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Korean Multinational Corporations' Global Expansion Strategies in Manufacturing Sector: Mother Factory Approach

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Abstract

The study explores the evolving landscape of overseas expansion strategies by Korean corporations, focusing on recent geopolitical tensions, the COVID-19 pandemic, and disruptions in global supply chains. It emphasizes the challenges faced by industries producing high-value products and delves into the concept of "Friend-Shoring" policies in the United States, leading major Korean companies to invest in local semiconductor, battery, and automotive factories. Recognizing the potential fragmentation of Korea's manufacturing sector, the paper introduces the "Mother Factory" strategy as a policy initiative, inspired by Japan's model, to establish core production facilities domestically. The discussion unfolds by examining the cases of major companies in Japan and the United States, highlighting the need for Korea to adopt a mother factory strategy to mitigate risks associated with friend-shoring policies. Inspired by Intel's "Copy Exactly" approach, the paper proposes a Korean mother factory model integrating smart factory technology and digital twin systems. This strategic shift aims to enhance responsiveness to geopolitical challenges and fortify the competitiveness of Korean high-tech industries. Finally, the paper proposes a Korean Mother Factory based on smart factory concepts. The suggested model integrates smart factory technology and digital twin frameworks to enhance responsiveness and fortify competitiveness. In conclusion, the paper advocates for the adoption of a comprehensive Korean Mother Factory model to address contemporary challenges, foster advanced manufacturing, and ensure the sustainability and competitiveness of Korean high-tech industries in the global landscape. The proposed strategy aligns with the evolving dynamics of the manufacturing sector and emphasizes technological advancements, collaboration, and strategic realignment.

Keywords: *Multinational corporates, Global Expansion, Mother factory, Copy exactly, Smart Factory, Digital Twin*

1. INTRODUCTION

Over the past few decades, prominent Korean corporations such as Samsung, Hyundai, LG, among others, renowned for their global competitiveness in the manufacturing sector, have actively pursued overseas expansion to secure market share and diversify their business portfolios. Initially, Korean companies

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predominantly entered international markets by exporting products or services, successfully establishing a presence in the global market and generating revenue. Furthermore, some major corporations opted for a strategy involving direct investment abroad, operating businesses and establishing production facilities in foreign countries to adapt to local market peculiarities and achieve cost efficiency[1][2].

However, recent geopolitical tensions of within US and China, the ongoing COVID-19 pandemic, and disruptions in global supply chains have prompted companies to reassess their overseas expansion strategies and seek innovative solutions. Particularly, industries producing high-value products such as semiconductors, batteries, and electric vehicles have faced new challenges, including the "friend-shoring" policies emerging from the United States[3].

The friend-shoring policies in the United States have led major Korean companies to invest billions of dollars in establishing semiconductor, battery, and automotive factories within the U.S. This trend raises concerns about the potential fragmentation of Korea's manufacturing sector and underscores the need for flexible production strategies that can safeguard against technology leaks and adapt to sensitive situational changes.

To address these challenges, South Korea is advocating for the "Mother Factory" strategy as a policy initiative. Originating from Japan, the Mother Factory approach involves establishing a core production facility equipped with state-of-the-art technology domestically, which then serves as a foundation for penetrating foreign markets.[4]

This paper analyzes the cases of major companies in Japan and the United States and emphasizes the need to adopt a mother factory strategy to resolve the risks of friend-shoring policies. This paper also proposes a new strategy leveraging smart factory technology, drawing Inspiration from Intel's copy exactly approach, and based on Japan's existing mother factory concept. By doing so, it aims to support Korean manufacturing enterprises in navigating the complexities of global competition, ensuring sustainable success in the future.

2. RECENT ENVIRONMENT OF KOREAN MANUFACTURING COMPANIES AND MOTHER FACTORY POLICY

The Biden administration, spurred by global disruptions caused by the COVID-19 pandemic, trade and technology conflicts, and the Russia-Ukraine crisis, emphasizes awareness of shared values among allied nations or alliance partners to address worldwide supply chain turmoil. As a potential means to minimize latent supply chain risks, the administration proposes concepts such as 'Friend-Shoring' and 'Ally-Shoring.'[5]

U.S. Treasury Secretary Janet Yellen underscores the necessity of Friend-Shoring, proposing it as a strategy to manage global economic risks through enhanced relationships with trustworthy partner nations. She straightforwardly states that the abuse of power and dominance in specific markets by China will no longer be tolerated, signaling a shift in economic dynamics with China and Russia.[5]

These developments indicate a macroscopic shift in U.S. manufacturing supply chain policies. While the dominant trend from the 1990s was based on the efficiency of free trade and international division of labor through Offshoring and Outsourcing, the post-2007 global financial crisis era witnesses the emergence of Reshoring policies, focusing on fostering domestic manufacturing and expanding employment. This shift suggests a strategic move by the United States to emphasize the stability of its manufacturing supply chain and reduce domestic economic risks.

As a result of these implications, particularly in advanced industries such as the semiconductor sector, notable changes are taking place. The semiconductor industry, recognized as a pivotal sector driving future economic and security landscapes, is witnessing a surge in importance as a key element in the reconfiguration of a global semiconductor supply chain centered on allied nations. The essential framework for this transformation is evolving through the establishment of the "East Asian Semiconductor Supply Chain Network" (hereinafter referred to as the semiconductor agreement).

Acknowledging the critical role of the semiconductor industry in future economic and security strategies, the semiconductor agreement is propelled by aggressive investments aimed at securing domestic manufacturing capabilities and technological prowess. This initiative is strategically designed to reshape the global semiconductor supply chain with a focus on allied nations, enhancing regional cooperation in East Asia to elevate the industry's competitiveness.

This strategic approach emphasizes collaboration among allied nations and integration within the East Asian region, providing essential conditions for the semiconductor industry's sustained growth and the maintenance of a stable supply chain. Recognizing the significance of the semiconductor industry in the global economic and security arenas, this groundbreaking strategy is evaluated as a proactive response to address and capitalize on its pivotal role.

Amid growing concerns about deindustrialization, the concept of "Mother Factory" is gaining attention. The recent trend of Korean manufacturing companies relocating abroad is not a new issue. However, traditional manufacturing powerhouses are promoting reshoring. The importance of robust manufacturing facilities and infrastructure has increased in the aftermath of COVID-19, prompting countries worldwide to competitively foster their manufacturing sectors.

Intense competition in the industrial power struggle between the US and China has heightened the significance of manufacturing from a supply chain management perspective. Due to factors like rising labor costs, Korea has faced challenges in retaining its manufacturing base. While relocating factories for cost competitiveness is inevitable from a manufacturing cost perspective, specific measures are needed to minimize domestic deindustrialization damages. The government's announced strategy to promote advanced manufacturing in six key sectors, including semiconductors, displays, secondary batteries, bio, future cars, and robots, holds significant importance in terms of timeliness and strategic relevance.

Global industrial dominance is undeniably linked to manufacturing competitiveness. Korea must overcome price competition with late-developing countries for general products and face competition with established manufacturing powerhouses like the US, Germany, and Japan for advanced products. The government's execution of the advanced manufacturing promotion strategy is crucial for transitioning from past large-scale industries to a smart, flexible, and small-scale industrial structure [5].

However, domestic manufacturing conditions remain vulnerable. Labor costs continue to rise, and the manufacturing aversion among the younger generation exposes chronic labor shortages. The intensification of the deindustrialization of root industries, which are the foundation of manufacturing, raises concerns about destabilizing the manufacturing base. As a result, companies are increasingly moving production facilities to regions with relatively lower labor costs and easier labor utilization. According to data from the Export-Import Bank, as of 2021, there were 5,404 foreign-invested companies, employing 2 million local employees, with a total investment balance of $264.5 billion. Notably, 562 manufacturing companies cited low-wage utilization as their goal for overseas expansion.

In response to these challenges, the government announced plans in March to establish Mother Factories, with a focus on leading manufacturing plants that have played a crucial role in responding to the deindustrialization caused by overseas relocation. The concept of Mother Factory emerged in the early 2010s when the trend of domestic manufacturers moving factories overseas reached its peak. Although detailed plans have not been announced, the centralization of functions such as product planning, design, research and development (R&D), and high-value-added functions in Mother Factories aims to prevent deindustrialization by leaving advanced manufacturing facilities in the country.

The success of Mother Factories, which the current government is actively promoting, depends on strengthening the competitiveness of the manufacturing industry through the advanced manufacturing promotion strategy. Detailed plans should be developed, especially for supply chain management, including small and medium-sized enterprises essential to the value chain. The nurturing strategy for key companies involved in the value chain, such as those providing components and materials necessary for complete product manufacturing, is also a critical issue. Cooperation between large companies and small to medium-sized enterprises across the entire industrial ecosystem requires careful consideration to avoid accusations of favoritism toward large companies. Particularly, as the competitiveness of large companies' finished products is derived from the competitiveness of cooperating companies in components and materials, enhancing the R&D capabilities of these companies and advancing the construction of smart factories are urgent tasks that cannot be postponed any longer.

The success of the Mother Factory initiative, which the current government is energetically pursuing, depends on strengthening the manufacturing industry's competitiveness through the advanced manufacturing promotion strategy. The increasing importance of a supply chain capable of supplying high-quality components and materials promptly underscores the need for our industrial policy to focus on this aspect. Additionally, the collaboration with local universities for specialized workforce training and utilization, as well as the reinforcement of the functions and roles of local specialized research institutions, should be enhanced to drive regional economies through the creation of manufacturing plants in each region.

3. CASE OF ADVANCED FOREUGN MANUFACTURING COMPANIES' TECHNOLOGY TRANSFER

3.1 Japanese Mother Factory – Toyota

Let us examine the case of Japan where the concept of the Mother Factory was pioneered. Following the concept of the Mother Factory leads us to the overseas expansion strategy of Toyota Motor Corporation. Toyota's overseas direct investment began in the 1960s and 1970s through partnerships with local companies in Mexico, South Africa, Thailand, Indonesia, etc., establishing a production system using knock-down (KD) parts. Particularly, upon entering Thailand, a key country in Southeast Asia, Toyota transplanted a factory that was almost identical to Japan's assembly line. Using Japan's Matsumoto factory as a model, Toyota Motors Thailand (TMT) adopted a nearly identical production line system.[6][7]

As a result, Toyota ensured that workers in the Thai factory possessed similar process and quality management capabilities as their counterparts in Japan. To address such challenges, Toyota introduced a system where the GPC (Global Production Center) divided the roles of the mother factory.

This approach of Japan's leading manufacturing companies in overseas factory expansion spread to other manufacturing companies. Notably, after 1990, when the yen's appreciation became a concern for domestic manufacturing competitiveness, Japanese companies, including Toyota, shifted their focus to overseas investments across various industries. Toyota, in particular, expanded by establishing mother factories in Japan and placing subsidiary factories in North America, Europe, and Asia to meet demand.

With Toyota's unique production system, the Toyota Production System (TPS), becoming the foundation of competitiveness, GPC (Global Production Center) was established as a specialized organization to promote the standardization of Toyota's production system. GPC played a crucial role in providing education for mid-level managers and on-site workers in overseas factories, emphasizing the transfer of the mother factory's production concepts.

Through the establishment of GPC, which included the creation of guidance manuals for overseas operations and training for expatriates, Toyota aimed to standardize the functions of the Toyota Production System. The nurturing of overseas factories to endow them with the functions of the mother factory and the introduction of a system to manage other overseas factories were also implemented.

Designating U.S., U.K., and Thai factories as comprehensive hubs for manufacturing in North America, Europe, and Asia, respectively, Toyota efficiently operates a global production network. By standardizing manufacturing and management functions across diverse regions, Toyota has successfully increased productivity.

Figure 1. Toyota Global Manufacturing Sites (Mother Factory and Children Factories)[8]

The Japanese Mother Factory serves as a central hub for planning advanced products and leading production innovation by introducing new equipment. It performs key functions such as technology transfer, technology guidance and troubleshooting. First, technology transfer is transferring products and production lines developed in the Mother Factory as-is or adapting them for localization to overseas facilities. Second, technical guidance is cultivating the skills and capabilities of local engineers and workers in overseas factories to build up their production and development capabilities. Finally, troubleshooting is regularly checking the operations of overseas factories and addressing any problems that cannot be resolved locally.

Recently, there has been an increasing trend to utilize Japanese domestic factories as specialized Mother Factories for advanced production technology and high-value-added product manufacturing, particularly as production lines are being relocated overseas for market expansion and cost reduction.[8]

The Mother Factory system aims to maintain Japan's excellent manufacturing base, known as "monozukuri," while transferring technology and expertise to overseas factories to harmonize Japan's outstanding manufacturing capabilities with cost savings in foreign facilities. This system, by establishing a domestic-centric production network, allows Japanese factories to compete with overseas facilities, thereby giving significance to the existence of domestic factories in Japan.

3.2 United States Semiconductor mother FAB – Intel's Copy Exactly

The "Copy Exactly!" strategy employed by Intel is a meticulous approach to innovation, involving the emulation of various experimental and research tiers used in identifying new techniques. This strategy focuses on optimizing parameters at manufacturing sites to achieve maximum throughput, down to minor details like glove color and workbench height. Researchers dedicate at least four years to perfecting a technique, and employees worldwide spend a year learning and replicating these changes at their sites. This strategy, initiated in the 1980s under Craig Barrett, aims to maintain consistency across manufacturing sites.[9]

Moving on to the concept of subsidiaries and their benefits for businesses, there are two types of integration: vertical and horizontal. Vertical integration, or integrated development and manufacturing (IDM) in the semiconductor industry, involves controlling the entire supply chain. However, this model faces challenges like flexibility and loss of focus. To address these issues, companies, including Samsung, detach their foundry businesses as subsidiaries.

Samsung's foundry model transitioned from being an IDM to a subsidiary-based structure in 2017. This shift was driven by a desire to avoid conflicts of interest with customers and to diversify the foundry portfolio. Subsidiaries provide benefits such as diversification, independence, and financial opportunities, allowing companies like Samsung to raise funds and focus on specific market segments.

The comparison between Intel's IDM 2.0 strategy and Samsung's model reveals similarities, with Intel seemingly emulating Samsung's approach. Intel aims to manufacture ARM's RISC-based CPUs, collaborate with EDA providers for process acceleration, become a leading chip manufacturer in the US and EU, and venture into automotive chip production. While Intel's entry into the foundry business poses a potential challenge to Samsung, the latter's strategy of focusing on consumer communication electronics and high-performance computing hardware can help maintain its position.

In conclusion, the "Copy Exactly!" strategy and the use of subsidiaries are integral aspects of Intel and Samsung's approaches to innovation and business structure, respectively. The competitive landscape in the foundry business, with both companies making strategic moves, suggests potential collaboration opportunities and challenges that could shape the industry's future.

Intel's Copy EXACTLY! (CE) technology has undergone significant evolution since its initial introduction. This methodology, developed to seamlessly replicate manufacturing processes across various facilities, plays a crucial role in Intel's global operations. The CE approach emphasizes achieving identical conditions, equipment, and procedures at destination facilities to minimize any differences in the manufacturing process.

Table 1. Intel's Technology Transfer Strategy upon Technology Generation [9]

Tech. Generation (micron = 10^3 μ)	Transfer Strategy	Comments
1.5	Make it work	Small band of engineers. Few ground rules needed.

1.0 ~ 0.8	Process Output Matching	Copy process selectively. Match to existing factory condition.
0.5	Copy Exactly	Copy everything that might affect the process.
0.35 ~ 0.25	System Synergy	Copy all manufacturing systems.

The evolution of CE technology can be understood through six key stages. The first stage is “introduction and initial implementation”. In this stage, initially, Intel recognized the need for a standardized method to successfully replicate manufacturing processes across diverse facilities worldwide. CE was employed to establish a systematic and repeatable approach. The primary goal was to ensure uniform product quality and performance across various manufacturing sites. The next step is “enhancement of process standardization”. Over time, Intel continuously improved the CE methodology to enhance process standardization. This included comprehensive standardization of procedures, training protocols, and environmental conditions, not just equipment replication. This enhanced standardization ensures faithful replication of not only equipment but the entire operating environment. The third one is “integration of advanced technologies”. Adapting to the rapid advancements in semiconductor technology, Intel adjusted the CE approach to seamlessly integrate cutting-edge technologies into new facilities. This includes delivering not only mature technologies but also the latest enhancements in manufacturing processes, materials, and equipment. This approach keeps Intel at the forefront of global semiconductor innovation. The fourth stage is called “globalization and scalability”. As Intel expanded globally, the CE methodology evolved to address the challenges of globalization and facility expansion. This method ensures that each facility adheres to high standards of quality and consistency globally. The fifth stage is “flexibility and adaptability”. The CE methodology demonstrated flexibility and adaptability to cope with the dynamic nature of semiconductor manufacturing. By accommodating changes in equipment models, process technologies, and facility layouts, it ensures improvements and innovations without compromising existing processes. The final stage is “quality assurance and risk mitigation”. CE remains central to Intel's quality assurance and risk mitigation strategies. By successfully replicating processes, Intel minimizes the risk of errors, shortens time-to-market for new products, and enhances product reliability.[10]

In conclusion, the evolution of Intel's Copy EXACTLY! Technology continues to be refined to meet the dynamic demands of the semiconductor industry. By combining process standardization, integration of advanced technologies, and global expansion, Intel consistently delivers products of the same high quality across manufacturing facilities worldwide, positioning itself at the forefront of semiconductor innovation.

4. PROPOSED KOREAN MOTHER FACTORY BASED ON SMART FACTORY

In the aforementioned case study of Toyota, one of the notable advantages lies in the attainment of production quality and productivity akin to its originating Japanese facility within consumer-proximate regions. However, akin to the challenges encountered by Toyota in a large-scale recall, a potential drawback arises when universally applying identical standards and production management protocols across all global factories. This approach renders all facilities susceptible to a singular external risk factor, amplifying the ripple effect across the entirety of the manufacturing network. This lack of diversification poses a substantial risk to the resilience of the production ecosystem.

Moreover, a vulnerability emerges in the face of external disruptions, such as the recent tensions between the United States and China, which necessitate agile supply chain reorganization. The rigidity of a uniform global standard may impede adaptability to geopolitical shifts, potentially impacting the competitiveness and sustainability of the manufacturing network.

Drawing parallels with Intel's successful implementation of the "copy exactly" strategy in semiconductor production, the replication of this model by Korean semiconductor companies, particularly in their foray into the Chinese market, has been beneficial. However, the escalation of the US-China conflict has resulted in de facto prohibitions on the import of advanced semiconductor facilities into China, thereby jeopardizing the competitiveness of Korean semiconductor companies.

In response to this predicament, a strategic imperative emerges for South Korea's high-tech industries, encompassing semiconductors, batteries, smartphones, and electric vehicles. A proposed solution involves the establishment of designated mother factories within Korea for each parent company. This paradigm shift is complemented by the implementation of cutting-edge technologies, specifically the integration of smart factory capabilities and the deployment of digital twin systems. This transformative approach aims to imbue the designated Korean mother factories with a central control center role, facilitating enhanced responsiveness to dynamic geopolitical challenges and bolstering the resilience of the manufacturing ecosystem.

In this chapter, we advocate for the conceptualization and implementation of a comprehensive Korean mother factory model, underscored by the incorporation of smart factory technologies and digital twin frameworks. This strategic realignment seeks not only to mitigate geopolitical risks but also to fortify the competitive standing of Korean high-tech industries in the ever-evolving global landscape.

4.1 Smart Factory

A smart factory is a digitized manufacturing facility utilizing connected devices, machinery, and production systems for continuous data collection and sharing. This data informs decisions not only to address potential issues but also to enhance processes. Smart manufacturing practices within smart factories are made possible by various technologies, including artificial intelligence, big data analytics, cloud computing, and the industrial Internet of Things (IoT).[10]

Smart factories optimize manufacturing processes related to the fourth industrial revolution (Industry 4.0) using diverse technologies such as sensors, cloud computing, big data analytics, and virtual/augmented reality. Sensors on devices and machines in smart factories collect data at specific manufacturing stages for process monitoring. For instance, sensors can monitor variables like temperature, self-correct issues, or alert staff, and they can be networked for integrated monitoring across machines. Cloud computing is employed for storing and processing sensor-collected data, offering flexibility and cost-effectiveness over traditional on-site storage.[11]

As more data is collected, it provides insights into production process performance. Big data enables the identification of error patterns and facilitates predictive quality assurance with increased accuracy. This data sharing across different factories or organizations contributes to problem-solving and process optimization. This is about big data analytics. Lastly, virtual and augmented reality technologies are employed in smart factories. Augmented reality overlays digital information onto the physical world via smartphones, while virtual reality creates a more immersive virtual environment requiring special glasses. Both technologies assist smart factory operators in organizing products, managing production tasks, and maintaining and repairing equipment.

4.2 Digital twin

The concept of a digital twin for manufacturing plants refers to a virtual replica of a physical production facility, created through the integration of real-time data, simulation models, and advanced analytics. This digital representation enables manufacturers to monitor, analyze, and optimize various aspects of their operations in a virtual environment.[12]

A digital twin encompasses both the physical elements and the processes within a manufacturing facility. It leverages data from sensors, IoT devices, and other sources to create a real-time, dynamic simulation of the plant's activities. This virtual counterpart allows for the visualization of the entire production process, from the performance of individual machines to the overall efficiency of the factory floor.[13]

The benefits of implementing a digital twin in a manufacturing setting are multifaceted. Firstly, it provides a comprehensive view of the production ecosystem, facilitating better decision-making by identifying bottlenecks, predicting maintenance needs, and optimizing workflows. By continuously analyzing data, manufacturers can enhance operational efficiency, reduce downtime, and improve overall productivity.

Moreover, a digital twin serves as a powerful tool for scenario testing and risk assessment. Manufacturers can simulate changes in production parameters or introduce new technologies in the virtual environment to understand potential impacts before implementing them in the physical plant. This proactive approach minimizes the risk of disruptions and enhances the agility of the manufacturing process.[14]

The integration of artificial intelligence (AI) and machine learning (ML) algorithms further enhances the capabilities of a digital twin. These technologies enable the system to learn from historical data, identify patterns, and make predictions about future performance. Predictive maintenance, for example, becomes more accurate, allowing manufacturers to address potential equipment failures before they occur, reducing unplanned downtime and associated costs.

Collaboration across different departments and teams is also streamlined through the digital twin. It provides a shared platform for engineers, operators, and decision-makers to collaborate, share insights, and collectively work towards optimizing production processes. This collaborative approach fosters innovation and continuous improvement.

Therefore, the implementation of a digital twin in manufacturing plants represents a paradigm shift in how industries approach production optimization. It harnesses the power of real-time data, advanced analytics, and simulation models to create a holistic view of the manufacturing process, fostering efficiency, reducing costs, and enhancing overall competitiveness in today's rapidly evolving industrial landscape.

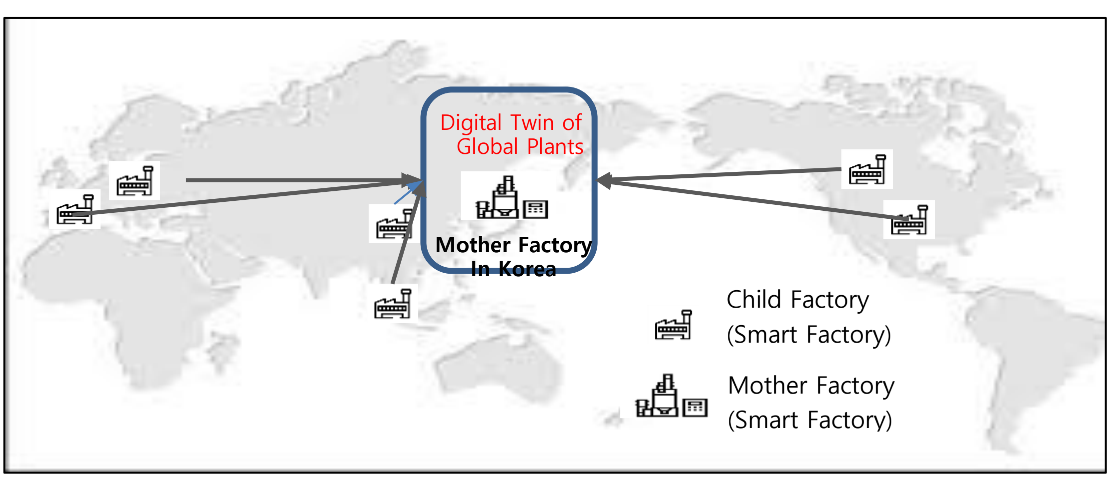

Figure 2. Supposed Korean Mother Factory coined by LGES case

Lastly, the mother factory strategy of a Korean battery leader company can be an example of a Korean-style strategy. LG Energy Solution is currently building the Mother Line with a $500 million investment in Energy Plant 2 in Cheongju, North Chungcheong Province, where its core production line is located. Mother Line is characterized by being able to test-produce products with next-generation design and process technology, as well as verify mass production. General pilot lines can only be test-produced, so separate follow-up work such as mass production tests is required. The construction of the Mother Line is also expected to significantly reduce the time it takes to stabilize the mass production of new models. In addition, the mother line is converting images of production lines around the world and building the Factory Monitoring Control Center (FMCC), a deep learning system based on artificial intelligence (AI).[15]

It is also introducing smart factory systems such as remote support, manufacturing intelligence, and logistics automation, and is focusing on building the world's first battery education institution and cultivating next-generation battery experts through this. The Ochang plant is home to suppliers, so even if facilities, automated robots, and sensors have problems, it can be solved locally without going on a business trip using digital twins. As such, it will be the prototype of the Korean mother factory that can become a hub for technology management and manpower management as one mother factory located in the headquarters becomes the control tower for factories around the world.

5. CONCLUSION

In this work, a comprehensive analysis of Japanese and U.S. manufacturing strategies is conducted, proposing the implementation of a strategic "Mother Factory" approach as a response to the evolving global challenges confronting Korean manufacturing enterprises. Highlighting the pivotal role of the semiconductor industry and drawing inspiration from the U.S. "Friend-Shoring" policies, the paper advocates for a uniquely Korean model that integrates advanced smart factory technologies and digital twin frameworks. The suggested paradigm shift involves the establishment of designated Mother Factories, seeking to strike a balance between production quality and resilience while remaining adaptable to dynamic geopolitical shifts. The case study of LG Energy Solution's Mother Line serves as a pertinent example, underlining the significance of technology management and talent cultivation in this proposed approach. Ultimately, adoption of the mother factory strategy in Korea is imperative for bolstering competitiveness and ensuring sustained success on the global stage.

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