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The impact of proactive risk management, collaboration, and digital tools on supply chain performance in the Moroccan automotive industry

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A B S T R A C T

The automotive industry faces significant challenges stemming from market instability and supply chain complexities. This study examines how proactive risk management, collaboration with OEMs, and the adoption of digital tools influence supply chain performance in the Moroccan automotive sector. Survey data from 135 industry experts were analyzed using a structural equation modeling approach to test three hypotheses. The results show that proactive risk management significantly enhances service levels, while collaboration with OEMs strengthens risk management practices. Additionally, digital tools facilitate collaboration, albeit with a moderate overall effect. This research offers actionable insights for addressing uncertainties in automotive supply chains.

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1. Introduction

The automotive industry represents one of the most dynamic and complex supply chain environments globally. Recent disruptions, such as the COVID-19 pandemic, geopolitical instability, and environmental crises, have emphasized the need for proactive risk management, robust collaboration, and technological innovation. In Morocco, an emerging hub for automotive manufacturing, these challenges are particularly pressing as the sector strives to strengthen its global competitiveness (Echrigui et al., 2021; Kayouh & Dkhissi, 2024). The rapid growth of Morocco's automotive industry has been fueled by government incentives, strategic proximity to European markets, and significant infrastructure investments. However, the sector's increasing supply chain complexity, involving Original Equipment Manufacturers (OEMs) and Tier 1 suppliers, necessitates advanced strategies to address logistical and operational challenges. Prior studies highlight that effective risk management and stakeholder collaboration are crucial for enhancing operational performance, especially in volatile markets (Wahdan & Emam, 2017). Supply chain disruptions are not merely operational issues but strategic challenges that demand coordinated efforts across stakeholders. Research from Uncertain Supply Chain Management underscores the role of technology-driven solutions and integrated production planning in mitigating risks, improving service levels, and fostering competitive advantages (Allahham et al., 2024; Herath & Mittal, 2022) .However, these benefits are contingent on effective collaboration with OEMs, the adoption of digital tools, and the seamless exchange of information. Collaboration between Tier 1 suppliers and OEMs has been identified as a cornerstone of proactive risk management. High levels of trust and consistent information exchange enable stakeholders to better anticipate disruptions and align strategies. Additionally, digitalization, through tools such as artificial intelligence and data analytics, enhances predictive capabilities and supports real-time decision-making (Ali et al., 2024). This study investigates the interplay between proactive risk management, collaboration, and technological innovation within the Moroccan automotive supply chain. Using survey data from 135 industry experts, analyzed with structural equation modeling (SmartPLS 4), the research evaluates the impact of these factors on supply chain performance, focusing on service rates to OEMs. The findings provide actionable insights for stakeholders in Morocco's growing automotive ecosystem.

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2.Theoritical framework and research hypothesis

In this section, we will present a review of the literature on three important themes: digital tools (AI, data analytics, etc.), collaboration with OEMs, and supply chains proactive risk management. Then we will present the research hypothesis.

2.1. Artificial intelligence and data analytics

The rapid development and adoption of emerging technologies such as artificial intelligence (AI), big data analytics (BDA), machine learning, cloud computing, and blockchain have fundamentally transformed the way businesses operate. These technologies are integral to the digital evolution of industries, enabling organizations to address complex challenges, improve efficiency, and unlock new opportunities. Among these, big data has emerged as a cornerstone, driven by the massive amounts of information generated through social media, mobile technology, transactional systems, and other digital platforms (Juma & Kilani, 2022). Big data is characterized by its "four Vs": volume, velocity, variety, and veracity, requiring organizations to employ advanced data acquisition and analysis techniques to extract meaningful insights for strategic decision-making (Abuzaid et al., 2023). Big data analytics capabilities hinge on an organization's ability to gather, process, analyze, and visualize extensive datasets. This process includes steps such as data acquisition, mining, cleansing, and modeling. Advanced techniques like machine learning and predictive modeling are employed to uncover patterns and trends, enabling firms to adapt to dynamic market conditions and make data-driven decisions (Alzboun, 2023; Juma & Kilani, 2022). However, successfully leveraging big data analytics requires a seamless integration of infrastructure flexibility, robust management practices, and skilled personnel. Infrastructure flexibility ensures the adaptability of technological systems to evolving demands, while management capabilities encompass data governance, lifecycle management, and strategic planning. Personnel expertise in data processing, statistical analysis, and domain knowledge complements these efforts, enhancing a company's ability to derive actionable insights (Alzboun, 2023). Artificial intelligence has further revolutionized business processes by automating and optimizing operations. AI technologies offer significant advantages, including the ability to manage and analyze large-scale data with speed and precision. In supply chain management, AI enhances operational efficiency by enabling predictive analytics, demand forecasting, and real-time problem-solving. For instance, AI systems streamline warehouse operations, optimize delivery routes, and automate compliance processes, reducing costs and improving responsiveness (Ali et al., 2024; Sharabati et al., 2024). AI-powered bots also elevate customer engagement by providing personalized interactions, assisting with inquiries, and enhancing service quality, thereby fostering brand loyalty and competitive differentiation (Ali et al., 2024; Alshurideh et al., 2024).

The integration of AI with other Industry 4.0 technologies, such as blockchain and BDA, has shown transformative potential in supply chain risk management (SCRM). Blockchain technology ensures data transparency, traceability, and security, which are critical for fostering trust and reliability within supply chains. BDA, when combined with predictive analytics, enhances an organization's ability to anticipate and mitigate risks. For instance, risk alert tools, underpinned by AI and BDA capabilities, enable real-time risk assessments and improve decision-making processes. However, the adoption of these technologies also faces challenges, including AI apprehensions and the need for organizational change, which can moderate their effectiveness (Allahham et al., 2024; Kalbouneh et al., 2023). Beyond operational efficiency, AI and digital solutions also play a pivotal role in innovation and market adaptation. They serve as powerful tools for product development and customer interaction. AI-driven insights allow businesses to design tailored products, predict consumer behavior, and respond swiftly to market shifts (Hanandeh et al., 2024). Furthermore, AI's self-learning and natural language processing capabilities facilitate autonomous system operation, reducing human intervention and enabling scalability (Alshurideh et al., 2024).These technologies contribute to a reimagined digital economy, where firms are better equipped to manage small margins, large-scale operations, and rapidly changing environments (Sharabati et al., 2024). The implementation of these advanced technologies extends to enhancing supply chain resilience and sustainability. The integration of blockchain and AI in SCRM underscores their potential to strengthen supply chain performance by enabling predictive analytics, enhancing supply chain visibility, and automating key processes. Such advancements not only improve operational responsiveness but also drive competitive advantage through cost reductions, efficiency gains, and improved customer experiences (Kalbouneh et al., 2023; Salhab et al., 2023). In conclusion, the convergence of AI, BDA, and other emerging technologies has revolutionized how businesses operate, providing tools to analyze vast amounts of data, predict trends, and innovate effectively. These technologies empower organizations to optimize operations, foster customer engagement, and navigate the complexities of modern markets. However, realizing their full potential requires addressing challenges such as infrastructure adaptation, workforce development, and overcoming apprehensions related to technology adoption. As businesses continue to integrate these tools, they are better positioned to achieve sustainable growth and maintain a competitive edge in the digital age (Alshurideh et al., 2024; Juma & Kilani, 2022).

2.2 Collaboration tools

Collaboration with Original Equipment Manufacturers (OEMs) in the automotive sector has become a cornerstone for improving supply chain performance. Studies have consistently demonstrated that aligning objectives among supply chain partners fosters a collaborative spirit, ultimately leading to enhanced operational and strategic outcomes (Research Laboratory on Development and Valorization of Resources in Desert Zones, Laayoune Higher School of Technology, Ibn Zohr University, Agadir, Morocco et al., 2023). This alignment emphasizes the importance of joint participation in planning and

executing supply chain operations, where goal congruence becomes a critical factor in achieving superior performance metrics. Supply chain collaboration is defined as the joint effort of two or more independent organizations to plan, manage, and execute supply chain operations more effectively than acting independently (Ibn El Farouk et al., 2020).This collaboration often transcends simple cooperation or coordination, requiring a higher level of trust, commitment, and information sharing to meet customer demands with minimal costs. In the context of OEMs, long-term relationships built on trust and mutual benefit are essential for achieving competitive advantages and addressing complex challenges in global supply chains (Han et al., 2021). Collaborative relationships enable organizations to integrate resources, improve decision-making, and enhance the efficiency of supply chain processes. Trust and effective information exchange are foundational elements of these relationships, facilitating joint problem-solving and strategic planning. For instance,(Sadha et al., 2024) highlight that collaboration should occur both internally and externally to create seamless integration across suppliers, manufacturers, and distributors. Effective collaboration with OEMs often involves activities such as joint forecasting, resource sharing, and synchronized decision-making, which contribute to building a unified and valuable supply chain network. Strategic collaboration with OEMs provides significant advantages by allowing companies to adapt to market dynamics, mitigate risks, and improve resilience. For example, (Novijanti et al., 2023) emphasize that sharing product planning information, coordinating to meet demand, and aligning incentives are essential practices in such collaborations. These partnerships also create added value for consumers and foster a competitive position by leveraging collective expertise and resources. Furthermore, integrating artificial intelligence (AI) capabilities into collaborative efforts enhances supply chain flexibility and resilience. AI-driven predictive analytics can proactively identify risks, re-route shipments, or secure alternative suppliers, enabling OEMs to recover quickly from disruptions (Ali et al., 2024). Despite the numerous benefits of collaboration, challenges remain in fostering effective partnerships. Trust plays a dual role, with both competence trust and integrity trust being critical to collaboration. However, distrust can emerge due to cultural differences, contract complexities, or inconsistent performance expectations, particularly in international contexts.(Han et al., 2021) suggest that understanding the interplay between trust and distrust is crucial for sustaining collaborative relationships, especially when working with global OEMs. Ultimately, collaboration with OEMs is not merely about sharing information or coordinating efforts; it requires a deeper integration of systems, processes, and strategic objectives. This includes aligning incentives, managing shared risks, and fostering open communication to ensure long-term success. Effective collaboration can transform supply chains into resilient networks capable of adapting to dynamic market conditions and achieving sustainable growth. As the automotive industry continues to evolve, building robust collaborative frameworks with OEMs like Renault, Stellantis, and BMW will remain a vital strategy for driving innovation and competitiveness in the global market.

2.3 Proactive risk management

Proactive supply chain risk management (SCRM) has emerged as a critical domain within both academic and industrial landscapes. As globalization intensifies supply chain complexities, organizations are increasingly compelled to adopt robust SCRM practices to address the multifaceted risks they face. While the concept of risk management has been widely studied, its application to supply chains intersects two pivotal areas: supply chain management and risk management. Despite the proliferation of definitions in the literature, there is no single universally accepted meaning of SCRM, reflecting its dynamic and context-dependent nature (Kayouh & Dkhissi, 2024). SCRM can be broadly understood as the identification, evaluation, mitigation, and monitoring of risks across supply chain operations. (Emrouznejad et al., 2023) describe SCRM as implementing strategies to reduce vulnerability through continuous risk assessment and collaboration among supply chain partners. Similarly, (Tang & Tomlin, 2008) emphasize that effective SCRM requires the alignment of all stakeholders to address uncertainties that impact logistics, resources, and operations. These strategies aim to ensure continuity and profitability, particularly in an era of increasing exposure to systemic risks. This integrative approach has evolved into a cornerstone for managing risks across global supply chains, addressing everything from natural disasters to cyber-attacks (Emrouznejad et al., 2023). Modern SCRM frameworks typically follow four interconnected processes: risk identification, risk assessment, risk mitigation, and risk monitoring. Identification involves pinpointing potential threats at macro and micro levels, such as supplier failures, quality inconsistencies, or disruptions in transportation. Assessment follows, where the likelihood and impact of these risks are evaluated. Mitigation strategies are then applied, ranging from diversifying suppliers to investing in technology for improved visibility and resilience. Lastly, continuous monitoring ensures dynamic adaptation to changing conditions and emerging threats (Al-Ayed & Al-Tit, 2023). Notably, SCRM strategies are categorized into two dimensions: addressing risk causes and mitigating risk effects. Cause-oriented strategies emphasize preventive measures, such as selecting financially stable suppliers, relocating production to secure regions, and training employees in information security protocols. On the other hand, effect-oriented strategies aim to minimize the consequences of disruptions. For instance, organizations may adopt multi-sourcing models to enhance supply chain diversity or design standardized products to better absorb demand fluctuations (Al-Ayed & Al-Tit, 2023).These approaches exemplify how proactive SCRM enables organizations to anticipate and address risks before they escalate into crises. The evolution of SCRM reflects the growing importance of resilience and adaptability in supply chain management. Historically, risk management within supply chains was limited to internal operations. However, the globalization of trade and interdependence among firms has necessitated a shift towards more sophisticated and collaborative frameworks (Ding & Huang, 2024). As modern supply chains confront a diverse array of risks, from geopolitical tensions to natural disasters, the role of technology has become pivotal. Tools such as predictive analytics, blockchain, and real-time monitoring systems enhance risk visibility, enabling timely and informed decision-making (Emrouznejad et al., 2023). In addition to technological advancements, the human dimension of SCRM

cannot be overlooked. Effective communication, inter-organizational collaboration, and the establishment of roles like chief risk officers are crucial for fostering a risk-aware culture (Al-Ayed & Al-Tit, 2023). Sharing risk information across stakeholders not only builds trust but also ensures coordinated responses to emerging threats. This collaborative ethos is central to reducing vulnerabilities and strengthening the overall supply chain network. As global supply chains become increasingly complex, the significance of proactive SCRM continues to grow. By integrating preventive and responsive strategies, organizations can navigate uncertainties, reduce liabilities, and maintain operational continuity. These practices not only enhance organizational competitiveness but also ensure the sustainability of supply chains in an ever-changing global landscape.

2.4. Research Hypotheses

This section presents the theoretical basis and development of the research hypotheses, emphasizing the relationships between proactive risk management, collaboration with OEMs, and the use of digital tools in the context of the Moroccan automotive supply chain.

H_1: *Proactive risk management in the supply chain positively influences service levels toward OEMs.*

Proactive risk management (PRM) involves identifying potential disruptions and implementing measures to mitigate their impact before they occur. This approach is especially relevant in dynamic supply chain environments, such as the automotive sector, where disruptions can lead to severe consequences, including delays and financial losses. Studies suggest that PRM practices, such as supplier diversification and predictive analytics, enhance operational resilience and improve service performance metrics, such as on-time delivery rates. In the Moroccan context, Tier-1 suppliers dealing with OEMs benefit significantly from PRM by ensuring continuity in operations despite external shocks. Adopting PRM not only minimizes disruptions but also strengthens trust between supply chain partners, which is critical for maintaining high service levels (Herath & Mittal, 2022).

H_2: *Strong collaboration with OEMs facilitates risk management among Tier-1 suppliers.*

Collaboration in supply chains involves information sharing, joint planning, and synchronized operations between stakeholders. Strong relationships with OEMs enable Tier-1 suppliers to better anticipate and respond to logistical and production-related risks. Collaborative practices create a platform for real-time communication, which is essential for identifying potential risks early and addressing them effectively (Chang et al., 2015). The Moroccan automotive industry, which heavily relies on exports to Europe, demonstrates how OEM-supplier partnerships play a pivotal role in navigating market uncertainties. Prior studies have found that robust collaboration mechanisms reduce uncertainty and enhance the ability of suppliers to manage risks proactively. In line with this, we hypothesize that strong collaboration with OEMs positively influences the risk management capabilities of Tier-1 suppliers.

H_3: *The use of digital tools in risk management improves collaboration between Tier-1 suppliers and OEMs.*

The adoption of digital tools, including artificial intelligence (AI), blockchain, and data analytics, has transformed supply chain management practices. These technologies facilitate real-time monitoring, predictive analysis, and improved decision-making, which are vital for effective collaboration. For instance, AI-powered algorithms can analyze historical and real-time data to forecast demand fluctuations, enabling better alignment between Tier-1 suppliers and OEMs (Wahdan & Emam, 2017) In Morocco, where digital adoption is on the rise, these tools provide a significant opportunity for suppliers to enhance their responsiveness and transparency. Research has shown that digital tools reduce communication lags and foster trust by providing accurate and timely data Consequently, the integration of digital tools into risk management processes is expected to enhance collaboration between Tier-1 suppliers and OEMs. These hypotheses form the foundation of the study and are tested using structural equation modeling to understand their interdependencies and their impact on supply chain performance. The figure below represents the research hypothesis.

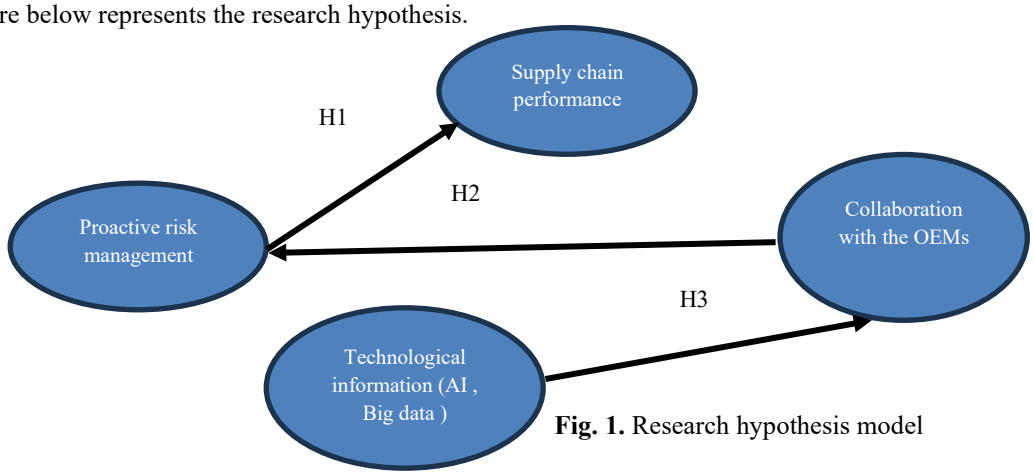

Fig. 1. Research hypothesis model

3. Research Methodology

3.1 Study Design

This research adopts a **quantitative methodology** to investigate the relationships between proactive risk management (PRM), collaboration with Original Equipment Manufacturers (OEMs), the use of technological tools, and logistics performance (PL) in Morocco's automotive supply chain. The study design is descriptive and correlational, focusing on analyzing the interplay of these constructs through a robust statistical model. The Moroccan automotive sector, as a growing hub for Tier-1 suppliers serving European OEMs, provides an ideal context for examining these dynamics. Automotive manufacturers and Tier-1 suppliers can be found in three main cities as demonstrated in the Fig. 2 below: Tangier, Kenitra, and Casablanca.

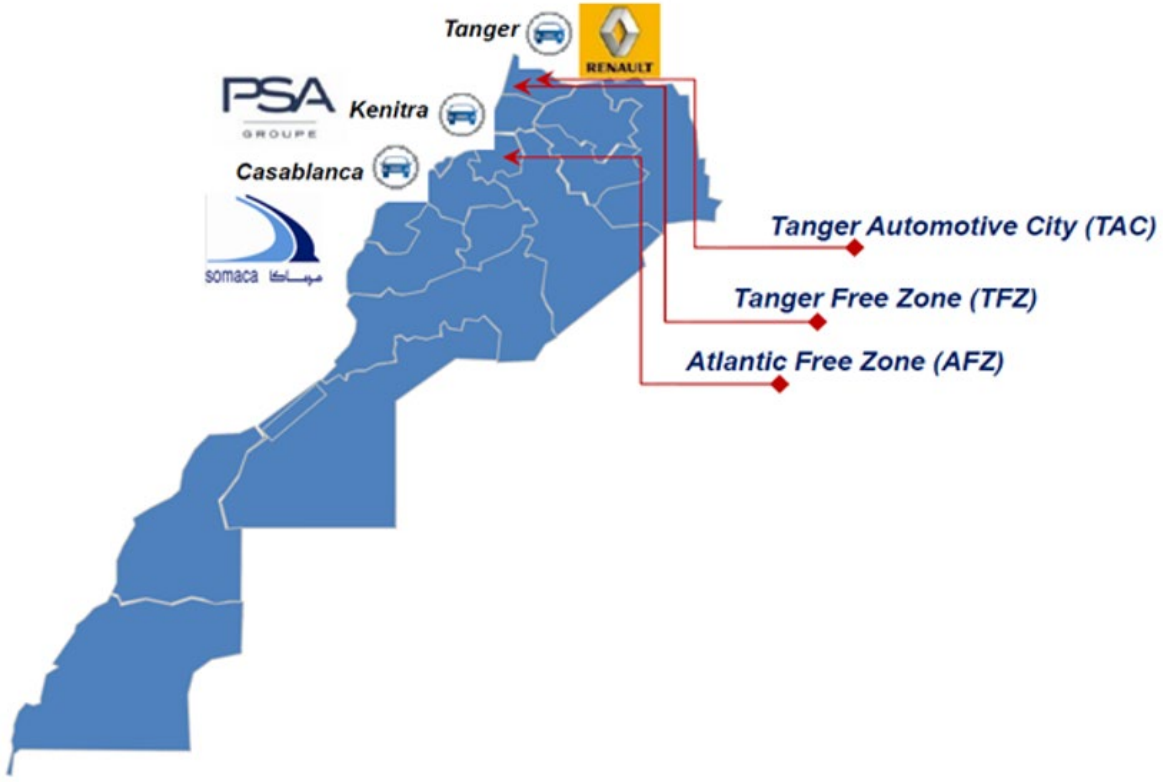

Fig. 2. Map of Morocco with the main automotive carmakers and free zones (*(6) La fiscalité du secteur de l'Automobile et des Zones Franches. De la maîtrise à l'optimisation | LinkedIn*, s. d.)

Experts in supply chain management, logistics operations, and risk mitigation were targeted to ensure high-quality insights. Participants represented a diverse range of companies, varying in size, market share, and experience levels, ensuring that the findings are generalizable across the industry.

3.2 Data Collection

The study employed a **structured questionnaire** to gather primary data. The questionnaire was designed to align with the theoretical constructs of the study and consisted of closed-ended questions to facilitate quantifiable analysis. The items were categorized as follows:

- **Proactive Risk Management (PRM):** Assessed through questions measuring strategies like supply base diversification, buffer stock policies, and predictive risk assessment practices.
- **Collaboration with OEMs (COEM):** Measured the frequency of communication, depth of information sharing, and joint problem-solving efforts with OEMs.
- **Technological Innovation (TI):** Evaluated the adoption of digital tools, such as artificial intelligence, data analytics, and blockchain, in managing risks and fostering collaboration.
- **Performance Logistics (PL):** Focused on operational metrics like service levels, delivery consistency, and responsiveness to disruptions.

A **Likert scale** ranging from 1 ("strongly disagree") to 5 ("strongly agree") was employed for all constructs to capture the intensity of participant opinions and ensure comparability.

To maximize the response rate, the questionnaire was distributed electronically to professionals identified through industry networks and associations. Of these, 135 valid responses were collected, participants were assured of confidentiality, and informed consent was obtained. Table 1 presents the working experience and the company size of the respondents.

Table 1
Working experience and company size

Item measurement	Descriptive	Percentage
Number of years of experience in Automotive sector	Less than 5 years	41.9%
	Between 5-10 years	42.6%
	More than 10 years	15.4%
Company size	Fewer than 100 employees	6.6%
	Between 100 and 500 employees	22.8%
	More than 500 employees	70.6%

3.3 Data Analysis

The data were analyzed using **SmartPLS 4**, a powerful tool for Partial Least Squares Structural Equation Modeling (PLS-SEM). This approach was chosen for its ability to model complex relationships, handle smaller sample sizes, and analyze reflective and formative constructs simultaneously. The analytical steps included:

Assessment of Measurement Model:

Reliability Testing: Cronbach's alpha and Composite Reliability (CR) were computed to ensure internal consistency. Acceptable thresholds (>0.7) confirmed reliability.

Convergent Validity: Average Variance Extracted (AVE) was calculated to ensure that the constructs adequately capture the variance of their indicators. AVE values exceeding 0.5 validated this criterion.

Discriminant Validity: The Fornell-Larcker criterion and cross-loadings were used to confirm that each construct is distinct from others.

Assessment of Structural Model:

Path Coefficients: Relationships between constructs were evaluated for magnitude and significance. A **bootstrap resampling** procedure (5,000 subsamples) was performed to test the significance of the hypothesized paths.

Coefficient of Determination (R^2): Assessed the proportion of variance in the dependent constructs explained by the independent constructs. R^2 values of 0.75, 0.50, and 0.25 were interpreted as substantial, moderate, and weak, respectively.

Model Fit and Predictive Relevance:

The **Standardized Root Mean Square Residual (SRMR)** was computed to assess model fit, with values below 0.08 indicating an acceptable fit.

The **predictive relevance (Q^2)** of the model was evaluated using a blindfolding procedure, confirming the model's robustness.

3.4 Justification for the Methodology

The PLS-SEM approach was chosen for its flexibility and suitability for exploratory research, particularly in fields where theoretical models are still evolving, as is the case for supply chain risk management in developing economies. Additionally, SmartPLS 4 allows for robust handling of multicollinearity, making it ideal for analyzing constructs with interdependent relationships, such as collaboration, technological innovation, and risk management.

4. Research Results and Discussion

4.1 Key Findings

The analysis reveals several significant relationships between the constructs under investigation, providing support for the proposed hypotheses. Figure 3 demonstrates the results obtained in SMARTPLS 4.

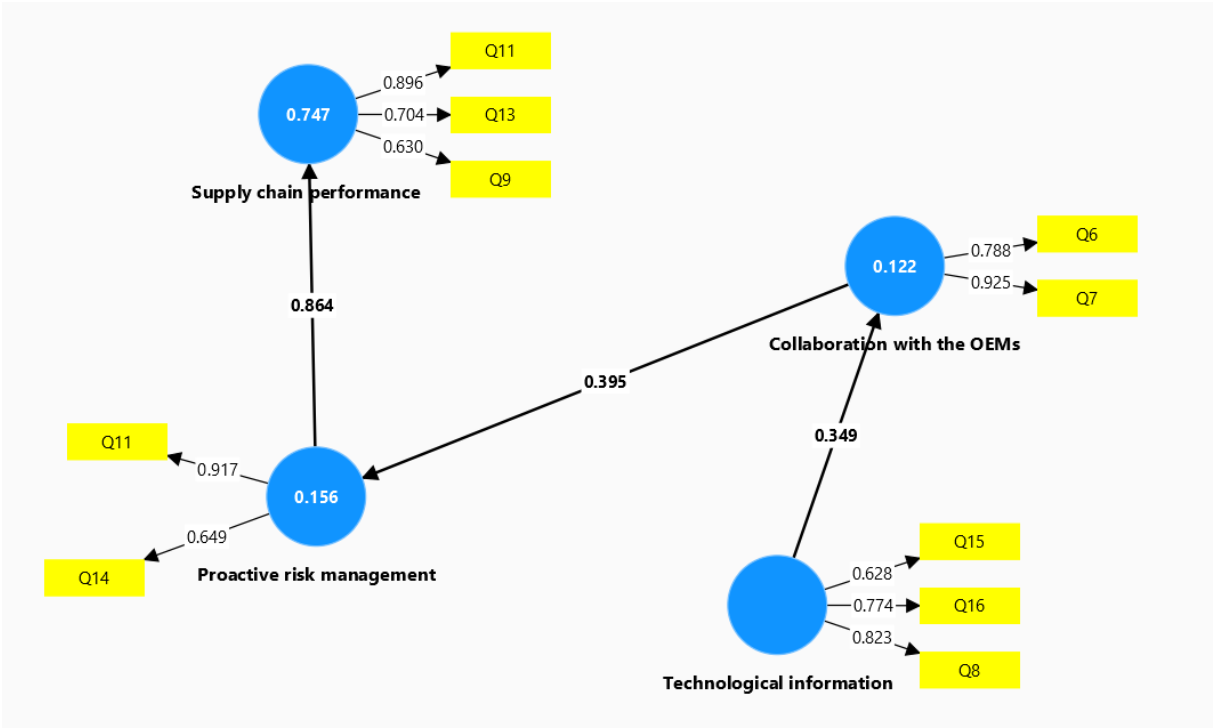

Fig 3. Results after the SMARTPLS4 simulation

1. **H1 Supported:** Proactive risk management (PRM) demonstrates a **strong and positive influence** on performance logistics (PL), with a path coefficient of **0.864** and a significance level of **p < 0.001**. This relationship explains **74.7% of the variance** in logistics performance, underscoring the critical role of proactive measures, such as supplier diversification and inventory management, in ensuring high service levels amidst uncertainties.

2. **H2 Supported:** Collaboration with OEMs (COEM) has a **moderate positive impact** on proactive risk management (path coefficient = **0.395**, **p < 0.001**). This finding highlights the enabling role of strong partnerships, characterized by information sharing and joint problem-solving, in enhancing risk management capabilities.

3. **H3 Moderately Supported:** The use of digital tools (TI) positively affects collaboration with OEMs, with a path coefficient of **0.349** (**p < 0.001**). However, the explained variance for collaboration (R^2 = **12.2%**) indicates a **moderate effect**, suggesting that while technological tools improve collaboration, other factors may also play a significant role.

4.2 Discussion

The findings provide empirical evidence for the importance of integrating proactive risk management, collaboration with OEMs, and digital tools in improving supply chain performance within the Moroccan automotive industry.

The first hypothesis: Proactive Risk Management and Logistics Performance

The strong influence of PRM on logistics performance reflects the growing emphasis on resilience in supply chains. This is consistent with existing research, such as (Hezla et al., 2020) which highlights the role of proactive strategies in mitigating disruptions and ensuring operational continuity. In the context of Morocco, the automotive supply chain faces unique challenges, such as geopolitical instability and fluctuating global demand. PRM practices, therefore, serve as a critical mechanism for maintaining service levels and meeting OEM expectations.

The second hypothesis: Collaboration with OEMs and Proactive Risk Management

The positive relationship between collaboration and PRM aligns with prior studies emphasizing the importance of strategic partnerships in risk management (Herath & Mittal, 2022). Collaborative practices, such as synchronized production planning and real-time data sharing, enable Tier-1 suppliers to anticipate and address risks effectively. However, the findings also suggest that Moroccan suppliers may need to strengthen their collaborative frameworks to maximize these benefits fully. Cultural factors and varying levels of trust between partners could influence the extent of collaboration.

The third hypothesis: Digital Tools and Collaboration

The moderate impact of digital tools on collaboration reflects the potential of technology to transform supply chain interactions. Digital tools, such as AI and data analytics, enhance transparency and responsiveness, creating a foundation for stronger partnerships. However, the relatively low R^2 value (12.2%) suggests that barriers to digital adoption persist in the Moroccan context, such as inadequate infrastructure and limited digital literacy among some stakeholders. These challenges align with findings in previous research, such as Chang et al. (2016), which highlight the importance of organizational readiness in realizing the full potential of digital transformation.

5. Conclusion

This study significantly contributes to the existing literature on supply chain management by providing empirical evidence on the interrelationships between **proactive risk management**, **collaboration with OEMs**, and **technological tools** in enhancing logistics performance. The findings underscore the importance of **proactive risk management** strategies in mitigating disruptions and achieving high service levels, particularly in an uncertain environment like the Moroccan automotive sector. In addition, the study demonstrates that collaboration with OEMs plays a vital role in strengthening risk management practices, emphasizing the need for robust partnerships.

For **practitioners**, the study highlights that investing in proactive risk management strategies is not only crucial for improving logistics performance but also essential for sustaining long-term competitiveness. Tier-1 suppliers should prioritize building strong, collaborative relationships with OEMs to leverage shared knowledge and resources in managing risks effectively. Additionally, fostering the adoption of **digital tools** will enhance information sharing and decision-making, ultimately leading to more agile and resilient supply chains.

For **policymakers**, the study suggests that boosting **digital infrastructure** should be a priority to enable the growth of the Moroccan automotive industry. Given the moderate impact of digital tools on collaboration in the current study, targeted policies could help address the barriers to technology adoption, such as enhancing internet connectivity, promoting digital literacy, and supporting companies in their digital transformation efforts. This will be key in fostering a more interconnected and efficient supply chain ecosystem in Morocco.

Limitations and Future Research

Although the study offers valuable insights, several limitations should be acknowledged. First, the research is limited to the **Moroccan automotive sector**, which may restrict the generalizability of the findings to other industries or regions. The context-specific challenges of Morocco—such as its evolving digital infrastructure, unique market conditions, and specific risk management practices—may not be fully representative of other emerging or developed markets. Future studies could address this limitation by conducting **comparative research** across different countries or regions to determine whether the identified relationships hold true in different industrial contexts.

Furthermore, the study primarily focuses on **Tier-1 suppliers** and OEMs, but the role of other supply chain actors, such as **Tier-2 suppliers** or logistics service providers, remains unexplored. Investigating their influence on supply chain risk management could offer a more comprehensive understanding of supply chain dynamics.

Additionally, **market dynamics** (e.g., supply chain disruptions, market volatility, and economic instability) and **cultural factors** (e.g., trust, communication styles, and management practices) could further influence supply chain performance, and exploring these dimensions could enrich future research. Understanding the broader contextual factors will help better understand how different organizational and environmental elements interact in shaping logistics performance and risk management practices.

In conclusion, while the study provides valuable insights into the role of proactive risk management, collaboration, and technology, it opens avenues for further investigation into the complex factors driving supply chain performance and resilience. By expanding the scope to include other regions, industries, and contextual factors, future research could continue to advance the understanding of supply chain management in an increasingly interconnected and technology-driven world.

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