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Evaluating Performance Measurement Metrics for Lean and Agile Supply Chain Strategies in Large Enterprises

Benameur Dahinine [1], Abderrazak Laghouag [2,*], Wassila Bensahel [1], Majed Alsolamy [1] and Tarek Guendouz [1]

[1] Department of Management, College of Business Administration, University of Tabuk, Tabuk 71491, Saudi Arabia; bdahinine@ut.edu.sa (B.D.); wbensasel@ut.edu.sa (W.B.); malsolamy@ut.edu.sa (M.A.); tguendouz@ut.edu.sa (T.G.)

[2] Department of Business Administration, College of Business, King Khalid University, Abha 62552, Saudi Arabia

* Correspondence: alaghouag@kku.edu.sa

Abstract: Previous research has identified metrics that are applicable to both lean and agile strategies and has hypothesised that financial and efficiency metrics are more relevant to the lean supply chain strategy, while customer service and flexibility metrics are more relevant to the agile supply chain strategy. These metrics need to be assessed empirically to confirm their relevance and validate these hypotheses. Drawing upon contingency theory, which mandates that supply chain performance metrics should vary based on the supply chain strategy, the research methodology resulted in developing a survey instrument that has been subsequently tested in 45 large enterprises and analysed by Partial Least Square-Path Modelling using XLSTAT software v.2020.4. The results support the existing beliefs and suggest that financial and efficiency indicator sets are more applicable to the lean supply chain strategy, whereas customer service and flexibility indicator sets are more pertinent to the agile supply chain strategy. This research distinguishes itself, through its novelty, in validating an adaptable framework for supply chain performance metrics, acknowledging the necessity of developing a suitable supply chain performance system. Ultimately, the findings of this research might serve as an initial foundation for practitioners in shaping the design of supply chain performance systems since the strong relationship between SC strategies and specific metrics may serve as a strategic approach to evaluate and improve performance.

Keywords: performance metrics; lean SC strategy; agile SC strategy; PLS-PM method; strategy

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1. Introduction

The goal of every supply chain strategy is to boost the SC surplus. This requires efficient indicators to manage the working capital, information, product flow, and assets well [1]. The design of SC determines the contribution of each actor based on his capabilities to meet the needs of the market segment and related uncertainty [2]. Based on customer priorities and uncertainty level, the companies deal with two types of products, namely innovative and functional, for which two distinctive SC strategies could be developed, namely agile SC and lean SC. The success of an SC strategy depends strongly on the effectiveness of the performance measurement system. This latest finding presents an issue that is still attracting the attention of both researchers and professionals [3–5]. Without an effective SC performance measurement, managing SC activities and deploying SC strategies is impossible. The previous literature has revealed a significant contribution in terms of developing SC performance measurements. The enhancement of supply chain performance involves creating and applying metrics for evaluating both the collective and individual performances of each participant in the supply chain. All entities engaged in the process should adopt a well-rounded approach to identify and measure factors crucial to the supply chain. The performance measurement system should be designed to assist in implementing the supply chain strategy and facilitating the orchestration of the supply chain [6] as well

as ensuring its sustainability [7]. It is essential to oversee the execution of an SC strategy and highlight areas for enhancement. Performance measurement enables SC monitoring, yet, in reality, the measurement process is intricate and challenging to put into practice [8].

Lean and agile approaches can be seen not just as separate strategies but also as distinct sets of performance capabilities. The disparities between these strategies would manifest in the selection of performance metrics employed to oversee the implementation of each strategy [9]. Many researchers pointed out that performance measurement systems should align with the specific context, considering factors such as strategy and the design of the supply chain [7]. Most SC measurement systems present a weak connection between indicators and the strategy since there is a predominance of financial and cost indicators with a lack of a balanced vision, and more focus on internal processes rather than expanding the visibility to external processes and environment [5]. Knowledge gaps exist regarding performance measurement in lean and agile supply chains. Gunasekaran [10] emphasised the need to develop and integrate performance measurement into agile SCM. Naim et al. [11] suggested delving deeper into the performance characteristics of agile and lean strategies. Additionally, Ciccullo et al. [12] advocated the integration of sustainability dimensions with lean and agile strategies and metrics.

The absence of suggested metrics suitable for lean and agile supply chains highlights a need for empirical validation of their relevance. Current discussions predominantly centre on SC performance characteristics rather than specific measures. Consequently, this paper aims to address this gap by reviewing and validating metrics tailored to the requirements of lean and agile supply chains. In other words, this study aims to review and evaluate SC performance metrics to align them with supply chain strategies and attempts to answer the following question: what are the most relevant SC performance metrics for each supply chain strategy? In fact, the gained understanding resulting from addressing this research inquiry will hold significant theoretical and practical value. Initially, it enhances theoretical comprehension by thoroughly examining and consolidating previous research, ultimately proposing a conceptual framework for evaluating lean and agile supply chains. Additionally, the empirical findings empower supply chain managers and decision makers to optimise the development of supply chain performance systems and investments in information technology, concentrating exclusively on indicators and technologies that correspond with the specific requirements of the supply chain strategy. This study presents a detailed overview of supply chain performance metrics customised to suit both lean and agile strategies.

To address the research question, this paper followed a typical structure to ensure clarity and coherence. The first section is dedicated to understanding the concepts of supply chain strategies and performance measurement metrics and, then, the connection between each supply chain strategy, namely lean and agile, with their relevant metrics. This section helps develop the theoretical model and its appropriate research hypotheses. Afterwards, the methodology followed in this study to develop a research instrument and test it empirically is listed. Lastly, comprehensive data analysis, discussions, conclusions, limitations, and future research areas are presented.

2. Theoretical Background and Hypotheses Development

2.1. Supply Chain Strategies: Lean and Agile Strategies

Indeed, when developing an SC strategy, the latter must be defined in a way that allows each actor in the SC to contribute as much as possible to the creation of value since the competition, nowadays, exists between one SC and another SC rather than between one company and another. Mason-Jones et al. [2] explain that it is the characteristics of the products and of the market that govern the sharing of roles and responsibilities between the actors of the SC. Similarly, Fisher [13] confirms that the nature of the demand for a given product determines the development of the SC strategy. The present research identifies two types of strategies, depending on the nature of the products, that are either innovative or functional. Functional products are known for having low uncertainty, which makes

it advisable to adopt an SC strategy based on cost. In contrast, innovative products are characterised by a relatively high level of uncertainty resulting from the unpredictability of demand. This type of product requires an agile SC strategy to meet customers' evolving expectations. In this current study, we focus on exploring and analysing two sets of relevant metrics applicable to distinct supply chain strategies. The strategies under consideration are lean and agile, and we will elaborate on these in the following text.

The lean approach originates from the Toyota Production System (TPS). This concept focuses primarily on eliminating waste (Muda) [14]. Lean SC cannot easily adapt to changes in the market [15]. Concerning the tools to be used within the framework of the lean supply chain strategy, Melton [16], Basu and Wright [17], Carvalho and Cruz-Machado [18], and Gilaninia et al. [19] list some tools and give examples of how to mobilise them, knowing that there are others. Among these tools, there are: the Total Productive Maintenance method, 5S, Just-in-Time, Single Minute Exchange of Die, Zero Quality Control (or Jidoka), Poka Yoke, and Value Stream Mapping (VSM).

Agile SC is crucial to create customer value, attract new customers and enhance their satisfaction and loyalty. A well-managed and responsive supply chain reflects positively on a brand's reputation [20]. Brand experience helps transform satisfied customers into enthusiastic advocates or promoters of a firm's product, service, or brand (evangelists) [21]. Agile SC requires three main enablers: a collaborative network of partners, information systems and technologies, and knowledge management. The interaction among these three variables should improve responsiveness in the market [10,22–24]. Indeed, the critical characteristics of an agile organisation are flexibility [16,25], connectivity [26], integration of partners, structure dynamics, visibility of information along the SC [27], and market sensitiveness [14].

Table 1 summarises the characteristics of both strategies.

Table 1. Lean SC strategy vs. agile SC strategy.

	Lean SC Strategy	Agile SC Strategy	Related Researches
Definition	This strategy is based on cost reduction and flexibility, and process improvement, through the elimination of wastes generated by the existence of non-value added activities.	This strategy ensures that capabilities are developed to respond quickly to unpredictable changes in demand and supply (downstream/upstream flows).	[7,8,15–19,22–38]
Objectives	Low cost, high usage, minimum stock	Quick response, buffer capacity, deployed stock	
Organisational Structure	Low level of hierarchy levels	Virtual organisation with dynamic partnership	
Manufacturing Planning	Confirmed orders and reliable forecasts	Ability to respond quickly to different customer needs.	
Pricing	Low margin—price is an advantageous factor	High margin—price is a qualifying factor	
Supplier Selection	Selection is based on cost and quality.	Selection is based on speed, flexibility and quality.	
Product Life Cycle	Relatively long (+2 years)	Short (3 months–1 year)	
Collaboration with Partners	Traditional alliances such as operational level partnerships	Dynamic alliances (virtual organisation) that work on product design	
Product design Strategy	Maximise performance and minimise costs.	Product designs to meet individual customer needs.	

Table 1. *Cont.*

	Lean SC Strategy	Agile SC Strategy	Related Researches
Delivery Time Management	Reduction in delays as long as this does not penalise costs.	High investment in methods to reduce delays.	
Demand Structure	Precisely predictable demand with an average deviation of 10%.	Unpredictable demand with a deviation exceeding 50%.	
Inventory Management	High inventory turnover which is minimised along the SC.	Manufacturing based on customer demand	
Product Characteristics	Functional product, low variety, low margin	Innovative product, high variety, high margin	
Process Characteristics	Elimination of wastes, high efficiency, quality	Flexibility, market sensitivity, virtual network	
Enablers	Standardisation, quality improvement, trust between SC, Industry 4.0 technologies, kanban system.	Virtual enterprises, customer satisfaction, adaptability, Industry 4.0 technologies a collaborative network of partners, and knowledge management	
Main Performance Metrics	Efficiency, productivity, cost, inventory, delivery	Responsiveness, flexibility, joint planning, integration, information sharing, market sensitivity.	

2.2. Supply Chain Performance Metrics for Lean and Agile Strategies

2.2.1. Supply Chain Performance Systems: An Overview

Supply chain performance pertains to creating and applying metrics for the comprehensive evaluation of the collective and individual performances of each participant within the supply chain. All entities engaged in the supply chain should adopt a comprehensive and equitable strategy to recognise and gauge factors crucial for the entire supply chain [39]. Assessing performance is an essential managerial function within an organisation, tightly interwoven with other activities like planning, organising, motivating, and controlling [40]. Metrics can be organised into bands to establish a system for measuring performance that establishes connections among strategy, implementation, and value creation [41]. Measuring performance contributes to the development and clarification of strategy, the provision of management information, both vertical and horizontal communication, decision making and coordination, as well as motivation and learning [42]. The selection of metrics for measuring supply chain performance holds significant importance [43].

Many measurement systems have been designed to evaluate SC performance, such as SCOR (Supply Chain Operations Reference), EVALOG (Evaluation of Logistics), ASLOG (French Association for Logistics), and BSC models (Balanced Scorecard). The previous literature has revealed a significant contribution in terms of developing SC performance measurements: Beamon [3] distinguished four groups of SC metrics, namely, financial performance, efficiency, customer satisfaction, and flexibility. These metrics have been widely adopted in previous research. Shafiee et al. [5] collected most of the metrics and categorised them in terms of different dimensions as follows: (1) qualitative or quantitative indicators [3,4]; (2) purposive indicators such as cost, quality, delivery, flexibility, visibility, resource utilisation, collaboration, and coordination [44]; (3) hierarchical indicators: strategic, tactical, and operational [45]; (4) internal and external indicators: supply-side indicators, internal process indicators, and demand side indicators [46]; (5) the significant activities to satisfy a customer need are the Supply Chain Operations Reference Model (SCOR) model: plan, source, make, deliver, and return [47]. Similarly, Santos et al. [48] summarised the SC performance systems (SCPS) researched in the literature. For some researchers, developing an SCPS has been based on the Balanced Scorecard method (BSC), such as Park et al. [49] as well as Bhagwat and Sharma [50]. Some other researchers com-

bined BSC and SCOR models [51]. Laihonen and Pekkola [52] divided the SCP indicators according to their impacts on staff behaviour, and then organisational capabilities, and, finally, performance. Santos et al. [48] evaluated the previous systems' weaknesses regarding the dimensions of sustainability and then came up with a theoretical model that integrates economic, social, and environmental dimensions. Kruger et al. [53] followed the same path and developed a system for sustainable SC in the agricultural sector using the Delphi method. Zhang et al. [54] designed a typology to evaluate and manage green supply chain strategy. First, a list of 24 critical indicators has been identified based on the BSC Model and the SCOR Model. Varadejsatitwong et al. [55] proposed a procedural framework to measure SC performance, enabling the deployment of SC strategies. The proposed measurement has been developed by combining the PDCA approach with the evidence-based management (EBM) approach. The performance dimensions were divided into two types: (1) input performance that includes service quality, social and environmental, and inter-organisational relationships, and (2) output performance that englobes financial, efficiency, and effectiveness. Piotrowicz et al. [8] reviewed metrics and proposed a methodology for monitoring supply chains that are lean and agile. The literature is used to identify metrics that apply to both lean and agile methods, which are then divided into two groups to reflect each strategy. Although the researchers developed an applicable typology, their contribution remains theoretical and then destitute of empirical validation.

2.2.2. Matching SC Metrics with SC Strategy: A Contingency Theory

Contingency theory asserts that the effectiveness of a firm depends on how well its strategy aligns with a particular environment or situation. In other words, an organisation's performance results from its ability to converge its technological, financial, and human characteristics with the needs of the environment in which it operates [56]. Burns and Stalker [57] highlight the environmental impact on changing companies' structures. Eccles [58] recognised the increased necessity for all companies to continuously assess and adjust their performance metrics to adjust to the fiercely competitive and quickly evolving business environment. The underlying idea of the contingency approach to performance measurement is that there is not a single performance assessment applicable for every organisation in every situation [59]. Among the first to recognise that performance metrics needed to be periodically examined and modified to be relevant were Wisner and Fawcett [60]. They draw attention to the necessity of reconsidering the suitability of the existing performance measurement systems in light of the state of competition today. Bititci et al. [50] confirm this fact and recognise that dynamic performance assessment systems are necessary to account for shifts in internal and external environments. The main factors that push for change in performance measurement are consumer requirements, information technology development, laws and regulations, the nature of collaboration such as outsourcing or alliances, and future uncertainty [56,61]. The environment, organisational structure, and technology are the three types of contingent factors that Emmanuel et al. [62] claim impact the design of any performance assessment system. For our research, the contingency theory explains the relationship between the different types of supply chain strategies that have been designed according to contingency factors such as customer requirements, market segment characteristics, and environment uncertainty on one hand and performance measurement metrics on the other hand. The contingency leads to developing groups of suitable and applicable metrics for both supply chain strategies, lean and agile SC.

2.2.3. Specific Metrics for Lean Supply Chain Strategy

Indeed, performance in the context of lean supply chain is the result obtained from the efficient use of resources by eliminating all kinds of waste, including non-added value time. Lean supply chain can bring many benefits to the business through its philosophy, which states that a business should produce only what is needed, when, and where it is required [63,64]. According to this strategy, production is based on demand, which makes

the risk linked to cost and stock obsolescence shallow (use of Kanban). Thus, the processes are customer-oriented; therefore, only the activities which add value to customers are consolidated following a process mapping (VSM); regarding activities that do not add value, companies strives to eliminate these. Anti-error processes are developed (Poka-yoke and Jidoka as part of Kaizen), which improves product quality. Indeed, this logic of eliminating waste allows for the improvement of return on investment (ROI) and reduces logistics costs, such as storage costs, delivery costs, warehouse management, etc. [65]. In the same context, lean SC can boost quality based on rapid identification of problems, reducing non-quality cases. Thus, this strategy consists of improving and pushing productivity to a high level by acting on the efficiency of resources and not on the volume of resources by focusing only on activities that create value for customers. This strategy results in happier customers as long as products are delivered where and when customers need them. Thus, it contributes to reducing operational costs due to reducing inventories, which also improves the working capital requirement (WCR) [66]. Lean practices have been positively and significantly associated with SCM integration and organisational financial performance, according to the findings of Salah et al. [67]. Arrifu-azzaman [68] stated that profit per unit, logistics costs, production costs, total cycle time, purchase order cycle time, production time/piece and delivery lead time are highly important. Malmbrandt et al. [69] listed the following metrics: productivity, lead time, inventory turnover rate, quality and stock level. Govindan [70] highlighted the need to consider reducing inventory turnover rate and stock level costs. Hines [71] emphasised the fact that reducing costs should be linked to value and customer satisfaction. Piotrowicz et al. [8] studied the meaningfulness of SC performance metrics for each SC strategy. The most noticeable metrics for lean strategy are cost, profitability, productivity, efficiency, and an inventory program. By confronting the metrics proposed by Beamon [3], namely, financial performance, efficiency, customer satisfaction, and flexibility, with the metrics discussed in this section, it is said that organisations adopting lean strategies are called to give more importance to financial and efficiency metrics rather than the others. Consequently, the following hypotheses are formulated:

H1: *Financial and efficiency metrics are more relevant to the lean supply chain strategy than customer service and flexibility metrics.*

2.2.4. Specific Metrics for Agile Supply Chain Strategy

The agile supply chain strategy seeks to improve the performance of a company based on market knowledge supported by a virtual (electronic) existence to exploit opportunities in a volatile market [11,72,73]. This market knowledge helps improve flexibility to enable a company to adapt to changes in customer demand. Flexibility means the ability to change volume, flexibility in terms of product variety, flexibility in terms of delivery times, and flexibility in terms of innovation and new product development [24]. Thus, agile SC contributes to improving customer satisfaction by offering personalised products and services based on customer orders while ensuring rapid delivery [74]. Lee et al. [65] conducted an empirical study to test the causal relationship between agile SC and customer effectiveness and cost efficiency. The results show that customer effectiveness is the primary target of agile SC. Lin et al. [75] distinguished four sets of metrics for managing agile SC: responsiveness, competency, flexibility, and quickness. Some researchers stated that agility is predominantly associated with the responsiveness of services, attentiveness to customer needs, and the enhancement of customer satisfaction through a thorough understanding, analysis, and effective management of customer expectations. It also involves adeptly and efficiently addressing customer complaints [76,77]. Piotrowicz et al. [8] found that the most significant and substantial measurements for agile SC strategy are alertness, market responsiveness, quick services, cooperation, coordination, integration, adaptation, exchange of information, and flexibility. By confronting the metrics proposed by Beamon [3], it can be said that organisations adopting agile strategies are called to give more importance

to customer satisfaction and flexibility metrics. Consequently, the following hypothesis is formulated:

H2: *Customer service and flexibility metrics are more relevant to the agile supply chain strategy than financial and efficiency metrics.*

Drawing upon the discussion above, it can be concluded that the first two dimensions of performance metrics proposed by Beamon [3], namely, financial performance and efficiency, are much more applicable to the lean SC strategy, while the last two dimensions, namely, customer services and flexibility, are much more applicable to agile SC strategy. Figure 1 summarises the research hypotheses.

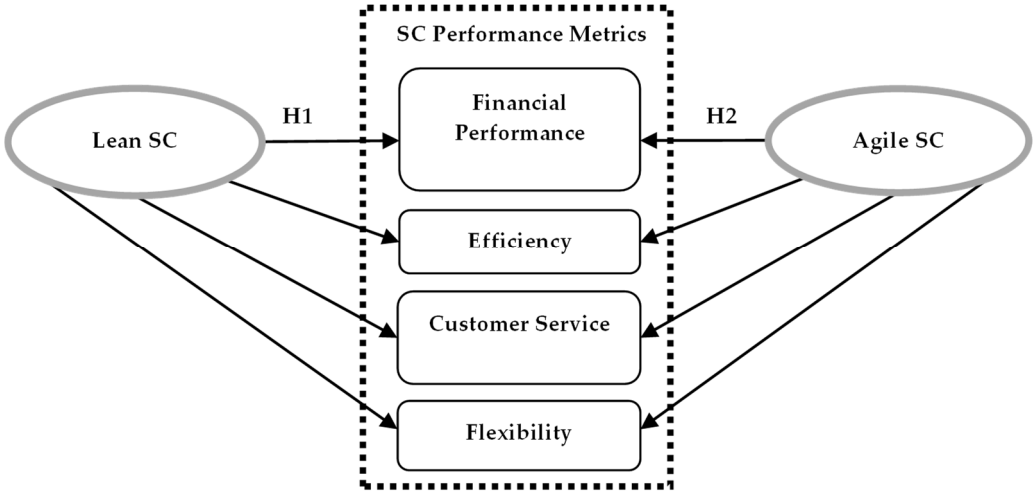

Figure 1. Research model.

3. Research Methods

3.1. Research Instrument Development

Research methodology refers to the precise steps or methods used to find, collect, and evaluate data on a subject to generate knowledge about its reality. As this study aligns with the post-positivism paradigm, the methodology relied on a quantitative approach through the development of a research questionnaire to get closer to the reality of SC strategies and their relationship with SC performance dimensions; the process took place in two main phases: (1) the development of the preliminary questionnaire and validation by a pre-test. (2) Then, this pre-test allowed us to make some modifications to obtain the final version of the questionnaire (Appendix A). The first phase consisted of developing the research instrument with the objective of determining the main constructs, which are mutually exclusive (discriminant validity), and their items, which are jointly exhaustive (convergent validity). These constructs and their items were developed based on an in-depth literature review. Table 2 below summarises all the constructs, their items, and the related research. The questionnaire employed a 5-point Likert scale regarding its benefits in supply chain research. The use of a 5-point Likert scale offers several advantages. (1) The simplicity and ease of understanding inherent in a 5-point scale make it particularly well suited for assessing the nuanced perceptions of participants regarding various aspects of SC strategy. (2) The balanced response options encourage respondents to express their opinions distinctly, helping to avoid a default to neutral choices. (3) Additionally, the scale's versatility allows for effective measurement of performance metrics related to SC strategies. (4) Furthermore, the time efficiency of collecting data through a 5-point Likert scale is beneficial when gauging the multifaceted dimensions of SC strategy and performance, making it a practical and widely accepted tool. Once the preliminary questionnaire was established, we moved on to the second stage, which was validating the questionnaire

before administering the final version. This validation was critical so that the research questionnaire could be generalised. Two main stages of the pre-test were carried out. First, the questionnaire was submitted to three academicians in SCM and a consultant and logistics auditor affiliated with the French Association for Logistics (ASLOG). The specialists contacted mainly aimed to assign facial validity by evaluating whether each item reasonably measured the construct concerned. In other words, is the level of representation quality of each item considerable? The specialists also checked the content validity to ensure the level at which the measured construct is represented. In other words, to what extent do the chosen items represent the construct they seek to measure? Indeed, the feedback from this first step allowed us to correct, modify, or eliminate a few items to develop a relevant questionnaire and provide an answer to our research problem. Once the questionnaire was completed, it was then subjected to a second pre-test with ten (10) companies in English and Arabic. The results obtained from this pilot study, as well as contact with a few respondents about the relevance of the questions, allowed us to eliminate three questions relating to SC strategies. Thus, we tested the reliability to ensure that all the items of the research instrument were consistent and did not change and measure the same construct that we were supposed to measure. Given that the research model should be tested with firms exhibiting a distinct and precisely outlined supply chain strategy, the study opted to select only large companies since they have well-established and mature supply chain strategies, leveraging advanced technologies and efficient processes to optimise their supply chain operations. These companies often have dedicated teams and resources focused on continuous improvement and innovation within the supply chain.

Table 2. Description of research instrument.

Axes	Construct	Items	Scales	Related Research
Supply Chain Strategies	Lean SC	4 items	Likert 1–5	[1,2,72,78,79]
	Agile SC	4 items	Likert 1–5	
Supply Chain Performance	Financial Performance	5 items	Likert 1–5	[3,55,79]
	Efficiency	2 items		
	Customer Service	4 items		
	Flexibility	4 items		
Total number of items		23 items		

3.2. Sampling Technique and Data Collection

As for the sampling method, the study adopted a simple random sampling method, which is a commonly employed sampling technique in quantitative research using survey instruments. It is argued that this method is advantageous when dealing with homogenous populations and is consistently selected [80]. Before we present the frequency of responses, it should be noted that only 45 out of the 110 organisations contacted by email (Via LinkedIn) responded, indicating a response rate of about 40%. In terms of the businesses themselves, about 73.33% of them are in the private sector, with the remaining 26.66% being public. Regarding firm type, production companies make up the bulk, accounting for more than 68% of the sample. Also, commercial firms make up about 23% of all of the firms. More than 6% of the businesses are service providers, and most work in the construction and public works sectors. Three per cent or less are providers of raw materials. Indeed, supply chain and logistics practices are apparent in these companies. This shows that the companies in our sample can respond quickly to the research questionnaire. Regarding the sector of activity, the companies in our sample operate in the agri-food sector (42.22%), public work sector (22.22%), pharmaceutical sector (15.55%), chemicals, and the para-chemicals sector (6.66%) as well as trading and negotiation sector (6.66%), mechanical sector (2.22%), metal-

lurgy (2.22%), and the transportation sector (2.22%). Regarding the level of competition, most of the companies we contacted are subsidiaries of worldwide corporations and so face international competition; roughly 60% of the enterprises operate in an international market. Also, organisations participating in national competitions account for almost 31% of our sample, but only 8.6% of the companies contacted participate in continental competitions. Lastly, our sample does not include businesses that compete on a regional basis. The findings reveal the flow management practices adopted by the contracted companies. The results indicate that over 51% of them use the make-to-stock strategy, and about 26% use the make-to-order strategy. Additionally, 20% of the firms develop projects using an engineer-to-order strategy. Lastly, only two firms use the assemble-to-order strategy.

4. Data Analysis

The PLS-PM method using XLSTAT software has been adopted for outer and inner model analysis. XLSTAT is a statistical software used for various applications, including descriptive statistics, hypothesis testing, and regression analysis). Partial Least Squares (PLS) is a statistical method used in structural equation modelling (SEM) and regression analysis. In PLS-PM, the emphasis is on predicting the dependent variables rather than explaining their variance. This method is also applicable when dealing with small sample sizes.

4.1. Outer Model Analysis

4.1.1. One-dimensionality Analysis and Composite Reliability

Regarding the one-dimensionality analysis and composite reliability, this study enables us to assess the reliability of each latent variable's significant dimensions and the dimensions themselves. One dimension must be identified for every latent variable. Table 3 below shows that, for our investigation, every single latent variable is unidimensional if one component or one factor has an eigenvalue significantly greater than one and a second less than one. As a result, the first component's value is higher than the critical value, and the eigenvalues of the other factors produced are lower than one. Consequently, to analyse the structural model and determine the relationships between the variables, only one dimension will be kept. Table 3 shows that both Dillon-Goldstein's Rho and Cronbach's Alpha coefficients are significant, indicating that the dimensions have remained reliable. For instance, the first dimension's eigenvalue, lean SC strategy (LSCS), is 2.0975, higher than the critical value (1), whereas the second dimension's eigenvalue is 0.8929. This demonstrates that the first dimension alone needs to be kept. As for the reliability of LSCS, Cronbach's Alpha is 0.6949 as well, and Dillon-Goldstein's Rho is 0.8141, which is highly significant. Similar results were obtained for the remaining variables, with the efficiency dimension (EFP) with the lowest eigenvalue (1.6622), although still significant, since the Dillon-Goldstein's Rho is more than 0.80 and the Cronbach Alpha values are more significant than 0.67 according to Table 3. According to Taber [81], an Alpha coefficient between (0.67 and 0.87) is reasonable. Consequently, all variables exhibit significant reliability, according to Taber. In other words, every dimension that was employed was trustworthy.

Table 3. One-dimensionality and composite reliability of latent variables.

Dimensions	Items	Cronbach's Alpha	Dillon-Goldstein's Rho	Critical Value	Eigenvalue
LSCS	4	0.6949	0.8141	1.0000	2.0975
					0.8929
ASCS	4	0.6745	0.8041	1.0000	2.0308
					0.8070
FIP	5	0.8595	0.8996	1.0000	3.2160
					0.7769

Table 3. *Cont.*

Dimensions	Items	Cronbach's Alpha	Dillon-Goldstein's Rho	Critical Value	Eigenvalue
EFP	2	0.7968	0.9078	1.0000	1.6622
					0.3378
CSP	4	0.8561	0.9029	1.0000	2.7983
					0.4931
FLP	4	0.8359	0.8922	1.0000	2.7079
					0.8103

Legend: LSCS: lean SC strategy; ASCS: agile SC strategy; FIP: financial performance; EFP: efficiency performance; CSP: customer service performance; FLP: flexibility performance.

4.1.2. Convergent Validity Analysis

Convergent validity refers to the ability of the items to address the same construct [82]. From Table 3, we can see that the average variance extracted (AVE) is more significant than 0.4 for all the variables, which shows that the manifest variables for each latent variable are sufficiently intercorrelated and converge well towards the latter. The ASCS variable is the exception. However, this difference is slight.

4.1.3. Convergent Validity Analysis

Discriminant validity refers to checking whether the latent variables do not represent or measure other variables they are not supposed to measure [82]. According to Table 4 below, the latent variables of our research model show a distinct variable since the R2 associated with each latent variable is less than AVE.

Table 4. Discriminant validity (R^2 < AVE).

	LSCS	ASCS	FIP	AFP	CSP	FLP	AVE
LSCS	1	0.4667	0.4858	0.1746	0.4219	0.2356	0.4711
ASCS	0.4667	1	0.2748	0.1507	0.4880	0.3582	0.3691
FIP	0.4858	0.2748	1	0.4218	0.4998	0.3579	0.5247
EFP	0.1746	0.1507	0.4218	1	0.3946	0.3742	0.7240
CSP	0.4219	0.4880	0.4998	0.3946	1	0.5461	0.5997
FLP	0.2356	0.3582	0.3579	0.3742	0.5461	1	0.6079
AVE	0.4711	0.3691	0.5247	0.7240	0.5997	0.6079	0

Legend: LSCS: lean SC strategy; ASCS: agile SC strategy; FIP: financial performance; EFP: efficiency performance; CSP: customer service performance; FLP: flexibility performance.

4.2. Inner Model Analysis (Hypotheses Testing Using PLS-PM Method)

This section will present an in-depth understanding of the relationship between SC strategies and SC performance metrics. The degree to which a supply chain strategy influences a particular performance metric directly correlates with the importance of that metric within the strategy. This signifies that metrics closely aligned with a specific supply chain strategy hold greater significance for the overall success and effectiveness. Consequently, supply chain strategies are expected to prioritise practices aimed at enhancing these pivotal metrics. For instance, in a lean supply chain strategy focused on minimising waste and optimising efficiency, inventory turnover or lead time metrics assume heightened importance, prompting the implementation of practices geared towards inventory management and process streamlining. Similarly, in an agile supply chain strategy emphasising responsiveness and flexibility, metrics such as customer response time or product customisation capability become paramount, leading to adopting practices geared towards enhancing agility and adaptability within the supply chain. Therefore, the alignment of supply chain strategy and performance metrics underscores the need for tailored practices to optimise these

critical metrics to drive overall strategy success. To validate the research hypotheses, the coefficient of determination, structural coefficient, and the percentage of the contribution to R^2 will be calculated and supported by a graphical representation of the importance of each performance metrics group.

In the upcoming point, the analysis will delve into calculating the coefficient of determination, a pivotal statistical measure used to assess the strength of the relationship between variables in our study. This essential metric provides valuable insights into how one variable can be predicted by another, laying the groundwork for a deeper understanding of our research findings.

Table 5 reveals a coefficient of determination of 0.4901, indicating that the two types of strategies influence over 49% of the financial performance. These strategies account for around 20% of the efficiency performance distribution, meaning that 19.44% of the Efficiency Financial Performance (EFP) is attributable to the variation in ASCS and LSCS. Similarly, the inner model analysis results demonstrate a coefficient of determination of 0.5437 for the CSP variable. This implies that more than 54% of the CSP data distribution stems from variations in the lean and agile SC strategies. Lastly, according to the results depicted in Table 4, lean and agile SC strategies contribute to approximately 37% of the data distribution regarding performance in terms of flexibility.

Table 5. Coefficient of determination for FIP, EFP, CSP, and FLP.

Performances Metrics	R^2	F	Pr > F	R^2 (Bootstrap)	Standard Error	Critical Ratio (CR)	Lower Bound (95%)	Upper Bound (95%)
Financial Performance	0.4901	15.3785	0.0000	0.5292	0.1369	3.5791	0.1570	0.8236
Efficiency	0.1944	3.8613	0.0315	0.2777	0.1527	1.2730	0.0237	0.6643
Customer Service	0.5437	19.0656	0.0000	0.6002	0.1548	3.5126	0.3040	0.8961
Flexibility	0.3692	9.3652	0.0006	0.4846	0.1301	2.8386	0.1974	0.7270

Following the presentation of the coefficient of determination, the subsequent stage involves computing the structural coefficient for FIP, EFP, CSP, and FLP.

Table 6 indicates that financial performance is predominantly influenced by the lean strategy, as evidenced by its structural coefficient of 0.6354, contrasting with the insignificant coefficient of 0.0902 for the agile strategy. Additionally, the findings underscore the continued significance of the lean strategy in determining efficiency, with respective structural coefficients of 0.2863 and 0.1926 for agile SC. Consequently, the findings highlight the notable association between lean strategy, financial performance, and cost optimisation. On the other hand, the analysis reveals that the agile strategy holds greater importance in the customer service dimension, with a structural coefficient of 0.4778 compared to 0.3231 for the lean strategy, indicating a solid linkage between customer services and the agile strategy. Moreover, Table 5 further demonstrates that the agile SC strategy exerts a more substantial impact on flexibility, as evidenced by its higher structural coefficient of 0.5005 compared to 0.1435 for the lean strategy, emphasising the robust connection between FLP and the ASCS.

Following the determination of the structural coefficient, the subsequent step involves calculating the contribution percentage to R^2 of the FIP, EFP, CSP, and FLP, providing additional insight into the variance explained by the model.

As indicated in Table 7 above, it becomes apparent that the lean SC strategy plays a predominant role in determining financial performance, accounting for over 90% of the R^2. In comparison, approximately 10% is attributed to the agile SC strategy, emphasising the lean SC strategy's focus on production costs and pricing to bolster sales. Additionally, the table illustrates that the lean SC strategy contributes more than 61% to the R^2 of business efficiency, whereas the agile SC strategy's contribution represents about 39% of the R^2. Conversely, it is evident from Table 6 that, for customer service, the agile SC strategy's contribution is more significant, exceeding 61%, while that of the LSCS variable represents

approximately 39%. Table 6 further confirms the predominance of the agile SC strategy in enhancing flexibility, with a contribution rate to R^2 exceeding 81%, while the proportion of LSCS represents approximately 19% of R^2. Consequently, an agile SC strategy has a more pronounced influence on performance in terms of services and customer satisfaction compared to a lean SC strategy, which is more closely associated with financial performance and costs. Figure 2 highlights the correlation between each performance's metrics and SC strategies.

Table 6. Structural coefficient for FIP, EFP, CSP, and FLP.

	LV	Value	Standard Error	t	Pr > |t|	f^2	Value (Bootstrap)	Standard Error (Bootstrap)	Critical Ratio (CR)	Lower Bound (95%)	Upper Bound (95%)
Financial Performance	LSCS	0.6354	0.1729	3.6758	0.0009	0.4222	0.5697	0.1975	3.2175	0.0397	0.9333
	ASCS	0.0902	0.1729	0.5216	0.6055	0.0085	0.1378	0.2335	0.3862	−0.4450	0.5023
SE* for FIP	Financial Performance (FIP) = 0.63537 × LSCS + 0.09016 × ASCS										
Efficiency	LSCS	0.2863	0.2173	1.3177	0.1970	0.0543	0.2826	0.2348	1.2192	−0.4539	0.7563
	ASCS	0.1926	0.2173	0.8866	0.3819	0.0246	0.1822	0,2628	0.7329	−0.5048	0.7618
SE* for EFP	Efficiency (EFP) = 0.28629 × LSCS + 0.19263 × ASCS										
Customer Service	LSCS	0.3231	0.1635	1.9762	0.0568	0.1220	0.3763	0.1623	1.9904	0.0255	0.7358
	ASCS	0.4778	0.1635	2.9223	0.0063	0.2669	0.4234	0.1908	2.5041	−0.3797	0.7375
SE* for CSP	Customer Service (CSP) = 0.32313 × LSCS + 0.47784 × ASCS										
Flexibility	LSCS	0.1435	0.1923	0.7463	0.4610	0.0174	0.2397	0.2008	0.7144	−0.1796	0.6968
	ASCS	0.5005	0.1923	2.6034	0.0139	0.2118	0.4718	0.2067	2.4214	−0.2981	0.8080
SE* for FLP	Flexibility (FLP) = 0.14347 × LSCS + 0.50052 × ASCS										

Legend: SE* = structural equation.

Table 7. Percentage of contribution to R^2 of the FIP, EFP, CSP, and FLP.

Impact and Contribution of Variables to:	Financial Performance		Efficiency		Customer Service		Flexibility	
	LSCS	ASCS	LSCS	ASCS	ASCS	LSCS	ASCS	LSCS
Correlation	0.6970	0.5242	0.4179	0.3882	0.6986	0.6496	0.5985	0.4854
Path coefficient	0.6354	0.0902	0.2863	0.1926	0.4778	0.3231	0.5005	0.1435
Correlation coefficient	0.4428	0.0473	0.1196	0.0748	0.3338	0.2099	0.2996	0.0696
Contribution to R^2 (%)	90.3560	9.6440	61.5368	38.4632	61.3956	38.6044	81.1378	18.8622
% cumulative	90.3560	100.0000	61.5368	100.0000	61.3956	100.0000	81.1378	100.0000

In summary, the results of the inner model analysis conducted using structural equation modelling (SEM) based on the PLS-PM approach reveal that both supply chain (SC) strategies, namely lean and agile, exert a positive influence on the four dimensions of supply chain performance: financial performance, efficiency, customer service, and flexibility. The direct effect of the lean SC strategy on these dimensions was 0.6354, 0.2863, 0.3231, and 0.1435, respectively, whereas the direct impact of the agile SC strategy was 0.0902, 0.1926, 0.4778, and 0.5005, respectively. Based on these findings, we can categorise the performance dimensions into two groups: the first group encompasses financial performance and efficiency, wherein the direct effects of the lean SC strategy were greater than those of the agile SC strategy, with respective direct effects of 0.6354 and 0.2863 for the lean SC strategy compared to 0.0902 and 0.1926 for the agile SC strategy. In contrast, for the dimensions of the second group, namely customer service and flexibility, the impact of the agile SC strategy surpasses that of the lean SC strategy, with direct effects of 0.4778 and 0.5005 from the agile SC strategy, while those from the lean SC strategy are 0.3231 and 0.1435, respectively.

Figure 2. Impact and contribution of LSCS and ASCS to FIP, EFP, CSP, and FLP.

5. Discussion

Aligning supply chain strategies with performance metrics is essential for enhancing overall operational effectiveness and achieving organisational goals. Companies can gain valuable insights into their efficiency, responsiveness, and customer satisfaction levels by ensuring that performance metrics are directly linked to supply chain strategic objectives. This alignment allows for continuous monitoring and evaluation of key performance indicators, enabling businesses to identify areas of improvement, optimise resource allocation, and drive strategic decision making. Ultimately, the synergy between supply chain strategies and performance metrics contributes to better-informed decision making, improved operational agility, and the ability to proactively address challenges, leading to sustained competitiveness and success in the ever-evolving business landscape.

The analysis of the data in this research study unveiled numerous intriguing discoveries. Initially, it is worth noting that financial performance measures, namely, turnover, ROI, market share, profit margin, total costs, and productivity, are more critical and should be considered in the context of the lean SC strategy more than performance measures in terms of customer services, such as the speed of delivery, rate of product innovation, flexibility in terms of product variety, etc. These measures are more important within the framework of the agile SC strategy. As mentioned in the theoretical background, the lean SC strategy is characterised relatively by a stable environment where customer demand is known. This strategy is relevant to customers who are willing to sacrifice product variety and delivery times to have a low price. So, to face competition in this type of customer segment, companies act on operational costs through a reduction in inventories as well as the improvement of working capital requirements to produce at the lowest price. On the other hand, the agile SC strategy is based mainly on product customisation, product variety, and delivery times, which justifies that this strategy is strongly linked to customer service and flexibility.

Regarding the research hypotheses, the findings affirm hypothesis H1, which posits that financial and efficiency metrics are more relevant to the lean supply chain strategy than

customer service and flexibility metrics. Specifically, financial performance and efficiency metrics exhibit a robust correlation with a lean supply chain rather than an agile supply chain. The results demonstrate that a significant proportion of the variance in financial performance metrics (including return on investment, return on sales, net profit before taxes, sales growth, and market share) attributed to a lean supply chain strategy. In contrast, the remainder is attributed to an agile supply chain strategy. Similarly, the lean supply chain strategy emerges as the primary determinant of efficiency metrics. This can be justified by the concentration of a lean supply chain strategy on production costs and prices to increase sales. Comparing these results with the previous studies, Lee [83] confirms the importance of SC integration with suppliers through a lean approach to enhance operational performance in terms of efficiency. Also, Piotrowicz et al. [8] proposed a framework, based on a systematic review, that regroups the primary metrics for a lean supply chain: profitability, cost, efficiency, and productivity. Vanichchinchai [84] concluded that achieving high performance with suppliers, especially in terms of costs, can be achieved through the implementation of lean manufacturing.

Similarly, the results affirm hypothesis H2, asserting that customer service and flexibility metrics are more relevant for the agile supply chain strategy than financial and efficiency metrics. Specifically, customer service and flexibility metrics strongly correlate with agile supply chain strategies. The findings indicate that the contribution of the agile SC strategy to customer service is more substantial, while that of the LSCS variable is comparatively less pronounced. In contrast to the previous dimensions, the agile SC strategy exerts a more significant influence on performance in terms of services and customer satisfaction compared to the lean SC strategy, which is more closely associated with financial performance and costs. Additionally, the results underscore the predominance of the agile SC strategy in enhancing flexibility, while the contribution of LSCS is relatively marginal. Comparing these results with previous studies, Piotrowicz et al. [8] confirmed this fact. They declared that the most dominant and noticeable metrics for the agile SC strategy are alertness, sensitivity to the market, rapidity, flexibility and adaptability, and information sharing. Also, Tarafadar and Qrunfleh [85] found a close relationship between the agile supply chain strategy and SC performance in terms of the ability to manage challenging non-standard orders, fulfil unique consumer requirements, create goods with a wide range of features, sizes, and colours, quickly modify capacity to increase or decrease production in response to shifts in client demand and finally to introduce numerous product enhancements rapidly.

6. Conclusions

The main objective of this study is to assess the relevance of SC performance metrics for both lean and agile SC strategies. To develop this framework, in-depth analysis of the existing literature about supply chain strategies and performance metrics has been carried out. This phase involved identifying distinctive characteristics of supply chain strategies and their applicable supply chain performance dimensions and metrics. To achieve the research goal, this study employed a quantitative approach based on a survey conducted for large enterprises since mature supply chain strategies and practices characterise these. The findings revealed that financial and efficiency metrics are more relevant to the lean supply chain strategy, while customer service and flexibility metrics are more related to agile supply chain strategy.

6.1. Theoretical Contributions

This study expands the supply chain performance evaluation understanding by delineating the key metrics applicable to lean and agile strategies. It advances theoretical insights through a comprehensive analysis and synthesis of prior research, culminating in proposing a conceptual framework for assessing lean and agile supply chains. Subsequently, the framework was empirically validated, with the results bolstering its theoretical underpinnings. The following theoretical contribution relates to methodology. This aspect

involves the development of a research model, validating its measurement scales, and testing hypotheses using structural equation modelling (SEM) with the PLS-PM approach.

6.2. Managerial Contributions

Regarding managerial and practical contributions, the framework outlined in this paper offers managers and decision makers a collection of essential metrics for lean and agile supply chains, serving as a foundational reference for developing organisational and, subsequently, supply chain performance systems. Furthermore, by offering insights into the foundational elements and competencies underlying each supply chain (SC) strategy, this research empowers SC managers and decision makers to streamline information system investments, focusing solely on technologies that align with the respective SC strategy's requirements. Drawing from empirical findings, this study introduces a comprehensive profile of SC performance metrics tailored to both lean and agile strategies.

6.3. Limitations and Future Research Scope

It is essential to recognise the limitations of this study, which provide avenues for future research. Firstly, this study employed a survey as its research methodology to examine the extent to which supply chain (SC) strategies are associated with SC performance dimensions and metrics, aiding in the development of metric groups for each SC strategy. While this quantitative approach utilised a questionnaire primarily derived from the existing literature, future research could incorporate a qualitative approach to capture expert perspectives and gain a deeper understanding of the relationship between SC strategies and pertinent metrics. Secondly, concerning SC performance metrics, this study utilised Beamon's typology, which is widely accepted among researchers, yet lacks insights into SC management practices and which drivers or capabilities require focus. Future research should identify critical drivers such as facilities, inventory, transportation, information, sourcing, and pricing for both lean and agile strategies and subsequently develop metrics for each driver to pinpoint weaknesses and optimise decision making. Thirdly, this study's methodology permits only correlational analysis at a specific time, thus precluding the establishment of causality beyond reasonable doubt. Future longitudinal research could provide deeper insights into relevant metrics for each SC strategy. Fourthly, this study did not consider sustainability's social and environmental dimensions or the combined "leagile" strategy, which are increasingly relevant in contemporary discourse. Developing frameworks for sustainable lean or agile supply chains poses challenges that warrant investigation in future studies. Fifthly, the results and discussions of this study pertain solely to firms serving a single market segment, while future research could explore firms serving multiple market segments. Sixthly, future studies could adopt a comparative analysis, examining different industries, manufacturing versus services, or various process designs. Lastly, future research could focus on developing comprehensive measurement frameworks that integrate triple bottom line considerations (economic, environmental, and social) across the entire supply chain for sustainable and resilient supply chains. This includes exploring the development of new metrics to capture circular economy principles, quantifying environmental footprints, assessing supply chain resilience to various disruptions, integrating life cycle assessment metrics, measuring stakeholder engagement, and evaluating the role of digitalisation and emerging technologies.

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Appendix A. Research Instrument

Axes	Construct		
Supply Chain Strategies	Lean supply chain For efficiency, our strategy consists of:	1	Meeting customer demand at the lowest possible cost.
		2	Designing standard products (the rate of product variety is low)
		3	Reducing production costs through manufacturing large quantities (economies of scale)
		4	Keeping storage costs as low as possible (Just-in-Time, for example)
	Agile supply chain For responsiveness, our strategy consists of:	5	Responding quickly to evolving customer demand requirements.
		6	Designing products and services that are easy to customise according to customer requirements.
		7	Ensuring production flexibility to cope with market uncertainty
		8	Building up safety stocks to manage market volatility.
SC Performance How do you rate your performance compared to your competitors in the following areas (1 strogly disagree to 5 strongly agree):	Financial Performance	9	Return on investment (ROI): net profit/total assets
		10	Return on sales (ROS): net profit/sales
		11	Net income before taxes
		12	Sales growth
		13	Market share
	Efficiency	14	Control of total costs (distribution costs, manufacturing costs, inventory management costs)
		15	Productivity
	Customer Service	16	Product quality
		17	Customer satisfaction
		18	Speed of execution and delivery of orders
		19	Delivery reliability
	Flexibility	20	Flexibility regarding volume (ability to easily change production volume)
		21	Flexibility regarding product variety
		22	Flexibility regarding delivery dates
		23	Flexibility in developing new products and services

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