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ỨNG DỤNG CÔNG NGHỆ TRÍ TUỆ NHÂN TẠO VÀO PHÂN TÍCH DỰ BÁO TRONG QUẢN TRỊ LOGISTICS: NGHIÊN CỨU TRƯỜNG HỢP ĐIỂN HÌNH CỦA DHL VÀ ĐỀ XUẤT CHO DOANH NGHIỆP VIỆT NAM

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Tóm tắt

Ngày nay, việc hợp tác và kết nối toàn cầu giữa các kênh truyền thống trực tiếp và trực tuyến đã đặt ra những thách thức mới cho thị trường logistics. Trong một thế giới đặc trưng bởi sự biến động không ngừng, các cuộc cách mạng về quy trình kinh doanh và vận hành trong ngành logistics cùng với những khó khăn kèm theo đó đã mở đường cho sự xuất hiện của khái niệm quản trị logistics dự báo. Là một trong những công ty tiên phong trong ngành logistics, DHL đã và đang cải tiến và triển khai ứng dụng công nghệ trí tuệ nhân tạo để vận hành và quản lý hoạt động của công ty theo hướng chủ động và tự dự báo. Trong nghiên cứu này, mục tiêu của nhóm tác giả là tiến hành một đánh giá toàn diện về việc ứng dụng trí tuệ nhân tạo trong quản trị logistics dự báo tại công ty DHL, thông qua việc sử dụng dữ liệu thứ cấp từ cáo về hoạt động doanh nghiệp, báo cáo về thực trạng ứng dụng trí tuệ nhân tạo từ công ty, từ đó rút ra bài học và đề xuất những giải pháp cho doanh nghiệp Việt Nam. Kết quả của nghiên cứu đã chỉ ra được công ty DHL đã đạt được những lợi ích từ việc ứng dụng trí tuệ nhân tạo trong quản trị logistics dự báo để nâng cao hiệu quả hoạt động và giảm thiểu rủi ro. Các bên liên quan trong hoạt động logistics tại Việt Nam, bao gồm chính phủ và chủ doanh nghiệp có thể lưu ý và học hỏi để cải thiện và tận dụng tối đa tiềm năng của trí tuệ nhân tạo.

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Từ khóa: Công nghệ Trí tuệ nhân tạo, quản trị logistics dự báo, công ty vận tải DHL

APPLICATIONS OF ARTIFICIAL INTELLIGENCE TECHNOLOGY IN PREDICTIVE ANALYTICS IN LOGISTICS MANAGEMENT: CASE STUDY OF DHL AND RECOMMENDATIONS FOR VIETNAMESE ENTERPRISES

Abstract

The global collaboration and integration of online and offline channels have brought new challenges to the logistics industry. In a world characterized by uncertainty and volatility, the revolution in the business procedures and the entailment to modify the operation in the logistics along with the complications involved in it have paved the way for the emergence of predictive analytics in logistics management. As one of the global leaders in the logistics industry, DHL has developed and implemented AI to run and manage their operations toward a more proactive and predictive approach. Our aim is to conduct a comprehensive review on noteworthy contributions made in the applications of AI technologies in predictive analytics in logistics management of DHL, using secondary data from DHL's business performance report, data from DHL's use of AI in logistics management report in order to draw lessons from it and make suggestions to Vietnamese logistics enterprises. The findings demonstrate how DHL has benefited from AI in predictive analytics in logistics management for enhanced operational efficiency and risk mitigation. Stakeholders in logistics management in Vietnam, such as the government or business owners, could take note of that and use adaptation to overcome the difficulties and unlock the full potential of AI technology.

Keywords: Artificial Intelligence, predictive analytics, logistics management, DHL Logistics

1. Introduction

Artificial Intelligence (AI) is the capacity of a computer or computer-controlled robot to execute tasks typically linked with human capabilities. The terminology "intelligence" in AI indicates that the task performed by a machine, script, or algorithm would necessitate intelligence if performed by a human. Despite AI existing since the late 1950s, it has only gained widespread recognition in the past decade. Presently, AI powers various aspects of our daily lives, such as our smartphones, TV suggestions, and organization of photo libraries. In the business sphere, AI has evolved from an unfamiliar term to a popular buzzword. According to a survey, 77% of executives acknowledge that their IT infrastructure significantly contributes to their organization's overall success, nearly 58% of surveyed executives have integrated at least one AI capability in their companies (Accenture survey, 2021). These industry insights send a clear message: AI is a permanent fixture, and companies that effectively embrace and expand its use stand to gain a competitive edge.

Logistics is considered one of the living backbones of the digital economy in many areas, from production, distribution, and circulation to consumer goods —supporting, connecting, and promoting the country’s socio-economic development and localities. The recent breakthrough of the fourth industrial revolution is seen as a driving force for predictive analytics in logistics management - the next operation paradigm in the logistics industry. Currently, some well-known

logistics companies have launched AI applications aiming to utilize predictive analytics in logistics management, including DHL Logistics with significant achievements. However, applications of AI technology in predictive analytics in logistics management is still seen as a complex issue for logistics business in practice.

In the following, this paper provides a comprehensive review on papers that are related to how DHL has utilized AI technologies in predictive analytics in logistics management. Moreover, we explore and discuss the context of Vietnam logistics sectors and based on the findings, we give some potential recommendations to improve the predictive level in logistics management in Vietnam.

2. Theoretical framework

2.1. Artificial Intelligence Technology

2.1.1. Definition

AI can be defined as human intelligence exhibited by machines; systems that approximate, mimic, replicate, automate, and eventually improve on human thinking (Gesing, Peterson, and Michelsen, 2018). Throughout the past half-century a few key components of AI were established as essential: the ability to perceive, understand, learn, problem solve, and reason.

Countless working definitions of AI have been proposed over the years but the unifying thread in all of them is that computers with the right software can be used to solve the kind of problems that humans solve, interact with humans and the world as humans do, and create ideas like humans. In other words, while the mechanisms that give rise to AI are 'artificial', the intelligence to which AI is intended to approximate is indistinguishable from human intelligence. In the early days of science, processing inputs from the outside world required extensive programming, which limited early AI systems to a very narrow set of inputs and conditions. However since then, computer science has worked to advance the capability of AI-enabled computing systems.

Current understanding of AI can quickly become convoluted with a dizzying array of complex technical terms and buzzwords common to mainstream media and publications on the topic today. Two terms in particular are important in understanding AI – machine learning which is a subset of AI and deep learning which is a subset of machine learning, as depicted following:

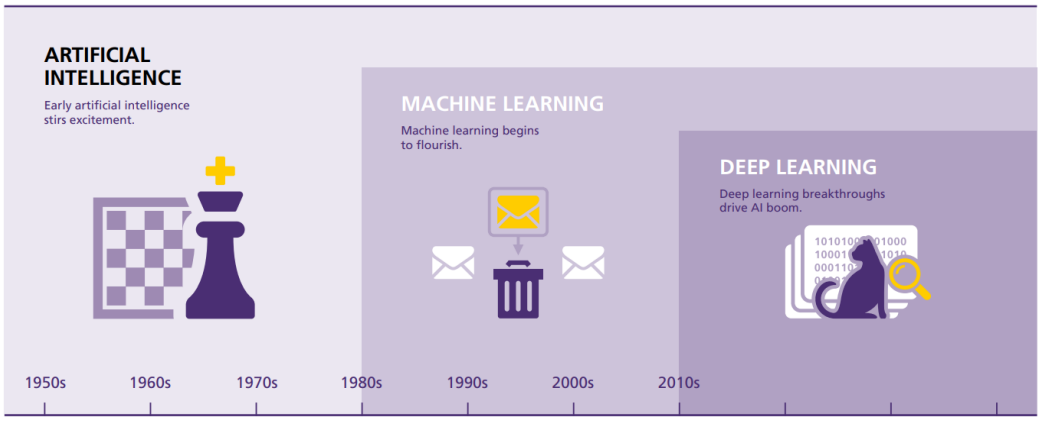

Figure 1: A visual representation of AI, machine learning, and deep learning

***Source**: Nvidia*

Whereas AI is a system or device intended to act with intelligence, machine learning is a more specific term that refers to systems that are designed to take in information, usually within a specific domain, and learn from what they have been given. These systems draw on the ability to evaluate and categorize received data, and then draw inferences from this. The output of this process is an insight, decision, or conclusion. For example, when the input is an image of you uploaded to a social media platform, image recognition software analyzes the content of the image pixels for known patterns using machine learning algorithms in the hidden layers, and produces an output in the form of an automatic tag of your name in the uploaded photo. It is able to do this based on statistical probability that characteristics of the image resemble existing images you have uploaded previously.

Deep learning takes the concept of machine learning a bit further. Deep learning is about learning continually; the intention of the system is to learn from the real world and adjust the learning model as it takes in new information and forms new insights. Deep learning is typically done with neural networks. Neural networks are humanity's best attempt to mimic both the structure and function of the human brain. As new data is fed into a neural network, connections between nodes are established, strengthened, or diminished, in a similar fashion to how connections between neurons in the human brain grow stronger through recurring experiences. Furthermore, each connection in a neural network can be tuned, assigning greater or lesser importance to an attribute, to achieve the quality of the output.

2.1.2. Components

Despite the oversimplification that tends to define AI in the popular press, AI is not one single, unified technology. AI is actually a set of interrelated technology components that can be used in a wide variety of combinations depending on the problem it addresses. Generally, AI technology consists of sensing components, processing components, and learning components.

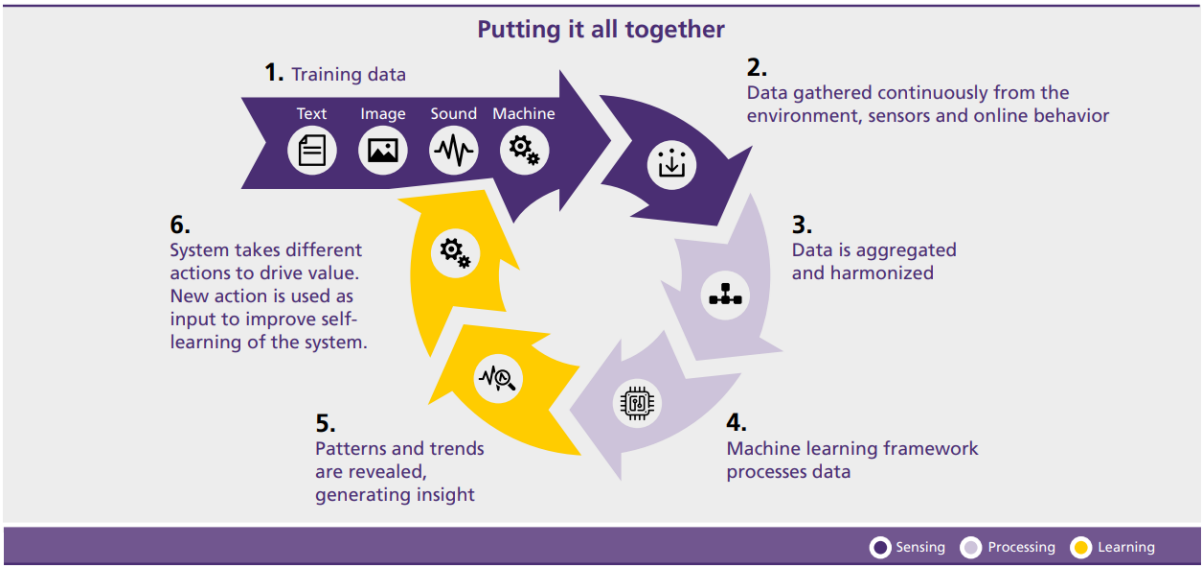

Figure 2: A full AI learning cycle;

***Source**: IBM/DHL*

Sensing: The Fuel of AI

To be able to understand or "sense" the real world, AI must take in information. As real-world information comes in many forms, AI must be able to digest text, capture images and video, take in sound, and eventually gather information about environmental conditions such as temperature, wind, humidity, etc. – everything that is typically understood by humans through our sense of touch.

Processing & Learning Components: Frameworks & Training Techniques

Once an AI system has collected data from sensing, it processes this information by applying a learning framework to generate insight from the data. In addition to the similarities that exist between human intelligence and AI, strong parallels have also been observed between how humans and AI systems learn. Youngsters tend to learn from their parents and teachers in highly structured settings with lots of reinforcement, whereas older, more experienced adult learners are well adapted to seeking their own inputs and learning from the world around them. Similarly, AI systems use supervised, unsupervised, and reinforcement learning to take in and process information about the world.

Supervised learning, as the name suggests, is learning that takes place when an AI-enabled system is directly informed by humans. A doctor who evaluates x-ray images to detect cancer risk, for example, can annotate the images with his or her expert input, then feed them into an AI system to facilitate supervised learning. Another example of supervised learning is when the AI system sorts through x-ray images for a doctor to review and approve in an effort to help improve the learning of the AI system.

Unsupervised learning takes place when an AI-enabled system is able to identify clusters or dimensions in the data itself without additional guidance from human data or computer scientists.

This technique can lead to significantly novel and unexpected results based on the data the system is exposed to. As an example in 2014, unsupervised learning is how YouTube was able to recognize cat faces from uploaded videos, simply by "watching" 10 million of them with little guidance of the desired output (Oremus, W., 2012).

Reinforcement learning takes place when the AI system is tasked with not only processing the available inputs but also learning the 'rules of the game'. This is based not on direct human interaction but on the amassed data from environmental responses given to the AI system. An analogous example of reinforcement learning is how infants first learn to walk: they first observe others until they find the ability to try it themselves. They then try to walk on their own many times unsuccessfully, but they improve their abilities each time until they can successfully walk unaided.

Many different types of machine learning framework exist today, each with its own core functionality of a deep learning capability based on neural networks. Data scientists and software developers need to access this core functionality in order to develop AI solutions, so they must select the framework that works best with their defined AI objectives and delivers the required deep learning capability.

2.1.3. The Relevance of Artificial Intelligence in Logistics

There are many reasons to believe that now is the best time for the logistics industry to embrace AI. In logistics, the network-based nature of the industry provides a natural framework for implementing and scaling AI, amplifying the human components of highly organized global supply chains. Furthermore, companies deciding not to adopt AI run the risk of obsolescence in the long term, as competitors seize and effectively use AI in their business today.

Researchers at IBM estimate only 10% of current systems, data, and interactions include elements of AI analysis and results. However the returns on AI investments are already improving; relatively moderate outlay is generating a much larger return than ever before. A research by McKinsey estimates that logistics companies will generate $1.3-$2 trillion per year for the next 20 years in economic value by adopting AI into their processes (The Economist, 2018). But as complexity grows – with more unstructured data, more sophisticated learning algorithms and techniques, and more high-level decision-making tasks – the cumulative nature of AI means that AI analysis and results will improve even further.

There is another indicator that now is a good time for AI to flourish – this is the state of its adoption in the world today. Innovations occur first and become mainstream in the consumer world. Companies need to change their behaviors from looking in the rear-view mirror to what has happened and start looking forward to using real-time and predictive insights (Muynck, 2023). AI is stretching beyond consumer ubiquity and into customer-focused commercial ventures. Eventually, once the value of AI is proven in the commercial context it will arrive in the industrial setting. The specific timing of these transitions is impossible to predict, but the fact that AI is now deeply embedded in consumer markets and is experiencing explosive growth in customer-facing commercial areas clearly indicates the use of AI in industrial sectors such as logistics is quickly approaching.

Logistics companies are uniquely positioned to benefit by applying AI in almost all aspects of the supply chain. One of the most underutilized assets in the industry is the high volume of data that logistics generate on a daily basis. This data is both structured and unstructured, and AI will enable logistics companies to exploit it. In addition, as many logistics companies around the world embrace digital transformation, transitioning away from legacy enterprise resource planning systems to advanced analytics, increased automation, and hardware and software robotics, and mobile computing, the next obvious step in the increasingly digital logistics is to apply AI.

Furthermore, logistics companies depend on networks – both physical and increasingly digital – which must function harmoniously amid high volumes, low margins, lean asset allocation, and time-sensitive deadlines. AI offers logistics companies the ability to optimize network orchestration to degrees of efficiency that cannot be achieved with human thinking alone. AI can help the logistics industry to redefine today's behaviors and practices, taking operations from reactive to proactive, planning from forecast to prediction, processes from manual to autonomous, and services from standardized to personalized.

2.2. Predictive analytics in logistics management

2.2.1. Definition

Predictive analytics, as the name suggests, focuses on forecasting future patterns in key logistics indicators like sales demand, exchange rates, and other areas. In order to identify, comprehend, and create future trends, the methodology uses regression analysis and statistical modeling applied to historical data (Coby Nilsson, 2021).

According to Riverlogic blog, predictive analytics in logistics management refers to the use of advanced technologies, such as predictive analytics, machine learning, and artificial intelligence, to forecast and anticipate future events, risks, and opportunities within the supply chain and logistics operations. By analyzing historical and transactional data, predictive logistics modeling helps organizations make informed decisions, optimize operations, and proactively address potential disruptions, ultimately leading to more efficient and cost-effective logistics management.

Predictive analytics have a big impact on the effectiveness and caliber of warehouse operations as they become more and more prevalent in logistics management.

2.2.2. The relevance of AI technology and predictive analytics

Predictive analytics involves several steps through which a data analyst can predict the future based on the current and historical data. While companies have been using data to make predictions for decades, the use of AI, statistical algorithms and advanced modeling have enabled companies to be able to process more data than ever before. Industries ranging from insurance and financial services to travel and hospitality are finding benefits from predictive analytics. Predictive analytics helps reduce risks, optimize operations and increase revenue.

With any AI system, the goal is to get the machine to process data quickly and to be able to analyze data more efficiently. The ultimate application of predictive analytics is to look for patterns in data sets, see how those patterns have developed over time and then use that information to

predict future trends. The goal is to ultimately help humans make better decisions based on what the computer predicts to be the likely outcomes for the future. Since this is the fundamental goal, there are lots of applications that this pattern has in the real world. (Kathleen Walch & Cognilytica, 2020)

For companies looking to derive benefit from predictive analytics, there are a few approaches that can provide benefit (Gamco blog, 2021). *Classification models* are fairly simple but can provide significant value. They engage in supervised learning in order to predict a "category" or "class label" based on the collected historical data. They are best used when asking simple, yes-no questions. Companies are able to take their historical data and have the model make a decision based on that data. The spam detector of an email account is a good example of such an algorithm; in this case each email is automatically assigned a label with two possible values: "Spam" or "Not Spam".

Another way companies can apply AI-enabled predictive analytics is through *clustering*. Clustering models sort your data into separate groups based on similar attributes. In this unsupervised learning approach, the model works on its own and learns to sort, or cluster, your data. This approach sees computers cluster data in ways humans may not think to do, resulting in potentially unique insights. For example, k-means is a method that partitions the data into k clusters based on their distance from each other. It participates in unsupervised learning in order to group data into clusters based on similar patterns and characteristics. These types of algorithms are often used in e-commerce to classify customers based on their browsing and/or purchase history and then, predict the customers' demand.

Regression algorithms is one of AI applications in supervised learning in order to predict a "value" or "number" based on the historical data collected. This allows establishing a methodology to link a certain number of characteristics and a target variable that has continuous values (prices, product demand, stocks, temperatures, ...). These kinds of algorithms can estimate the time it takes a person to reach a destination or predict the value of a house based on its location, orientation or size.

Forecasting is also a popular way to apply the predictive analytics pattern. AI algorithms are based on deep learning, and neural networks can identify complex patterns within such data that enable more accurate predictions of market trends, revenue, margins and other financial metrics. It constantly tests its output to self-adjust its calculations to enhance the precision of its forecasts. One of the most common use cases is weather forecasting, but it can also be used for predicting how many customers will convert, how many people are expected to enter a store in a given hour or how much inventory should be kept in stock. (Vineet Jain, 2023)

Some AI- based predictive analytics applications vary across various industries and business sector (Velibor Božić, 2023):

Marketing: AI can analyze vast amounts of customer data, such as demographic information, purchase history, online behavior, and social media interactions, to optimize marketing campaigns. Machine learning algorithms can segment customers, identify preferences, and predict responses to different marketing strategies, helping businesses target their marketing efforts more effectively.

Credit Risk Analysis: AI can analyze diverse data sources, such as credit history, income, employment status, and other relevant variables, to assess credit risk and predict the likelihood of default for loan applicants. Machine learning models can be trained on historical data to identify patterns and assess credit risk, assisting financial institutions in making informed lending decisions.

Healthcare: AI can analyze patient data, such as electronic health records, sensor data, and other relevant variables, to predict disease outcomes, identify potential health risks, and optimize treatment plans. Machine learning models can analyze large datasets and identify patterns that may not be apparent to human clinicians, assisting in early diagnosis, personalized treatment planning, and disease management.

Logistics & Supply Chain Management: AI can analyze various factors, such as demand, transportation costs, inventory levels, and production capacity, to optimize supply chain operations. Machine learning algorithms can make predictions about demand patterns, optimize inventory levels, and optimize transportation routes, helping businesses streamline their supply chain processes and reduce costs.

2.2.3. The importance of the shift to AI-based predictive analytics in logistics management

Dynamic Business Environment

Nowadays, the logistics industry is more demanding and complicated than it has ever been. Businesses are battling higher demands along the logistics, such as reducing inventory errors, anticipating customer purchasing patterns, and offering prompt and effective delivery.

AI-based predictive analytics was once considered a nice-to-have tactic for forward-thinking companies. However, a predictive analytics plan is now required. Additionally, businesses are better equipped to fulfill rising needs as predictive analytics are incorporated into supply chain management and logistics procedures.

According to the MHI Annual Industry Report, 82% of supply chain and industrial executives expect to employ predictive analytics by 2025, indicating that decision-makers are broadly accepting of this transition towards anticipatory logistics.

Risk Mitigation

AI-based predictive analytics allows organizations to identify and mitigate potential risks in the supply chain, such as disruptions due to natural disasters, geopolitical events, or supplier issues. This proactive risk management enhances overall logistics resilience.

Cost Reduction

Proactive management through AI systems reduces the costs associated with reactive measures and excess inventory. By accurately predicting demand and optimizing routes, organizations can minimize transportation costs and avoid unnecessary holding of inventory.

Businesses are gaining pace thanks to predictive analytics, which also lowers risks, lowers expenses, and meets customer expectations. Logistics experts can now optimize all aspects of operations, including demand forecasting, predictive maintenance, inventory management, and warehousing, thanks to cutting-edge technology.

2.2.4. Key components of predictive analytics in logistics management

Demand Forecasting

Predictive analytics forecasts future demand for your product based on patterns in customer behavior by combining real-time and historical data. Precise prediction is essential for inventory management and production about vacations and seasonal demand. Additionally, it enables company executives to plan weeks or even months ahead of time, resulting in less stagnant inventory and more on-time delivery.

Accurate demand forecasting is a linchpin in optimizing inventory levels and ensuring a seamless logistics. Predictive analytics in logistics management leverages historical sales data, market trends, and other relevant factors to forecast future demand. This component allows organizations to align their production and distribution processes with anticipated demand, minimizing the risk of stockouts or overstock situations.

Inventory Management & Optimization

Without the right procedures, inventory control can become chaotic and disjointed. Finding the ideal mix of supply, demand, and capacity is crucial for a business's reputation and financial performance in the present environment of economic instability, impatient consumers, and fragile procurement.

Predictive analytics can assist with future project development in addition to filling gaps and strengthening your inventory management approach.

Data Customization

Businesses can use predictive analytics to correlate multiple groups of data across locations, departments, or functional teams, and to pull certain data sets based on their needs. Leaders can make well-informed, comprehensive decisions about operations, finances, and inventory when they have access to comprehensive insights. Businesses can plan and create long-term initiatives to support upward mobility by using this viewpoint.

Route Optimization

Predictive logistics employs algorithms for route optimization, taking into account variables such as traffic conditions, fuel costs, and delivery deadlines. This component not only enhances operational efficiency but also contributes to cost reduction by optimizing transportation routes.

Last-mile delivery can be greatly impacted by predictive analytics. Similar to carbon dioxide, transportation-related greenhouse gas (GHG) emissions make up the greatest portion of all U.S. GHG emissions, estimated at 27%. Predictive analytics, however, can support sustainability initiatives and yield noticeable gains in robotics, anticipatory shipping, and route optimization—particularly in last-mile delivery.

Risk Management

In the unpredictable landscape of global business, risk management is paramount. Predictive analytics in logistics management identifies and assesses potential risks in the supply chain, such as disruptions due to natural disasters or geopolitical events. Proactive risk management strategies are then developed to mitigate these risks, enhancing overall logistics resilience.

Predictive analytics in logistics management represents a comprehensive and forward-thinking approach to logistics optimization. By applying it, organizations can transition from reactive to proactive logistics operations. This not only ensures operational efficiency and cost-effectiveness but also positions businesses to navigate the challenges of an ever-evolving market landscape.

3. Literature review

3.1. Previous research

In recent years, researchers and organizations have given particular attention to the integration of AI in predictive analytics for logistics management, which plays a pivotal role in optimizing inventory management, demand forecasting, route optimization, and warehouse operations. A study by Chen et al. (2020) demonstrated that employing machine learning models in inventory optimization reduced excess stock levels while ensuring product availability, thereby minimizing carrying costs and enhancing overall supply chain efficiency. Lee et al. (2019) and Wang et al. (2021) emphasize the use of AI techniques like neural networks and time series analysis to forecast demand accurately. By considering multiple variables such as seasonality, market trends, economic indicators, and external factors, predictive analytics models can provide more precise demand forecasts, enabling companies to optimize their production and distribution strategies. Another research by Lin et al. (2018) discusses AI-powered predictive analytics models that leverage real-time data on traffic conditions, weather forecasts, historical shipment data, and geographical information to suggest the most efficient routes. Chen et al. (2019) and Ivanov et al. (2020) indicate that AI-driven predictive analytics can enhance warehouse efficiency by predicting maintenance needs for equipment, minimizing downtime, and improving overall operational productivity.

Besides, Christopher (2016) emphasized the importance of AI-driven supply chain visibility tools in enhancing responsiveness and resilience within logistics networks. This visibility enables logistics managers to identify potential disruptions, mitigate risks, and make informed decisions promptly.

In Vietnam, Le Duy, et al (2020) proposes a method to assess the reliability of input data for short-term load forecasting in a Ho Chi Minh City distribution network, using statistical analysis

to detect and correct outliers and missing values in the historical load data. The author claims that this can improve the accuracy and quality of load forecasting models. Research by local scholars (Nguyen et al., 2021) highlights the effectiveness of machine learning models in demand forecasting for Vietnamese retail and distribution sectors. Vietnamese enterprises can leverage AI-driven predictive analytics to forecast demand accurately and optimize inventory levels. In addition, Optimizing transportation routes, particularly in urban areas with traffic congestion, is crucial for Vietnamese logistics companies. AI algorithms can process real-time traffic data, consider local conditions, and suggest efficient delivery routes. Studies (Tran et al., 2020) indicate that AI-based route optimization reduces delivery times and transportation costs, specifically catering to the unique challenges faced by Vietnamese enterprises in urban logistics. In the meantime, AI-driven predictive analytics can aid Vietnamese enterprises in warehouse operations, by predicting maintenance needs, optimizing storage space, and improving operational productivity. Research by local academics (Le et al., 2019) highlights the effectiveness of AI in predicting maintenance requirements for warehouse equipment, reducing downtime for Vietnamese logistics firms.

Although there are concerns regarding data privacy and transparency in AI algorithms remain significant hurdles, the future of AI in logistics management holds promise with advancements in AI techniques like natural language processing (NLP), edge computing, and federated learning. Integrating NLP capabilities into predictive analytics systems can facilitate better communication between AI systems and human operators, enhancing decision-making capabilities, ensuring data privacy and security in logistics operations (Ivanov et al., 2020).

3.2. Research gap

While the literature on the application of AI technology in predictive analytics in logistics management has grown significantly, there are still identified research gaps that underscore the need for more comprehensive and targeted studies. The existing literature often lacks more in-depth and detailed cases that outline challenges, successes, and lessons learned. We also found that there is limited literature available which covers how AI technology will impact logistics management in terms of its predictive analytics in Vietnam.

Therefore, the purpose of our research is to fill this gap by discussing the potential of AI in optimizing logistics management, particularly in evaluating data and making forecasts about demand, optimizing logistics and transportation routes, and identifying supply chain inefficiencies. We examine the case of DHL Global to see how AI can help logistics management professionals to make better decisions by providing them with contextual information that can be used to manage inventory better, reduce operating costs, and respond to clients quickly. Moreover, successful implementation of AI technology in the field of logistics management in DHL's case and analysis of the Vietnamese logistics industry will provide a recommendation for Vietnamese supply chain situations.

4. Analysis of the applications of AI in predictive analytics in logistics management: case study of DHL

4.1. Overview of DHL

DHL, or DHL International GmbH, is a global logistics and courier delivery services company headquartered in Bonn, Germany. It is a division of the larger Deutsche Post DHL Group, one of the world's leading mail and logistics services providers. DHL operates in over 220 countries and territories worldwide, making it one of the most extensive and recognizable logistics networks globally.

DHL has established itself as a pioneer in the logistics industry, continually adapting to the evolving demands of the global supply chain. As a researcher focused on AI applications in predictive logistic management, studying the case of DHL provides valuable insights into how advanced technologies are being harnessed to optimize and revolutionize logistics operations.

Key Aspects of DHL's Operations:

● *Comprehensive Logistics Solutions:* DHL offers various logistics services, including express parcel delivery, freight transportation, supply chain solutions, and e-commerce fulfillment. This comprehensive service portfolio positions DHL as a one-stop solution for diverse logistical needs.

● *Global Network:* DHL's extensive global network is a distinguishing feature. With a vast presence in various countries, the company has built a robust infrastructure to facilitate international trade and supply chain management. This expansive network is essential for handling diverse logistics challenges, such as customs clearance, cross-border shipments, and last-mile delivery.

● *Innovation and Technology Integration:* DHL has consistently committed to innovation, embracing technology to enhance its logistics capabilities. This is particularly relevant in the context of AI applications, where the company has been at the forefront of adopting advanced technologies to optimize predictive logistic management.

● *Resilience and Risk Management:* The logistics industry is inherently prone to disruptions, and DHL has shown a proactive approach to managing risks in the supply chain. The Resilience360 platform, mentioned in the context of AI applications, exemplifies DHL's dedication to ensuring supply chain continuity by leveraging cloud-based risk management solutions.

● *Strategic Initiatives:* DHL has undertaken strategic initiatives to address emerging challenges in the logistics landscape. The SmartTruck routing initiative, developed in the early 2000s, showcases the company's foresight in anticipating the need for intelligent route optimization. This initiative aligns with the evolving customer demands and the changing soft infrastructure of cities.

In the realm of AI applications, DHL's endeavors reflect a forward-looking approach to leveraging predictive analytics, machine learning, and other AI technologies. The case study of DHL provides a real-world illustration of how a global logistics leader integrates AI into its

operations to enhance efficiency, mitigate risks, and stay ahead in an increasingly complex and dynamic industry.

4.2. Applications of AI in DHL toward predictive analytics in logistics management

In the realm of logistics operations, the incorporation of AI-driven ***predictive network management*** holds immense potential for enhancing efficiency. Air freight, constituting merely 1% of global trade in tonnage but a substantial 35% in value (Boeing, 2016), demands precision in on-time and in-full shipments. Typically, historical data and industry expertise guide the planning of air freight lanes and networks. DHL has taken a significant leap by introducing **a machine learning-based tool designed to predict air freight transit time delays and facilitate proactive mitigation**. Analyzing 58 internal data parameters, this model can forecast changes in the average daily transit time for a specific line up to a week in advance. Furthermore, it identifies key factors influencing delays, ranging from temporal aspects like departure day to operational factors such as airline on-time performance. This solution empowers air freight forwarders to plan strategically for optimal shipment routes and carriers by eradicating subjective guesswork.

- ***Demand Forecasting and Capacity Planning***

The need for ***Demand Forecasting and Capacity Planning*** is self-evident in predictive analytics in logistics management, and **DHL's Global Trade Barometer** is another DHL's successful application of AI in this area. This innovative tool harnesses vast amounts of operational logistics data, advanced statistical modeling, and artificial intelligence to offer a monthly forecast of global economic trends. By analyzing import and export data from seven key countries, measuring air freight and containerized ocean freight levels, the system evaluates an impressive 240 million variables representing 75% of global trade (DHL, 2018). Utilizing an AI engine alongside analytical models, it generates a singular value reflecting the weighted average of current trade growth and the forthcoming two months, providing a reliable three-month outlook. Through historical data validation, the tool has demonstrated a strong correlation with actual containerized trade, empowering businesses with foresight into market dynamics, enabling proactive decision-making, and optimizing supply chain operations in response to evolving demand patterns.

- ***Predictive Risk Management***

Predictive Risk Management emerges as a linchpin in ensuring the uninterrupted flow of the supply chain. DHL's **Resilience360 platform**, a cloud-based risk management solution, caters specifically to the needs of global logistics operators. Managing the flow of components from myriad suppliers worldwide is a daily challenge in industries like automotive, technology, engineering, and manufacturing. DHL's Resilience360 Supply Watch module exemplifies the potency of AI in mitigating supplier risks. The system gauges the sentiment of online conversations by monitoring 8 million posts from over 300,000 online and social media sources, employing advanced machine learning and natural language processing (Figure 3) (DHL, 2018). The system's capability allows supply chain managers to identify risk indicators beforehand, enabling them to take corrective action and avert disruptions. That Tobias Larsson, Founder and CEO of Resilience360, said that this system had grown rapidly over the last couple of years and now had

over 13,000 users world-wide is clear evidence proving the usefulness and relevance of DHL's Resilience360.

Figure 3: DHL Supply Watch - a new integral part of its Resilience360 risk management platform called

***Source**: Business Wire*

● ***Route Optimization***

The significance of ***Intelligent Route Optimization*** cannot be overstated for logistics operators striving to transport, pick up, and deliver shipments efficiently. While logistics providers possess extensive knowledge of cities and their physical characteristics, new customer demands, such as time-slot deliveries and instant pickups, introduce complexities. DHL Group's pioneering **SmartTruck routing initiative**, initiated in the early 2000s, has developed proprietary real-time routing algorithms. Leveraging the soft infrastructure of cities, including digital and satellite maps, traffic patterns, and social media check-in locations, augments systems like SmartTruck. This reduces transit times by up to 50 percent compared to the traditional trucking industry, and provides over 95 percent reliability with ease of use, end-to-end consignment visibility, temperature-controlled capabilities and real-time tracking (DHL, 2018). This integration also enhances the overall routing of truck drivers on delivery runs, with a reduce in mileage by 15% and significant decreases in fuel consumption and CO2 emissions; while aligning with evolving customer expectations.

Figure 4: DHL Smart Trucking

***Source**: Motorindia magazine*

In conclusion, DHL's strategic integration of AI applications in predictive logistics management reflects a commitment to leveraging cutting-edge technology for **enhanced operational efficiency and risk mitigation**. The intersection of AI and logistics is paving the way for a future where data-driven insights and predictive analytics are central in shaping the global logistics landscape.

5. Implications of Artificial Intelligence technology in predictive analytics in logistics management for Vietnamese enterprises

5.1. Overview of Vietnamese current logistics industry

The logistics industry in Vietnam has been growing rapidly in recent years, and it is expected to continue to grow in the future. According to a 2021 McKinsey report, Asia is expected to account for roughly half of the world's trade growth by 2030, and Vietnam is among the top 10 emerging logistics markets in the world. Vietnam's unique position with more than 3,200 km of coastline and major international ports in the north, center, and south of the country makes it an ideal hub for shipping. The logistics sector's steady growth in Vietnam has led it to become an industry valued at US$ 40 billion today. (CBIP Logistics, 2021)

However, the logistics industry in Vietnam also faces several challenges. One of the biggest challenges is the relatively low quality of road networks, ports, and warehouses, which remains a challenge for Vietnam's logistics industry. The development of infrastructure requires a lot of time and investment to be improved. Another obstacle is that most domestic enterprises are facing a

shortage of capital, quality human resources, and technical knowledge. Evaluating the impact of the Covid-19 illness, shipping container shortages (due to the influence of global social distance), and freight tends to rise significantly are also some of the challenges that the logistics industry in Vietnam is expected to confront in the future.

Despite these challenges, there are several opportunities for the logistics industry in Vietnam. Vietnam's logistics sector has benefited from the increasing domestic consumption. Besides, the country has benefitted from both a spike in foreign direct investment and from the country itself becoming more ingrained in global supply chains. Vietnam also has the advantage of cheap labor costs, a central location in Asia, and a favorable regulatory environment. It's no surprise that international firms are getting in on the action. Some prominent examples include Apple, which has shifted production of iPads and AirPods from China to Vietnam. Samsung, with a significant production base in Vietnam that accounts for nearly 50% of its smartphones and tablets, and footwear giants like Nike and Adidas continuing to move factories to Vietnam, solidifying its place as a textile hub and making it the third-largest shoe producer in the world (Viettonkin consulting, 2022). Additionally, the government's commitment to improving infrastructure and streamlining administrative procedures, developing the logistics industry by investing in infrastructure, such as building new highways, airports, and seaports is expected to create a more favorable environment for logistics businesses.

5.2. Current applications of AI in predictive analytics in logistics management in Vietnam

Over the past three years, logistics businesses in Vietnam have shown an increasing trend in applying technology to their operational management. Currently, the logistics market of Vietnam has the participation of more than 4000 enterprises, with 89% of them begin small- and medium-sized and which have capital of less than VND 10 billion; about 5% have capital of VND 10 to 20 billion, approximately 10% are joint venture enterprises, and 1% have foreign-owned enterprises provide international logistics services such as DHL, FedEx, Maersk Logistics, APL Logistics, CJ Logistics, and KMTC Logistics (Statista, 2022). The emergence and growth of numerous distribution and transportation companies in Vietnam, such as Giao hàng tiết kiệm, Giao hàng nhanh, Viettel Post, have created a vibrant market. That is when the government and logistics businesses are realizing the outstanding benefits of predictive analytics in logistics management with the support of AI technology.

However, the term "Predictive analytics in logistics management" seems quite new to Vietnamese logistics sectors. In Vietnam, AI technology has just been utilized for data storage techniques and vehicle tracking for ***route planning optimization***, but has not been extensively applied as this process still heavily relies on the experience of the drivers. There is little capability to design and develop technologies or software for optimal route selection for domestic business. This creates an opportunity for third parties who recognize this trend and begin producing and trading such software.

Abivin and In-tech are two pioneering companies in providing route optimization software in Vietnam, and they have expanded their market to other Southeast Asian countries. The Startup model Abivin vRoute with its AI-driven Logistics Optimization solution has integrated route

optimization algorithms, assisting enterprises like Tan Cang Saigon, Coteccons, Habeco, A.O.Smith,... Technically, Abivin vRoute is a cloud-based software comprising web and mobile applications. Primarily, the software optimizes delivery routes, solving route planning problems while ensuring constraints such as different store opening hours, various vehicle types with different payloads, territorial divisions, and support for models like x-dock, sun warehouse, etc. Additionally, Abivin vRoute features Transport Management and Inventory Management functions, enabling managers to track delivery processes and real-time inventory data.

Abivin stands out due to its optimization technology and suitability for the ASEAN and Asian markets. Leveraging advanced technologies, Abivin vRoute possesses several outstanding features to compete with other logistics software products. Abivin vRoute integrates Abivin's proprietary Route Optimization algorithm, capable of satisfying over 20 different conditions in the delivery process, such as varying store opening hours, different vehicle types, maximizing vehicle weight/volume, or different traffic conditions... Previously, delivery coordinators in enterprises had to spend 2 to 4 hours manually solving these problems daily. With Abivin vRoute's support, coordinators now spend only 5 to 15 minutes daily to plan optimal delivery routes. The application of AI in the solution enables the software to autonomously address repetitive, inefficient issues within the supply chain operation. The intelligent algorithm also supports meeting characteristics like narrow roads, numerous alleys, frequent changes, limitations; facilitating deliveries using various vehicles such as motorcycles, trucks, containers, or forklifts, irregular store opening hours, and more. (Market Development and Science-Technology Enterprises Bureau of Vietnam, 2018)

Beside the Abivin vRoute model, some logistics companies in Vietnam have begun the trend of procuring foreign software. An example of this is the collaboration of KMP Company in importing route optimization software from Locus - a leading firm in designing route optimization software globally.

Apparently, it is seen that in Vietnam, AI has not been effectively applied to reach predictive analytics in logistics management, leading to resource waste and inefficiencies in logistics and transportation. The inefficiency stems from the limited technological proficiency of companies, both individually and within the broader national and regional context. Moreover, concerns regarding information security have led companies to resist adopting AI and information technology. In Vietnam, the underdevelopment of transportation infrastructure and information technology systems stands as the primary cause of this situation. According to an evaluation by the Thua Thien Hue Department of Transportation in 2018, the integration of information technology into the business operations of Vietnamese enterprises still significantly lags behind international standards.

5.3. Lessons for Vietnamese logistics enterprises

The successful implementation of AI technology in DHL’s predictive analytics in logistics management holds several promising implications for Vietnamese logistics enterprises seeking to enhance proactive level in management:

Assess the current systems, considering time, labor, and capital costs of existing processes and identify areas for improvement: Initially, companies should evaluate the scope of available solutions. Factors to consider include the scale and complexity of their main areas in logistics, IT infrastructure, and expected return on investment. After selecting a solution or software option, companies may conduct trials to understand how the technology functions in various situations. When piloting new programs, successful implementation relies on alignment between planning, transportation, and customer service teams. Positive communication with customers can further optimize the process.

Enhance digital transaction models by promoting logistics technology, research, development, and sharing open data: Enterprises themselves are the key players, so they should proactively digitize their activities. Thorough market research is essential—both in logistics and software markets. Specifically, there's a need to invest in researching technology models, AI techniques that can support route selection based on operational realities. Establishing a specialized department comprising technology experts, actively sending staff for exchanges, networking, and learning modern techniques among enterprises in the region and globally is advisable.

Strengthen real-time data through drivers by developing an application for updating information: While driver experience remains pivotal in some main areas of logistics in Vietnam, companies could consider launching a mobile app to enable drivers to report and resolve issues in real-time. Drivers witness road conditions directly during deliveries: weather, traffic jams, customer rescheduling requests, obstacles, and even law enforcement. They can then update and store this data in the company's internal database, allowing managers and other drivers to access information and devise appropriate next steps. Furthermore, drivers can collect and enhance information in complex terrain areas or data-deficient areas based on their experiences, then input it into the company's server. This not only fills the company's data repository but also serves as potential business data.

Construct a delivery model leveraging the abundance of carriers in Vietnam: Optimal route selection becomes easier for AI with more diverse transportation types available, such as certain areas being suitable for motorcycles while others for pickup trucks. Drivers aren't as constrained as formal employees of the company, reducing personnel cost pressures. With a substantial number of drivers, deliveries will always ensure the most suitable and effective vehicles for the enterprise.

Investing in AI talent and training: Enterprises should prioritize training personnel in AI and data analytics to leverage these tools effectively. Collaborating with AI experts or solution providers can ensure successful implementation and maintenance of AI-driven systems, optimizing their utility. Having dedicated experts enables the organization to navigate complex AI implementations, develop advanced algorithms, and optimize logistics predictive analytics effectively. These experts can also provide opportunities for hands-on experience with AI projects related to logistics management and encourage employees to work on pilot projects or initiatives where AI technology is applied to real-world logistics scenarios.

Compliance with Vietnamese regulations regarding data privacy, security, and ethical AI use: Enterprises should implement robust encryption techniques, access controls, and regular security audits to mitigate potential threats. Compliance includes adherence to national cybersecurity standards and the implementation of secure protocols for data transmission and storage within logistics AI systems. For Vietnamese enterprises engaged in international logistics, compliance with regulations on cross-border data transfers is crucial. Adherence to legal frameworks governing the transfer of data across borders, such as data localization requirements or adherence to international data transfer agreements, is essential to avoid legal implications.

6. Conclusion

The recent progress in the calculation power of computers has enabled the growth and complexity of AI applications. According to the purpose of this study, the results showed that AI technology creates a new analytics intelligence to justify the choice of strategic decision making rather than heavily focused on intuition intelligence in logistics management. AI can also provide an in-depth assessment of the future, at capturing the big picture of information and learning within the bounds of paradigm. Researchers also provided the extensive use of artificial intelligence among logistics firms as essential and necessary for shaping the future of the logistics management of industry 4.0 through the case study of DHL Logistics. DHL's air freight transit time prediction, DHL's Global Trade Barometer, DHL's Resilience360 platform and DHL's SmartTruck have demonstrated a commitment to leveraging cutting-edge technology for operational efficiency and risk mitigation.

The paper also concerns AI-based logistics management with promising predictive analytics in the Vietnam logistics context. The logistics industry in Vietnam has experienced a surge in technological adoption among a majority of small- and medium-sized enterprises, with only a fraction incorporating third-party logistics services. However, AI technology in predictive logistics management in Vietnam primarily aids in data storage, vehicle tracking, and basic route optimization, relying heavily on drivers' experience with the example of Abivin vRoute. Overall, there is immense potential for the application of predictive analytics in Vietnamese logistics, but advancements in technology and greater integration of AI are needed to propel the industry towards international standards and improve efficiency.

Although the paper has provided information about using AI in predictive analytics in logistics management and recommendations for Vietnamese logistics enterprises, there are still academic gaps in this field. There is still a need for research of the results of which could in selecting only the most appropriate AI technology approach for forecasting in logistics and production in Vietnam. Academicians and universities should work together and create affordable and reliable artificial intelligence solutions for the logistics management that have the potential to contribute towards sustainable development goals.

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