Knowledge Transfer Factors for Internal Combustion Engine (ICE) Industry to Electric Vehicle (EV) Industry by Artificial Intelligent: Machine Learning

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Abstract: This study aims to identify the factors influencing knowledge transfer within companies transitioning from the internal combustion engine (ICE) industry to the electric vehicle (EV) industry through an extensive literature review. In addition to summarizing findings and proposing strategies for utilizing artificial intelligence in knowledge transfer, our framework reveals the relevance of three key knowledge transfer factors and three distinct forms of artificial intelligence, including machine learning, in facilitating knowledge transfer. These insights can prove invaluable to entrepreneurs operating within the internal combustion engine automotive sector, offering essential guidance for enhancing the knowledge transfer process and navigating the transition to the electric vehicle industry. By implementing these strategies, businesses can maintain and support their competitiveness in this evolving business.

1 INTRODUCTION

An overview of the automobile industry reveals a consistent decline in sales since 2019, largely attributed to the COVID-19 pandemic, which significantly impacted overall economic growth. Global car sales experienced a sharp decline, resulting in a substantial 11% reduction in global sales in 2021 compared to 2019 (Worldwide Car Sales 2010–2022, Statista Research Department, 2022) (Richter, 2022). Another contributing factor is the rise in fuel prices, stemming from reduced import and export activities in major fuel-producing countries during 2021–2022. This directly impacted the sales of fuel-based vehicles. Conversely, an examination of electric vehicle (EV) sales in 2021 revealed a remarkable growth trend, diverging significantly from internal combustion engine vehicles (ICE), which rely on gasoline as their primary fuel source. This shift can be attributed to the current surge in fuel costs, prompting consumers to prioritize energy conservation and seek vehicles powered by alternative energy sources more frequently. Additionally, EVs have gained popularity due to their energy-saving advantages (Egbue & Long, 2012) , superior driving experience compared to ICE vehicles, and diminishing concerns regarding mileage per charge (Sovacool & Hirsh, 2009). Furthermore, several governments in various countries have shown support by reducing taxes on electric vehicles. EVs also contribute significantly to reducing carbon emissions (Hofmann et al., 2016) and greenhouse gas emissions (Qiao et al., 2020) as part of efforts to align with the Paris Agreement's goals for addressing climate change (Horowitz, 2016). Consequently, electric vehicles are increasingly appealing to consumers. The exponential growth of various types of electric vehicle trends worldwide has brought about a revolutionary and disruptive transformation (Christensen et al., 2013) within the automotive industry. The conventional internal combustion engine (ICE) parts manufacturing industry faces significant pressure to

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adapt swiftly in response to rapidly advancing technologies. Every entrepreneur within this sector must act promptly to effect necessary modifications and prevent falling behind. It is noteworthy that all entrepreneurs in the ICE industry possess substantial potential, primarily due to their ability to manufacture automotive components and adhere to highly systematic and stringent quality, safety, and cost control procedures. Entrepreneurs in the auto parts sector require both explicit and tacit knowledge. Explicit knowledge, which can be documented in forms such as operation manuals and work standards, including a knowledge database system stored electronically, is essential. Additionally, tacit knowledge, unique to individuals within the organization, plays a crucial role. This includes accumulated past working expertise, encompassing problem-solving techniques developed through practical experience (Nonaka, 1994). Such invaluable knowledge assets are integral to assisting ICE entrepreneurs in adapting to the evolving global electric vehicle (EV) industry and maintaining their competitiveness. This paper explores knowledge transfer factors that facilitate the transition from the Internal Combustion Engine (ICE) industry to the Electric Vehicle (EV) industry, leveraging Artificial Intelligence and Machine Learning.

Knowledge management stands as a crucial strategy employed to bolster an organization's adaptability. Emerging from the framework of a learning organization (Senge, 1990), the concept of the 'fifth discipline' offers a blueprint for cultivating organizational learning. This discipline comprises five fundamental principles that play a pivotal role in propelling, promoting, and for nurturing the development of a learning organization: personal mastery, mental models, shared vision, team learning, and systematic thinking. This paper explores the significance of knowledge management in the context of transitioning from the Internal Combustion Engine (ICE) industry to the Electric Vehicle (EV) industry, leveraging Artificial Intelligence and Machine Learning.

Knowledge transfer within a global organization, particularly when aligned with the overarching vision, necessitates a profound comprehension of the firm, encompassing its sources of knowledge and internal information storages. This comprehensive understanding not only expedites but also fosters the efficient dissemination of knowledge throughout the organization. Such knowledge dissemination, in turn, serves as a catalyst for innovation, enhancing the competitiveness of the organization's products and corporate services (Rios-Ballesteros & Fuerst, 2022).

Artificial intelligence (AI) technology finds extensive applications across diverse industries. AI, characterized by a machine's capacity to learn and comprehend knowledge across various domains, including reasoning abilities (Miller, 2019), has significantly impacted and benefited the commercial sector. Its ability to enhance efficiency is achieved by streamlining processes, automating repetitive tasks, and simplifying complex procedures, originally designed to enhance precision and overall workforce productivity (Agrawal et al., 2017). In the realm of knowledge management, researchers have long explored knowledge transfer in various contexts. However, scant attention has been devoted to the transfer of knowledge from the internal combustion engine (ICE) industry to the electric vehicle (EV) industry. More specifically, the integration of AI into the knowledge transfer process remains an underexplored area, lacking comprehensive training and alignment with knowledge management best practices. Consequently, our study seeks to address a fundamental question: What factors influence knowledge transfer from the ICE industry to the EV industry through the utilization of Artificial Intelligence?

2 KNOWLEDGE TRANSFER

The authors have conducted a literature review, which serves as a methodology for synthesizing knowledge and evaluating the applicability of findings from significant studies to practical contexts (Souza et al., 2010).

2.1 Knowledge Transfer Definition

Knowledge transfer refers to the conveyance of information or knowledge from individual, group, or organization to another, addressing the knowledge needs of the recipients. It constitutes a pivotal step within the realm of knowledge management.

Szulanski (1996) defines knowledge transfer as a form of communication involving the transmission of messages from the sender to the recipient. Davenport and Prusak (1998) offer an intriguing perspective, considering knowledge transfer as an integral part of daily work within an organization. Knowledge-seeking practitioners actively seek sources of knowledge and information to apply in their work. Martinkenaite (2011), emphasizes that knowledge transfer is a vital process aimed at equipping individuals within an organization with the necessary knowledge to enhance job practices, foster efficiency, and bolster the organization's competitiveness. Moreover, the concept of knowledge transfer extends to open innovation practices. Olaisen and Revang (2017), stress the importance of knowledge becoming valuable when transferred to those who seek to apply it within the organization. This enhances organizational learning and overall effectiveness (Al-Emran et al., 2018). Efficiency in organizational knowledge transfer hinges on the relevance of the knowledge, measurable outcomes, and the organization's ability to learn and absorb information. Additionally, it must satisfy the recipients' needs (Bacon et al., 2020). Rios-Ballesteros and Fuerst (2022), examine knowledge transfer in the context of international organizations, where it plays a pivotal role in facilitating and encouraging the efficient transfer and utilization of innovative developments to enhance products and corporate services, ultimately elevating the organization's competitiveness.

Based on the results of the literature review, the authors have defined knowledge transfer as the process of transmitting experience and expertise from a sender to a recipient within a specific context, empowering the recipient to become an expert within their own domain.

2.2 Knowledge Transfer Effectiveness

Research studies on knowledge transfer effectiveness often investigate the indicators of success within the knowledge transfer context. The authors aim to gather pertinent research ideas as follows:

Davenport and Prusak (1998) delineated success indicators for the knowledge transfer process as the recipient's ability to efficiently apply the transferred knowledge for the benefit of their organizations, thereby enhancing their effectiveness in tasks requiring that knowledge. This efficacy is a direct outcome of our capacity to communicate and effectively transfer knowledge. In cases where the knowledge is less complex, the likelihood of successful transfer is higher, resulting in improved organizational efficiency and keep competitiveness (Argote et al., 2000). Gupta and Govindarajan (2000) expounded on success indicators for knowledge transfer, considering them from the perspective of knowledge transfer recipients. These indicators encompass the willingness of recipients to embrace knowledge transfer, their motivational disposition, their aptitude for absorbing knowledge, absorptive capacity, and the choice of transmission channels. Easterby - Smith et al. (2008) described success indicators in the knowledge transfer process as contingent on the recipient's ability to effectively utilize the knowledge in tasks, adapt it to their working context, and apply it to generate new knowledge, all aligned with the organization's objectives. Pérez - Nordtvedt et al. (2008) identified four pivotal indicators for the success of knowledge transfer: comprehension, usefulness, speed, and economy. Furthermore, success is measured by the recipient's ability to employ the transferred knowledge effectively to ensure the success of assigned projects. Zhu and Xu (2019) emphasized that the success of knowledge transfer hinges on organizations' capacity to discover new knowledge through the application of knowledge by recipients, ultimately enhancing innovation capabilities and sustaining competitiveness in the business area. Li and Zhu (2021) conducted comprehensive research on the success of knowledge transfer across five dimensions:

1. The speed of knowledge transfer.
2. The appropriate cost for utilizing knowledge in the transfer processes.
3. The effectiveness of leveraging knowledge.
4. The validity of the information being transferred.
5. The satisfaction of knowledge recipients.

2.3 Knowledge Transfer for EV Shift

In the current electric vehicle industry landscape, knowledge and technology have significantly evolved across various domains critical for electric car production. Notably, some of this knowledge is transferable from the internal combustion automobile industry. The authors have diligently conducted research, scrutinizing literature across diverse fields essential for the development and manufacturing of electric vehicles.

Kumar and Revankar (2017) assert that the knowledge and technology employed in electric vehicle production encompass:

1. Energy storage systems, notably batteries.
2. Electric propulsion systems, involving the conversion of electrical energy into mechanical energy through a driving system.
3. Microelectronics controllers for electric propulsion systems, which are crucial for overall efficiency.

Furthermore, electric vehicle manufacturers, particularly those focused on electric propulsion, should possess fundamental knowledge of electrical engineering. This knowledge is essential for designing components, such as strategically positioning permanent magnets in electric motor drives to meet the desired characteristics of electric vehicles. (Feng & Magee, 2020) conducted extensive research on the requisite knowledge and technology for electric vehicles. They assert that electric vehicle production necessitates expertise in four key areas:

1. Energy storage knowledge, encompassing equipment used for battery energy storage.
2. Charge and discharge expertise, including the design of infrastructure for charging.
3. Knowledge of drive systems that convert electrical energy into mechanical energy, such as motors.
4. Proficiency in electric power control devices for electric propulsion systems, with particular emphasis on battery management systems.

Bhatti et al. (2021) conducted noteworthy research on program development knowledge and technology, highlighting the importance of collecting data from various sources, including wireless connection technology systems (wireless), the Internet of Things (IoT) system, and artificial intelligence. These technologies are vital for driving models, such as autonomous driving systems and various driver assistance systems, as well as for monitoring battery and vehicle health. Adu-Gyamfi et al. (2022) assert that electric vehicles play a pivotal role in reducing carbon emissions and mitigating climate change through the use of renewable energy. Therefore, knowledge of renewable energy is indispensable in the electric vehicle industry. Manufacturers need expertise in various fields related to renewable energy to design equipment used in electric vehicles and effectively engage in renewable energy initiatives. Costa et al. (2022) conducted a study affirming that knowledge of renewable energy is essential for businesses operating in the electric vehicle industry. Such knowledge is crucial for the deployment of devices like meters or smart sensors, facilitating activities related to renewable energy systems. This expertise is invaluable for organizations seeking to enter the electric vehicle industry.

To sustain their business from the disruptive transition to electric vehicles current internal combustion engine manufacturers must focus on acquiring knowledge related to automotive design and manufacturing, which can facilitate a successful transition to EVs. This transformation includes considerations such as material selection knowledge, as discussed by (Czerwinski, 2021) . Additionally, factors like quality control, lean manufacturing concepts, automation, and robotics play a crucial role in this transition. Casper and Sundin (2021) delve into the challenges and opportunities faced by the remanufacturing industry as electric vehicles gain a larger market share compared to internal combustion engine vehicles. They emphasize the necessity of investing in knowledge, equipment, and sustainable solutions. In terms of manufacturer knowledge, supply chain management is an importance. Beltagui et al. (2022) explore the convergence of digital transformation and sustainability in supply chains, emphasizing the need to carefully assess the impact of digital technologies on sustainability initiatives. Through case studies of electric vehicles, they highlight the importance of this assessment. Creating an electric vehicle ecosystem also involves considerations related to environmental and safety standards in public regulations. explored the convergence of digital transformation and sustainability in supply chains, examining their interplay and potential conflicts. Through case studies of electric vehicle emphasizes the importance of carefully assessing the impact of digital technologies on sustainability initiatives. For making electric vehicle eco system, also relate to environment and safety standard in public regulation. Meckling and Nahm (2019) argue that recent announcements to phase out internal combustion engine vehicles primarily serve as a form of political signalling in a competitive race among countries for leadership in green industrial advancements in electric vehicles. They stress the significance of safety standards, particularly in lithium-ion batteries for automotive applications, and provide an overview of international standards and regulations governing safety testing under various and abusive conditions. This comprehensive review aims to identify areas for improvement and boost confidence in the adoption of electromobility. (Ruiz et al., 2018).

2.4 Artificial Intelligent: Machine Learning

Computer engineering within the field of information technology has seen significant development and widespread adoption across various industries, including the automotive sector. Artificial intelligence (AI), which has the capacity to emulate human cognitive processes, finds extensive application in the automotive industry. The authors have conducted a thorough review of the literature concerning artificial intelligence and the different types of machine learning. This review forms the basis for establishing a research framework aimed at facilitating the transfer of essential knowledge required for transitioning to the electric vehicle industry.

The inception of artificial intelligence can be attributed to a computer scientist who devised a test to evaluate a computer's ability to answer questions and engage in conversations under specific conditions. If humans cannot distinguish whether the responses come from a person or a computer, it is deemed that the computer possesses the intelligence to answer questions autonomously. This test, famously known as the Turing Test (Turing, 1950), marked the beginning of artificial intelligence. Modern interpretations and applications of artificial intelligence have expanded significantly. Rajkomar et al. (2018) highlighted the potential of proper artificial intelligence utilization, enabling rapid development and providing organizations across various industries with a competitive edge. Today, nations worldwide prioritize the use of artificial intelligence as a pivotal strategy for national development. Lu (2019) described artificial intelligence as a technology capable of synthesizing knowledge and information, encompassing diverse scientific disciplines to replicate human cognitive processes, including learning, memory, decision-making, differentiation, and response to stimuli. In the current landscape, artificial intelligence systems have access to vast amounts of network data, leading many industries to harness this technology to reduce costs and enhance competitiveness (Cai-Ming & Hao-Nan, 2020). When applied in educational systems, artificial intelligence has demonstrated a profound impact on teaching methodologies and knowledge management practices (Chen et al., 2020). Individualized instruction has proven highly effective for learners, enabling them to take charge of their learning and decision-making processes (Nilsson, 1982). Machine learning, categorized into four types - supervised learning, unsupervised learning, semi-supervised learning, and reinforcement learning, plays a pivotal role in this context Janiesch et al. (2021). Machine learning involves training artificial intelligence systems to learn from data or algorithms, enabling them to make decisions based on virtual models and analyze data to devise problem-solving strategies. It is important to note that the aforementioned studies do not delve into the factors influencing knowledge transfer from the internal combustion engine industry to the electric vehicle industry through artificial intelligent machine learning.

The paper, however, does not explore the factors influencing knowledge transfer from the internal combustion engine industry to the electric vehicle industry through artificial intelligent machine learning.

2.5 Knowledge Transfer by Artificial Intelligent: Machine Learning

Artificial intelligence has significantly contributed to the business sector, resulting in increased overall work efficiency, and allowing organizational members to dedicate more time to the development of essential and value-added tasks. It has also brought about notable improvements in knowledge transfer. Lombardi (2019) suggests that the future of knowledge transfer research related to organizational performance and business processes may focus on exploring emerging and captivating areas, such as the Internet of Things (IoT), artificial intelligence, big data, analytics, cyber-security, simulations, digital integrations, and the broader context of Industry 4.0 environments.

The characteristics of knowledge are closely related with knowledge transfer and the imperative of AI machine learning. Taherdoost and Madanchian (2023) delved into the evolving landscape of knowledge management within the context of remote and hybrid work arrangements, underscoring the pivotal role of artificial intelligence (AI) in addressing KM challenges. Some studies have introduced a framework for the application of AI in tackling training and managerial challenges. They elucidate how AI can enhance various facets of the training process, encompassing knowledge management, needs analysis, training organization, and feedback. This transformation ultimately empowers organizations to become knowledge-driven entities capable of delivering personalized training and elevating learning quality (Chen, 2022).

Despite the existing research on AI, machine learning, and knowledge transfer, there remains a dearth of information pertaining to the application of knowledge transfer in facilitating the transition from the internal combustion engine industry to electric vehicles. This gap in knowledge has made the authors' interest in investigating the factors that influence this transition to electric vehicles, leveraging AI and machine learning to facilitate an efficient.

3 FINDING AND DISCUSSION

Drawing from a comprehensive literature review encompassing various viewpoints, the authors have synthesized and consolidated multiple fields, as outlined in Figure 1. These characteristics, accompanied by relevant authors, have been organized based on knowledge transfer components. The conceptual framework depicted in Figure 1 is constructed upon these variables. The resultant study framework will yield knowledge transfer guidelines applicable to the internal combustion engine industry across all organizational levels. This framework not only promotes knowledge development but also showcases skills and abilities, facilitating the pursuit of business opportunities and enabling entrepreneurs to attain a competitive advantage over their counterparts.

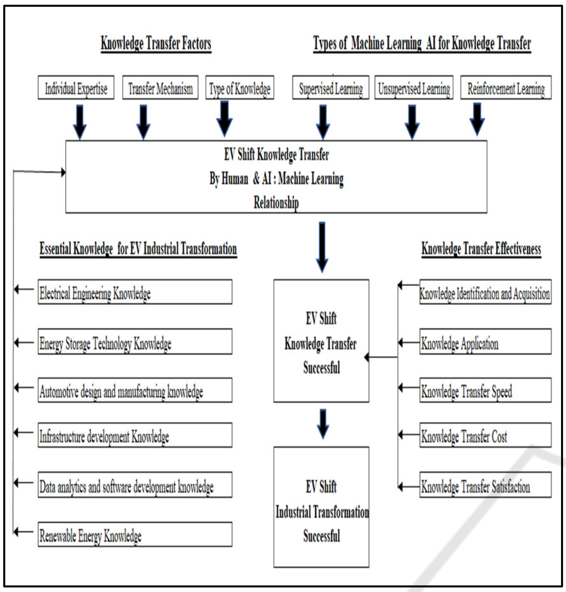

Figure 1: A Conceptual Framework: Literature Review.

The comparison between the characteristics of automotive design and manufacturing knowledge and the necessity of knowledge transfer through AI and machine learning is shown in Figure 2.

Automotive Design and Manufaturing Knowledge	Knowledge Characteristic	Potential for EV Transition	AI Implement Necessarily
Materials Expertise	Big data , Always update	Understanding the properties of materials used in ICE components and applying this knowledge to select suitable materials for EV.	High
Manufacturing Process Expertise	Wide range , Big data , Skill , Tacit Knowledge	Knowledge of traditional manufacturing processes used in ICE part production adapting these processes for EV.	High
Quality Control and Assurance	Practical , Explicit Knowledge	Experienced in quality control techniques and testing methodologies in ICE and adapt for ensuring the reliability and performance of EV.	Low
Lean Manufacturing and Process Optimization	Practical , Explicit Knowledge	Knowledge of lean manufacturing principles used in ICE apply to optimize processes for EV to reducing waste and improving efficiency.	Low
Automation and Robotics Experience	Technical , Various Application , Tacit Knowledge	Expertise in utilizing automation and robotics in ICE for designing automated production lines for EV.	Moderate
Supply Chain Management Proficiency	Big data , Always update	Experience in managing complex supply chains for ICE apply to sourcing and managing components for EV.	High
Environmental Regulations and Sustainability Practices	Practical , Always update , Explicit Knowledge	Knowledge of environmental regulations from ICE apply to environmentally conscious manufacturing of EV.	Low
Safety Standards and Compliance	Practical , Always update , Explicit Knowledge	Understanding safety standards from ICE and integrate to ensure the safe handling of high-voltage EV components.	Low

Figure 2: Characteristics of Knowledge: Literature Review.

4 CONCLUSIONS

This study aims to identify the factors influencing the transition from internal combustion engine (ICE) parts production to electric vehicle (EV) component manufacturing, which presents a significant challenge for suppliers in terms of knowledge transfer. This challenge is well-acknowledged in the industry due to the fundamental differences in technology, materials, and manufacturing processes required for EVs. Based on a thorough literature review, the results provide six criteria outlined in the conceptual framework. Additionally, the study reveals that these six characteristics positively impact knowledge transfer between the ICE and EV industries. The conclusions drawn from this research have both academic and practical implications. It contributes to the field of academic knowledge management and highlights the factors essential for effective knowledge transfer in the context of industry transformation. While knowledge transfer is crucial, specific strategies, particularly focused on the nature of knowledge transfer from ICE to EV, are essential. A more in-depth exploration of this specific knowledge transfer could offer practical guidance to suppliers. Identifying key knowledge domains and aligning them with EV manufacturing processes can provide valuable insights. Developing strategies tailored to address specific learning challenges is a valuable approach, and integrating AI technologies into these strategies can enhance knowledge transfer efficiency, especially in complex domains. The expected practical contributions include enhanced knowledge transfer support and increased competitiveness for enterprises in the internal combustion engine vehicle industry. This can be achieved by harnessing knowledge transfer and knowledge management as innovative tools facilitated by machine learning-based artificial intelligence to improve the efficiency of the transition to electric vehicle production. Entrepreneurs involved in the automotive industry and related businesses can use these factors as guidance for engineers seeking a competitive advantage through practice, improvement, and development. However, it's important to note that the study is based on a literature review, and further empirical testing of the conceptual framework is recommended before practical application.

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