng *et al.* (2016) concluded that internal quality integration impacts operational performance only if it is synchronised with external integration. Such integration can be achieved through suppliers' involvement in product development, enhancing information, technology, and efficiency and contributing to failure, recall avoidance, and cost reduction (Murali *et al.*, 2023). Van Echtelt *et al.* (2008) defined supplier involvement as developing buyers' competencies in products, services, and processes. Involving key suppliers can help companies to take advantage of suppliers' capabilities to enhance their products (Abdallah *et al.,*2021; Alkalha *et al*., 2019). Therefore, the knowledge obtained from suppliers regarding new technologies and process development enhances companies' decision-making processes regarding new product development (Vafaei-Zadeh *et al*.,2020; Najafi Tavani *et al*., 2013).

Chiang and Wu (2016) claimed that supplier involvement reduces manufacturing risk through supplier involvement in knowledge, experience and capacity. Furthermore, internal quality integration (cross-functional integration and problem-solving) between functions allows companies to build better relations with their suppliers, which helps reduce quality defects and improve efficiency (Herold *et al*.,2023; Yu and Huo, 2018). More specifically, coordination with suppliers reduces companies' obstacles and minimises information asymmetries; these efficiently link SC networks and improve operational performances (Garcia-Buendia *et al*.,2023; Pourjavad and Shahin, 2020a). Hence, the following hypotheses have been developed:

H1 (a-d): Supplier involvement mediates the relationship between cross-functional integration and (a) quality performance; (b) cost performance; (c) delivery performance; and (d) flexibility.

H2 (a-d): Supplier involvement mediates the relationship between problem-solving and (a) quality performance, (b) cost performance, (c) delivery performance, and (d) flexibility.

### *2.4.2 Mediating role of supplier development*

Suppliers significantly impact manufacturers' performance, as their input affects the manufacturers' outputs. Thus, it is in a firm's interest to enhance its key suppliers' performance (Sharma and Joshi 2023). When supplier capabilities are developed, there is an improvement in quality, delivery and flexibility, which improves the manufacturers' performances (Van Nguyen *et al.,* 2024). Masoudi and Shahin (2021) found that supplier quality criteria such as process and product quality reduce the quality costs. Moreover, Supplier development emphasises improvement in supplier performances mainly in terms of quality, cost, and delivery and is most effective if it occurs gradually (Yawar and Seuring, 2020; Busse *et al*., 2016). The rationale behind developing supplier performance is to create a sustainable competitive advantage through nurturing existing relationships rather than establishing new ones with other suppliers and identify the main determinants of sustainability through supplier development (Sikombe and Phiri, 2022; Shahin and Razavi ,2020). Pourjavad and Shahin (2020b) indicated that internal quality management system such as ISO 14,000 leads to improve the environmental performance of suppliers. In addition, the internal quality integration practices (cross-functional integration and problem-solving) support suppliers' communications and improve their responsiveness (Luo *et al*.,2023; Ganbold *et al.,* 2021).

Accordingly, the following hypotheses have been developed:

H3 (a-d): Supplier development mediates the relationship between cross-functional integrations and (a) quality performance; (b) cost performance; (c) delivery performance; and (d) flexibility.

H4 (a-d): Supplier development mediates the relationship between problem-solving and (a) quality performance, (b) cost performance, (c) delivery performance, and (d) flexibility.

*2.4.3 Mediating role of procurement policy*

Fostering the right procurement policy is an important aspect of the management of the SC due to its impact on the production process, as it is responsible for approximately 60% of a company's total costs (Sartor *et al.*, 2015). Procurement is defined as managing a firm's input, which needs to be obtained from appropriate sources of suppliers with an acceptable certain quality level and an exact delivery schedule (Lysons and Farrington,2020). Paul *et al.*(2024) and Shahin *et al. (*2017) concluded the importance of procurement in terms of supplier selection and contract in improving companies' flexibility performance. The company's problem-solving ability and cross-department collaboration facilitate the procurement practice to quick responses to environmental changes (Hallikas *et al*., 2021). The internal process of cross-functional integration and problem-solving improves the procurement policy regarding selecting suitable suppliers, deciding the required quality, and evaluating suppliers (Sharma and Modgil, 2020; Alkalha *et al.,* 2019). Therefore, the company's operational and financial performance enhanced (Abdallah *et al.,*2023). As a result, the following hypotheses have been developed:

H5 (a-d): Procurement policy mediates the relationship between cross-functional integration and (a) quality performance; (b) cost performance; (c) delivery performance; and (d) flexibility.

H6 (a-d): Procurement policy mediates the relationship between problem-solving and (a) quality performance; (b) cost performance; (c) delivery performance; and (d) flexibility.

### *2.5 Research model*

A study model has been developed to test the hypotheses, (Figure 1). As discussed, the main variables of the study are internal quality integration, supplier quality integration and operational performance. Firstly, the internal quality integration is measured through cross-functional integration and problem-solving dimensions. Secondly, supplier quality integration is measured through supplier involvement, supplier development, and procurement policy. Thirdly, the operational performances considered are product quality, cost of production, delivery and flexibility. Finally, the mediation impact of supplier quality integration practices is measured, as depicted in Figure (1).

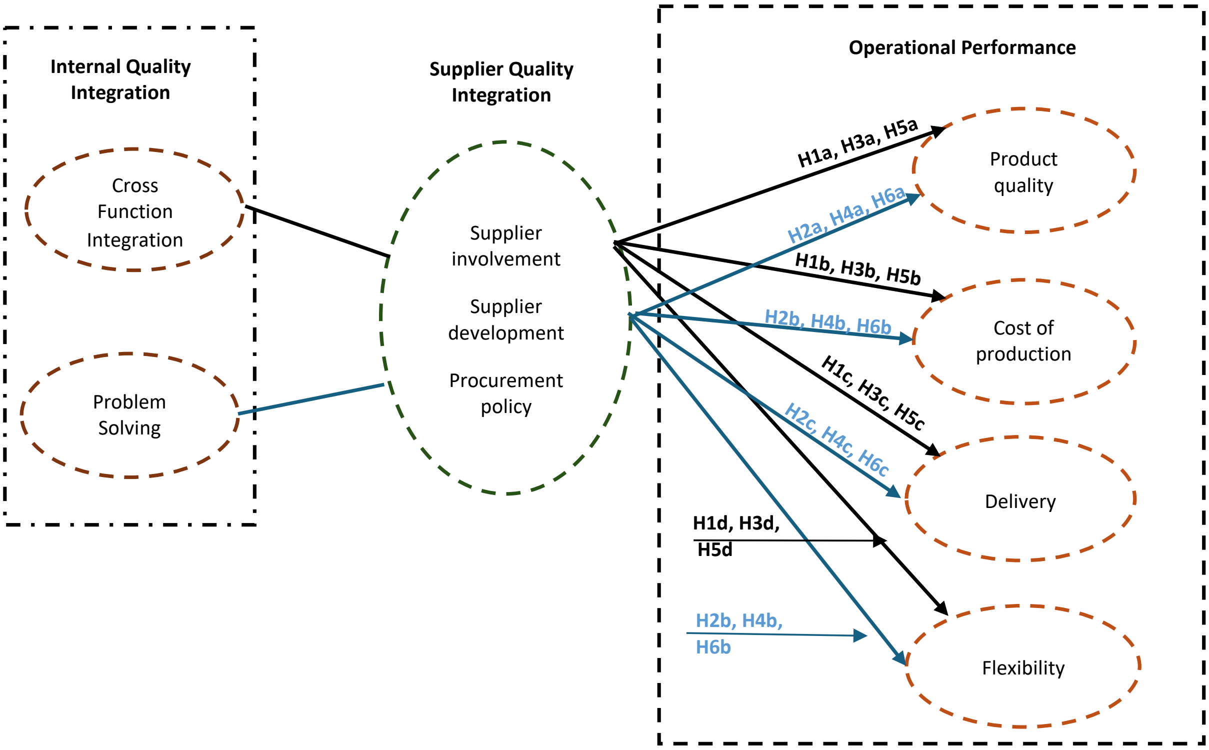


*Figure 1: The mediating impact of supply chain quality integration*

## 3. Methodology

### *3.1 The sample and respondents*

In order to test the model established, data was collected using a survey. A survey was developed to gather data; Neuman (2013) notes that the survey strategy search is frequently used in the social sciences to produce accurate and trustworthy conclusions. The survey has been piloted by 10 academic specialists in the field and an extra 10 experts in the pharmaceutical industry. The pilot enabled the adjustment of the survey accordingly by shortening and simplifying the terminologies. The survey consisted of 2 sections adapted from the literature. The first section is to classify the respondents' companies as either mature or evolving supply chains according to their research and development level, the rate of innovation, and the ability to maintain process capability as per global standards (Papalexi *et al*., 2021; Singh *et al.,* 2016; Fulco *et al*.,1995). The second section is to measure the study's variables.

Pharmaceutical supply chain managers were the target of the study. They were contacted randomly by email from " PharmaCompass" database. The total number of questionnaires distributed was 950. The survey received 180 questionnaires from evolving supply chain companies and 130 from mature supply chain companies based on the answers provided in the first section of the survey. The response rate of 32% exceeded the acceptable level of 20% (Malhotra and Grover, 1998). Table (3) shows profiles of responding companies and respondent characteristics.

*Table 3: Profiles of responding companies and respondent characteristics*

| **Category** | **Evolving Supply Chain Companies (n=180)** | **Mature Supply Chain Companies (n=130)** |
|---|---|---|
| Companies geographical location | Developing countries (Southeast Asia 30%, Sub-Saharan Africa 20%, Latin America 15%, and the Middle East 35%) | Developed countries (Australia 35%, North America 20%, 45% Europe) |
| Supply chain focus | Manufacturing: 45%<br>Distribution and Logistics: 35%<br>Procurement and Sourcing: 20% | Manufacturing: 50%<br>Distribution and Logistics: 30%<br>Procurement and Sourcing: 20% |
| Respondents Job title | Supply chain manager | Supply chain manager |
| Years of experience in the current position | 5-10 years: 30%<br>More than 10 years:70% | 5-10 years: 25%<br>More than 10 years:75% |

### *3.2 Measures and Reliability*

The survey instrument was developed from the literature, and validated constructs and measures were used and adapted, as shown in Table (4).

*Table :4 Instrument Reliability and validity*

| Construct (source)/indicator | Loading | AVE | Measures |
|---|---|---|---|
| **Internal quality integration** | | | Goodness of fit indices: CFI= 0.98 , IFI=0.98; TLI=0.97; RMSEA=.057, |
| **Cross-functional integration** | | 0.52 | Composite reality= 0.76. |
| Q1 | 0.66 | | |
| Q2 | 0.78 | | |
| Q3 | 0.70 | | |
| **Problem-solving** | | 0.64 | Composite reality= 0.84 |
| Q4 | 0.75 | | |
| Q5 | 0.74 | | |
| Q6 | 0.90 | | |
| **Supplier quality integration** | | | Goodness of fit indices: CFI= 0.93 , IFI=0.92; TLI=0.91; RMSEA=.088, |
| **Procurement** | | 0.64 | Composite reality= 0.84 |
| Q7 | 0.88 | | |
| Q8 | 0.79 | | |
| Q9 | 0.73 | | |
| **Supplier development** | | 0.56 | Composite reality= 0.79 |
| Q10 | 0.89 | | |
| Q11 | 0.60 | | |
| Q12 | 0.72 | | |
| **Supplier involvement** | | 0.63 | Composite reality= 0.84 |
| Q13 | 0.79 | | |
| Q14 | 0.73 | | |
| Q15 | 0.86 | | |
| **Operational performance** | | | Goodness of fit indices: CFI= 0.94 , IFI=0.94; TLI=0.93; RMSEA=0.071, |
| **Products quality** | | 0.66 | Composite reality= 0.85 |

| | | | |
|---|---|---|---|
| Q16 | 0.81 | | |
| Q17 | 0.88 | | |
| Q18 | 0.75 | | |
| **Cost of production** | | 0.60 | Composite reality= 0.82 |
| Q19 | 0.76 | | |
| Q20 | 0.82 | | |
| Q21 | 0.74 | | |
| **Delivery** | | 0.59 | Composite reality= 0.82 |
| Q22 | 0.72 | | |
| Q23 | 0.76 | | |
| Q24 | 0.83 | | |
| **Flexibility** | | 0.57 | Composite reality= 0.84 |
| Q25 | 0.72 | | |
| Q26 | 0.83 | | |
| Q27 | 0.77 | | |
| Q28 | 0.68 | | |

The data was analysed using LISREL software (Scientific Software International), with the first investigation involving confirmatory factor analysis to assess convergent validity (Hair *et al.*, 2010). LISREL allows for estimating the indirect impact of variables more comprehensively and provides an accurate parameter regardless of the same size compared to other approaches such as AMOS (Sarstedt *et al*., 2020). Thus, LISREL have an advantage in providing robust results when dealing with limited sample sizes (Goodhue *et al.,* 2012).

The results showed that the factor loadings for all factors were above 0.60 (Comrey and Lee, 2013). Furthermore, the constructs' covariance was estimated with the average variance extracted (AVE) for all variables exceeding 0.5, and the composite reality is above 0.7, showing that the variables have high-reliability values. Thus, the variables can be considered to have suitable convergent validity and reliability (Hair *et al.*, 2010). These results indicate that the square root of the AVE of all constructs is greater than the correlation between any pair (see Table 5). This provides evidence that the constructs have convergent validity (Hair *et al.*, 2010). Furthermore, the goodness of fit indices tested using the comparative fit index (CFI), incremental fit index (IFI), and Tucker Lewis index (TLI) exceeded the minimum accepted value of 0.90. Moreover, the RMSEA values for all variables were below the 0.09 threshold (Sivo *et al.*, 2006).

*Table 5: Correlation & convergent validity*

| | Cross-Fun | P.Solv | Procur | S.Develop | S.Involv | Q.Per | Cost. Per | De. Per | F. Per |
|---|---|---|---|---|---|---|---|---|---|
| **Cross-Functions** | **0.72*** | | | | | | | | |
| **P.Solving** | 0.21 | **0.80*** | | | | | | | |
| **Procurement** | 0.53 | 0.57 | **0.80*** | | | | | | |
| **S.Development** | 0.59 | 0.64 | 0.32 | **0.75*** | | | | | |
| **S.Involvement** | 0.52 | 0.55 | 0.27 | 0.38 | **0.79*** | | | | |
| **Quality.Per** | 0.65 | 0.62 | 0.63 | 0.69 | **0.5**9 | **0.81*** | | | |
| **Cost. Per** | 0.54 | 0.51 | 0.47 | 0.51 | 0.52 | **0.36** | **0.77*** | | |
| **Delivery. Per** | 0.52 | 0.56 | 0.58 | 0.65 | 0.36 | 0.31 | 0.49 | **0.76*** | |
| **Flexibility. Per** | 0.54 | 0.59 | 0.55 | 0.61 | 0.60 | 0.22 | 0.38 | 0.36 | **0.75*** |
| **Note: *Square root of AVE presented on the diagonal** | | | | | | | | | |

### *3.3 PROCESS analysis technique*

We aimed to test the hypotheses in both mature and evolving PSCs. The valid data used for the analysis was N=162 for evolving PSCs and N=102 for mature PSCs. To test the set hypotheses, the PROCESS analysis technique was adopted for this study (Hayes and Rockwood,2020). PROCESS is a "macro" within SPSS that streamlines the execution of mediation, moderation, and conditional process analysis with observed (i.e., "manifest") variables (Hayes *et al.*, 2017). PROCESS is particularly useful for comparing the two different samples, the mature and evolving PSCs.

The mediation impact was tested using bootstrapping, a computational method involving repeated sampling from the data set and estimating the indirect effect of each resampled data set resulting from empirical approximation rather than assumptions (Preacher and Hayes, 2008). The bootstrapping approach computes the indirect effects via confidence intervals (CI) and offers more robust results for direct effects, which have strong statistical power (Latham and Hill, 2014). In addition, the confidence interval is significant when it does not contain the zero-point (Hayes, 2017; Preacher and Hayes, 2008).

## 4. Findings

### *4.1 Hypotheses and mediation test*

Table (6) shows the results of hypotheses and mediation tests, with a summary of hypotheses testing in mature and evolving PSCs as provided in Table (7). The test was run using three mediators: supplier involvement, development, and procurement policy. The hypotheses test shows that supplier involvement significantly mediates the relationship between cross-functional integration and all the components of operational performances in the mature PSCs. The highest effect is on the quality performance, where the total effect has a β value of 0.61 (t=4.04, CI95%= 0.15, 0.25), and it fully mediates the relationship as the direct impact is not significant (β= 0.43, t=1.53, p>.001), followed by flexibility (β= 0.58, t=8.78, CI95%= 0.24, 0.42), cost (β= 0.56, t=8.85, CI95%= 0.14, 0.22) and delivery (β= 0.49, t=8.04, CI95%= 0.11, 0.32). These results support H1a, H1b, H1c, and H1d mature PSCs. On the other hand, in evolving PSCs, the result shows that supplier involvement only mediates the relationship between cross-functional integration and flexibility performance (β= 0.50, t=4.30, CI95%= 0.24, 0.42), supporting H1d while rejecting H1a, H1b, and H1c.

The results also indicate that supplier involvement in mature PSCs significantly mediates the relationship between problem-solving and quality (β= 0.62, t=10.29, CI95%= 0.15, 0.36), supporting H2a. Similarly, in the mature PSCs, it significantly mediates the relationship between problem-solving and cost (β= 0.53, t=6.56, CI95%= 0.17, 0.42) and flexibility (β= 0.49, t=5.14, CI95%= 00.43, 0.66), supporting H2b and H2d, while it does not mediate the relationship between problem-solving and delivery in the mature PSCs (β= 0.55, t=9.55, CI95%= -0.01, 0.16) rejecting H2c. In evolving PSCs, supplier involvement significantly mediates the relationship between problem-solving and quality (β= 0.51, t=6.92, CI95%= 0.09, 0.16) and flexibility (β= 0.50, t=4.33, CI95%= 0.04, 0.10), supporting H2a and H2d, while rejecting H2b and H2c.

*Table 6: Hypothesise & mediation test*

| | **Mediator 1 (Supplier involvement)** | | | | | | **Mediator 2 (Supplier development)** | | | | | | **Mediator 3 (Procurement)** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ind/Dep** | **β** | | **SE** | | **t** | | **β** | | **SE** | | **t** | | **β** | | **SE** | | **t** | |
| **Path summary** | **Mat** | **Evol** | **Mat** | **Evol** | **Mat** | **Evol** | **Mat** | **Evol** | **Mat** | **Evol** | **Mat** | **Evol** | **Mat** | **Evol** | **Mat** | **Evol** | **Mat** | **Evol** |
| **Cross.Fun- Qual.Per** | | | | | | | | | | | | | | | | | | |
| Total effect | 0.61 | 0.38 | 0.07 | 0.11 | 4.04** | 1.44 | 0.66 | 0.44 | 0.07 | 0.10 | 5.72** | 1.13 | 0.58 | 0.37 | 0.07 | 0.10 | 10.23** | 4.43** |
| Direct effect | 0.43 | 0.30 | 0.07 | 0.11 | 1.53 | 1.14 | 0.28 | 0.32 | 0.07 | 0.12 | 1.35 | 1.04 | 0.25 | 0.18 | 0.08 | 0.09 | 6.94** | 5.97** |
| Mediation effect | 0.28* | 0.08 | 0.06 | 0.06 | | | 0.38* | 0.12 | 0.08 | 0.08 | | | 0.33* | 0.19* | 0.06 | 0.08 | | |
| $R^2$ | 0.55 | 0.38 | | | | | 0.64 | 0.35 | | | | | 0.45 | 0.41 | | | | |
| **Probl.Solv- Qual.Per** | | | | | | | | | | | | | | | | | | |
| Total effect | 0.62 | 0.51 | 0.07 | 0.10 | 10.29** | 6.92** | 0.50 | 0.43 | 0.07 | 0.09 | 08.34** | 4.36** | 0.61 | 0.64 | 0.07 | 0.10 | 3.12** | 2.87** |
| Direct effect | 0.34 | 0.42 | 0.08 | 0.11 | 5.78** | 5.64** | 06 | 0.31 | 0.08 | 0.12 | 3.44** | 4.99** | 0.33 | 0.44 | 0.08 | 0.11 | 1.7 | 1.65 |
| Mediation effect | 0.27* | 0.09* | 0.06 | 0.06 | | | 0.34* | 0.12 | 0.07 | 0.08 | | | 0.28 | 0.20 | 0.05 | 0.07 | | |
| $R^2$ | 0.52 | 0.35 | | | | | 0.61 | 0.42 | | | | | 0.49 | | 0.41 | | | |
| **Cross.Fun- Cost.Per** | | | | | | | | | | | | | | | | | | |
| Total effect | 0.56 | 0.39 | 0.04 | 0.10 | 8.85** | 3.74** | 0.45 | 0.25 | 0.04 | 0.10 | 8.20** | 2.79** | 0.53 | 0.25 | 0.06 | 0.10 | 7.21** | 3.24** |
| Direct effect | 0.39 | 0.27 | 0.07 | 0.11 | 5.60** | 2.46** | 0.15 | 0.21 | 0.07 | 0.12 | 4.32** | 3.62** | 0.39 | 0.17 | 0.07 | 0.11 | 5.2** | 2.67** |
| Mediation effect | 0.17* | 0.12 | 0.05 | 0.05 | | | 0.31 | 0.04 | 0.05 | 0.07 | | | 0.14* | 0.08 | 0.05 | 0.05 | | |
| $R^2$ | 0.41 | 0.18 | | | | | 0.33 | 0.13 | | | | | 0.38 | 0.15 | | | | |
| **Probl.Solv- Cost.Per** | | | | | | | | | | | | | | | | | | |
| Total effect | 0.53 | 0.31 | 0.04 | | 6.56** | 3.09** | 0.50 | 0.34 | 0.06 | 0.10 | 7.53** | 2.86** | 0.48 | 0.28 | 0.09 | 0.10 | 5.60** | 2.24** |
| Direct effect | 0.34 | 0.19 | 0.06 | | 4.92** | 1.78 | 0.23 | 0.31 | 0.07 | 0.12 | 3.40** | 2.89** | 0.32 | 0.18 | 0.04 | 0.12 | 1.26 | 1.89 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mediation effect | 0.19 | 0.12 | 0.05 | | | | 0.27 | 0.03 | 0.06 | 0.07 | | | 0.16 | 0.10 | 0.05 | 0.05 | | |
| $R^2$ | 0.39 | 0.16 | | | | | 0.32 | 0.14 | | | | | 0.36 | 0.12 | | | | |
| **Cross.Fun- Deliv.Per** | | | | | | | | | | | | | | | | | | |
| Total effect | 0.49 | 0.48 | 0.09 | 0.10 | 8.04** | 4.80** | 0.52 | 0.38 | 0.04 | 0.09 | 7.15** | 3.47** | 0.43 | 0.24 | 0.10 | 0.10 | 4.32** | 4.17** |
| Direct effect | 0.22 | 0.33 | 0.06 | 0.10 | 3.85** | 3.21** | 0.15 | 0.27 | 0.06 | 0.11 | 2.25 | 3.24** | 0.23 | 0.19 | 0.06 | 0.11 | 4.09** | 3.09** |
| Mediation effect | 0.27* | 0.15 | 0.05 | 0.05 | | | 0.37* | 0.11 | 0.05 | 0.07 | | | 0.21* | 0.15 | 0.05 | 0.10 | | |
| $R^2$ | 0.29 | 0.25 | | | | | 0.45 | 0.22 | | | | | 0.29 | 0.27 | | | | |
| **Probl.Solv- Deliv.Per** | | | | | | | | | | | | | | | | | | |
| Total effect | 0.55 | 0.45 | 0.06 | 0.09 | 9.55** | 4.72** | 0.47 | 0.35 | 0.09 | 0.10 | 5.47** | 4.34** | 0.51 | 0.42 | 0.05 | 0.09 | 7.56** | 3.74** |
| Direct effect | 0.29 | 0.31 | 0.06 | 0.10 | 4.80** | 3.13** | 0.12 | 0.24 | 0.06 | 0.11 | 2.90 | 3.67** | 0.28 | 0.26 | 0.08 | 0.10 | 1.21 | 2.82 |
| Mediation effect | 0.26 | 0.14 | 0.05 | 0.04 | | | 0.35 | 0.11 | 0.05 | 0.07 | | | 0.23 | 0.16 | 0.05 | 0.07 | | |
| $R^2$ | 0.52 | 0.28 | | | | | 0.47 | 0.22 | | | | | | | 0.47 | 0.26 | | |
| | **Model 1 (Supplier involvement)** | | | | | | **Model 2 (Supplier development)** | | | | | | **Model 3 (Procurement)** | | | | | |
| **Ind/Dep** | **β** | | **SE** | | **t** | | **β** | | **SE** | | **t** | | **β** | | **SE** | | **t** | |
| | **Mat** | **Evol** | **Mat** | **Evol** | **Mat** | **Evol** | **Mat** | **Evol** | **Mat** | **Evol** | **Mat** | **Evol** | **Mat** | **Evol** | **Mat** | **Evol** | **Mat** | **Evol** |
| **Cross.Fun- Flexib.Per** | | | | | | | | | | | | | | | | | | |
| Total effect | 0.58 | 0.50 | 0.04 | 0.12 | 8.78** | 4.33** | 0.47 | 0.38 | 0.06 | 0.12 | 6.80** | 5.67** | 0.66 | 0.44 | 0.03 | 0.11 | 7.24** | 4.24** |
| Direct effect | 0.31 | 0.35 | 0.09 | 0.12 | 4.79** | 2.87 | 0.20 | 0.21 | 0.07 | 0.13 | 3.78** | 2.57** | 0.31 | 0.28 | 0.07 | 0.12 | 5.15** | 2.72 |
| Mediation effect | 0.27* | 0.15* | 0.04 | 0.07 | | | 0.27* | 0.17 | 0.05 | 0.09 | | | 0.35* | 0.16 | 0.05 | 0.08 | | |
| $R^2$ | 0.49 | 0.24 | | | | | 0.36 | 0.22 | | | | | 0.43 | 0.27 | | | | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Probl.Solv-Felxib.Per** | | | | | | | | | | | | | | | | | | |
| Total effect | 0.49 | 0.65 | 0.05 | 0.09 | 5.14** | 6.53** | 0.38 | 0.47 | 0.09 | 0.10 | 6.49** | 5.97** | 0.55 | 0.40 | 0.06 | 0.10 | 9.31** | 5.68** |
| Direct effect | 0.27 | 0.54 | 0.06 | 0.10 | 4.74** | 5.11** | 0.17 | 0.37 | 0.07 | 0.11 | 3.56** | 4.80** | 0.36 | 0.26 | 0.07 | 0.11 | 5.32** | 4.82** |
| Mediation effect | 0.22* | 0.11 | 0.05 | 0.06 | | | 0.21* | 0.10 | 0.05 | 0.07 | | | 0.19* | 0.14* | 0.05 | 0.06 | | |
| $R^2$ | 0.49 | 0.35 | | | | | 0.33 | 0.30 | | | | | 0.40 | .33 | | | | |

* CI 95% does not contain zero.

**Significant P <0.001

Analysing the data from the mature PSCs shows that supplier development significantly mediates the relationship between cross-functional integrations and quality (β= 0.66, t=5.72, CI95%= 0.26, 0.56) and fully mediates the relationship, as the direct impact is not significant (β= 0.28, t=1.35, p>0.001), on delivery (β= 0.52, t=7.15, CI95%= 0.26, 0.48) and flexibility (β= 0.47, t=6.92, CI95%= 0.19, .40) supporting H3a, H3c, and H3d, while it does not significantly impact cost (β= 0.45, t=2.79, CI95%= -0.08, 0.12), rejecting H3b.

In evolving PSCs, supplier development does not mediate the relationship between cross-functional integration and operational performances, rejecting hypotheses from H3a to H3d.

The analysis also indicates that in the mature PSCs, supplier development significantly mediates the relationship between problem-solving and quality (β= 0.50, t=8.34, CI95%= 0.31, 0.60) and flexibility (β= 0.38, t=6.49, CI95%= 0.19, 0.42), supporting H4a and H4d. In contrast, it does not significantly mediate the relationship with delivery and cost, rejecting H4b and H4c. In evolving PSCs, supplier development does not mediate the relationship between problem-solving and any of the operations performance components, rejecting hypotheses from H4a to H4d.

The analysis shows that in the mature PSCs., the procurement policy significantly mediates the relationship between cross-functional integrations and all the operational performances; the cross-functional integrations have the highest impact on flexibility performance with (β= 0.66, t=7.24, CI95%= 0.10, 0.31), supporting hypotheses from H5a to H5d. In evolving PSCs, procurement policy significantly mediates the relationship between cross-functional integration and quality performance (β= 0.37, t=4.43, CI95%= 0.09, 0.22), only supporting H5a and rejecting H5b, H5c, and H5d. On the other hand, the analysis shows procurement policy in the mature PSCs. only significantly mediates the relationship between problem-solving and flexibility (β= 0.55, t=9.31, CI95%= 0.12, .34), supporting H6d while rejecting H6a, H6b, and H6c. Likewise, in evolving PSCs, procurement strategy only significantly mediates the relationship between problem-solving and flexibility (β= .40, t=5.68, CI95%= 0.02, 0.14).

*Table 7: Summary of hypothesis testing for the mature and evolving PSCs*

| Hypothesis | Mature PSCs | Evolving PSCs |
|---|---|---|
| H1a | Supported | Rejected |
| H1b | Supported | Rejected |
| H1c | Supported | Rejected |
| H1d | Supported | Supported |
| H2a | Supported | Supported |
| H2b | Supported | Rejected |
| H2c | Rejected | Rejected |
| H2d | Supported | Supported |
| H3a | Supported | Rejected |
| H3b | Rejected | Rejected |
| H3c | Supported | Rejected |
| H3d | Supported | Rejected |
| H4a | Supported | Rejected |
| H4b | Rejected | Rejected |
| H4c | Rejected | Rejected |
| H4d | Supported | Rejected |
| H5a | Supported | Supported |
| H5b | Supported | Rejected |
| H5c | Supported | Rejected |
| H5d | Supported | Rejected |
| H6a | Rejected | Rejected |
| H6b | Rejected | Rejected |
| H6c | Rejected | Rejected |
| H6d | Supported | Supported |

## 5. Discussion

Previous studies have acknowledged the importance of internal quality integration on supplier quality integration and the significant impact of both activities on overall operational performances (Ganbold *et al*., 2021; Zhang *et al*., 2019). However, the literature remains unclear on supplier quality integration practices that improve each operational performance indicator (Salimian *et al*., 2021; Yu and Huo, 2018). Thus, this study investigates the mediating impact of supplier quality integration on the operational performance of PSCs by comparing mature and evolving PSCs. Our study focused predominately on two main questions: i) what is the mediating impact of supplier quality integration components in PSCs' operational performance? And ii) what are the differentiating factors between mature and evolving PSCs? Our discussion is broken down into three key sections: the first discusses the mediating impact of supplier involvement, the second discusses supplier development's mediating impact, and the third discusses the mediating impact of procurement policy.

### *5.1 Mediating impact of supplier involvement and the differences between mature and evolving PSCs*

Our results identified that supplier involvement partially mediates the relationship between cross-functional integration and operational performance in mature PSCs and fully mediates the relationship with quality performance. Yu and Huo (2018) and Tsang *et al*. (2022) concluded that supplier involvement in product design and solving quality problems enhances efficiency and reduces quality defects. However, Murali *et al*. (2023) showed that supplier collaboration in terms of sharing knowledge improves the new product development more than collaboration with customers.

The previous studies did not show the practices of supplier quality integration's and their impact on operational performance indicators especially in evolving supply chains. Moreover, previous studies explained that the reason behind the weak impact of suppliers is due to the lack of a learning environment that supports utilising suppliers' expertise (Van Nguyen *et al*.,2024; Kim *et al.,*2022). Our results demonstrated that supplier involvement only mediates cross-functional integration and flexibility performance in evolving PSCs. Moreover, Alkalha *et al*. (2019) highlighted the weak capability of evolving PSCs to absorb SC knowledge. The results demonstrated that in the mature PSCs supplier involvement partially mediates the relationship between problem-solving from one side and cost, quality, and flexibility performance from the other side. At the same time, it does not have a significant mediation impact on delivery. On the contrary, Ganbold *et al.* (2021) concluded that supplier integration improves the delivery performance of Japanese manufacturing companies. Ruzo-Sanmartín *et al.*(2023) and Maaz and Ahmad (2022) revealed that the delivery performance needs to integrate with customers rather than suppliers. Moreover, the results showed that supplier involvement does not significantly mediate problem-solving, delivery, and cost performance in evolving PSCs. Maware *et al.* (2022) emphasised that weak quality awareness in developing countries is the reason behind the poor quality impact on companies' performance.

### *5.2 Mediating impact of supplier development and the differences between mature and evolving PSCs*

Regarding mediating supplier development's impact, the results indicated that supplier development in the mature PSCs fully mediates the relationship between cross-functional integration and quality performance. In contrast, it partially mediates delivery and flexibility but does not mediate the relationship between cross-functional integration and cost performance. Some authors argued that supplier development activities such as strategic efforts and supplier development programs enhance operational performance, as per Sikombe and Phiri, (2022), and Benton *et al*. (2020). However, Free and Hecimovic (2021) highlighted that supplier development increases companies' costs as companies invest money in training and exchanging experts

Moreover, the results revealed that in the mature PSCs, supplier development does not mediate the relationship between problem-solving, delivery, and cost performance. Abdallah *et al.* (2023) found that while supply chain integration does not directly lead to improved operational performance, supply chain quality plays a significant role in influencing overall operational effectiveness. On the contrary, Mousavi *et al*. (2022) concluded that supplier development through increasing investment in R&D in pharmaceutical companies minimises costs and improves the quality of products. More specifically, Andalib Ardakani, *et al*. (2023) concluded that suppliers' development enhances quality and delivery performance. Whereas in evolving PSCs, the results showed that supplier development does not mediate the relationship between cross-functional integration or problem-solving and any of the operational performances. Nevertheless, Debnath *et al*. (2023) and Abdallah *et al.* (2014) demonstrated that supplier development is an important factor in developing efficiency in the competitive environment in developing countries. Moreover, others concluded that other aspects might affect operational performances in the pharmaceutical industry, such as patency agreements, geographical position, large investments, and the industry's rules (Jommi *et al.*,2023;Tawfik *et al.*, 2022; Savage *et al.*, 2006; Shah, 2004).

### *5.3 The mediating impact of the procurement policy and the differences between mature and evolving PSCs*

Overall, our findings demonstrated the partially significant mediation impact of the procurement policy between cross-functional integration and all operational performance indicators with the highest impact on flexibility in the mature PSCs. However, it has only a partially significant mediation impact on quality performance in evolving PSCs. Similarly, Paul *et al*.(2024) concluded that supplier integration enables joint understanding and reduces procurement and production costs. However, supplier integration needs to be modified to cope with environmental changes and match costs and benefits. More specifically, Erkoc *et al.*(2023) concluded that procurement policies such as inspection mechanisms on high-cost suppliers lead to quality improvement; but, they increase companies' costs. Hallikas *et al*. (2021) found that companies that have digital procurement policies have better supply chain performance. Likewise, Asif (2022) emphasised the importance of procurement policy on the viability of supply chain sustainability.

Our results showed that procurement policy only partially mediates between problem-solving and flexibility performance in the mature and evolving PSCs. In contrast, Bag *et al*. (2020) concluded that reducing waste in procurement policy significantly impacts operational performance in quality, productivity, and customer service, which is key when establishing a new pharmaceutical supply line. Furthermore, Nair *et al.* (2015) demonstrated that procurement might improve innovation only if it is integrated with suppliers' involvement practices in new product development or product refinement. Also, Alzoubi *et al*. (2020) revealed the importance of procurement strategies in improving supply chain sustainability in the Jordanian pharmaceutical industry. Kohler and Dimancesco (2020) suggested that to improve the procurement policy in the pharmaceutical industry in an evolving supply chain companies are required to better integrate accountability, transparency and anti-corruption mechanisms.

## 6. Conclusion

Previous studies focused on measuring the impact of supply chain quality on operational performance. However, the pathways through which supplier quality integration influences operational performance indicators remain unclear in mature and evolving PSCs. Thus, this study investigates the mediating impact of supplier quality integration components on the operational performance of PSCs by comparing mature and evolving PSCs. The result demonstrates the differences between mature and evolving PSCs. For example, the result reveals that in mature PSCs supplier involvement is partially mediated in the relationship between cross-functional integration and operational performance indicators with a full mediation effect on quality performance. On the contrary, in evolving PSCs, supplier involvement only mediated cross-functional integration and flexibility performance. Moreover, supplier involvement in mature PSCs partially mediates the relationship between problem-solving and operational performance indicators except for the delivery performance while it does not have any mediation impact in evolving PSCs.

The result demonstrates that supplier development in the mature PSCs fully mediates the relationship between cross-functional integration and quality performance but does not mediate the relationship between cross-functional integration and cost performance. Moreover, supplier development does not mediate the relationship between problem-solving, delivery, and cost performance. However, supplier development in evolving PSCs did not mediate the relationship between cross-functional integration or problem-solving and any operational performance indicators.

The procurement policy partially mediates between cross-functional integration and all operational performance indicators in mature PSCs. However, it has only a partially significant mediation impact on quality performance in evolving PSCs. Also, the procurement policy partially mediates between problem-solving and flexibility performance in the mature and evolving PSCs. Consequently, the result of this study provides valuable insights into academics and practitioners which are explained in theoretical and practical contributions.

### *6.1.1 Theoretical contribution*

The theoretical contribution of this study lies in its advancement of the current understanding of supplier quality integration by specifically examining the mediating role of supplier quality integration and its impact on operational performance indicators. By focusing on this specific aspect of supplier quality integration, the study fills a notable gap in the existing literature, which has tended to treat supplier quality integration as a holistic concept without delving into the nuances of supplier quality integration practices such as Abdallah *et al*. (2023) and Hong *et al.* (2019). Thus, the study provides evidence of the specific practices through which supplier quality integration influences various operational performance indicators across different stages of supply chain evolution (mature vs evolving PSCs). To the best of our knowledge, this study is one of the leading studies investigating this phenomenon in both mature and evolving PSCs. Therefore, the result enriches the literature with the differences between mature and evolving PSCs and the reasons behind these differences. Consequently, by testing these relationships, the study enriches the recent understanding of the impact of supplier quality integration on operational performance and highlights the differences between mature and evolving PSCs and the reasons behind these differences. Thereby advancing the knowledge base in supply chain management literature.

Furthermore, this study highlights the importance of creating technical activities through internal quality integration, and evolutionary activities through supplier quality integration practices, in enabling companies to sense, seize, and reconfigure resources effectively. By empirically testing these relationships, the study extends existing theoretical frameworks and provides valuable insights into how the dynamics capability of supplier quality integration may vary between evolving and mature PSCs. Through its theoretical contributions, the study advances the understanding of how companies can create and enhance their dynamic capabilities through supplier quality integration practices, ultimately contributing to the advancement of theory in the field.

### *6.1.2 Practical contribution*

The implications of this study are significant for practitioners and policymakers in the PSC industry. The findings give operative implications for practitioners in charge of supply chain management by emphasising supplier quality integration practices as an effective tool for operational performance improvement. By understanding the specific practices through which supplier quality integration influences operational performance indicators, practitioners can develop targeted strategies to improve their supply chain processes. For instance, they can pay more attention to supplier development, make key suppliers more involved, and adopt a robust purchasing policy.

Furthermore, the study shows the significance of the importance of tailoring supply chain management practices to the specific stage of supply chain evolution. Practitioners operating in evolving PSCs can benefit by recognising the unique challenges and opportunities associated with supplier quality integration in such a supply chain. Based on these insights, they can develop strategies that would respond to the changing supply chain therefore, the need to invest in building supplier capabilities and knowledge exchange partnerships is identified. Additionally, policymakers could utilise the insights obtained from this study to design appropriate policies that will drive the quality and efficiency of the PSCs. By identifying the critical role of supplier quality integration in improving operational performance, policymakers can prioritise initiatives that support integration between pharmaceutical companies and their suppliers, stimulate supplier development, involvement, and arrange purchasing policies.

Finally, the impact of this study also lies in its potential to improve the quality and efficiency of PSCs. Through the identification of those factors that underlay the operational performance, the study can direct pharmaceutical companies into process improvement, cost reduction and safety service delivery to consumers.

### *6.2 Limitations of the Study and Future Research Directions*

This study focused on respondents' perceptions for assessing operational performance. Thus, future research could increase objectivity levels by introducing more measurable techniques like financial statements. This could enable researchers to validate findings and provide a comprehensive view of performance dynamics, paving the way for more robust and accurate assessments in the future. Furthermore, extending the study to other industries could offer broader insights into supply chain quality integration practices. Exploring diverse sectors would enrich understanding and facilitate cross-industry benchmarking, fostering innovation and adaptation of best practices across industries. Finally, future research could use longitudinal data to spot the evolution of supplier quality integration practices over time. This would enable researchers to capture temporal changes and longitudinal trends, providing deeper insights into their dynamic nature and adaptive potential. Longitudinal studies could also address the changes in respondents' perceptions over time and validate them against objective measures.

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