SUPPLY CHAIN MANAGEMENT: RECONFIGURATION FOR HIGH CUSTOMIZED PRODUCTS IN THE AUTOMOTIVE INDUSTRY

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Abstract

This study, in the vein of previous research by Aichner and Salvador (2023) and Trentin et al. (2025), examines the reconfiguration of supply chains delivering hard customized products in Morocco's automotive industry. Using a rigorous quantitative approach through structural equation modelling (PLS-SEM) with a sample of 67 observations, it investigates the influence of key constructs such as supply chain network design (proximity, delivery modes) and supply chain capabilities (integration, process reengineering, human resources, outsourcing). The results reveal significant relationships between these variables and performance. Notably, network design promotes operational performance (flexibility, lead time, quality) and responds more effectively to market volatility, while capabilities remain driven by profitability and cost performance. This research provides valuable insights for automotive sector stakeholders aiming to produce and deliver hard customized products while controlling costs. Additionally, it offers guidance to researchers planning exploratory qualitative studies on the production and delivery of complex products, emphasizing that network configuration, rather than internal capabilities, plays a central role in this specific context, thus helping avoid misleading conclusions on a methodological level. Its findings underscore the importance of an integrated approach that balances a network oriented toward responsiveness with organizational practices focused on efficiency, enabling companies to meet the growing demand for hard customized offerings in a volatile market environment.

Keywords: Market Dynamics, Supply Chain, Capabilities, Network Design

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1. INTRODUCTION

As markets become increasingly volatile, supply chains are evolving through the adoption of specific configurations or models, such as the agile model, to better navigate growing turbulence (Nguyen, Le, et al., 2024), which means coping with volatile demand for volume and variety (Patel & Sambasivan, 2022; Do & Tran, 2024).

The agile supply chain model has progressively evolved since the early 2000s to enhance responsiveness and adaptability (Christopher, 2000). It emphasizes market sensitivity, supported by real-time information sharing and closer collaboration between supply chain partners. Other key aspects include focusing on core competencies through outsourcing, postponing product differentiation to remain flexible, and simplifying processes by reducing non-value-adding complexity. Over time, additional capabilities have been integrated into the agile model to enhance its adaptability, particularly through digitalization and the use of advanced technologies (Mak & Max Shen, 2021; Trentin et al., 2025).

However, by distinguishing between soft-customized products, which allow for postponement and complexity reduction, and hard-customized products, which do not (Aichner & Salvador, 2023), it becomes evident that the application of the agile model is largely limited to the former (Zheng et al., 2022).

The application of the agile model has certain limitations. Salvador et al. (2004), Salvador et al. (2009), and Aichner and Salvador (2023) conducted a series of studies distinguishing between soft customized and hard customized products. Their findings, supported by further research and field observations (Zheng et al., 2022), indicate that hard customized products do not accommodate strategies such as postponement and complexity reduction. As a result, the agile model proves to be applicable primarily to soft-customized products.

Given the limitations of the agile model in addressing the challenges posed by highly customized products in turbulent markets, the broader research project to which this article contributes aims to explore how supply chains can be configured for complex products in such unstable environments (Ben-Jebara & Modi, 2021; Jafari et al., 2022; Wang et al., 2024; Shen et al., 2025).

The empirical context chosen for this study is the Moroccan automotive industry — a sector that has rapidly grown to host a variety of companies from different countries, primarily from Europe and China (Boussas et al., 2018). Before addressing the central research question, this article focuses on analyzing the supply chain in this context by examining its dual relationship: first, with operational performance (in terms of flexibility, lead time, cost, and quality), and second, with market turbulence, measured by fluctuations in demand volume and variety. This leads to an impact study, framed around the following research question:

RQ: What impact do market dynamics have on the supply chain network as well as its capabilities, and these on its performance in the automotive industry in Morocco?

While methodologically this is a confirmatory study, the nature of the topic and context also lends it an exploratory dimension (Balambo & Baz, 2014).

The rest of the paper is structured as follows. Section 2 provides a comprehensive literature review and formulates the research hypotheses based on existing theoretical frameworks and empirical insights. Section 3 describes the research methodology, including the study design, data collection process, and the application of structural equation modelling using the partial least squares (PLS) approach. Section 4 presents the results of both the measurement and structural models. Section 5 discusses the empirical findings, highlighting the theoretical and managerial implications. Finally, Section 6 concludes the study, outlines its limitations, and suggests future research directions, particularly for qualitative and comparative explorations.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1. Supply chain models

The lean supply chain model remains primarily suited for stable and predictable markets due to its fundamental focus on efficiency and waste reduction rather than responsiveness to rapid demand fluctuations. Lean practices are especially effective when demand variability is low and the production environment is stable, allowing for optimal inventory management and cost minimization. However, when applied in turbulent or highly volatile contexts, the lean approach faces significant limitations, as it lacks the flexibility needed to rapidly adapt to changes in demand volume and variety (Rossini et al., 2022).

The agile supply chain model is particularly suited for volatile markets, emphasizing strategies such as postponement, market sensitivity, process integration, and the identification of strategic suppliers. Postponement involves delaying product customization until customer demand is clearer, enhancing flexibility and responsiveness (Patel & Sambasivan, 2022). However, this strategy is more effective for products with low customization rather than highly personalized items. Highly customized products often require early-stage specific configurations, making postponement less feasible. This limitation challenges the applicability of the agile model in markets characterized by significant changes in product mix or volume (Zheng et al., 2022), aspects which we will discuss in the following section.

2.2. Supply chain configuration and capabilities

Supply chain configuration and modeling involve developing tailored models to suit specific situations or markets. Recent research underscores the importance of customizing supply chain configurations to align with the unique demands of new product development and market dynamics. Sinha and Anand (2021) propose a multi-objective decision-making model that integrates supply chain management considerations into the new product development process, aiming to optimize total supply chain cost and time-to-market (Trentin et al., 2025).

Aichner and Salvador (2023) discuss strategies for aligning supply chain operations to deliver personalized products, emphasizing the role of customer-centric approaches in product development and distribution. This alignment is crucial for firms aiming to meet the growing demand for customized products without compromising on cost or delivery performance. For hard customized products, it is essential to have strategic suppliers located nearby and to maintain a short distribution chain. Proximity facilitates robust and seamless communication channels between suppliers and companies, fostering an environment where coordination is streamlined and potential disruptions can be addressed quickly.

Moreover, in complex product industries, firms leverage multiple capabilities to configure their supply chains for high customization and demand variability. Supply chain integration is crucial, as close alignment and information-sharing with suppliers and customers improve coordination and responsiveness, enabling quick product modifications to meet fluctuating requirements. Simultaneously, business process reengineering helps redesign and streamline production and logistics processes for greater flexibility and efficiency, which in turn promotes resilience and competitiveness in uncertain, variable-demand environments (Isaid et al., 2025).

Human resources play a crucial role in supply chain configuration, particularly when aiming for agility, adaptability, and responsiveness. Practices such as employee empowerment, teamwork involving diverse skills, and rotation across tasks enhance the workforce's flexibility and problem-solving capabilities, which are essential for managing dynamic and volatile markets (Hui et al., 2024; Kok & Akbari, 2024; Nguyen, Malik, et al., 2024).

Furthermore, firms use strategic outsourcing to enhance flexibility, tapping external partners for specialized tasks or surge capacity. Outsourcing can reduce internal complexity and transaction costs by streamlining product structures and processes, allowing companies to handle a broader variety of custom components while focusing on core competencies. Together, integration, process reengineering, human resources, and outsourcing form a synergistic configuration strategy that enables product customization and swift adaptation to complex, fluctuating demand (Sam & Islam, 2024).

H1a: Supply chain capabilities have an impact on supply chain operational performance.

2.3. Supply chain network design

Supply chain network design (SCND) involves the strategic configuration of supply chain components, including suppliers, manufacturing facilities, warehouses, and distribution centers, to optimize the flow of goods, information, and finances. A well-designed supply chain network enhances flexibility, reduces costs, and improves service levels, enabling firms to respond adeptly to market dynamics. In volatile markets characterized by frequent fluctuations in product mix and demand volumes, effective SCND becomes essential for maintaining operational performance and achieving strategic objectives (Ivanov & Dolgui, 2020).

Incorporating flexibility within the supply chain network is vital for coping with unforeseen changes. Strategies such as diversifying supplier bases, establishing multiple production sites, and maintaining modular production systems enable firms to manage demand variability and supply uncertainties more effectively (Zhang et al., 2025).

Aligning SCND with sustainability objectives also supports long-term operational success. Designing networks that minimize carbon emissions, optimize transportation routes, and promote responsible sourcing practices not only contributes to environmental goals but can also improve operational efficiency and cost-effectiveness (Mancini Cia & Cunha, 2024).

Ultimately, SCND addresses the challenge of managing a diverse range of products with varying life cycles and demand patterns. Effective SCND integrates approaches such as advanced demand forecasting and modular product design to better accommodate product variability and market fluctuations (Guo et al., 2024). Companies operating in low-volume, high-mix environments increasingly rely on part segmentation, dynamic stocking algorithms, and adaptive planning methods to manage complexity and maintain high service levels (Xiong et al., 2018). Recent research emphasizes that flexible and modular supply chain structures not only improve operational efficiency but also enhance the firm's ability to meet customized product demands in dynamic markets (Hossain et al., 2023).

H1b: The supply chain network design has an impact on supply chain operational performance.

2.4. Supply chain performance

Operational performance in supply chains refers to the efficiency and effectiveness of activities involved in delivering products and services to customers, encompassing dimensions such as flexibility, lead time, cost efficiency, and quality. Both supply chain capabilities and network design significantly influence this performance. Effective supply chain capabilities, including integration and resilience, enhance responsiveness to market changes, thereby improving operational outcomes (Junaid et al., 2023). Simultaneously, a well-structured SCND that considers factors like transportation reliability and facility location can mitigate risks and reduce lead times, contributing to overall performance (Müllerklein & Fontaine, 2025). Therefore, aligning supply chain capabilities with strategic network design is crucial for optimizing operational performance in today's complex and dynamic market environments (Trentin et al., 2025).

2.5. Market dynamics and volatility

Market dynamics refer to the forces that impact supply and demand within a market, influencing pricing, consumer behavior, and overall market behavior. These forces include economic conditions, technological advancements, competitive actions, and regulatory changes. Understanding market dynamics is crucial for businesses to adapt strategies effectively in response to evolving market conditions (Ross et al., 2024).

Market volatility, a component of market dynamics, describes the degree of variation in market prices over time, reflecting the uncertainty and unpredictability in market behavior. High volatility indicates significant price fluctuations, often resulting from factors such as economic crises, geopolitical events, or sudden changes in supply and demand. For instance, recent studies have shown that geopolitical risks, like military conflicts, can substantially increase volatility in energy markets, thereby affecting global economic activities. Additionally, supply chain disruptions, such as those experienced during the COVID-19 pandemic, have led to heightened market volatility by causing trade imbalances and widening the gap between supply and demand in commodity markets. Recognizing and managing market volatility is essential for businesses to mitigate risks and maintain stability in unpredictable environments (Bouri et al., 2025).

In this study, we define dynamic markets as those characterized by fluctuations in demand and a diverse product mix, particularly involving highly customized products that do not permit the use of postponement strategies. In such environments, supply chains face significant challenges in maintaining efficiency and responsiveness. Highly customized products often require early-stage specific configurations, making postponement less feasible and necessitating alternative approaches to meet customer requirements effectively (Lyons et al., 2020; Framinan, 2022; Zheng et al., 2022).

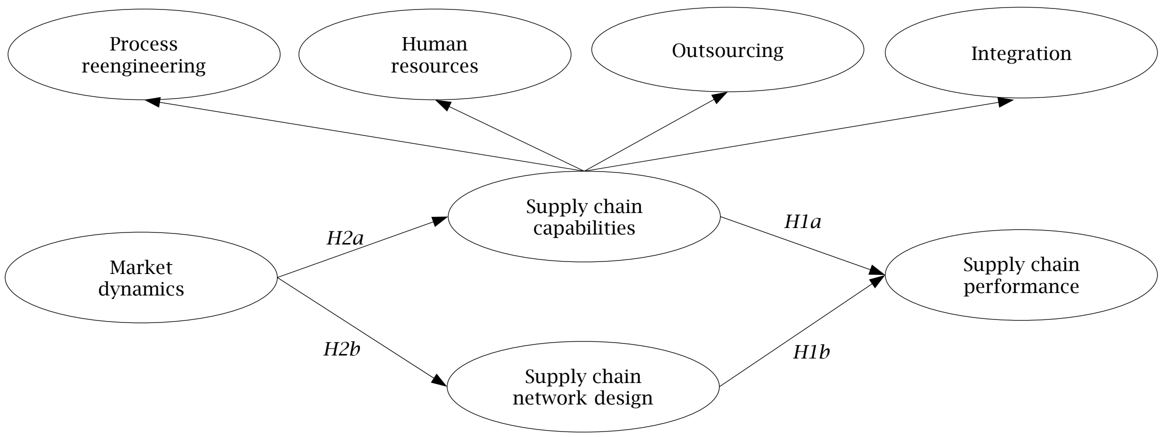
Such dynamic environments require firms to develop specific supply chain capabilities and to rethink their network design in order to maintain efficiency and responsiveness. Capabilities such as supply chain integration, human resource management, strategic outsourcing, and process reengineering are crucial to build flexibility and resilience under volatile conditions (Rajaguru & Matanda, 2019; Jena & Ghadge, 2021).

In parallel, supply chain network design must also adapt to turbulence by incorporating decentralized structures, flexible sourcing strategies, and geographically diversified suppliers, which have been shown to enhance resilience and responsiveness in uncertain markets (Guo et al., 2025).

H2a: Market dynamics positively influence supply chain capabilities.

H2b: Market dynamics positively influence the supply chain network design.

Figure 1. The conceptual model



Source: Authors' elaboration.

3. RESEARCH METHODOLOGY

This study adopts a quantitative, confirmatory research design aimed at investigating how market dynamics influence supply chain configuration — operationalized through two key constructs: supply chain capabilities and network design — and how these, in turn, affect supply chain performance. The ultimate objective is to understand which aspects of supply chain design are most critical in responding effectively to turbulent and highly customized markets, such as those found in the automotive industry. In line with this objective, a structured conceptual model was developed and tested using structural equation modelling (SEM).

To estimate this model, the PLS-SEM approach was selected. This technique is particularly suitable for studies involving complex models with multiple latent variables, especially when the theoretical framework is still evolving and the sample size is moderate. PLS-SEM offers the advantage of estimating both the measurement model (reliability and validity of constructs) and the structural model (hypothesis testing) simultaneously, while accommodating both formative and reflective constructs. This flexibility made it the most appropriate method for analyzing our conceptual framework.

Although the methodological posture is confirmatory, the research itself is part of a broader exploratory project focused on how supply chains can be configured to handle highly customized products in volatile environments. As emphasized by Balambo and Baz (2014), many logistics and supply chain studies adopt a confirmatory design while retaining an exploratory nature, especially when they seek to understand the nuances of context-dependent configurations. In this case, the aim is not merely to confirm a universally valid model, but to identify key variables and interactions that can guide future research and managerial choices. Hence, this confirmatory phase acts as a diagnostic stage, laying the groundwork for subsequent qualitative investigations to explore specific configurations in more depth.

Alternative analytical methods could have been considered. For instance, covariance-based structural equation modelling (CB-SEM) is often recommended when the objective is strong theory testing and the data meet assumptions of normality and large sample size. However, given the complexity of the model and the limited availability of respondents in this sector, PLS-SEM was deemed more appropriate. Similarly, multiple regression analysis would not have been adequate for handling latent constructs or the simultaneous modelling of multiple dependencies within the system.

The empirical study was conducted in the Moroccan automotive sector, which is characterized by increasing international investment and growing product complexity. The data collection relied on a validated survey instrument targeting supply chain managers and operations executives. A total of 67 valid responses were obtained, exceeding the commonly accepted 10-times rule in PLS-SEM (Chin, 1998), which ensures minimum statistical power given the model's complexity.

The modelling process followed the standard two-stage procedure: first, assessing the measurement model (including convergent and discriminant validity, and internal consistency reliability), and second, evaluating the structural model through path coefficients, explained variance (R^2), and the predictive relevance of endogenous constructs using SmartPLS 4.0. A detailed survey questionnaire was developed to operationalize the constructs, with each item corresponding to a specific aspect of the conceptual model. The full list of measurement items is provided in the Appendix.

4. RESULTS

Our structural model is complex since there are several explanatory variables and variables to be explained (the impact of market dynamics on the network and the capabilities and their impact on performance). In order to deal with model complexity, the structural equations method proves useful, as it allows the measurement of the effect of several variables on others (Roussel et al., 2002).

4.1. Evaluation of the measurement model: External validity

Before assessing causality, it is necessary to check the reliability and validity of the measurements. To assess convergent validity, it is necessary to consider the external or factor loading of the indicators and the average variance extracted (AVE). The former must have a value of at least 0.7 or more, while the latter must have a value of at least 0.5, which means that the construct explains more than half of the variance of its indicators. Otherwise, more variance remains in the item error than in the variance explained by the construct (Hair et al., 2013). It is therefore necessary to remove certain items whose saturation coefficient is less than 0.7. Otherwise, it is still possible to keep some if their saturation coefficient is between 0.4 and 0.7, which allows the improvement of the AVE. If its value is lower than 0.4, it should be removed (Bagozzi et al., 1991; Hair et al., 2011). Like Cronbach's alpha, composite reliability measures internal consistency, with a threshold of 0.7 (Netemeyer et al., 2003).

Table 1. Results of the measurement model: Convergent validity

Constructs	*Items*	*Loading*	*CR*	*AVE*
Market dynamics	*AV*	0.786	0.760	0.613
	HCP	0.779		
Process reengineering	*SPPD*	0.935	0.871	0.772
	EID	0.819		
Human resources	*HR2*	0.847	0.740	0.590
	HR3	0.680		
Outsourcing	*OS1*	0.978	0.773	0.644
	OS6	0.577		
Integration	*IC1*	0.580	0.703	0.522
	IC2	0.877		
Supply chain network design	*LDN2*	0.662	0.756	0.613
	LSN	0.887		
Supply chain performance	*C1*	0.720	0.769	0.455
	D1	0.590		
	F2	0.692		
	Q	0.691		

Source: Authors' elaboration.

The AVE for the *supply chain performance* variable is lower than 0.5 but remains above 0.4. According to Fornell and Larcker (1981), an AVE of 0.4 can be considered acceptable provided that the composite reliability exceeds 0.6. This condition is satisfied in the present case, with a composite reliability value of 0.758.

After confirming convergent validity, we move on to discriminant validity, the purpose of which is to check whether the latent variables are represented by themselves (Hair et al., 2013; Hubley, 2014). For this reason, the external loading of an indicator associated with its construct must be greater than any of its cross-loads.

Table 2. Discriminant validity: Cross-loading

Variables	*Market dynamics*	*Human resources*	*Outsourcing*	*Integration*	*Process reengineering*	*Supply chain network design*	*Performance*
AV	0.786	0.389	-0.140	0.178	0.091	0.344	0.178
HCP	0.779	-0.018	-0.228	-0.093	-0.110	0.439	0.350
HR2	0.173	0.847	0.273	0.449	0.293	0.164	0.585
HR3	0.204	0.684	-0.055	0.344	0.213	0.067	0.221
OS1	-0.269	0.149	0.978	-0.023	0.448	0.012	0.086
OS6	0.016	0.181	0.577	-0.130	-0.150	0.147	0.063
IC1	-0.352	0.309	0.054	0.580	-0.038	-0.182	0.068
IC2	0.275	0.453	-0.093	0.877	0.075	-0.066	0.317
SPPD	0.010	0.356	0.010	0.171	0.935	0.241	0.151
EID	-0.041	0.203	0.403	-0.177	0.819	0.451	0.382
LDN2	0.311	0.106	-0.228	-0.044	0.211	0.662	0.277
LSN	0.453	0.141	0.198	-0.157	0.337	0.887	0.501
C1	0.140	0.543	0.078	0.314	0.325	0.305	0.724
D2	0.220	0.149	0.442	0.341	0.031	0.234	0.594
F2	0.475	0.342	-0.014	0.428	0.114	0.400	0.692
Q	0.132	0.365	0.142	0.161	0.172	0.440	0.691

Source: Authors' elaboration.

It is also necessary to assess the discriminative validity (Fornell & Larcker, 1981). It compares the square root of the AVE values with the correlations of the latent variables, the aim being to avoid problems of multicollinearity (Hair et al., 2013; Ab Hamid et al., 2017).

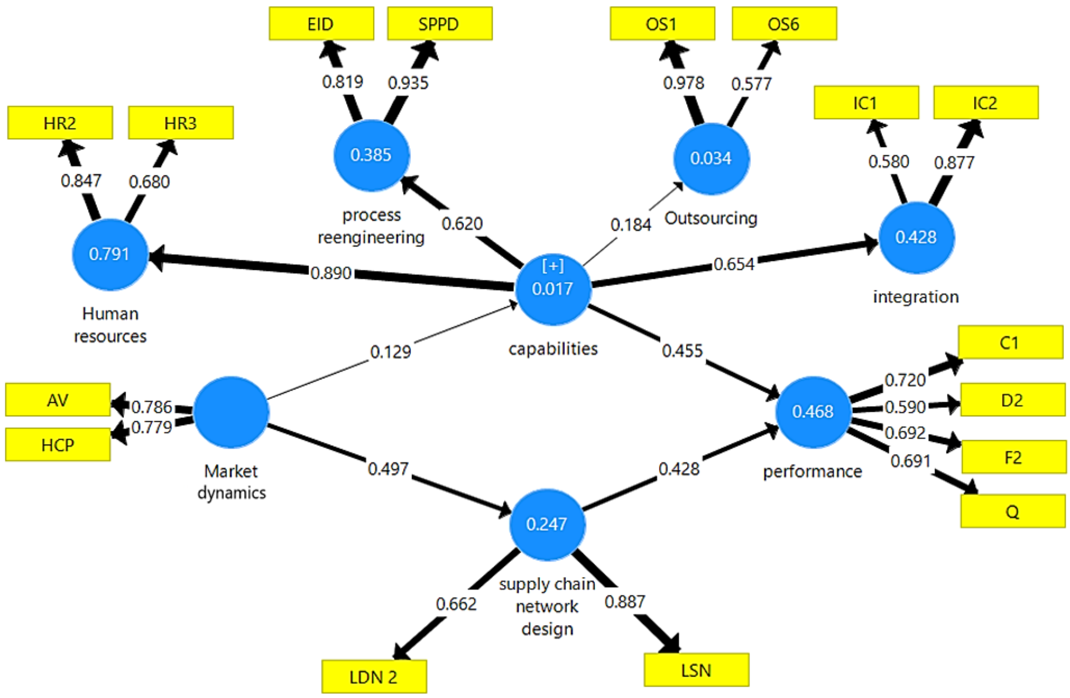
Table 3. Latent variable correlations

Latent variables	*Human resources*	*Market dynamics*	*Outsourcing*	*Integration*	*Performance*	*Process reengineering*	*Supply chain network design*
Human resources	0.768						
Market dynamics	0.239	0.783					
Outsourcing	0.174	-0.235	0.803				
Integration	0.521	0.055	-0.050	0.743			
Performance	0.556	0.336	0.091	0.293	0.675		
Process reengineering	0.334	-0.011	0.008	0.043	0.268	0.879	
Supply chain network design	0.159	0.497	0.045	-0.143	0.518	0.360	0.783

Source: Authors' elaboration.

As shown in Table 3, for each construct, the square root of the AVE exceeds the correlations with all other constructs, indicating satisfactory discriminant validity and the absence of multicollinearity issues.

Figure 2. Structural model (PLS-SEM results)



Source: Authors' elaboration.

The results of the PLS-SEM structural model analysis are presented in Figure 2. This figure displays the standardized path coefficients for each hypothesized relationship, as well as the R^2 values indicating the explained variance for each endogenous construct.

All latent constructs were measured through reflective indicators, with item loadings presented in the diagram. These items correspond to specific questions listed in the appendix, which detail the operationalization of each construct. The analysis allows for an evaluation of the strength and significance of the relationships between market characteristics, supply chain capabilities, supply chain network design, and operational performance.

4.2. Internal measurement model evaluation

In order to test the research hypotheses, the first step is to calculate the standard beta, the standard error, the t-value, and the p-value. The latter (the p-value) must be less than 0.05 (Hair et al., 2013).

Table 4. Path coefficient of research hypotheses

Hypotheses		Std. Beta	Std. Error	T-value	p-value	Decision
H1a	*Capabilities → Performance*	0.431	0.210	2.171	0.030	Supported*
H1b	*Supply chain network design → Performance*	0.475	0.153	2.791	0.005	Supported**
H2a	*Market dynamics → Capabilities*	0.113	0.320	0.404	0.687	Rejected
H2b	*Market dynamics → Supply chain network design*	0.505	0.153	3.257	0.001	Supported**

*Note: * moderate effect; ** strong effect.*
Source: Authors' elaboration.

According to the results in Table 4, *H2a* is rejected while *H2b*, *H1a,* and *H1b* are accepted. This may be explained by the relatively rigid nature of these capabilities in the short term and the strategic inertia often observed in established manufacturing systems. This result contrasts with studies emphasizing agile capabilities (Junaid et al., 2023) but aligns with Bouri et al. (2025), who argue that under uncertainty, firms tend to rely more on structural rather than organizational adjustments.

Table 5. Model quality test

Construct	R^2	Adjusted R^2
Performance	0.468	0.439
Capabilities	0.017	-0.011
Supply chain network design	0.247	0.226

Source: Authors' elaboration.

The structural model's explanatory power was assessed using the R^2 values for endogenous constructs (Falk & Miller, 1992; Chin, 1998). The results reveal distinct explanatory strengths for each construct:

Operational performance ($R^2 = 0.468$, adjusted $R^2 = 0.439$). The moderate R^2 indicates that 46.8% of the variance in operational performance (flexibility, lead time, quality) is explained by the combined effects of supply chain capabilities and network design. This aligns with Chin's (1998) benchmark for moderate explanatory power ($0.33 < R^2 < 0.67$), suggesting that the model captures a substantial portion of the performance drivers. The adjusted R^2 (0.439) further confirms robustness, accounting for model complexity.

Supply chain network design ($R^2 = 0.247$, adjusted $R^2 = 0.226$). The weak but significant R^2 (0.247) implies that 24.7% of the variance in network design is attributable to market dynamics. While this falls within Chin's (1998) "weak" range ($0.19 < R^2 < 0.33$), it underscores that market turbulence influences structural reconfiguration (e.g., proximity, delivery modes), albeit alongside other unmeasured factors (e.g., investment constraints, power dynamics among supply chain actors).

Supply chain capabilities ($R^2 = 0.017$, adjusted $R^2 = -0.011$). The negligible R^2 (0.017) and negative adjusted R^2 indicate that market dynamics alone fail to explain capability development (integration, human resources practices, outsourcing). This rejection of *H2a* (Table 4) suggests that capabilities are shaped by internal strategic priorities (e.g., cost efficiency) rather than external volatility, corroborating Bouri et al.'s (2025) findings on strategic inertia in turbulent environments.

The correlation coefficient measures the relationship between all exogenous variables with the endogenous variable. The effect size f^2, however, measures the degree of impact of each exogenous variable on the endogenous variable. The effect can be considered large for a value greater than 0.35, medium between 0.15 and 0.35, and small between 0.02 and 0.15. A value below 0.02 indicates that there is no effect (Cohen, 2013).

Table 6. Evaluation of f^2

Hypotheses	F^2	Effect
Market dynamics → Capabilities	0.017	No effect
Market dynamics → Supply chain network design	0.328	Moderate
Capabilities → Performance	0.374	Substantial
Supply chain network design → Performance	0.330	Moderate

Source: Authors' elaboration.

The impact of capabilities and network on performance is 0.374 and 0.330, respectively. This means that the impact of capabilities on performance is high, while the impact of the supply chain network is medium. The impact of market dynamics on capacity is to be rejected ($f^2 = 0.017 < 0.19$), while on the supply chain network is 0.328, considered as a moderate effect.

Regarding the predictive relevance of the model, Fornell and Larcker (1981) suggest that Q^2 must be greater than 0. If the value is negative, the model lacks predictive relevance. In our case, the Q2 is:

Table 7. Forecasting capacity Q^2

Latent variables	Q^2	Forecasting capacity
Capabilities	-0.011	No
Supply chain network design	0.11	Yes
Performance	0.162	Yes

Source: Authors' elaboration.

These results indicate that the model demonstrates a satisfactory predictive capacity for SCND and operational performance, as reflected by the positive Q^2 values. However, the model does not exhibit predictive relevance for capabilities, suggesting that market dynamics alone do not sufficiently explain the development of supply chain capabilities in this context. This result aligns with the earlier finding where the effect size (f^2) between market dynamics and capabilities was very weak, reinforcing the need to consider additional factors beyond market turbulence when analyzing capability-building mechanisms.

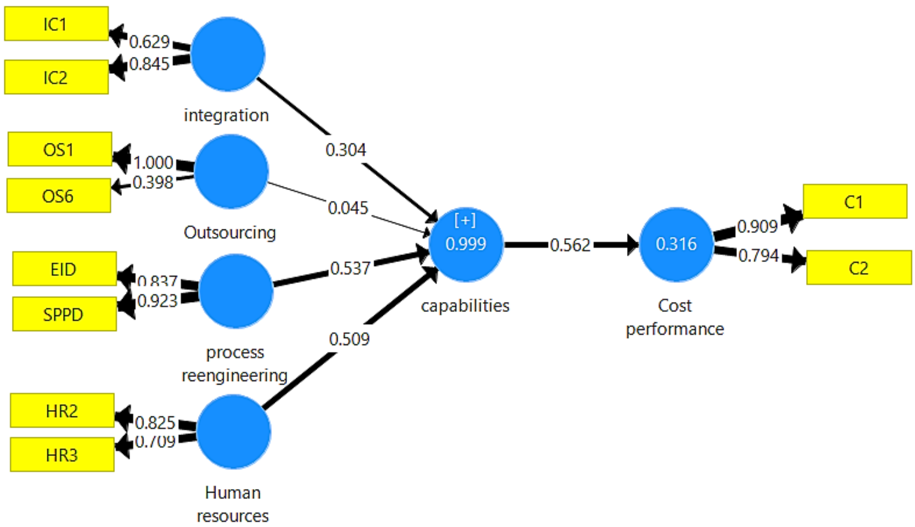
5. DISCUSSION

Our supply chain modeling distinguishes between supply chain practices and capabilities on one hand, and SCND on the other, both of which impact performance. A distinctive feature of our study is that it attempts to capture the complexity of the relationships between market dynamics, supply chain configuration, and operational performance simultaneously, an approach made possible through structural equation modeling. The value of this modeling approach is particularly evident in the interpretation of the results presented in this section.

Indeed, with a p-value lower than 0.05, both hypotheses *H1a* and *H1b* are confirmed. This being, supply chain performance is explained by the supply chain's capabilities (*H1a*) as well as by the design of its network (*H1b*). The f^2 of 0.374 of the capabilities versus 0.330 of the network design show that the capabilities play a more important role in determining supply chain performance. This aligns with the work of Junaid et al. (2023), who demonstrated that supply chain integration, resilience, and process reengineering enhance operational outcomes in complex and dynamic environments. Similarly, Hossain et al. (2023) emphasized the role of modular and responsive supply chain architectures in achieving operational agility.

Returning to the *H2*, the *H2a* is invalidated; its p-value is greater than 0.05, as shown in Table 4. Market trend or otherwise fluctuation in volume and variety does not explain supply chain capabilities. As for the *H2b*, this is confirmed with a p-value below 0.05. The design of the supply chain network is explained by market dynamics, and it can be said that it is designed to respond to the market trend. Its R^2 and f^2 are respectively 0.247 and 0.328. This shows that the relationship is moderate since the design of the network can be explained by other factors, as well as investment, the balance of power between the actors of the chain, and also by the fact that many factors in the market can evolve when the supply chain network remains unchanged.

Figure 3. The relationship between capabilities and cost performance



Source: Authors' elaboration.

It so happens that human resources are the linchpin in terms of supply chain capabilities, followed by integration, represented in our study by the coordination of operations and information sharing with the supply chain collaborators, and then process reengineering. As far as outsourcing is concerned, it does not show a strong dependence on capabilities, and to explain this, we will come later in this analysis.

That said, considering hypotheses *H1a* and *H2a*, it can be concluded that the supply chain capabilities do not adequately address the market trend, but still have an impact on supply chain performance. At first glance, this seems contradictory: How do supply chain capabilities meet performance requirements when they are out of step with the market trend?

Before delving into this inquiry, it is crucial to emphasize that it stems from the simultaneous modeling of the three variables — market dynamics, supply chain capabilities, and supply chain performance — made possible by the structural equation method. Without this integrated approach, the question at hand would not have arisen.

Returning to the question mentioned above, this is explained by the very fact that some supply chains give more importance to performance in terms of efficiency and profitability rather than responsiveness and availability of products to customers.

Table 8. The relationship between capabilities and cost performance

Hypothesis	*Items cost performance*	*Charge external item*	*p-value*	R^2
Capabilities → Cost performance	C1	0.909	0.004	0.316
	C2	0.794		

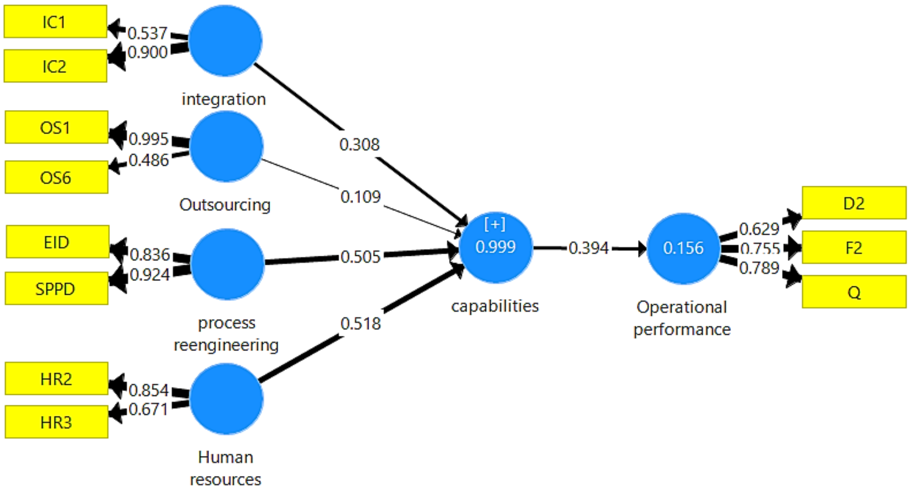
Source: Authors' elaboration.

Nowadays, many companies place more importance on cost performance than operational performance, which can have a negative impact on service. Indeed, the results of our research confirm this. Separating cost performance from operational performance (flexibility, quality, lead time), it turns out that supply chain capabilities depend on cost performance with an R^2 of 0.316; the relationship is confirmed with a p-value of 0.003. This reflects a managerial orientation toward efficiency and profitability, often at the expense of responsiveness. This pattern is also observed in recent studies by Isaid et al. (2025), who found that in certain contexts, capabilities tend to prioritize economic efficiency unless explicitly aligned with responsiveness strategies.

As for operational performance expressed in terms of flexibility, quality and lead time, its relationship with capabilities is confirmed with a p-value of 0.008 and an R^2 of 0.156 considered low.

From the analysis thus conducted, it becomes clear that capabilities are more oriented towards efficiency than operational performance, with a weak R^2 of 0.156. Nevertheless, they are still dependent on both types of performance.

Figure 4. The relationship between capabilities and operational performance



Source: Authors' elaboration.

Table 9. Evaluation of the relationship between capabilities and operational performance

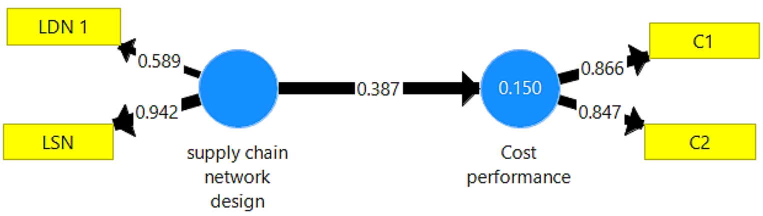
Hypothesis	*Items operational performance*	*Charge external item*	*p-value*	*R^2*
Capabilities → Operational performance	F2	0.755	0.008	0.156
	D2	0.629		
	Q	0.789		

Source: Authors' elaboration.

One of the most insightful findings of this study lies in the rejection of *H2a*: market dynamics do not significantly influence the development of supply chain capabilities ($f^2 = 0.017$). This contradicts assumptions found in earlier literature but finds resonance in the work of Bouri et al. (2025), who showed that firms under market turbulence often decouple short-term operational reactions from long-term capability development. In contrast, the confirmed relationship between market dynamics and network design (*H2b*, $f^2 = 0.328$) highlights how companies reconfigure their logistical and structural settings more readily than they transform internal practices.

If a similar analysis is carried out with regard to the SCND. The results in Table 10 show that the relationship between network design and cost performance is confirmed; its p-value is 0.042 (less than 0.05).

Figure 5. Relationship between supply chain network design and cost performance



Source: Authors' elaboration.

Also, the relationship between network design and operational performance is confirmed with a p-value of 0.004. The R^2 shows a result of 0.214. This demonstrates that the design of the supply chain network in the automotive industry in Morocco is conceived in such a way that it meets the requirements of operational performance in terms of quality, flexibility, and lead time, more than efficiency, although it takes into account both types of performance.

Figure 6. Relationship between supply chain network design and operational performance

Source: Authors' elaboration.

These results are consistent with the findings of Trentin et al. (2025), who argue that reconfiguring network structures, including proximity to customers, decentralized hubs, and flexible delivery systems, is key to maintaining responsiveness in volatile markets.

The tables below summarize the results analyzed.

Table 10. Evaluation of the relationship between network design and cost performance

Hypothesis	*Items cost performance*	*Charge external item*	*p-value*	R^2
Supply chain network design → Cost performance	C1	0.866	0.042	0.150
	C2	0.847		

Source: Authors' elaboration.

Table 11. Evaluation of the relationship between network design and operational performance

Hypothesis	*Items operational performance*	*Charge external item*	*p-value*	R^2
Supply chain network design → Operational performance	D2	0.702	0.004	0.214
	F2	0.742		
	Q	0.746		

Source: Authors' elaboration.

From a methodological point of view, Chin (1998) suggests that an R^2 between 0.19 and 0.33 is considered low. However, given the constraints on the supply chain network design, an R^2 of 0.214 remains significant. We recall that other factors explain it as well as investment, the balance of power between the actors of the chain, and also the fact that many factors in the market can evolve when the supply chain network remains unchanged. Table 12 summarizes the relationship between supply chain, performance, and market dynamics expressed by R^2.

Table 12. The relationship between supply chain, performance, and market dynamics expressed by R^2

	Cost performance	*Operational performance*	*Market dynamics*
Supply chain network design	0.150 (+)	0.214 (++)	0.247 (++)
Supply chain capabilities	0.316 (+++)	0.156 (+)	0.017 (-)

Source: Authors' elaboration.

6. CONCLUSION

This study examined the impact of market dynamics on supply chain capabilities and network design, and how these two dimensions influence operational performance in the Moroccan automotive industry. By distinguishing between capabilities (such as integration, human resources, process reengineering, and outsourcing) and network configuration (location proximity, delivery modes), our findings reveal that both constructs significantly impact supply chain performance, although in different ways. Capabilities are more closely associated with cost performance, reflecting a predominant orientation towards efficiency, whereas network design is more strongly linked to operational performance (flexibility, lead time, and quality), demonstrating an ability to respond to market turbulence and customer requirements.

Notably, the impact of market dynamics on supply chain capabilities was found to be insignificant, while its impact on supply chain network design was moderate and significant. This highlights that, in volatile environments, delivering highly customized products, reconfiguring the network structure may be more effective than relying solely on internal practices and capabilities.

However, this research is not without limitations. First, the study focuses exclusively on the Moroccan automotive sector, which may limit the generalizability of the findings to other industries or geographical regions. Second, although the structural model provides valuable insights, the relatively small sample size (67 observations) necessitates caution in interpreting the results, even if the PLS-SEM method is robust for small samples. Third, the study adopts a cross-sectional approach, which does not capture the dynamic evolution of supply chain configurations over time. Future research could thus benefit from longitudinal studies or comparative analyses across sectors. In particular, exploratory qualitative studies could deepen the understanding of the mechanisms underlying the relationships identified in this research. Such studies could use the findings of the present work as a foundation to examine how, in the context of highly customized products, it is more effective to focus on network design rather than solely on internal capabilities. While supply chain capabilities primarily enhance efficiency, network flexibility appears to be more critical for achieving responsiveness and supporting the production of highly customized products. Insights drawn from the automotive supply chain studied here could guide future investigations in other sectors facing similar customization challenges.

From a managerial perspective, the results suggest that companies operating in complex and dynamic environments should prioritize network flexibility and responsiveness. Decision-makers should invest in network design strategies such as supplier proximity, decentralized logistics hubs, and agile delivery systems to better meet operational performance goals. At the same time, while internal capabilities remain important, they should be aligned not only toward cost control but also toward enhancing flexibility and customer responsiveness through more agile human resource practices and reengineered processes focused on adaptability.

In sum, this study underlines the critical role of supply chain network design in responding to market volatility for highly customized products, while also shedding light on the nuanced role of capabilities, which, if not strategically oriented, may inadvertently prioritize efficiency at the expense of responsiveness.

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APPENDIX

Table A.1. Survey instrument for data collection

	Market characteristics and supply chain characteristics	*1*	*2*	*3*	*4*	*5*	*Item*
Q1	You face either a very stable demand in terms of volume (1) or a highly variable demand (5). Please rate according to the level of demand variation.						*AV*
Q2	Your customers request highly customized products; each time, the client may require different dimensions or options. More than a hundred variants according to different measurements/options (5). Customers request customized products with fewer than a hundred variants (4). Customers request moderately customized products, with about a dozen variants (2 to 3). Customers request standardized, non-customized products (1).						*HCP*
Q3	Your market is characterized by frequent structural changes. A structural change refers to a technological change in the product that requires modifying your manufacturing equipment.						*TD*
Q4	Do you resort to outsourcing in terms of capacity? Very frequently (5). Not at all (1). Please rate from 1 to 5 according to the frequency of outsourcing.						*OS1*
Q5	Do you resort to outsourcing for specialized activities (such as international transport monitoring and customs clearance)? Always (5). Very often (4). Not at all (1). Please rate from 1 to 5 according to the frequency of outsourcing.						*OS2*
Q6	Please indicate the extent to which you rely on outsourcing for specialized activities (e.g., national transport), from 1 (Not at all) to 5 (Always).						*OS3*
Q7	Please indicate the extent to which you rely on outsourcing for specialized activities (e.g., storage), from 1 (Not at all) to 5 (Always).						*OS4*
Q8	Please indicate the extent to which you rely on outsourcing for specialized activities (e.g., quality control), from 1 (Not at all) to 5 (Always).						*OS5*
Q9	Please indicate the extent to which you rely on outsourcing for specialized activities (e.g., manufacturing of certain components), from 1 (Not at all) to 5 (Always).						*OS6*
Q10	You collaborate with your main customer regarding transport, inventory, operations, etc. Very frequent collaboration (5). No collaboration (1). Please rate from 1 to 5 according to the frequency or level of collaboration.						*IC1*
Q11	Your main customer shares information with you regarding demand forecasting, orders, etc. Information sharing occurs very frequently or always (5). No information sharing (1). Please rate from 1 to 5 according to the frequency or level of information sharing.						*IC2*
Q12	Please indicate whether teams in your company work collaboratively with teams from your suppliers or customers.						*HR2*
Q13	Your company adopts a reward system that rewards employees who improve certain processes or solve specific problems.						*HR3*
Q14	Please indicate whether several teams simultaneously participate in the development of new products and manufacturing processes.						*SPPD*
Q15	Please indicate whether several departments (production, process engineering, quality, sales) participate in the development of new products.						*EID*
Q16	Please indicate your location relative to your main customer's plant: (5) Very close; (4) In the same country or a neighboring country; (3) In a nearby country; (2) Far away; (1) Very far away. If you have multiple customers or projects, please respond based on your closest customer.						*LDN 1*
Q17	There is no intermediary between your company and the manufacturer (5). There is one intermediary (4). There are two intermediaries (3). There are three intermediaries (2). There are four intermediaries (1). If you have multiple customers, please answer based on the customer involving the fewest intermediaries between your company and the manufacturer.						*LDN 2*
Q18	Your main supplier is located very close to your plant (5). In the same country or a neighboring country (4). In a nearby country (3). Far away (2). Very far away (1). Please answer based on your closest or main supplier.						*LSN*
	Supply chain performance	*1*	*2*	*3*	*4*	*5*	
Q19	You manage to meet your customers' demand despite its variation (variation in volume).						*F1*
Q20	You manage to manufacture a highly customized product; each time, the customer may request different dimensions or options. You manufacture more than one hundred different variants (5). You manufacture fewer than one hundred variants (4). The product is moderately customized (2 to 3 variants) (3). You manufacture and deliver a standard, non-customized product (1).						*F2*
Q21	You deliver good quality products with no returns due to quality defects. No complaints or returns (5). This rarely happens (4). It happens occasionally (3). It happens often (2). It happens very often (1).						*Q*
Q22	You believe that your manufacturing costs are within industry standards and are not very high. Costs are well controlled (5). Costs are not very high (4). Costs are more or less high (3). Costs are high (2). Costs are very high (1).						*C1*
Q23	You believe that your logistics costs (storage, handling, and transportation) are within standards and not high.						*C2*
Q24	The time needed to manufacture a customer's order is a few hours or less (5). A few days up to a maximum of one week (4). Between 2 and 3 weeks (3). One month (2). More than one month (1). In case of multiple production cycles, please answer based on the shortest cycle.						*D1*
Q25	The delivery time from your plant to the customer's plant is a few hours or less (5). A few days up to a maximum of one week (4). Between 2 and 3 weeks (3). One month (2). More than one month (1). In case of multiple delivery cycles, please answer based on the shortest cycle.						*D2*
Q26	The total time (order reception + manufacturing + delivery) is a few hours or less (5). A few days up to a maximum of one week (4). Between 2 and 3 weeks (3). One month (2). More than one month (1). In case of multiple cycles, please answer based on the shortest cycle.						*D3*