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# *Digital Intelligence Enables Silicon Carbide Supply Chain Upgrade*

**Lefei Xu[1,a], Qingyun Zhang[1,b], Yanyu Zhang[1,c,*]**

[1]*Faculty of Management, Law and Social Sciences, University of Bradford, Bradford, United Kingdom*
*a. xulefei092@gmail.com, b. cherie01723@hotmail.com, c. hoshiameyanyu@gmail.com*
**corresponding author*

***Abstract:*** From the perspective of supply chain management, the silicon carbide supply chain currently exists in the technical force is low, the development situation is poor, as well as the traditional silicon-based devices still occupy the relevant areas of the market, silicon carbide in addition to the urgent need for breakthroughs in the field of technology, due to the adjustment and transformation of the industrial structure as well as the upstream production capacity expansion makes the silicon carbide industry is also faced with the lack of supply chain management capabilities and the backwardness of the management structure. This is also the core element that this paper will focus on. The research theme of this paper is how to complete the transformation and upgrading of the silicon carbide supply chain through the role of digital intelligence, to effectively increase the production capacity of silicon carbide and change the current production dilemma. To this end, this paper focuses on the feasibility of solving the existing problems of the silicon carbide supply chain by upgrading the supply chain empowered by Digital Intelligence. The results of this paper are based on the successful reform experience of the steel industry, through management restructuring, supply chain expansion, industry chain extension, improving industrial technology, manufacturing to service transformation, and the combination of digital intelligence technology for industrial restructuring, to increase the production capacity of the silicon carbide industry.

***Keywords:*** Digital Intelligence, Silicon Carbide, Supply Chain Upgrade

## 1. Introduction

Supply chain is a very mature research direction, the earliest definition can be traced back to the 1970s; and the concept of supply chain management, in 1985 by the American management scientist Michael Porter in the Competitive Advantage book, and the growth over four decades gradually evolved into a variety of mature strategy systems.

Today, the definition of supply chain management has evolved to mean that supply chain management is responsible for handling the entire production process of a good or service - from the original component to the delivery of the final product to the consumer. To accomplish this task, a company creates a network of suppliers that are used to transfer products from raw material suppliers to organizations that deal directly with users [1]. It can be seen that supply chain management is an essential part of the supply chain, and the level and skill of supply chain management can greatly affect how well the upstream and downstream of the supply chain are connected.

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The third generation of semiconductors, represented by silicon carbide and gallium nitride, currently have excellent material physical properties, which provide greater scope for further enhancing the performance of power electronic devices. Current market performance shows that semiconductor electronic devices and circuits based on silicon carbide are currently being developed for use at high temperatures, high power, and high radiation conditions where conventional semiconductors are unable to function adequately. The ability of SiC to function under such extreme conditions is expected to bring significant improvements to a wide range of applications and systems. These range from vastly improved high-voltage switches for public power distribution and electric motor drives to more powerful microwave electronics for radar and communications, to cleaner, more energy-efficient sensors and controllers for jet and car engines. In the specific area of power devices, theoretical evaluations have shown that SiC power MOSFETs and diode rectifiers will operate at higher voltages and temperatures, have superior switching characteristics, and have chip sizes that are almost 20 times smaller than the corresponding rated silicon-based devices. However, these enormous theoretical advantages have not yet been widely realised in commercially available SiC devices, primarily because SiC's relatively immature crystal growth and device fabrication technologies have not yet evolved sufficiently to be reliably incorporated into the majority of electronic systems required [2]. According to market research statistics, the industry is set to drive the overall silicon carbide power device market to a value of US$2.28 billion by 2023, with annual growth projected to reach 41.4%, as partnerships with automotive and energy players such as ONSMI and Infineon become clear [3].While this rapid growth is encouraging, it is minimal compared to the $515.95 billion that the overall semiconductor market is worth [4], essentially because SiC's industrial strengths have yet to be fully realised - it is still limited by its small size, which means that it is not yet fully utilised. It is essentially because the industrial advantages of silicon carbide have not yet been fully realised - it is still limited by small production capacity and outdated management models. From the domestic and foreign market background and the use of the background, the world in the semiconductor field is currently in a state of relative technological stagnation; from the Russian-Ukrainian conflict, inflation and central bank monetary policy tightening and other impacts caused by the worldwide recession, the current global economy to the medium and low-speed growth to return to the semiconductor industry lacks the basis of the driving force. In the three years since the outbreak of the new crown epidemic, the average global GDP growth rate fell close to 50%, it is expected that in 2023 and the coming period the global economy will return to a GDP growth rate of less than 3% of the medium and low-speed growth. The semiconductor industry is a full reflection of the global economy weathervane, the future is likely to be a long time into the lack of macroeconomic fundamentals to support the predicament, the global semiconductor industry in 2023 will likely usher in a negative growth of 5% -10%. At the same time, with the domestic and foreign-based energy market changes and environmental protection under the changing situation, the new energy industry also has high hopes. This objectively makes the semiconductor industry on new technologies and new equipment requirements are increasing day by day. In this context, with the complexity of end-use electronic architecture to enhance the physical limits of silicon-based devices cannot meet some of the high-voltage, high-temperature, high-frequency, and low-power application requirements, with high thermal conductivity, high critical breakdown field strength, high electron saturation drift rate and other characteristics of silicon carbide devices as a power device material end of the technology iteration of the product appears, applied to new energy vehicles, photovoltaic, industrial control and other fields in the power electronic devices to achieve efficient management of electric energy[5]. At present, silicon carbide and gallium nitride as the representatives of the third generation of semiconductors with excellent physical properties of the material, to further enhance the performance of power electronic devices to provide more space. It also becomes a foreseeable technology target to boost the industry and stimulate the economy. Although silicon carbide power semiconductors by

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the market attention, the supply gap in the short term to make up is not easy. According to a survey by the China Economic Times, it usually takes at least five years or so from organizing funding to forming productivity. Due to the technical attributes of silicon carbide, it is unlikely to be realistic to achieve rapid growth in production, and the market may continue to be oversupplied for four or five years[6].The silicon carbide industry is the most important and promising upstream raw material for the third-generation semiconductor industry, the current development and market size are at a relatively early stage, while the related supply chain research and management research are still close to a blank state. On this basis, it is worthwhile to carry out research projects to upgrade the supply chain by combining silicon carbide with digital intelligence reform.

## 2. Silicon Carbide Industry Status and Problems

From the perspective of supply chain management, the silicon carbide supply chain currently exists in the technical force is low, the development situation is poor, as well as the traditional silicon-based devices still occupy the relevant areas of the market,silicon carbide in addition to the urgent need for breakthroughs in the field of technology, due to the adjustment and transformation of the industrial structure as well as the upstream production capacity expansion makes the silicon carbide industry is also faced with the lack of supply chain management capabilities and the backwardness of the management structure. This is also the core element of this paper will focus on. In this regard, this paper will focus on the feasibility of solving the existing problems by upgrading the silicon carbide supply chain with digital intelligence.

Digital intelligence refers to the current era of prominent industrial organization and micro business organizational change in the platform organization to lead the entire new economy continues to move forward, the platform-based organizations with the Internet of Everything and a high degree of social resource allocation to reshape the productivity of the entire society, breaking the traditional business organization production and service process of space and time constraints, based on the user network effect to create a new platform for the commercial ecosystem and thus create a huge economic value. It creates a new platform business ecosystem based on the user network effect and creates huge economic value. In particular, with the rapid development of artificial intelligence technology in the era of digital intelligence, the depth of empowerment of traditional industries, but also with the Internet platform organization of networked resource allocation continues to be deeply integrated, artificial intelligence enterprises have become based on algorithms, data and arithmetic power-driven by a new micro-enterprise organization [7]. Industrial structural transformation and enterprise structural change through digital intelligence have experience and cases in some traditional industries, while there are also many conducted studies. For example, China has been facing the problem of huge crude steel production and small specialty steel production since the turn of the millennium, and a large number of giant iron and steel enterprises are facing the transformation dilemma of removing backward production capacity and increasing advanced production capacity. To a certain extent, this also coincides with the characteristics of the transformation and upgrading of the silicon carbide industry. Based on the logic that a stone from another mountain can attack a jade, this paper will use the transformation of the steel industry using Numerical Intelligence as a case study to deeply analyse the experience of Numerical Intelligence transformation as well as its characteristics.

## 3. Lessons from the Transformation of China's Steel Industry - Baosteel as an Example

Today's Baosteel is called China Baowu Iron & Steel Group Company Limited and is a wholly state-owned iron and steel conglomerate of the People's Republic of China, headquartered in Shanghai, resulting from the joint reorganisation of the former Baosteel Group Company Limited and Wuhan

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Iron and Steel Company. Today it is a great success, and behind this success, it faced a continuous decline in business volume and profit from 2012 to 2015 and was revitalised after reforms in 2015.

At present, the development of China's iron and steel industry is gradually moving towards maturity. In 2017, the output of Chinese iron and steel accounted for 49.11 percent of the total global output. However, there are still outstanding problems such as overcapacity, low industrial concentration imbalance in regional development, etc. Horizontal mergers and acquisitions (M&A) within the industry can effectively increase industrial concentration and digest overcapacity, which is an effective way to enhance competitiveness and promote industry integration [8]. Taking Baosteel as an example to start our analysis. In 2015, the performance of Baosteel Group and Wuhan Iron and Steel Group has been in the leading position in China's iron and steel industry, but the financial situation has not satisfactory for around 15 years due to the impact of supply and demand in the international market and overcapacity in China's iron and steel industry. In 2015, WISCO had nearly 70 billion yuan of liabilities, a gearing ratio of more than 70%, and a net profit loss of more than 7.5 billion yuan, making it the "king of losses" for listed companies in the industry [9]. At that time, Baosteel carried out a variety of means to carry out drastic reforms, including management restructuring, supply chain expansion, industry chain extension, improving industrial technology, manufacturing to service transformation, mergers and acquisitions, and other strategies.

Among them, the merger of Baosteel and WISCO became the key change due to the existence of the national factor of capacity removal in China, while other changes were centered on this feature. According to China's State Council's Opinion on Steel Industry De-Capacity issued in February 2016, the Opinion, in response to the current situation of serious overcapacity in the domestic steel industry, proposes to reduce 100-150 million tonnes of steel production capacity within five years, and M&A and restructuring is one of the most important ways of de-capacitating the steel production capacity, Baosteel and WISCO, both groups of companies, have numerous subsidiaries, which have been suffering from the steel industry's main business in recent years[10]. Appearing different degrees of losses, Baowu restructuring and merger will cause these subsidiaries part of the inefficient production capacity to be compressed or retired, to dissolve part of the domestic iron and steel production capacity, which will cause the steel market to reduce certain pressure [11].

On this basis, the merger of the two world-class steel giants has brought about a huge total production capacity and enterprise scale, which in turn has brought about a series of management, personnel, and equipment problems. The restructuring of the management structure has been characterised by a further streamlining of the company's size and a reduction in the number of unnecessary management layers. Much of the success in this area lies in the promotion and application of information technology.

Digital intelligence is an important way to increase production capacity, improve management capabilities, and facilitate the transformation of Industry 4.0. The transformation and upgrading of digital intelligence are roughly divided into three steps: the first step is to build intelligent workstations, develop corresponding information systems, and connect all kinds of automation equipment on the production line through the industrial Internet to achieve interconnectivity [12]. The use of sensors to achieve automatic collection of online data, to achieve transparency and visibility of the entire production process, and to establish a digital intelligent marketing platform. In the second step, virtual debugging, simulation analysis, and improvement activities are achieved through digital twin technology. Intelligent prediction, pre-control, and pre-conditioning are achieved by piggybacking future models on the large amount of data collected, and data-based decision-making solutions are provided to decision-makers and staff. In the third step, autonomous decision-making is achieved through a large number of machine learning and model applications, upgrading intelligent manufacturing to a higher level, achieving greater improvement in product development, manufacturing, sales service, and cost control, and getting closer to the growing needs of users and

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the merger of Baosteel and Wuhan Iron and Steel first used the advantages of digital intelligence to streamline the corporate structure, while seizing the Internet as an element combined with the steel industry, in the face of the Internet e-commerce and other new economic forces of the rapid rise of the implementation of the transition from manufacturing to service, to create a comprehensive service platform for domestic steel trading and services, to provide personalised services for steel companies and users, to develop new Profit mode, Baosteel shareholding set up EUROMETRIC and its subordinate professional companies[13]. In February 2015, Baosteel shareholding together with its wholly-owned subsidiary Baosteel International and Baosteel Group jointly invested 2 billion yuan, initiated the establishment of EUROMETRIC, of which: Baosteel shareholding and Baosteel International contributed 51% of EUROMETRIC's shareholding with 100% of the shareholding of Oriental Steel for 1.02 billion yuan, to make the e-commerce trading platform, purchasing service platform, chemical e-commerce platform, and third-party payment qualification were reorganised into the steel service platform[14]. It is a good attempt to expand the company, which was originally located in the field of traditional materials, to many windy areas such as the Internet, Internet of Things, big data, and mobile Internet. Ouye Yuncheng has constructed a top-level design of Internet and steel, linking e-commerce, logistics, finance, materials, and data with each other. At the same time, Ouye Financial has followed the example of Ant Gold Service to build a variety of financial services. At the same time, OuYeYunShang also pioneered the 020 models in the steel field, integrating steel procurement, logistics inquiry, warehousing, pick up, payment, and settlement into an intelligent APP terminal, which greatly improves the efficiency of traditional business. In this way, through mode innovation, new technology can serve the main business of steel manufacturing and sales, and the two complement each other to jointly promote the performance growth of Baosteel Group.

## 4. Conclusion

This paper summarises the current situation of the semiconductor industry and the silicon carbide industry and analyses the current situation faced by the silicon carbide industry. After that, it analyses the current situation of the silicon carbide industry, which is faced with the problems of low technological power, poor development, and the traditional silicon-based devices still occupying the market in the relevant fields, as well as the insufficiency of supply chain management ability and the backwardness of the management structure due to the adjustment of the transformation of the industrial structure and the upstream expansion of production capacity.

Therefore, the silicon carbide industry can adopt the strategies of management structure adjustment, supply chain expansion, industry chain extension, improving industrial technology, manufacturing to service transformation, mergers and acquisitions, and restructuring, and combine with digital intelligent technology to adjust the industry. Currently, most of the research on silicon carbide is based on the physical properties of silicon carbide and technological upgrading as the object of research, and there is little research on the management of silicon carbide or the supply chain of silicon carbide in the academic world. This article bridges the gap of the lack of management research on silicon carbide, and its main contribution is to facilitate silicon carbide enterprises to refer to some of the ideas in this article, so as to adjust their production management and is also a reminder for other industries, not only focus on the technical field and ignore the basic management issues.

The current study still has some shortcomings, such as the lack of analysis of specific enterprises of silicon carbide, and the lack of data for specific enterprises. The study of the silicon carbide industry in this paper is based on the analysis of the whole industry situation, while the solution is mainly to analyse and summarize the analysis by referring to the existing cases, and lacks the specific data for this industry. This paper lacks a data-supported model to analyse some assertions. Future

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research should attempt to relate and obtain specific silicon carbide industry conditions, to more into the specific problems to carry out research.

## Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

## References


[1] *Guo Jinhui .(2022). From the "budding period" to the "growth period" third-generation semiconductor market penetration accelerated. China Economic Times, 004.*

[2] *Li Xingcai & Qin Mi. (2022). Vertical integration mode to solve the contradiction between supply and demand of silicon carbide. Shanghai Securities News, 005.*

[3] *Fu Yuanliu. (2021). Research on industrial chain supply chain integration and its value management digital intelligence. Finance Research 03, 3-10.*

[4] *Fei Wenjin, Lu Ji, Wu Yijun & Rao Yaqing.(2023). Accelerating the overall improvement of new energy vehicle manufacturing quality through "digital intelligence". China Quality 06, 11-15.*

[5] *Yao Yuan. (2023). Introduction to the implementation path of digital intelligence transformation and upgrading in iron and steel industry. Shandong Metallurgy 04, 78-79.*

[6] *Hu Changhua. (2023). Analysis and Prospect of the Development Trend of Automotive Manufacturing Digital Intelligence Transformation and Upgrading. Automotive Craftsman (Z1), 16-21.*

[7] *Liu Xiangjun. (2020). Study on Cost Control Improvement of Runze Silicon Carbide Co. Ltd (Master's thesis, Lanzhou University).*

[8] *Neudeck, P. G. (2006). Silicon carbide technology. CRC Press.*

[9] *Oscar, K. (2022) Securing supply of silicon carbide semiconductors.*

[10] *UMESH K., M. (2023) Gallium Nitride Versus Silicon Carbide: Beyond the Switching Power Supply.*

[11] *Yang (2023) Innovation and governance of corporate social responsibility in the age of digital intelligence.*

[12] *Zhang Lunping & Zhou Li. (2019). "Exploration of the motivation of mergers and acquisitions of state-owned enterprises under the background of "going to production capacity" - A case study based on the absorption and merger of Baosteel and WISCO. Business Accounting 21, 85-87.*

[13] *Fang Qian. (2017). "The steel grand union under the "de-capacity" - Baowu restructuring and merger. Economic and Trade Practice (13), 52-53.*

[14] *Zhang Rui. (2017). Analysis of transformation road and operation status of Baosteel Group. Enterprise Reform and Management (03), 78-80.*