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Integrating AI into Logistics Audit
Intégration de l'IA dans l'audit logistique

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Abstract:

The longitudinal analysis undertaken in this article aims to carefully scrutinize the deployment of full traceability within a specific supply chain. The main objective is to discern the determining elements that influenced this implementation and to detail the evolution of the traceability system over time within this particular supply chain. This analytical approach is intrinsically linked to the contemporary adoption of Artificial Intelligence (AI) as a central tool.

However, at the heart of this exploration lies a crucial question: how does the integration of AI within the framework of total traceability impact the performance and resilience of the supply chain? In other words, what are the practical implications of using AI on data management, anomaly detection, and decision-making within this specific supply chain?

The integration of AI in the context of full traceability offers substantial benefits for various aspects of the supply chain, from the initial data collection phase to real-time monitoring. The article will focus on an in-depth exploration of the specific contributions of AI in this context. This encompasses its remarkable ability to quickly and efficiently analyze large quantities of data, anticipate potential anomalies, and facilitate informed decision-making throughout the traceability process.

Keywords: Audit, supply chain, Artificial Intelligence
JEL Classification: M 42
Paper type: Theoretical Research

Résumé :

L'analyse longitudinale entreprise dans cet article vise à scruter minutieusement le déploiement de la traçabilité totale au sein d'une chaîne d'approvisionnement spécifique. L'objectif principal consiste à discerner les éléments déterminants qui ont influencé cette mise en œuvre et à détailler l'évolution du système de traçabilité au fil du temps au sein de cette chaîne d'approvisionnement particulière. Cette démarche analytique est intrinsèquement liée à l'adoption contemporaine de l'Intelligence Artificielle (IA) en tant qu'outil central.

Cependant, au cœur de cette exploration réside une problématique cruciale : comment l'intégration de l'IA dans le cadre de la traçabilité totale impacte-t-elle véritablement la performance et la résilience de la chaîne d'approvisionnement? En d'autres termes, quelles sont les implications pratiques de l'utilisation de l'IA sur la gestion des données, la détection des anomalies et la prise de décision au sein de cette chaîne d'approvisionnement spécifique?

L'intégration de l'IA dans le contexte de la traçabilité totale offre des avantages substantiels pour divers aspects de la chaîne d'approvisionnement, depuis la phase initiale de collecte des données jusqu'à la surveillance en temps réel. L'article s'attardera sur une exploration approfondie des contributions spécifiques de l'IA dans ce contexte. Cela englobe sa remarquable capacité à analyser rapidement et efficacement d'importantes quantités de données, à anticiper les anomalies potentielles, et à faciliter la prise de décision éclairée tout au long du processus de traçabilité.

Keywords: Audit, supply chain, Intelligence Artificielle…
Classification JEL : M 42
Type de l'article : Article théorique

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1. Introduction

The enduring principle of the survival of the fittest has not only been a fundamental tenet but also a driving force shaping the dynamics of the business landscape. Small and medium-sized enterprises (SMEs), in particular, find themselves in a perpetual struggle to establish their presence amidst global powerhouses. This struggle is exacerbated by the relentless pace of technological advancements, cutthroat competition, and the ever-evolving and intricate demands of customers, which manifest in both explicit and implicit forms. These formidable challenges, inherent throughout the life cycle of a supply chain, compel SMEs to continuously adapt and innovate.

In response to this intricate business landscape, securing the Supply Chain (SC) has emerged as a critical imperative. Leaders across organizational hierarchies now grapple with the task of maintaining operational resilience and fulfilling commitments to customers, even in the face of potential disruptions. While larger corporations with well-established and robust supply chains have faced and overcome such challenges, the focus of this inquiry pivots towards the often-overlooked realm of SMEs.

The central thesis objective seeks to transcend mere acknowledgment of challenges by actively ensuring the comprehensive traceability of the supply chain. Recognizing the strategic significance of the supply chain, the research provides a detailed and adaptable framework for continual monitoring, extending this approach to the realm of logistics. By providing managers with the tools of cognitive governance, the objective is to empower them to make informed decisions, optimize resource and capacity allocation, and seize emerging strategic opportunities. The practical guide accompanying the thesis functions not only as a theoretical construct but as a practical aid, facilitating traceability implementation and offering tailored solutions to the unique challenges confronted by SMEs in their supply chain endeavors.

The landscape of supply chain optimization has been extensively explored in existing literature, with discussions spanning characteristics, advantages, and limitations. A recurring theme in this discourse is the paramount importance of quality and product return as key determinants of business success. However, this thesis endeavors to push the boundaries of understanding by systematically calculating the return on investment for each facet dedicated to optimizing diverse components of the supply chain. This quantitative approach aims to equip companies, particularly SMEs, with the strategic insights necessary for managing the entire business cycle—from the initial design phase, through order processing, and concluding with timely delivery of quality products at the most competitive prices.

To anchor this research in established methodologies, classic models such as the SCOR model (Supply Chain Operations Reference, 1996) are employed. Renowned for measuring logistics process performance and optimizing management indicators, these models serve as a robust foundation. However, what distinguishes our work is the deliberate integration of traceability—an innovative and distinctive feature that injects a new dimension into our understanding of product history, location, and use through recorded identification within an entity.

Grounded in the philosophical underpinnings of post-positivism, with a critical stance that encourages discerning analysis, our study adopts a model aimed at dissecting the shortcomings within the existing logistics of a specific company ('X'). The focus is not merely on identifying these gaps but on developing strategies to address them effectively. This includes optimizing transportation modes for goods, ensuring total visibility, and, perhaps most crucially, incorporating traceability through the application of artificial intelligence. This holistic approach involves a meticulous examination of supply chain data, going beyond the identification of inefficiencies and errors to uncover hidden opportunities for improvement. In

essence, our research aspires not only to diagnose challenges but to lay the groundwork for a comprehensive and proactive strategy that enhances the overall performance of supply chains, particularly in the context of SMEs navigating the complex global business environment.

2. Audit and supply chain

2.1.What is auditing

The audit is an activity that consists of setting up an expertise by a competent and impartial agent and making a judgment on the organization, the procedure, or any operation of the entity. However, the definition of the audit alone is not enough to understand all its issues, it is necessary to put the audit into perspective with other notions qualified as "neighbors", which is summarized in the table below.

Table 1: Audit and related concepts

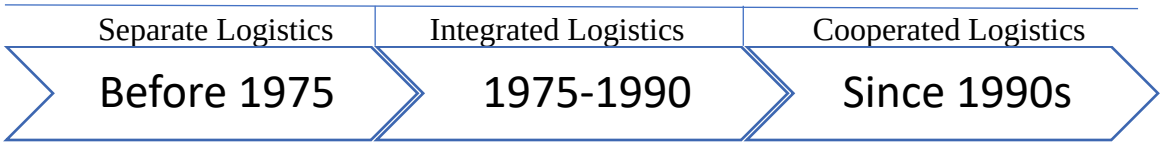
Audit and control	The term control is frequently associated with that of audit. The difference between the two concepts can be explained by reference to the theory of sets since the implementation of the audit involves carrying out various checks. The audit thus encompasses the set of control procedures and techniques constituting the in-depth examination by a professional and based on a methodology. The control is therefore presented as an audit tool; however, the latter includes an opinion which is the result of the controls.
Audit and advice	The distinction between audit and advice can only be appreciated beforehand and therefore characterizes the mission that is devolved to the auditor, and the link between auditor and auditee. If the mission is legal for example, such as that of the auditor, the audit cannot in principle lead to advice. If, on the other hand, the link between auditor and auditee is contractual, the audit can lead to advice, opinions and proposals.
Audit and review	By referring to the fields of application of auditing and accounting, we see that accounting review is the old name of accounting audit. According to Jacque 0, the accounting audit is: "like a practice with a restricted object devoid of the flattering aspects of the audit but that the technical discrepancies fade and that it is advisable to use equivalently the terms of auditor, controllers accounts or auditors.

Source: Authors

2.2 What is a Supply Chain

The evolution of logistics has known three main periods: “separate logistics”, “integrated logistics” and “cooperated logistics”. They are shown in the figure below.

Figure 1: Evolution of logistics



Source: Authors

- Separate logistics phase (before 1975):

The economy is booming during this period. Consumer demand has increased sharply and companies are trying to produce as much as possible to satisfy a mainly national market in quantity.

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Separate logistics stands out according to Ben Kahla with:

- High inventory levels;
- Opaque logistics costs;
- A low level of service (many stock shortages);
- Parcelized logistical responsibilities;
- Conflicts at the interfaces of the traditional functions of the organization.

Logistics, during this phase, exists mainly through activities such as transport, packaging, storage and processing of customer orders, as well as a performance oriented towards controlling the costs of distribution activities serving mainly to meet the requirements client.

- Integrated logistics phase (1975 – 1990):

During this period, many companies have appeared for the same market segment, which has led to an increase in supply and growth in competition, which has forced companies to review the quality of the products they offer. This resulted in production in small series but with great diversity while keeping costs competitive.

Integrated logistics has therefore made it possible to find an optimal global solution while considering all of the company's logistics services.

At this point, the status of the customer has changed to the producer, and has now become 'King' whose satisfaction has become imperative. As a result, optimization has become global within the framework of the company and not local, since all departments (design, production, distribution, etc.) collaborate and exchange technical data.

- Cooperative Logistics Phase (1990s to present):

Following the birth of new forms of organization, it has become necessary to instantly match supply and demand, between load and capacity. This is the stage where the supply of production is greater than the demand, resulting in stronger competition than before. This disrupted the forecasts of customer consumption behavior which had become unpredictable due to the multiple choices available to them. As a result, demand uncertainty is an important feature of the market.

Table 2: Characteristics of each of the three phases

Criteria	**Before 1975**	**1975 - 1990**	**90s**
Offer demand	Offer > Request	Supply = Demand	Supply < Demand
Requirement	Determined	Predictable	Uncertain
Producer Priority	Quantity	Quality and flexibility	Response speed
Product life cycle	Long	AVERAGE	Short
Customer's Choice	Limit	Diversified	Custom
Walk	National	Continental	Global
Client Provider	Producer is 'King'	Customer is 'King'	Cooperation between the two
Goals	Mass production; zero idle time	Nothing wrong; zero inventory	Zero response time; optimize the supply chain
Definition	Logistics or logistics management is the process of planning, involving and controlling the effectiveness and efficiency of the flow of goods and services, from their point of departure to their point of consumption, to conform to the needs and desires of the client		

Source: Merzouk S., 2007

The logistics chain is the translation of the English term “Supply Chain” which means “supply chain”. It should be noted that there is no universal definition of the "supply chain", there are a multitude of definitions including:

"A supply chain is a network of organizations (suppliers, factories, distributors, customers, logistics providers, etc.) that participate in the manufacture, delivery and sale of a product to a customer. These organizations exchange products, information and money with each other".
The concept and scope of a supply chain can be interpreted according to the context, we can distinguish:

- Local logistics chains: these are the company's small logistics chains that product flows use. They can be made up, for example, of different workshops of the same factory; these can be considered as customer and supplier one another within the framework of an analysis for example (Cattan, 1998).
- Intra-organization supply chains: Stadler used this term to characterize large companies located in different countries. However, it can be used even for companies with different sites in the same country.
- Inter-organization supply chains: these are supply chains in which one or more organizational units operate in different countries. It is well presented by the Anglo-Saxon term "Global Supply Chain" which word for word means "global logistics chain" does not have the same meaning in French as in English. "Global supply chain" means global/international supply chain; as for the "global supply chain" determines the supply chain in its entirety, namely from the customer's customer to the supplier's supplier.
- The supply chain linked to a product: unlike previous definitions which focused on an entity (the company with its partners); some companies can manage very different product flows calling on separate players (suppliers, customers). In this case, it can be considered that the company participates in several supply chains characterized by their type of product (both at the level of operational management and collaboration processes).

There are multiple definitions in the context of the supply chain, focusing on the objective of the diagnosis, two concepts seem interesting to deepen:

Figure 2: Internal and extended logistics chain

The internal logistics chain

- It represents all of the company's stakeholders involved from the purchase of raw materials from suppliers to the delivery of products to customers. Generally, the issues associated with it correspond to the control of information flows (physical and decision-making) along the internal chain.
- It is a transversal vision of the functioning of the company focused on the processes that go through it.

The extended logistics chain

- It places the company within a chain or network of actors extending from the first producer to the final customer. In this context, it is constituted BY the company, its customers and suppliers, as well as the customers of the customers and suppliers of the suppliers.
- Its objective is better collaboration and coordination with stakeholders external to the company.

Source: Authors

2.3. Logistic Audit

The literature shows the many researches and studies carried out in the modeling and the evaluation of the performance and the integration of the Supply chain, according to either a process approach or a referential approach of audit.

- ❖ SCOR Model: Supply Chain Operations Reference

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Initialized in 1996 by the organization SCC: Supply Chain Council, the SCOR model defines a set of approaches, good practices, and indicators, to represent, diagnose, and evaluate the SC to control and optimize its processes logistics.

Various research works have shown that the measurement of the performance of logistics processes and the optimization of management indicators remain the major purposes of a SCOR model. Added to this, its contribution to internal and external integration both horizontally, from end to end of the supply chain, and vertically from strategy to transaction.

Among the main contributions of a SCOR model, we find:

- Securing the supply chain,
- Its alignment,
- Its robustness,
- And its adaptation to strategic changes.

The SCOR model remains a static, rigorous, structuring and generic model, which first seeks to ensure the performance of the supply chain, by ensuring that of its suppliers, its internal players and its customers, and through the control of its processes, its operational and financial indicators, and its best practices.

❖ ASLOG repository

Based on the reference set up by the VOLVO company in the 1990s, ASLOG: the French Logistics Association has designed a logistics reference to assess the aptitude of a Supply Chain, improve its competitiveness, and measure its logistics performance, in a precise and uniform way, whatever the environment observed, to allow a total integration of its external partners: subcontractors, suppliers, customers... Also to create added value and favor the implementation of collaborative approaches.

It is a catalog of measures and progress actions for a company, and a cross-cutting tool to ensure continuous improvement, achieve the level of excellence, and implement good logistics practices. It is a question of giving a structure of approach to the problems, of designing a management of the key processes, and of establishing the action plans, to guarantee continuous progress and optimal quality.

Composed of ten chapters, the ASLOG repository is broken down into open questions in the form of a veritable checklist, necessary for evaluating the proper functioning of the Supply Chain, and making it possible to effectively help the personnel involved in the logistics function. Each of the questions is dealt with either from a risk, a problem, or a way of progress or performance.

For each question, three levels of requirement give a satisfaction score, according to a scale of 0 to 3, ranging from basic to excellence, translated by knowledge and prevention of all risks, anticipation and permanent progress. .

The ASLOG standard remains a universal, objective and independent model, which seeks to provide logistics intelligence by ensuring the responsiveness, efficiency and agility of the supply chain, while respecting the golden triangle: Time, Quality, and Cost.

❖ GLOBAL EVALOG repository

It is the result of collaboration between Odette's French repository: EVALOG and the American AIAG (Automotive Industry Action Group) repository: MMOG (Materials Management Operations Guideline). A global standard tool intended for the automotive sector allowing the self-assessment and logistics audit of partner sites such as factories and suppliers, via a questionnaire to be completed and a score to be calculated.

This repository represents a lever of excellence, for the continuous improvement and management of all logistics processes, to have a common language that facilitates efficient communication between the different partners.

GLOBAL EVALOG is based on the evaluation of five important themes in an automotive supply chain, namely:

- Its vision and strategy
- Her goals,
- Analysis and action plans,
- The amelioration keeps going,
- And the development of its supply chain.

It is a repository of good practices, which links each axis to a very specific objective to be achieved through an evaluation by weightings and criteria, by an action plan to be followed to attenuate the dysfunctions linked to external partners and improve the communication and governance of logistics processes in the automotive chain.

❖ Supply Chain Masters (SCM) Repository

Built in 2007 by Supply Chain experts, the SCM repository is a tool for measuring the logistics maturity of a company of the SME-SMI type (Small and Medium Enterprises-Small and Medium Industries) in any sector of activity. It integrates norms, standards, and good logistics practices from well-known organizations such as: AFNOR (French Association for Standardization),
the SCC (Supply Chain Council), the ISO (International Organization for Standardization) and many others. Applied to SMEs-SMIs with 10 to 250 employees, this benchmark represents a knowledge base and an educational guide to understand the challenges and functions of a supply chain, assess its strengths and weaknesses, and position it according to a degree of maturity. logistics, ranging from the absence of the logistics structure, to the advanced phase of the collaborative Supply Chain.
This repository covers all logistics functionalities in the form of a wheel of 25 key modules, from business strategy to performance measurement, including the multiple components of logistics, following the approach continuous improvement PDCA (Plan, Do, Check, and Act) or the Deming wheel.
The models above give, whether it is a process approach or an audit reference approach, a transversal modeling and an overall evaluation of the components of the supply chain, its malfunctions and their deviations, its objectives, and its development plan. action, however, the absence of the dynamic aspect of the chain is difficult to illustrate through these models.
Through the four methods of modeling and evaluating a supply chain, the following table presents a comparative summary according to the following points and criteria:

Table 3: Summary and comparison of the main existing standards

	SCOR	ASLOG	Global EVALOG	SCM
Type of approach	Process approach	Thematic approach	Thematic approach	Module approach
N° of processes	6	10	5	25
Application areas	Ant type of activity	Ant type of activity	Sector Automotive	SME-SMI
Used tools	- Process description - Performance indicators - Manual of good practices - Data from - Bennchmarking	- Questionnaires - Performance and management indicators - Progress actions - Weightings	- Questionnaires - Performance indicators - Evaluation grid - Action plan - Good practices	- Evaluation grid
General structure of the model	Hiearchical levels	Audit repository	Audit repository	Wheel of 25 modules

Source: Authors

3. Logistics Audit and Artificial Intelligence

3.1.Definition of Artificial Intelligence

Artificial/digital intelligence has been defined by Marvin Lee Minsky as "the construction of computer programs that engage in tasks that are, for the time being, performed satisfactorily by human beings because they require mental processes of high level such as perceptual

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learning, memory organization and critical reasoning". From this fact, it can be concluded that the algorithms created by Man and the tools of digital intelligence allow the execution of the tasks carried out by Man requiring mental and physical effort. Digital today occupies a very important place and is identified as the 4th industrial revolution worldwide, bringing unprecedented changes since it creates major economic and social opportunities.

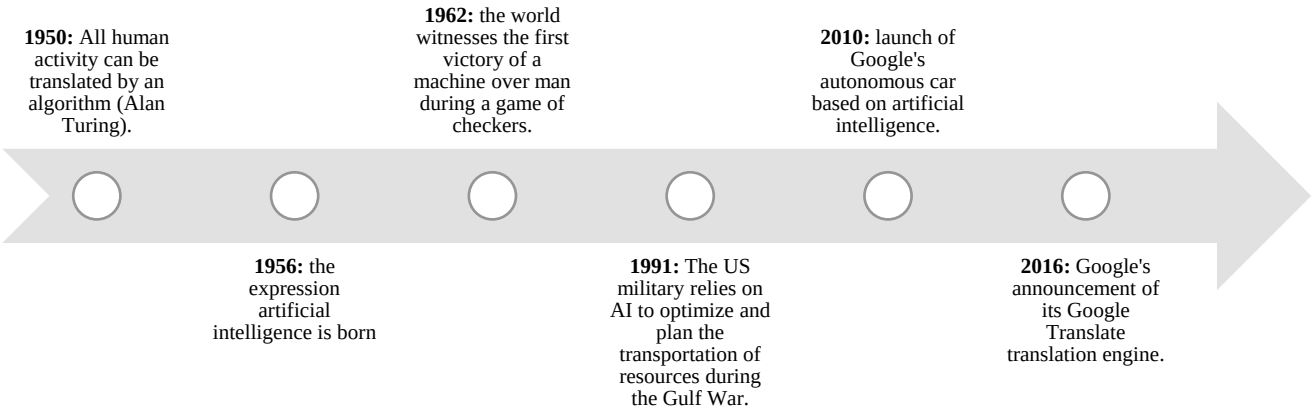
From this, we can say that its appearance dates back to the 90s, the evolution that the propagation of the culture of the Internet, the means of communication and other has known, makes companies think of modifying the organizational structure as well as their work methods. First appeared the notion of "company-network" in the sense that the entourage is full of relationships forged allowing the expansion of its network in the form of a strong relationship with Information Technology and Communication.

This intelligence that has marked the interest of the human being is based on 4 aspects that allow a machine or a computer:

- Self-learning: the ability to learn on your own over time (almost by experience)
- Audio-visual recognition: the ability to have sensory inputs such as vision, hearing or touch, just like a human being.
- Natural language processing: the ability to interact in natural language orally or in writing with a human.
- Task planning: the ability to plan series of actions and develop plans.

Digital has therefore become the trigger that will subsequently give rise to new management methods that companies will struggle to have. And any novelty calls into question the existing work tools already in the field, a change that was not perceived in the same way by all, they were mixed with the impact of artificial intelligence on their. If we go back in history, we can schematize the evolution towards digital as follows:

Figure 3: AI through time



Source: Authors

Since the translation engine google, we speak of "overlearning", developments have accelerated and the recourse to digital has become more and more a necessity for a global change. It has become a necessity and not just a luxury for companies to adopt AI, it will allow them to have a new look and create new management tools. (Dumitru, 2016).

3.2.The integration of AI in the logistics audit

It provides benefits in terms of accuracy, efficiency and more informed decision-making. Among the key areas where AI brings added value to the logistics audit:

- Real-Time Data Analysis: AI allows through its systems the real-time analysis of data from sensors, tracking systems and other sources to detect anomalies and deviations from standards. as quickly as possible.

- Predictions and Prevention: AI machine learning models enable the anticipation of potential problems in the supply chain, which enables prevention for companies avoiding delays and disruptions.
- Route Optimization: AI allows the analysis of traffic data in real time, in this sense, it proposes alternative routes for delivery vehicles to reduce both costs and travel times.
- Fraud Detection: AI enables the identification of unusual patterns in logistics transactions, leading to the detection of malicious or fraudulent activity.
- Process Automation: Automation using AI algorithms of manual and repetitive audit-related tasks allows more time for more in-depth analysis.

However, despite the obvious benefits, this integration also offers significant challenges, whether concerning data privacy, the continued reliance on human expertise to interpret AI results, and the need transparent and comprehensible model so that it can be assimilated by the AI. If below a scheme of some limits to take into consideration:

Figure 4: Limits of AI in the logistics audit

Variability of external factors:

- External factors such as weather conditions, government regulations and unforeseen events can have a significant impact on logistics operations. AI models can struggle to anticipate these changing factors.

Initial cost and expertise:

- The implementation of AI systems requires a significant financial investment for the training of teams, the development or purchase of software solutions, and the implementation of suitable infrastructures. Additionally, it can be difficult to find experts who can work at the intersection of logistics and AI.

Data quality:

- The effectiveness of AI models largely depends on the quality and quantity of available data. If the data is incomplete, incorrect, or unrepresentative, the AI results may be biased or unreliable.

Complexity of operations:

- Supply chain and logistics can be extremely complex, involving many interrelated factors. AI models can struggle to account for all of these interactions and anticipate very specific situations.

Interpretability of results:

- Complex AI models, such as deep neural networks, can produce results that are difficult to interpret. This can make it complex to understand why a model makes a particular decision, which can be problematic in an audit context where transparency is crucial.

Rapid evolution of technology:

- AI technologies are evolving rapidly, which means that models in place today could become obsolete relatively quickly. This requires constant updates and continuous monitoring to ensure the results remain relevant.

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Confidentiality and data security:

- The use of sensitive data in logistics operations can pose privacy and security issues. Businesses should put adequate safeguards in place to prevent data breaches and potential risks.

Prediction limitations:

- Although AI can help predict certain events, it cannot predict all eventualities with certainty, especially completely unexpected events or major disasters.

Source: Authors

4. Conclusion

The progress witnessed across diverse domains has undeniably left a profound impact, significantly altering various aspects of daily corporate operations. One realm that has experienced notable transformation is the supply chain, a discipline evolving at a rapid pace. Harnessing the capabilities of automation, acquisition, data transmission, and processing, the supply chain has strategically repositioned itself within companies, transcending its conventional role to become a vital business component.

However, as new technologies permeate the global landscape, they not only pose challenges but also present opportunities for cost optimization and enhanced customer service. The convergence of logistics audit and Artificial Intelligence (AI) opens up a realm of exciting possibilities to elevate supply chain efficiency and transparency. AI models, with their adeptness in data analysis, trend prediction, and task automation, empower companies to not only enhance their logistics performance but also gain a competitive edge in an ever-evolving business landscape.

This study aims to delve into the depth of possibilities, exploring the extent to which the collaboration between logistics audit and artificial intelligence can be seamlessly integrated into the operational fabric of Moroccan companies. By leveraging the synergy between these two realms, companies stand to unlock novel avenues for growth, efficiency, and competitiveness within the dynamic business environment.

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