

Upgrading and Reconstruction of Global Value Chain: Case of Chinese Firm's Catching Up Trajectory

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Abstract: *This study aims to evaluate and, more importantly, examine the path of a successful young Chinese high-tech firm in upgrading and reconstructing its position in the global value chain (GVC) of the chip industry. We examine the existing GVC positions of chip firms, the motivations for the firm's entry into the market, the choice of path to upgrading, and the attempt to restructure the GVCs. The study uses a qualitative approach, mainly interviews and secondary data. The findings suggest that devising and consistently implementing a targeted differentiation strategy, overcoming technological bottlenecks and developing products towards a high-value location, and targeting customers through open innovation and entrepreneurship are key for laggards to improve their position in the GVCs. Building an ecological alliance based on the existing ecosystem is an important means for upgrading a firm and rebuilding the GVC. This is possible for young firms in the emerging segments of Industry 4.0, which are moving into a highly digitised world where there are numerous market opportunities both internally and globally. We argue that the ability to upgrade requires not only internal capabilities, but also the creation of appropriate markets to support the development of capabilities. Our study also provides some managerial implications.*

Keywords: Global value chain; High-value position, Innovation, Upgrading; China

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1. Introduction

Multinational corporations (MNCs) are key players in the global value chain (GVC), with value chains increasingly separated across geographies and organisational boundaries (Benito et al., 2019; Anderer, et al., 2020). China, a preferred destination for foreign direct investment (FDI), has become increasingly integrated into the global value chain of MNCs. After decades of pursuing open policies and joining the World Trade Organisation (WTO), China has earned a reputation as the “manufacturing hub of the world” due to its cost advantages stemming from demographic dividends and resource endowments. Against this backdrop, Chinese manufacturing firms engaged in product processing and assembly have taken work from multinationals in developed economies. In the global value chain of MNCs, Chinese firms often play a role as production processors and contract manufacturers within the GVC, and have no say in the “high-end links” of the value chain (e.g. core technology, design and marketing, and rule-making). Indeed, the captivity effect (Gereffi et al., 2005), which means that leading firms in GVC exercise a high degree of monitoring and control over the GVC activities of laggard firms (Kano, 2018), may prevent the latter from moving up the value chain to high value-added activities (Corredoira & McDermott, 2014). Upgrading and insertion into GVC remains a critical challenge for Chinese manufacturing firms and is still far too under-researched by scholars. This is all the more true at a time when the industrial revolution and other developments, such as digitalisation, are shaping the GVC and providing opportunities for latecomers to reshape their position. China will be an interesting case as it has emerged as a global power shaping the new order within the catch-up process and the GVC perspective.

Therefore, it is crucial to understand how firms break the “low-end lock” in GVC and climb the ladder, as it has become a major concern for developing countries to pursue high-quality economic development (Zhang & Xiang, 2022). Nevertheless, some Chinese firms have successfully climbed the ladder to become global leaders in information, communication and technology (ICT), e-commerce, social media and other sectors. Learning from the success of some of these firms would be crucial. Against this backdrop, this paper aims to use a case study to examine the latecomer firms within the GVC. Our study uses the Global Value Chain Reconstruction (GVCR) approach and takes a single Chinese firm as a case in graphic

processing unit (GPU) design and production industry to examine how the Chinese chip firm climbs the ladder in the GVC. We examine the key strategies and behaviours that a typical chip company adopts when climbing the ladder on GVC, find out the path of GVCR for chip companies in emerging economies, and then extract general principles or theories for theoretical construction. Our study contributes in the following ways: First, it enriches the literature by finding out how a small and medium enterprise, as a latecomer in the chip industry, is able to rise in the GVC, as previous studies have mainly focused on how multinationals play a leading role in the GVC. Second, the study validates and verifies the application of the GVCR theoretical framework through the in-depth case study. The existing studies using GVCR are limited and less researched in the context of firm upgrading from the GVC perspective (Tang, 2019). Third, the study focuses on the chip industry, where further research is needed on how chip companies in developing countries break the "low-end lock" in GVC.

This paper is further structured as follows: Section 2 discusses the literature review and sets forward the analytical framework, while Section 3 presents the research methodology. Section 4 discusses the findings with Section 5 drawing conclusions and implications.

2. Literature Review

2.1 GVC Literature

The literature on internationalisation has evolved and GVC, which separates space across organisational boundaries, has increasingly become an analytical tool to understand and describe the increasingly disintegrated nature of value chain activities of MNCs (Gereffi et al., 2005). Earlier studies follow the Global Commodity Chains approach and examine the governance structures of commodity chains, looking at producer-driven and buyer-driven commodity chains as the two different types of governance structures for GVCs to coordinate transnational production systems (Gereffi, 1994). Firms participating in GVC need an appropriate governance structure to manage the internal and inter-firm cooperation associated with global networks. Arm's length market relationships, networks, quasi-hierarchy and hierarchy are four types of relationships in GVC. For export-oriented producers in developing countries, the quasi-hierarchical chain is seen as conducive

to rapid process and product upgrading, but hinders functional upgrading (Humphrey & Schmitz, 2002).

Further evolution is seen in the mapping of governance structures, where Gereffi et al. (2005) identify five types of GVC governance: market-oriented, modular, relational, leadership-oriented and hierarchical. Similarly, Gereffi and Lee (2016) distinguish GVC governance between vertical governance (collaborative governance between upstream and downstream industries) and horizontal governance (internal relations of production governance related to society, institutions, etc.). As governance structure has crucial implications for upgrading, research has begun to examine industrial upgrading within the GVC governance structure (Gereffi, 1999; Gereffi, 2019). Research on GVC also focuses on three aspects: First, on the impact of embedded GVCs on industrial upgrading in developing countries in the context of the development opportunity versus the threat of low-end locking (Gui, 2017); second, on the factors affecting industrial upgrading in GVCs (Yang & Qu, 2021); and third, on the strategies for industrial upgrading, such as improving embedded status, selecting appropriate enterprise strategies, combining resource capabilities and restructuring the value chain.

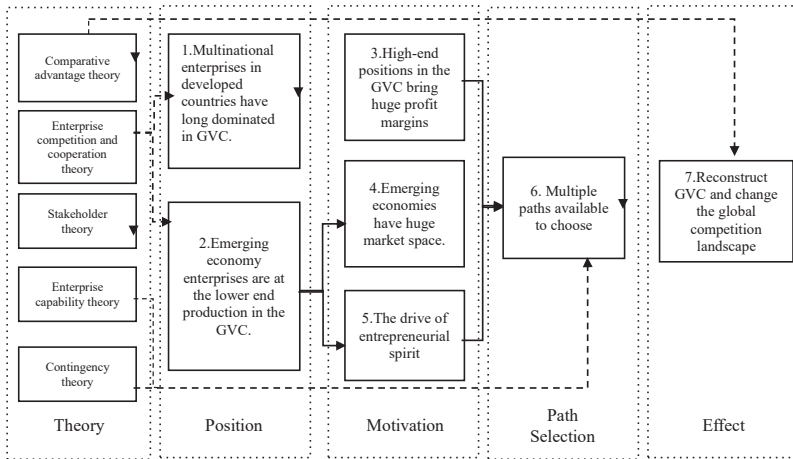
2.2 *GVC Reconstruction and the Analytical Framework*

The current debate on GVC relates to the restructuring or reconstruction of GVC. The escalation of trade disputes between China and the United States (US) since 2018, combined with other uncertain conditions, has severely affected the global economy in terms of supply and demand and accelerated the process of GVC restructuring. Yang and Gu (2021) consider that the driving forces behind the positive expansion of GVC in the past are changing and that factors that used to have positive momentum (e.g. technological progress, cost advantages and trade environment) are more complex in nature and impact. The information technology revolution has been considered by scholars as the driving force of globalisation. However, the new industrial revolution has several implications for GVCs: acceleration of technological iteration, more technological innovation, increase in uncertainty of technological investment and returns, insufficient diffusion dynamics of new technologies in GVCs, impediments to cross-border allocation of innovative elements. Recent studies show that digital technology (Dai, 2022; Lun, 2023) and the continued expansion of domestic

demand in emerging economies are the drivers of GVC reconstruction (McKinsey, 2019). Affected by technology and external political and social factors, GVCs have gradually exhibited the following new characteristics: regionalisation features, increasing intangible assets, multi-layered development models and solidified benefit distribution (Zhang et al., 2022). The economic transformation and upgrading of emerging economies and enterprises in these countries form the basis for promoting the reconstruction of GVCs (abbreviation GVCR). GVCR is essentially a process of redivision of the international market and a reorganisation of the global economy (Mao et al., 2015, 2016, 2022). GVCR is an upgrading process for manufacturing enterprises in an emerging economy located at the lower and middle ends of the GVC to break the lock-in to the lower end and move to the upper end of the GVC and promote structural changes in the global competitive landscape through the accumulation of capabilities, the search for and allocation of resources at the global level, and innovation. However, to understand GVC restructuring, we need to examine the current industry landscape, the motives of firms, the path creation efforts and implications for GVC restructuring.

Our study uses the GVCR framework, and in analysing the case, we build the analytical framework focusing on four factors, namely position, motivation, pathway, and impact through the seven narratives identified by the respective theories to assess the issue of upgrading and GVC. Figure 1 illustrates the analytical framework of the GVCR. The framework reflects the state and changes in the industrial landscape and the motivations for emerging market upgrading in GVCs, as well as the paths taken by firms and the ways in which GVCs are reconstructed. We argue that our case study will provide richer information to understand the trajectory of the four critical parts of the framework that also help validate upgrading as well as GVC restructuring. While GVC reconstruction is gaining popularity to explain the phenomenon of upgrading (Liu et al., 2019; Qin, 2017; Song et al., 2021), scholars have also called for the validation of such a process using case studies or empirical studies in emerging economies. This framework identifies the key internal and external factors that drive emerging market firms to restructure GVC, including huge profit margins at the upper end of GVC, a huge market in emerging markets, entrepreneurship, innovation, and capabilities of emerging market firms.

Figure 1: Analytical Framework of GVC



3. Research Design

3.1 Research Method, Data Collection and Case Selection

Our study uses a single case study as the research method. The reasons for this are as follows: First, the single case study summarises and extracts the characteristics of a representative case through in-depth analysis, which can better answer the questions of “how” and “why” (Yin, 2017; Eisenhardt, 1989). Answering the question of ‘what’ and ‘how’ Chinese chip companies can upgrade in GVC also lends itself to the use of an exploratory single case study. Second, previous research is silent on ‘what’ and ‘how’ Chinese chip companies can upgrade, and the black box needs to be discovered. Third, a vertical single-case study can provide an in-depth description and analysis of a particular phenomenon or problem (Yin, 2010), which helps to capture the temporal context and dynamic evolution (Cheng, 2022).

Chinese chip industry was the focus sector and firm A (not the real name) was selected as the study sample. It is a purposive selection based on a few criteria as to select a firm that has completed the process of upgrading and shows abnormal phenomena and meets the requirements of specific theoretical contexts (Cheng, 2022). Firm A meets the following criteria. First, it meets the principle of typicality (Patton, 1987). Firm A is a high-tech start up, established in 2020, and focuses on Graphics Processing Unit (GPU)

design and production. It has made breakthroughs in product technological research and development (R&D), market ecological layout, and financing, and has achieved remarkable success in embedding into the global high-end value chain. In terms of product R&D, heterogeneous GPU products using the 7nm process have been fabricated in 2022 and are expected to achieve mass production in early 2023. Its experience is worth studying and learning. Second, it matches the principle of adaptability (Han, 2021). For a long time, Chinese companies in the chip industry were constrained by key technologies. At the beginning of its establishment, Firm A insisted on building a professional R&D team and collaborating with industry and academia to develop fully independent intellectual property products. It is a representative of integrators in the global high-end value chain. In addition, Firm A focuses on creating an ecological business system and technological cooperation. At the market ecology level, Firm A has established close collaborative relationships with industry clients, such as server Original Equipment Manufacturers (OEMs), big data centres and Internet operators, rapidly building the industry's upstream and downstream ecology. In terms of technology, Firm A works closely with many well-known universities and research institutes to promote the application of cutting-edge technologies. Firm A has applied many unique strategies in embedding itself in the global high-end value chain, which can explain how Firm A has achieved remarkable results. Therefore, the practical and theoretical scenarios of the case enterprise are adaptable. Third, it fulfils the principle of data accessibility. Our research team has longstanding contact with the executives of Firm A and had several direct or indirect exchanges with the employees relevant to this study, which provides rich sources of data.

To ensure reliability, we collected data through multiple channels to ensure triangular validation (Yin, 2017). Primary data were collected through site visits and semi-structured interviews, while secondary data were collected by reviewing company announcements, news reports, industry reports, industry conferences, social media and others. The site visit and semi-structured interviews with two executives were conducted in May 2023. The content of the interviews included general information of Firm A, its business strategy and path to GVC's upgrading in the chip industry, as well as questions to validate the analytical framework of the study.

4.1 Results

4.1.1 The Position of Foreign Firms and Chinese Firms in the GVC

Within the GVC, Firm A is in the chip design segments, focusing in particular on the design and production of graphics processors, which are heavily foreign dominated. Before we examine how Firm A is breaking through this dominance and upgrading its GVC pathways, it is important to examine the position of foreign and Chinese firms in the GVC. The integrated circuit industry value chain comprises midstream industries (core industries), upstream industries (supporting industries) and downstream industries. The midstream industry chain is composed of four major sectors: Chip Design, Wafer Fabrication, Packaging and Testing. Chip design is a knowledge-intensive sector that requires experienced and cutting-edge talent and is at the top end of the value chain. Wafer fabrication is a capital- and technology-intensive sector that typically requires large investments and high barriers to entry and is located at the middle end of the value chain. The packaging and testing process is a labour-intensive sector that typically emphasises the benefits of industrial scale and is located at the lower end of the value chain. The integrated circuit design industry is at the heart of product innovation and technological progress in integrated circuits. Mainland Chinese firms lag behind international giants, such as ARM Holdings in the United Kingdom (UK), Synopsys and Cadence Design Systems in the US. American companies dominate the market share in integrated circuit design. About 80% of the global Electronic Design Automation (EDA) market is occupied by Synopsys, Cadence Design Systems and Mentor Graphics in the US, and only 5% of the market share is held by companies in mainland China. Approximately 65% of global Intellectual Property (IP) cores are provided by three companies: ARM Holdings, Synopsys, and Cadence Design Systems. Mainland Chinese companies hold only 1.8% of the market share (Yang, 2021). The global integrated circuit industry has undergone three transfers of industrial centres and formed the industrial characteristics of clear GVC, high specialisation, spatial agglomeration, high investment, high technology, high profits, and strong monopoly (Zhang, 2022). Foreign companies in developed countries have long occupied the high-end core areas of the sector that generate the most profit and create the highest technological barriers.

Companies in the US, Japan and Europe have gradually shifted to supplying wafer fabrication equipment and sealing and testing equipment in the Integrated Circuit (IC) industrial chain (Feng, 2018). Equipment, materials, EDA, IP cores and design are priorities for these companies to maintain global control of the integrated circuit industry, and they have strong supply control in equipment. Applied Materials and Lam Research in the US are the world's leading suppliers of semiconductor manufacturing equipment (e.g. etching, deposition and testing equipment) and have occupied over 40% of the global market share, followed by Japanese companies. Thus, IC key equipment is absolute control by firms in the US, Japan, and Europe. Other firms are facing the challenge of the unavailability of this core equipment. Overall, due to the strong control of developed countries and leading enterprises in the chip industry GVC, latecomer economies and enterprises face strategic threats from these leaders (Li, 2022). Recently IC, to maintain its competitive advantage in the industry and other fields, the US has successively implemented technology blockade and trade control against China through legislative means, such as "Section 301" and "the Export Control Reform Act". The US government has imposed huge fines on China's ZTE company twice and used national power to prohibit Huawei to purchase key components including chips from the US companies or companies used US technologies. The US has been exerting pressure on the Netherlands, Chinese Taiwan, South Korea, Japan, and other regions to hamper the sale of core products, such as photoresists, ultra-violet (EUV) microfilm equipment, and high-end chips to China through equipment lockdown and technology export restrictions.

In contrast, the position of Chinese firms seems to have long been locked in the lower-end segments in the chip industry GVC. Low value-added production, packaging and testing have been shifted to emerging economies, such as China, while high value-added design IC is firmly in the hands of traditionally developed countries, such as the US (Duan and Xia, 2022). Being a pillar industry of technological innovation, the integrated circuit industry needs persistently heavy investment in R&D and rapid technological upgrades (Gu et al., 2018). The world's leading integrated circuit companies typically gain a technological edge by investing heavily in R&D, and then rely on global market monopolies to generate high profits that return the investment in R&D (Zeng and Wu, 2021). They then continue to raise technological and capital barriers through patent protection,

technological protection, and other measures to maintain their strong monopoly position. Most integrated circuit enterprises in China focus on low-profit areas, such as non-advanced manufacturing, packaging, testing and low-end chips. Upstream or high-profit products, such as materials, EDA software, equipment and high-end chips, rely heavily on imports (Zhang & Zhang, 2022). TSMC, a giant among wafer foundries, has achieved mass production of 5nm and 6nm wafers and is moving towards high-end processes such as 4nm and 3nm wafers. However, SMIC International, one of the strongest chipmakers in mainland China, has reached 12nm mass production in 2020. There is a significant technological gap between the two. Take the global procurement of chips for Apple mobile phones as an example: Chinese firms have a high 35%-40% share of Apple's suppliers, but the products supplied are mostly on the periphery of ICs, and core chips are rare. In contrast, the US, Japan and Europe have a larger consumer electronics chip industry that includes world leaders, such as AMD, Ansemy, Bosch, Sony, Toshiba, Infineon and others. This indicates that China's IC industry has weak competitiveness and innovation capability and is still in the middle and low end of the GVC (Sun et al., 2022).

Basic research on integrated circuits has long been neglected in China. The lack of sufficient R&D investment and original technological innovation creates serious constraints for Chinese firms to be at the forefront of the chip industry GVC. China's R&D investment is woefully inadequate. According to the American Semiconductor Association, the total R&D expenditure of the integrated circuit industry in the US was US\$39.8 billion in 2019. Intel's R&D spending topped the list at US\$13.4 billion, accounting for 31% of total spending by the world's top ten IC firms. HiSilicon, the only Chinese company on the list, has made only 18% of Intel's R&D investment. Moreover, there is a huge gap in key technologies between Chinese firms and the leading foreign firms. EDA software and IP core are essential for integrated circuit design, with EDA software highly dependent on foreign firms. In 2019, the three major EDA companies in the US, namely Synopsys, Cadence Design Systems and Mentor Graphics under Siemens, together accounted for 70% of the global market share and over 90% of China's market share. Most IP cores come from abroad, with the main suppliers being ARM and Synopsys (Wang, 2020). The lack of IC talent is another factor restraining the development of the IC industry in China. In 2020, the talent gap between the supply and demand of IC workers in China exceeded

400,000 people. The number of graduates majoring in ICs in China is less than 30000 per year, making it difficult to meet market demand. The US and Europe strictly restrict Chinese companies from mergers and acquisitions of semiconductor companies in their territories, and rarely offer employees with Chinese nationality the opportunity to work in their companies' core integrated circuit business, which hinders the transfer of technology from abroad to China. From the above analysis, we can conclude that multinational companies in developed countries dominate the GVC in the chip industry and that companies in emerging countries have long played a subordinate role in the GVC and their business interests are negatively affected by the uncertain global environment.

4.1.2 The Motivation, High Profit Margin, Huge Emerging Economy Market and Entrepreneurial Spirits

Firm A's motivation to enter the GPU sector is driven by the high profit margin in GVC's high-end segments and the huge market potential in emerging markets. In the IC sector, American companies occupied a 68% market share in the global IC design sector in 2018, ranking first in the world, up 15% from 2017. Taiwanese companies had a 16% market share, the same as the previous year, ranking second globally. Mainland Chinese companies had a market share of 13%, ranking third globally (Min, 2019). Indeed, the Chinese GPU server market size is estimated to reach US\$6.4 billion by 2024 (Clarke, 2021). If domestic GPUs achieve a 30% share by 2024, they can capture a US\$2.2 billion market. As an "acceleration tool" for general computing, high-end GPUs are becoming a must-have in areas such as large-scale data centres, artificial intelligence and supercomputing. NVIDIA has long dominated the high-end GPU market with a market share of over 90% (Zhang, 2022). GPUs are considered the pearl on the imperial crown of the chip industry and have a huge potential market with high return on investment.

China is also the largest semiconductor market in the world, accounting for more than a third of the global market. It is one of the countries rapidly advancing into the emerging fields of fifth-generation mobile communication technology (5G), mobile payments, Big Data, new energy vehicles and other emerging fields, and striving to promote sixth-generation mobile technology (6G), digital transformation of the industrial manufacturing

sector, automated driving, etc. (Zhang et al., 2023). The rapid development of Big Data and other technologies will further increase the market demand for semiconductors. And this super-sized market advantage and huge domestic demand potential will be gradually revealed in the process of further high-end industrial development (Yang, 2021). With the surge in demand for the new 5G infrastructure, medical imaging, intelligent manufacturing, autonomous driving, smart cockpit, cloud computing power and smart terminal localisation, the application field of GPU will continue to expand, making the size and growth potential of China's GPU market huge. It is expected that the GPU market in China will grow at an average annual rate of 32.8% from 2021 to 2028, rising from US\$7 billion to US\$56 billion (Chen, 2022). In particular, the launch of the “East Data to West Computing” project is a great opportunity for the GPU industry in China. “East Data” refers to data generated in the eastern regions of China, while “Computing” refers to computing power, the ability to process data. The project facilitates the construction of nationwide integrated large-scale data centre clusters and computing power networks, which will directly boost market demand for GPU chips, Artificial Intelligence (AI) chips, server chips and others. The increasing market demand stimulates the development and growth of the related industrial chains (Chen, 2022). As the core computing engine in the digital economy era, the GPU is used in fields such as artificial intelligence, autonomous driving, scientific computing, bioinformatics, and oil and gas exploration, and plays an important role in the development and transformation of various industries (Guo, 2022). Many emerging cutting-edge industries are developing rapidly, such as autonomous driving and gene sequencing. The common feature of these industries is that they need to process massive data information and the required algorithm models are becoming increasingly large, resulting in a strong demand for computing power. The expanded application of the ChatGPT large-scale model also places higher demands on the required computing power network and infrastructure support. The interviews suggest that these external pull factors have motivated Firm A to invest and take the opportunity to operate within the GVC.

While market opportunities exist with the GVC, noticing the difficult situation Chinese semiconductor firms are facing, the founder, chairman, and Chief Executive Officer (CEO) of Firm A established the company in China in 2020 with a sense of mission and responsibility of making

business for the people, pursuing sustainable development, promoting social progress, and striving to shape a better future. The corporate culture of firm A emphasizes excellence, teamwork, and ambition, aiming to make the difference and mark the future. In the new year of 2022, the CEO wrote: “Strive for the most difficult areas and pursue the grandest goals” to express his firm willingness to break any difficulties in developing GPU chips. The founder of Firm A practices the corporate culture and fully devotes himself to the development of the company. Inspired by the founder’s entrepreneurial spirit and corporate culture, Firm A attracts hundreds of talents, including a very competitive team with abundant experience in high-performance GPU products. The company has been driven by entrepreneurial spirit and innovation to develop products with self-owned intellectual property rights. Starting from the instruction set of GPU, Firm A redefines the chip and redesigned the micro-architecture, compiler, and library functions of GPU. This ensures high performance of GPU products and their compatibility with the mainstream ecology of the current market.

4.1.3 Path Selection of Firm A for Restructuring GVC

4.1.3.1 Seize opportunities and focus on the GPU market.

In spite of lack of advanced core manufacturing processes and the constraints of application ecology scenes, the implementation of the “East Data to West Computing” project has provided more trial and application opportunities for the domestic chip enterprises. Firm A views the “East Data to West Computing” project as a significant development opportunity. As the core computing engine in the digital economy era, GPU has been widely used in fields such as artificial intelligence, autonomous driving, scientific computing, bioinformatics, and oil and gas exploration, playing a key supporting role in assisting the development and transformation of various industries (Guo, 2022). With the rise of the digital economy, a large number of emerging cutting-edge industries are rapidly developing, such as autonomous driving and gene sequencing. The common feature of these industries is that they need to process massive data information, and the required algorithm models are becoming increasingly large, with a strong demand for computing power. In this context, Firm A seizes development opportunities and focuses on the GPU niche market. Starting from the

fastest growing GPU universal computing market, Firm A develops high-performance GPU products that are compatible with the international mainstream GPU ecosystem, while also independently developing software stacks. While laying out high-performance GPU chips and software solutions, Firm A is gradually entering the GPU rendering market. Making the AI chip market as its entry point, Firm A has completed the architecture design of high-end rendering GPUs, covering application fields such as scientific computing, cloud games, digital twins, metaverse, and autonomous driving, and continues to develop towards the future of the digital economy.

4.1.3.2 Enhance innovation capabilities through open innovation.

The integrated circuit industry is a capital and technology intensive industry. To achieve a GVC upgrade, it needs strong R&D and technological capabilities. Firm A develops products with its own intellectual property right (IPR), by building a professional R&D team and implementing open innovation. As for the R&D team, Firm A has an excellent team covering chip R&D, mass production, operations, and maintenance. The core team members have an average of 20 years of R&D experience. They have led the complete process development of more than ten mainstream high-performance products worldwide, from design to mass production, and hold key IPRs for research results. Compared to other teams, Firm A has a large team size with experienced team members in GPU development, production, and delivery. The team has a high level of coordination and low internal friction, avoiding many management problems and smoothly promoting the rapid introduction of new products.

After only one and a half years since its establishment, Firm A, with a team of more than 500 employees, has filed more than 90 patents and has IPRs for its cutting-edge technologies. In terms of open innovation, Firm A has established joint laboratories with several domestic universities and enterprises to conduct research on reconfigurable GPU architecture, improve the performance and energy efficiency of GPUs in target application areas, and promote the implementation of high-performance GPU chips in key technology application areas through the close industry, universities and research institutes linkages. Firm A is also in close contact with its customers. It takes into account customer feedback and makes progress in product development.

Building core teams to support innovation is critical path selection. Firm A's team members have worked for more than twenty years in multinational companies (e.g. AMD, Trident, ARM, Cadence, Synopsys, Bytedance, Intel), gaining rich experience in chip design, algorithms, marketing and operations. Firm A has hired over 700 talents since its inception in September 2020 to date, and more than 80% of its employees are R&D staff. Within such a short period of time, Firm A has grown in size very quickly. In the beginning, it recruited talent through intermediaries. Later, the firm relies on internal referrals and recruitment on university campuses. When recruiting university graduates, creativity, potential development, teamwork and excellence of the degree are highly valued. In recruiting experienced staff, industry relevance and work experience are at the forefront of the selection criteria. Firm A offers an attractive welfare package to attract, retain and develop talent. This shows that the excellent performance of a company requires a mix of a brilliant strategy, talents and an attractive social system.

4.1.3.3 Integrate upstream and downstream industries and build application ecological alliances.

For the GPU industry, industrial ecology is key. The top managers of Firm A have emphasised from the beginning that Firm A should not only produce high quality hardware products, but also build a good ecology. In our on-site interview, a top manager of Firm A's subsidiary said, "We are not building a new ecosystem, ours builds on the existing CUDA ecosystem. Rather, we are trying to make better use of the existing ecosystem". The reason is that it is difficult for a new company to create a completely new ecosystem. Therefore, after careful analysis, Firm A decides to make its GPU products compatible with the mainstream international ecosystem and develop its ecosystem with the power of the existing ecosystem. The software stack developed by Firm A is compatible with the international mainstream GPU ecosystem, solves the problems of the application ecosystem and minimises the migration costs for users' existing applications. This helps Firm A extend its own advantages and create breakthrough opportunities in the global market for high-performance GPUs. The cooperative relationship between Firm A and target customers such as server hosting factories, Big Data centres and Internet operators has greatly helped build the industry's upstream and downstream ecology. In the future, Firm A will continue to

expand its GPU design team, focus on the R&D of core GPU technologies, and closely engage the domestic application market to build a complete GPU software and hardware ecosystem.

In 2022, Firm A initiated the creation of the “Advanced Intelligent Computing Alliance” together with other related companies. In 2023, Firm A established the Application Ecology Alliance and collaborated with several ecological partners to promote the application and landing of a series of its products and solutions to create various application scenarios, such as smart cities, intelligent transportation, cloud computing and intelligent video processing, and build a comprehensive, efficient and controllable domestic GPU application ecosystem. A co-founder and Chief Marketing Officer (CMO) of Firm A said, “Firm A is committed to solving the industry’s core computing performance chip problems and is working with ecosystem partners to create a mutually beneficial industrial ecosystem based on Firm A’s GPU products.” The establishment of this alliance is a sign that Firm A’s products have gained high recognition from partners after being introduced to the market and will be used and implemented in even more intelligent scenarios in the future with the help of alliance members. Firm A will deepen its cooperation with ecological partners in various positions of the industrial chain, continuously improve its product system, effectively promote the implementation of diversified scenarios, create a smart, efficient, and mutually beneficial industrial ecosystem, expand the breadth and depth of ecological application alliances, and cooperate with ecological partners to promote the rapid development of domestic smart industries and the digital economy.

4.1.3.4 Customer-centric product strategy

Product R&D is important, and bringing the product to market is equally important. A top manager of Firm A’s subsidiary said in our interview, “Many companies develop their products, but in the end the company collapses because their products do not create a market due to lack of customers. To attract and retain customers, Firm A has made several efforts. First, Firm A’s products are made compatible with the mainstream ecosystem. If the customer is already based on the Compute Unified Architecture (CUDA) platform, Firm A’s product compatibility strategy can enable its products to run quickly in the customer’s system, significantly reducing the cost to the customer and increasing the customer’s confidence

in Firm A's products. Secondly, Firm A's products have been significantly developed by its team and have proven their worth to customers so far. Thirdly, Firm A provides its customers with a fast and comprehensive service and tailors its services specifically to their needs. Firm A adheres to a customer-oriented strategy in the product design, product promotion and product service phases, which helps it to quickly penetrate the market and win the favour of customers.

4.1.4 Restructuring GVC by Firm A

The creative path selection of Firm A has enabled the firm to develop rapidly and make breakthroughs in R&D of product technologies, ecological market design and financing. In terms of financing, Firm A received a pre-B financing round of RMB 1 billion in July 2022. In terms of product R&D, heterogeneous GPU products using the 7nm process have been produced in January 2022, and mass production is expected to be achieved in 2023. In 2022, Firm A has achieved notable successes: the completion of mass production of the GPUMIXN100, the completion of the flagship GPU MXC500 to chip design, and the completion of the architectural design of the high-end rendering GPUMXG100. In terms of market ecology, Firm A has established close cooperative relationships with industry clients, such as server OEMs, big data centres and Internet operators, and works intensively with numerous well-known universities and research institutes to rapidly advance the construction of the industry's upstream and downstream ecology and promote the application of cutting-edge technologies. Table 1 shows the development path of Firm A. Firm A is engaged in restructuring GVC through new forms of division of labour in collaboration with mostly local actors in emerging industries. In August 2023, Firm A, together with Zhipu AI and Ucloud, unveiled the first domestically produced GPU 100 billion parameter model training and promotion all-in-one machine at the second "Western Digital Valley" Computational Power Industry Partner Conference. This delivers breakthroughs to the 100 billion parameter threshold for domestically produced high-performance GPU products. It also marks the rapid implementation of the comprehensive solution of "domestically produced large models+domestically produced computing power chips+domestically produced cloud services" in practical application scenarios in the fields of medicine and scientific computing.

Table 1: Firm A’s Rapid Development Trajectory

Date	Cooperative unit	Cooperation content
December 23, 2020	Zhejiang University	Established a joint research center
January 5, 2021	Sequoia & Zhenfund	Completed Pre-A funding
March 4, 2022	Tsinghua University	Signed endowment agreement for special training program
July 5, 2022	Chaos Investment & CCTV integrated media industry investment fund	Completed Pre-B funding
July 20, 2022	Western Institute of Computing Technology	Signed cooperation agreement
March 19, 2023	Baidu	Firm A passed the compatibility test of Baidu AI studio and reached the mutual recognition requirements of Class I adaptation
March 23, 2023	Changsha Mourui Network Technology Co., Ltd	Conducted in-depth research and cooperation in fields such as 3D digitization
March 23, 2023	Beijing Songying Technology Co., Ltd	Jointly created a software and hardware integrated collaborative solution that combines 3D engines with GPU chips; At the technical level, jointly promote the development of a domestically produced and controllable new generation GPU computing system; At the commercial level, jointly promote the application development and innovation of 3D content creation based on intelligent computing.
Date	Cooperative unit	Cooperation content
April 3, 2023	Kehua Cloud Group	Collaboration in the generative AI technology innovation represented by AIGC and the relevant application fields
April 6, 2023	Beijing Sinnet Technology Co., Ltd	Enter the emerging intelligent computing market, have an in-depth cooperation with smart agricultural industry, and jointly create a smart agriculture application scenario ecosystem based on fully self-developed universal GPUs, providing technical and computing support for the construction of Chinese agricultural data centers.

Source: Firm A annual report and website.

The current uncertain global environment, such as the trend of deglobalisation, the rise of unilateralism, nationalism and trade protectionism, the intensification of trade and geopolitical tensions, and the impact of COVID-19 on GVCs, has led to profound changes in the participation of Chinese manufacturing companies in GVCs (Li, 2022). As Yiru et al. (2021) have argued, and as the case shows, GVCs are in the midst of large-scale restructuring and this new form of GVC is shaping the way firms reorganise and use multiple value chains to compete. In this sense, examining the firm's efforts to improve within GVC from the GVCR perspective offers new insights.

5. Conclusion and Implications

This study takes single case to examine the catch-up trajectory of Chinese high-tech firm in the IC industry. The development of AI and other digital technologies has created a huge market and created new business opportunities. Targeting the domestic market and focusing on the GPU field allows competency building to compete. Continuously gathering technological resources and capabilities, improving products based on feedback from key customers, working closely with various sources of innovation (customers, suppliers, universities, research institutes, investors, etc.) and establishing ecological alliances matters for upgrading within GVC.

From the case of Firm A, we can summarize the managerial implications as follows: First, it is of great importance to develop and consistently implement a R&D strategy for niche products that focuses on a differentiation strategy: GPU chip development, production, marketing, and supply. Having a visionary product R&D strategy and adherence to it throughout the product development process helps firms stand out from the competition. A clear and constant strategy, consensus on the strategy from top to bottom, and uncompromising execution of the strategy enable companies to compete and achieve their desired goals. The successful implementation of the R&D strategy cannot be separated from excellent employees. Also, the requirements of a first-class, highly qualified R&D core team are critical. Importantly, the recruitment, retention and development of talent and the well-being of workers are key to progress.

Second, the Industrial Revolution 4.0, which is mainly about digital technologies, has created huge market spaces and business opportunities,

especially in Chinese market. Thus, path selection in seeking market entry with home ground advantage can leverage firms to complete. Firms should accumulate resources and capabilities and build ecological alliances to improve market share which is crucial to catch up in the GVC. Third, benchmarking with the world leader, R&D collaborative strategies especially with key customers, and strategy of upgrading with entrepreneurial spirit is instrumental. Importantly, innovative and high-performance products help gain the trust of customers and build a firm image. It is critical for firms to engage in self-discovery behaviour in improving the product performance through research and expanding the application scope of their products to ensure a larger market share.

Last but not least, valuing customers is another important consideration to be successful. Therefore, being at the side of consumers, thinking of their needs and integrating them into the whole process of product design, manufacturing, promotion and service is crucial to rise in the GVC. By offering customers high-performing products and efficient and timely service, it reduces the cost of product switching and ensures customers willingness to try the new products, creating new markets. Similarly, the experience of the case offers some implications for SMEs in emerging economies. Latecomers should seize business opportunities arising from the Industrial Revolution 4.0 and target a niche market to which the multinational giants pay less attention. Devising and consistently implementing a targeted differentiation strategy, overcoming technological bottlenecks and developing products towards a high-value segments, and favouring the customer through open innovation and entrepreneurship are key for latecomers to improve their position in the GVC. Building an ecological alliance based on the existing ecosystem is critical for technological upgrading.

The study offers insights into understanding the upgrading process from the perspective of position, motive, pathway and impact. Although we conducted an in-depth case study and tested the validity of the GVCR framework, the study is still not without limitations. While the use of a single case provides useful information, further studies are needed for generalisation.

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