

Characteristics and Cultivation Path of Intelligent Home Appliance Industry Cluster in Yangtze River Delta

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Abstract

The Yangtze River Delta (YRD) is one of the most economically active, open and innovative regions in China. The Outline of the Plan for the Integrated Development of the Yangtze River Delta (YRD) puts forward the need for the YRD to build world-class manufacturing clusters around 10 major areas, including smart home appliances. At present, the YRD smart home appliance industry cluster is characterized by a large scale of home appliance manufacturing industry, obvious industrial cluster effect, good industrial foundation, relative concentration of related scientific and technological research fields and concentrated spatial distribution of patent output. However, through analysis, the Yangtze River Delta smart home appliance industry cluster still exists problems such as low influence of local head enterprises, weak technical cooperation links, slower development of AI cutting-edge technologies and serious fragmentation of the smart home appliance ecology. To promote the Yangtze River Delta smart home appliance industry cluster to a world-class manufacturing industry cluster, it is necessary to improve the competitiveness of local leading enterprises, build an open and shared regional innovation platform, breakthroughs in artificial intelligence technology by combining hard and soft and promote the upgrading of smart home appliances to the direction of smart home.

Keywords

Yangtze River Delta; Smart Home Appliances; Industry Cluster.

1. Introduction

The Yangtze River Delta home appliance cluster has a relatively solid foundation, not only with strong local brands such as Meiling, Rongshida, Sanyo and Boss, but also with production bases of the world's top 500 home appliance companies such as Whirlpool, Midea and Gree. However, due to the durability of home appliances and the insensitivity of consumers to common innovative features, the traditional home appliance market has become saturated and stepped into the era of stock. Therefore, the head enterprises of major home appliances have begun to combine the Internet of Things (IoT) and Artificial Intelligence (AI) technologies to transform traditional home appliances into smart home appliances, to increase the attractiveness of their products and activate the stock market of the home appliance industry. In response to the Outline of the Plan for the Integrated Development of the Yangtze River Delta Region, the Yangtze River Delta Home Appliances Cooperation Alliance was established in 2020, aiming to promote the transformation and upgrading of the home appliance industry, maintain the competitiveness of the home appliance industry cluster, and support the development of smart home appliances.

2. Literature Review

The Yangtze River Delta, after more than four decades of development since the reform and opening up, has already possessed world-class capacity advantages in certain areas[1]. In the process of promoting high-quality development of manufacturing industry clusters, the Yangtze River Delta gives full play to the comparative advantages of each place to enhance the level of internal division of labor, and walks out of the development path of “industrial convergence-industrial synergies-industrial clusters”[2]. In terms of industry clusters in subdivided regions, Anhui Province has a significant spatial agglomeration of innovative firms, with Hefei and Wuhu being two of its important agglomerations[3]. The industry development in Zhejiang Province presents a “block economy”, characterized by a large scale of geographical agglomeration, early formation time, and distinctive regional industry cultur[4]. Based on block economy, enterprises in Zhejiang Province have formed a network of relationship alliances with each other, which reduces the innovation barriers within the cluster area[5], and the resulting innovation aggregation effect has a significant positive effect on total factor productivity in Zhejiang Province[6]. Network embedding of advanced manufacturing clusters in Jiangsu Province can effectively promote the knowledge search capability and innovation capacity of enterprises[7], and the inter-firm relational embeddedness brought about by cluster network embedding has a positive impact on the innovation performance of enterprises[8], but the over-agglomeration of resource-intensive, labor-intensive, and low-technology-intensive industries can produce a factor-crowding effect, which can have a negative effect on the negative effect on industrial growth[9]. Shanghai's IC industry is more developed, and it has gradually climbed to a core position in the global innovation clusters, but there is still a more serious dependence on patent applications[10]. Meanwhile, Shanghai's port equipment manufacturing clusters and port logistics cluster are also quite developed, and there exists a power hierarchy within them, and technological power is an important factor in promoting cluster innovation and development [11].

Home appliances are a national necessity, and the foundation of China's home appliance industry is relatively mature. However, it is now necessary to improve the quality and innovation capacity of the cluster, to realize the upgrade in the global value chain and industrial chain, and to enhance the competitiveness of the cluster[12]. In order to promote the transformation and upgrading of the home appliance cluster, effective policy guidance for the relocation of cluster firms is needed[13]. After years of development, Chinese home appliance clusters are mainly located in Qingdao, Shandong, Shunde, Guangdong, Cixi, Zhejiang, and Hefei, Anhui, of which the former three are clusters formed through spontaneous agglomeration, and Hefei, Anhui, is a cluster formed through the relocation of home appliance cluster firms [14]. In addition, taking the Shunde home appliance cluster as an example, informal ties among firms in the home appliance cluster can effectively transfer implied technological knowledge and thus promote firm innovation[15].

Throughout the industrial development of three provinces and one city in the Yangtze River Delta, Hefei in Anhui Province has the appliance manufacturing industry with an output value of hundreds of billions of dollars as well as the head enterprise of artificial intelligence, IFLYTEK, Wuxi in Jiangsu Province's Internet of Things (IoT) cluster has been selected in the list of China's advanced industrial clusters, Shanghai's microelectronics and IC design industry is in a leading position in the country, and Hangzhou in Zhejiang Province's Alibaba possesses a strong cloud computing capability. The advantageous industries in each province have laid a strong industrial foundation for the construction of the Yangtze River Delta smart home appliance industry cluster. However, at present, the Yangtze River Delta smart home appliance industry cluster is still a certain gap from the world-class advanced manufacturing industry cluster. This paper aims to analyze the current development status of the Yangtze River Delta smart home

appliance industry cluster and its problems, and then put forward the cultivation path, to provide policy references for accelerating the establishment of the world-class advanced smart home appliance industry cluster in the Yangtze River Delta.

3. Characterization Facts of Intelligent Home Appliance Industry Cluster in YRD

3.1. Large Industry Scale of The YRD Home Appliance Manufacturing

Table 1. Output of Four Major Home Appliances in Yangtze River Delta

Products Region	Products Region	2015	2016	2017	2018	2019	2020
Production of household washing machines (10,000 units)	Nationwide	7275	7621	7501	7268	7433	8041
	Shanghai	160	163	149	140	148	134
	Jiangsu	1652	1850	1879	1892	2240	2239
	Zhejiang	1527	1397	1227	1153	1119	907
	Anhui	1725	2006	2056	2126	2328	2380
Production of refrigerators (10,000 units)	Nationwide	7993	8482	8548	7993	7904	9015
	Shanghai	140	56	55	46	34	21
	Jiangsu	845	869	895	956	1068	1265
	Zhejiang	711	798	647	618	568	593
	Anhui	2703	3059	3257	2631	2506	2438
Room air conditioner production (million units)	Nationwide	14200	14342	17862	20486	21866	21035
	Shanghai	327	349	390	383	314	231
	Jiangsu	404	454	425	512	500	402
	Zhejiang	631	951	1484	1613	1939	1583
	Anhui	2916	2848	3736	3210	3366	3010
Production of color television sets (10,000 units)	Nationwide	14476	15770	15933	18835	18999	19626
	Shanghai	135	115	136	144	136	159
	Jiangsu	1273	1383	1369	1313	1383	796
	Zhejiang	641	658	610	722	193	1
	Anhui	734	829	948	1780	1941	1612

Source: China Industrial Statistical Yearbook.

Table 1 details the calendar year production statistics of the four major home appliances including washing machines, refrigerators, air conditioners and color TVs in the Yangtze River Delta region including Shanghai, Jiangsu, Zhejiang and Anhui during the long period of 2015-2020. According to statistics, by the end of 2020, the annual production of washing machines in the YRD region has accounted for 70% of the country's total washing machine production, 48% of the national total refrigerator production, 25% of the national air conditioner production, and 13% of the national color TV production. From these figures, it can be seen that the Yangtze River Delta region, as an economically developed region in China, has a well-developed home appliance manufacturing industry, especially in terms of washing machines and refrigerators, the two major large-scale home appliances essential to people's livelihood, and has become an important source of supply for the domestic home appliance market. Among the provinces and cities within the Yangtze River Delta, Anhui Province has the most prominent home appliance manufacturing industry, with high production of its four major home appliances, accounting for 42%, 56%, 58% and 63% respectively within the Yangtze River Delta

region, ahead of Shanghai, Jiangsu and Zhejiang, making it an important home appliance production base in the Yangtze River Delta region and even in the country as a whole. The rapid development of the home appliance manufacturing industry in Anhui has made an important contribution to the development of the home appliance industry in the Yangtze River Delta region and even the whole country.

3.2. Obvious Intelligent Home Appliance Industry Cluster Effect

A total of seven smart home appliance manufacturing companies are on the 2022 Fortune China 500 list, including Midea Group Corporation (82nd), Haier Zhijia Corporation (118th), Zhuhai Gree Electric Appliances Corporation (146th), Sichuan Changhong Electric Appliances Corporation (215th), Hisense Home Appliances Group Corporation (149th), Skyworth Group Ltd. (287) and Konka Group Corporation (433). A search of the Tianye Enterprise Database shows that the above seven Fortune 500 companies have set up production and R&D bases in the Yangtze River Delta. Among them, Midea Group has set up 18, Haier has set up 13, Gree has set up 6, Changhong has set up 4, Hisense has set up 3, Skyworth has set up 12, and Konka has set up 9. The investments and operations of these enterprises in the YRD region have made great contributions to the technological research and development, manufacturing, and innovation of smart home appliances in the YRD.

In terms of main business, Midea Group Co., Ltd. and Haier Zhijia Co., Ltd. are the most diversified enterprises in the Yangtze River Delta's smart home appliance industry cluster. In addition to the manufacturing business of household appliances, they are also involved in the fields of smart manufacturing automation system technology, the Internet, the Internet of Things, computer hardware, software and auxiliary equipment, semiconductor chips for household appliances, and the development of new electronic components. Followed by Skyworth Group Ltd. and Konka Group Co. Ltd. which, in addition to the manufacture of color televisions, are also involved in the fields of R&D and manufacturing of display components, high-tech R&D, etc. Zhuhai Gree Electric Appliances Co., Ltd. and Hisense Home Appliances Group Co., Ltd. mainly focus on the manufacture of household air conditioners. Sichuan Changhong Electric Appliances Co., Ltd. mainly focuses on the manufacturing of household appliances.

In terms of regional layout, the production and R&D bases of China's top 500 enterprises (home appliances) are mainly concentrated in Hefei, Shanghai and Wuhu. Among them, Hefei City has a total of 19, mainly focusing on the R&D of smart home appliance-related technologies and the manufacturing of smart home appliances; Shanghai City has a total of 9, mainly focusing on the R&D of smart home appliance-related technologies; and Wuhu City has a total of 8, mainly focusing on the manufacturing of smart home appliances. This dense industrial layout helps promote technological innovation and optimal utilization of resources, enabling the Yangtze River Delta region to continue to make remarkable progress in the field of smart home appliance industry.

3.3. Good Industrial Foundation

Smart appliances add intelligent sensing and autonomous decision-making capabilities to traditional appliances. The Yangtze River Delta not only has a well-developed manufacturing level of traditional home appliances, but also has a strong industrial base in smart home appliances.

3.3.1. Shanghai Integrated Circuit Industry

IC is the hardware foundation of smart home appliances, and the manufacture of smart home appliances mainly requires the use of micro control unit (MCU) chips, Internet of Things (IoT) chips, power supply chips, and power chips. At present, Shanghai's IC industry is in a leading position in the country. As of 2021, the revenue income of Shanghai's IC industry reached

257.885 billion yuan, a year-on-year growth of 24.50%. Among them, the design industry is 122.228 billion yuan, a year-on-year growth of 28.1%; the manufacturing industry is 59.604 billion yuan, a year-on-year growth of 27.58%; and the packaging and testing industry is 47.07 billion yuan, a year-on-year growth of 9.24%. Shanghai has formed a complete integrated circuit industry chain, covering all kinds of raw materials, semiconductor equipment, chip design, chip manufacturing and packaging and testing, and was selected as one of the 45 national advanced manufacturing clusters in 2022. In terms of the design and manufacturing of the four essential chips for smart home appliances, Shanghai has a layout, there are eight companies in MCU chip design, seven companies in IoT chip design, four companies in power supply chip and power chip design, and four companies responsible for chip manufacturing. Shanghai's strong IC industry provides key support for the development of smart home appliances in the Yangtze River Delta region and is an important backing for the upgrading of the smart home appliance industry, and its accumulated technological and industrial advantages in the field of integrated circuits will vigorously promote the higher-end and more intelligent smart home appliances in the Yangtze River Delta region.

3.3.2. Wuxi IoT Industry

IoT empowers traditional home appliances with the ability to sense the environment and interconnect everything, upgrading them to smart appliances and further connecting them to smart homes. IoT industry is one of the key industries in Wuxi, and was selected as one of the 45 national advanced manufacturing clusters in 2022. According to the information of Prospect Industry Research Institute, over the past 11 years since the construction of IOT in Wuxi, the average annual growth rate of industrial revenue has been 27.32%, with a total of 3,657 enterprises, and a complete industrial chain of associated chips, sensing devices, network communications, intelligent hardware and application services, and more than 50 key R&D institutions, with an average R&D investment intensity of 7.36%, and a cumulative total of more than 2,000 R&D projects above the provincial level, with more than 10,000 patent applications, and more than 2,000 patents. It has undertaken more than 2,000 R&D projects above the provincial level, applied for more than 10,000 patents and 3,658 invention patents for IoT within the validity period, led or participated in the formulation of 12 international standards for IoT, 62 national standards, and 17 industry standards, and 34 scientific and technological achievements have won the second prize of National Progress or the second prize of National Technological Invention, and the technological applications have covered more than 300 subsections of the industry in the city. Wuxi Municipal Government in the "Wuxi National Sensor Network Innovation Demonstration Zone Development Plan Outline (2021-2025)" pointed out that it will strengthen the Wuxi Internet of Things application empowerment leadership, promote the wisdom of life enhancement, to improve living conditions, enhance the quality of life for the purpose of accelerating the promotion of Internet of Things in the application of smart homes.

3.3.3. New Display Industry in Hefei

New display devices are an important part of smart TV. In recent years, the new display industry in Hefei City has developed rapidly, and three TFT-LCD mass production lines (a 6-generation line, a 8.5-generation line, a 10.5-generation line), a print OLED test line and a silicon-based OLED small-size line have been built, and a 6-generation flexible AMOLED line is under construction, forming a complete industrial chain that covers the upstream equipment, materials, devices, midstream panels, modules, and downstream smart terminals. We have formed a complete industrial chain covering upstream equipment, materials, devices, midstream panels, modules and downstream smart terminals. It has realized the layout of the whole industry chain from "sand to machine". At the 2023 New Display Industry Conference, Hefei was awarded the first place of "China's Top 10 New Display Cities", and its innovation

ability and localization support level are leading in China. As of the end of 2022, the city has gathered more than 150 new display industry chain enterprises such as BOE, Visuno, Vision Ace Technology, etc., and nearly 40,000 industrial talents. 2022, the production capacity of various types of panels accounted for 7.8% of the global total production capacity of display panels, and shipments accounted for 1/7 of the country's total, realizing an output value of more than one hundred billion yuan, and the overall scale of Hefei City has remained in the first domestic square. According to the "Hefei City," "14th Five-Year Plan" of the new generation of information technology development plan "pointed out in the content, Hefei City, continue to follow the" leading enterprises - large projects - industry chain - industry clusters Hefei City continues to follow the development idea of "leading enterprises - large projects - industrial chain - industrial clusters - industrial bases", looks at the global display industry and technology development trends, focuses on the forward-looking layout of new technologies and products, further improves the industrial chain, promotes the concentration of high-quality enterprise resources, improves the development quality and efficiency, and actively strives for the creation of a national advanced manufacturing cluster of new displays, consolidates and develops It will also consolidate and develop its position as the "Global Display Capital".

3.3.4. Intelligent Voice Industry in Hefei

Intelligent voice is an important carrier of human-computer interaction for smart home appliances. Relying on the University of Science and Technology of China (USTC) and the powerful intelligent voice R&D technology of IFLYTEK, the intelligent voice industry has become a key industry in Hefei, and has been selected as one of the 45 advanced manufacturing clusters in the country. 2012, Hefei created the "Sound Valley of China", which is the first national intelligent voice and artificial intelligence industry base built by the ministry and the province, and by the end of 2022, there are 2005 enterprises in the park, achieving a revenue of 205 billion yuan. By the end of 2022, there will be 2005 enterprises in China's Sound Valley, realizing a revenue of 205 billion yuan. In the 2023 World Manufacturing Congress, the Ministry of Industry and Anhui Province signed the third round of cooperation memorandum, clearly will focus on the national development strategy, the Ministry and the province to jointly promote the high-quality development of China's sound valley, with about five years, China's sound valley into a Hefei as the center, driven by the Anhui Province, radiation in the Yangtze River Delta, service the whole country, the impact of the global world-class advanced manufacturing clusters.

3.3.5. Cloud Computing Industry in Hangzhou

Cloud computing allows smart home appliances to upload data to the cloud for computation, supplementing the inadequacy of edge computing and thus making traditional home appliances intelligent. Hangzhou is a pioneer city in cloud computing in China, leading other cities in the country in terms of technology. Among them, the West Lake District has gathered two well-known industrial parks, namely the Hangzhou Cloud Computing Industrial Park and the Hangzhou Digital Information Industrial Park, thus providing good industrial park support services for cloud computing and related supporting enterprises. With a planned investment of 3.2 billion yuan, the Hangzhou Digital Science and Innovation Center in Linping District is expected to arrange 10,000 cabinets and provide an overall cloud computing service capacity of 200,000 servers. Hangzhou Yuhang District Future Science and Technology City goal is to create "facing the world, leading the future radiation province's innovation source" According to the Hangzhou Bureau of Statistics data, 2019-2021 Hangzhou cloud computing and big data added value from 120 billion yuan jumped to 161.5 billion yuan; accounted for the proportion of the digital economy increased year by year, 2021 Hangzhou Cloud computing and big data accounted for 33% of the scale of the city's digital economy, the first in the domestic market

share of cloud computing and big data, and the first in the Asia-Pacific market share of cloud computing infrastructure as a service (IaaS).

3.4. Relative Concentration of Relevant Scientific and Technological Research Areas

Table 2. Statistics of Intelligent Home Appliance Patent Inventions in Yangtze River Delta

IPC	Quantities	IPC	Quantities	IPC	Quantities
H04	1185	B29	14	F01	2
A47	1061	C02	14	F15	2
G05	759	A45	10	F17	2
H01	657	B66	10	C09	2
G06	419	A62	9	D05	2
H05	304	B32	9	A44	2
H02	255	B60	8	A46	1
F24	252	B62	8	B61	1
G01	218	C08	8	B64	1
G08	193	A63	7	C05	1
G10	100	H10	7	C23	1
F16	93	B01	6	C25	1
E05	89	B05	6	D21	1
A61	87	C07	6	E01	1
F21	83	G11	6	E21	1
D06	70	G16	6	F22	1
F25	67	B41	6	F23	1
G07	57	B28	5	B27	1
B65	51	B02	4	A21	1
E06	51	B24	4	B67	1
B25	43	C01	4	B31	1
E04	41	F26	4	B43	1
G09	41	G03	4	C04	1
F04	33	G04	4	C03	1
A01	28	F02	4	B42	1
H03	28	C22	3	B03	1
E03	26	B26	3	C12	1
G02	20	B09	2		
B08	17	B22	2		
B23	17	E02	2		

Source: Wisdom Buds Database.

Note: The search keyword is "smart home appliances", the use of wisdom bud artificial intelligence system automatically extends the search caliber to "smart home appliances", "smart home appliances", "home equipment", "smart home terminal", "smart appliances", "smart home system", "home smart terminal", "smart home appliance", "smart home gateway", "home control system ", "smart home controller", "smart home control system", "home appliance control module", " smart home control", "home appliances", "whole house", "smart sockets", "smart gateway ", "home system", "home terminal", "smart home appliance control", and finally manually eliminating irrelevant data.

As shown in Table 2, the patent inventions in the Yangtze River Delta in the area of smart home appliances are mainly concentrated in H04 (electrical communication technology), A47 (furniture; articles or equipment for household use; coffee mills; spice mills; vacuum cleaners in general), G05 (controlling; regulating), H01 (electrical components), and G06 (calculating; projecting or counting) Among them, the field of H04 mainly involves innovations in the electrical communication technology, which mainly addresses the issue of interconnection between smart home appliances. The LRD has not only made significant contributions to communication protocols, but has also developed communication standards between various smart devices, providing a solid foundation for home automation. Patent inventions in the field of A47 are mainly related to furniture and articles or equipment for household use, which can improve the appearance, functions and user experience of household equipment, and provide consumers with a more convenient, comfortable and efficient way of living in their homes. The field of G05 patents, on the other hand, cover control and regulation technologies, mainly addressing automation and remote control of smart home appliances. In addition, electrical components in domain H01 and computing technologies in domain G06 are also important components of smart home appliance patent inventions in the YRD. Innovations in electrical components support the stability and reliability of smart home appliances, while advances in computing technologies provide powerful tools for intelligentization and smart analysis of smart home appliances.

4. Problems in the Development of Intelligent Home Appliance Industry Cluster in YRD

4.1. Local Headline Companies are not Very Influential

The main production areas of home appliance enterprises in the Yangtze River Delta are mainly concentrated in small home appliances, kitchen and bathroom appliances, and household refrigeration equipment, and the competitiveness of the enterprises is weak. In the 2023 Fortune 500 list, there are six home appliance enterprises on the list, ranked from front to back: Samsung Electronics, Sony, LG Electronics, Panasonic Corporation, Midea Group Corporation and Haier Home Automation Co. Ltd. (Guangzhou-Foshan-Huizhou Intelligent Home Appliance Industry Cluster) and Haier Zhijia Co. In the list of China's Top 500 Enterprises in 2023, no enterprises from the Yangtze River Delta region are on the list, while two enterprises from the Guangzhou-Foshan-Huizhou Intelligent Home Appliance Cluster and one enterprise from the Qingdao Intelligent Home Appliance Cluster are on the list.

From the above horizontal comparison, it is clear that the competitiveness of local smart home appliance manufacturing enterprises in the Yangtze River Delta is weak, and the enterprises are small in scale and generate less profit. Although there are branches of domestic home appliance giants (Midea, Gree, etc.) in the Yangtze River Delta, their R&D capabilities as well as revenue capabilities are far less than those of their headquarters, and the region lacks enterprises and products with monopoly competition.

4.2. Weak Technical Cooperation Linkages

By analyzing the patent cooperation between cities of smart home appliances in the Yangtze River Delta, it is found that among the 26 cities in the Yangtze River Delta, only 11 cities have technical cooperation. Patent cooperation between Shanghai, Suzhou, Hangzhou and Jiaxing and other cities is closer, while patent cooperation links between other cities are weaker, reflecting the insufficient spatial spillover of innovation factors in the Yangtze River Delta smart home appliance industry cluster. From Figure 7, it can be seen that there is a strong cooperative relationship between Shanghai and Suzhou, Jiaxing, Hangzhou, Hefei, Yancheng, Nantong and Jinhua, and the weakest patent cooperative relationship between Jinhua and Hefei and other

cities, which has only 1 degree on the topological map and is at the edge of the topological map. Overall, the technical cooperation and communication between smart home appliance enterprises in the Yangtze River Delta region is not frequent enough, and the dissemination channels of knowledge and technology between cities are not smooth enough. There is a lack of effective technology transfer platforms in the region, and technical resources between cities cannot be efficiently allocated, thus resulting in obvious differences in the closeness of technical cooperation between core cities and neighboring cities, and weaker technical cooperation links between most cities.

4.3. Slower Development of Cutting-edge Artificial Intelligence Technologies

Artificial intelligence technology plays an important role in smart home appliances. At present, the development of AI technology in the Yangtze River Delta is relatively slow. From the hardware point of view, AI technology is extremely dependent on high-calculation graphic processors for parallel computing, and high-calculation graphic processors are basically monopolized by the U.S. NVIDIA Corporation. Although Shanghai Refined Technology has released the GPGPU model BR100, whose single-chip arithmetic power reaches 1,000 TFLOPs, surpassing Nvidia's flagship product A100, it has always been based on Nvidia's CUDA ecosystem for development, in which there are a large number of patents, and ultimately, the development of the product stopped after the flow of chips. It can be seen that AI technology in the Yangtze River Delta is deeply affected by Western hardware patent barriers. From the software point of view, the current generative artificial intelligence model (AIGC) is developing rapidly, and the combination of smart home appliances and AIGC is the future development direction. On August 30, 2023, the National Innovation Center for High-end Intelligent Household Appliances released the "White Paper on Innovation and Development of Intelligent Home Appliances and Generative Artificial Intelligence Large Models" with the aim of regulating the home appliance industry through the construction of a large model platform for the smart home appliance industry, standardizing the home appliance industry's The purpose of the white paper is to standardize the framework of data and knowledge fusion in the home appliance industry through the construction of a big model platform for the smart home appliance industry, accelerate the innovation and development of the underlying technology of the industry's big model, expand the vertical application scenarios of the ToB and ToC ends in the field of the smart home appliance industry, and explore the effective paths for the home-grown AIGC to promote the smart home appliance industry into the 3.0 era. At present, the Yangtze River Delta mainly possesses the Starfire Cognitive Grand Model developed by IFLYTEK and the Tongyi Thousand Questions Grand Model developed by Alibaba, but their algorithms are based on Transformer, which is more serious homogenization, and there is still a certain gap with the GPT-4 model of the U.S. OpenAI Company. In addition, constrained by various factors such as R&D costs, data resources, system security, industry standards, etc., the Yangtze River Delta has been developing more slowly in AIGC cutting-edge technologies. Overall, AI enterprises in the Yangtze River Delta region still have shortcomings in arithmetic architecture, arithmetic support for model training, massive multilingual data accumulation, algorithmic innovation of key arithmetic, security control of models, and richness of application scenarios. How to increase scientific research investment, attract high-end AI talents to gather, strengthen cooperation with international cutting-edge enterprises, improve data and computing resources support, enhance algorithm development capabilities, and pay attention to the ethical norms of technology application all require the joint efforts of all sectors of government, industry, academia, and research in the Yangtze River Delta region, so as to enable the AI technology in the Yangtze River Delta region to narrow the gap with the international leading level, and to play an important role in the country's AI innovation and development. strategic leading role in the development of national AI innovation.

4.4. Serious Ecological Fragmentation of Smart Home Appliances

At present, the two mainstream domestic smart home appliance ecosystems are Huawei Harmony and Xiaomi MiHome. The local home appliance enterprises in the Yangtze River Delta have more serious fragmentation in terms of smart home appliance ecosystem support. In the list of major local home appliance enterprises in the Yangtze River Delta in Table 6, a small portion of the products of Opple Lighting, Oxy, and Meiling support access to the Harmony ecosystem, while most of the products of Opple Lighting, most of the products of Oxy, most of the products of Meiling, most of the products of Fanta Kitchen, Boss Appliances, Subor, Rongshida, and all of the products of Sanyo use their own smart control platforms, and the rest of the brands do not support access to the smart ecosystems. platform. Local home appliance companies in the Yangtze River Delta region use different intelligent control platforms, resulting in incompatibility between smart home appliance products and the inability of users to realize seamless connectivity and collaborative operations between devices when using them. This inconsistent standard makes it challenging for consumers to purchase devices or integrate home smart systems and limits the further development of smart home technology. In addition, each company's own smart control platform can often only support limited functionality and cannot achieve full interconnectivity of cross-brand products, which severely limits user experience and functionality expansion; for example, users may not be able to control lights, air conditioners, kitchen equipment, and other multi-branded smart devices through a unified platform. At the same time, this ecological fragmentation also hinders cooperation and sharing among enterprises in the industry. Enterprises competing with each other are often unwilling to open up their own smart control platforms, leading to a waste of resources and market fragmentation, weakening the overall competitiveness of the smart home appliance industry in the Yangtze River Delta region.

5. Path to Cultivate World-Class Intelligent Home Appliance Industry Cluster in YRD

5.1. Improve the Competitiveness of Local Leading Enterprises

To increase policy support for key smart home appliance enterprises, such as giving preferential tax policies, special technology research and development funds to help them expand their scale and enhance their technological strength. And actively introduce talents and technologies, support enterprises to develop international markets, and cultivate local brands with core competitiveness and international influence. It can also form strategic cooperation alliances to enhance competitive advantages with upstream and downstream collaboration in the industry chain. In addition to increasing policy support, local smart home appliance enterprises should also strengthen their independent innovation capabilities, improve product quality and performance, and meet the diverse needs of consumers and personalized customization. At the same time, it is necessary to strengthen brand building and marketing promotion to enhance consumer awareness and trust in smart home appliances, expanding market share and influence. In addition, it is necessary to strengthen cooperation and integration with other related industries, such as the Internet, Internet of Things, artificial intelligence, big data, etc., to create an ecosystem of smart home appliances and provide consumers with a more convenient, comfortable and safe smart life experience.

5.2. Build an Open and Shared Regional Innovation Platform

Relying on the strong scientific and educational resource advantages of the Yangtze River Delta region, we will build an open public technology innovation platform, construct shared chip and sensor process lines, bring together all kinds of high-end innovation resources, promote the in-depth synergy of industry, academia and research with a point-to-point approach, strengthen

the inter-regional flow of talents, technology and information, and promote the optimal allocation of factors. The regional innovation platform can not only provide technical support and services for the smart home appliance industry, but also stimulate the innovation vitality and cooperation potential inside and outside the region, forming a benign innovation ecology. Through the open sharing of the platform, it can realize the efficient utilization and value transformation of technological resources, reduce innovation costs and risks, and improve innovation efficiency and quality. At the same time, it can promote knowledge overflow and technology diffusion within and outside the region, accelerate the technological progress and product renewal of the smart home appliance industry, and enhance the core competitiveness and international influence of the smart home appliance industry.

5.3. Combination of Hard and Soft Breakthroughs in Artificial Intelligence Technology

In terms of hardware, give full play to the advantages of Shanghai's integrated circuit industry cluster, focus on attacking advanced process chip manufacturing technology, realize the leap from infiltration deep ultraviolet etching technology to extreme ultraviolet etching technology, and break through the foreign technology blockade. At present, Huawei Rise 910b's computing power is slightly weaker than NVIDIA A100, but its price is lower than A100, so it can purchase a large number of domestic AI computing cards such as 910b to establish computing clusters, realizing the exchange of space for time, and reducing the damage caused by the U.S. blockade of high-calculation power AI chips against China. From the software side, the government should strongly support the improvement and promotion of the underlying architecture of domestic AI models, increase financial subsidies for the research and development of local AI underlying architectures, and set up a special fund to support relevant enterprises and scientific research institutes to carry out the innovation and optimization of underlying architectures. Introduce subsidies or preferential policies to encourage enterprises to adopt local AI underlying architectures for product development and application and accelerate the landing of local AI technologies in smart home appliances and other fields. Support the establishment of a series of local AI underlying architecture application demonstration projects to verify the feasibility and advantages of the technology with actual application cases and stimulate the recognition and adoption of local AI technology within and outside the industry. Encourage local AI enterprises to actively participate in international technology exchanges and cooperation and explore the development of AI underlying technology with advanced international enterprises to enhance international competitiveness.

5.4. Promote Smart Home Appliances to Smart Home Upgrading

The Government should take the lead in formulating a unified specification for smart home appliances to access mainstream smart control platforms, and ensure that enterprises follow this specification in the product design and development phase to achieve wider compatibility. Introduce an incentive mechanism to reward enterprises that comply with the standard and open up their interfaces, such as tax incentives, financial support, or market access priority, in order to encourage enterprises to actively participate in the design of standardized interfaces. Establish a regular assessment mechanism to evaluate the access standards, and update and improve the standards in a timely manner according to the development of the industry, so as to adapt to technological advances and changes in market demand. Promote ecosystem integration and upgrading to open up ecological links. Encourage smart home appliance enterprises to cooperate with the smart home ecosystem to jointly develop eco-products and improve interconnectivity and user experience. Open platform construction, the government supports the establishment of a smart home open platform to provide a unified access channel for different brands of smart home appliances and promote interconnection between devices. This will help establish an open and interoperable smart home appliance industry environment,

improve the current fragmentation of the smart home appliance ecosystem in the Yangtze River Delta, promote compatibility and interconnection between various brands of devices in the industry, promote the upgrading of smart home appliances in the Yangtze River Delta in the direction of the smart home, and provide consumers with a more convenient and diversified smart home experience, so as to make smart home appliances in the Yangtze River Delta more popular among consumers.

6. Conclusion

This paper discusses in detail the characteristics of the Yangtze River Delta smart home appliance industry cluster, the challenges it faces, and the path to develop into a world-class industry cluster. The Yangtze River Delta region has become an active region for domestic economic development with its huge scale of home appliance manufacturing, obvious industrial cluster effect, solid industrial foundation, concentrated scientific and technological research and patent output. Despite this, the region's smart home appliance industry cluster still has some problems, including the low influence of local leading enterprises, weak technical cooperation links, slow development of cutting-edge artificial intelligence technologies, and serious fragmentation of the smart home appliance ecosystem. To address these problems, this paper proposes a series of cultivation paths: first, enhance the competitiveness of local enterprises through policy support and independent innovation; second, build an open and shared regional innovation platform to promote in-depth collaboration between industry, academia and research; third, combine software and hardware to break through artificial intelligence technology, especially in hardware to overcome advanced process chip manufacturing technology, and improve and promote domestic AI underlying architecture in software; finally, promote the upgrade of smart home appliances to smart homes, and promote the interconnection between devices by formulating unified specifications and establishing open platforms. These measures aim to promote the Yangtze River Delta smart home appliance industry cluster to move towards a world-class advanced manufacturing industry cluster through the joint efforts of policies, enterprises, scientific research institutions and the market. Translated with DeepL.com (free version).

References

- [1] Z.Wang: A Study on the Promotion of World-Class Industrial Clusters Construction in the Yangtze River Delt, *Journal of Anhui University(Philosophy and Social Sciences Edition)*, Vol.44(2020), No.03, p.114-121.
- [2] Y.K.Yin, Y.Q.Tang: From Industrial Convergence to Industrial Cluster: A New Structural Economics Analysis of the Manufacturing Industry in the Yangtze River Delta, *Journal of Hohai University (Philosophy and Social Sciences)*, Vol.24(2022), No.02, p.45-52+110.
- [3] R.S.BAI, S.L.Hu ,L.Zhuang, Y.Liu, K.K.Liu, P.N.Huang: Spatial Patterns and Influencing Factors of Innovative Enterprises in Anhui Province Based on Subdivision Industry, *World Regional Studies*, Vol.29(2020), No.6, p.1190-1201.
- [4] R.Y.Chi, M.Z.Zhang: The Impact of Agglomeration Modes and its Driving Factors on Industry Growth--An Empirical Study Based on Zhejiang Manufacturing Industry, *Economic Theory and Business Management*, 2013, No.12, p.56-67.
- [5] H.Ren, Y.P.Jia: Knowledge Network Extension: Exploration of the Path of Improving the Regional Industrial Clusters' Industrial Upgrading Potentials, *Information Studies: Theory & Application*, Vol.36(2013), No.6, p.53-57.
- [6] J.Q.Chen, X.W.Zhou, J.D.Pan: Evaluation of the Process of Building a High-Level Innovative Province in Zhejiang Province--Empirical Analysis Based on County and City TFP and Innovation Agglomeration Effect, *Governance Studies*, Vol.36(2020), No.5, p.88-95.

- [7] S.Q.Wu, C.Q.He, G.J.Xia: Advanced Manufacturing Cluster in Jiangsu: Embedding, Dynamic Capabilities and Enterprise Innovation Performance, *East China Economic Management*, Vol.33 (2019), No.12, p.28-34.
- [8] S.Q.Wu, X.Y.Cao, T.T.Cai: Research on Relationship among Network Embeddedness, Knowledge Search and Enterprise's Innovative Capability: Empirical Test based on Jiangsu Advanced Manufacturing Cluster, *Science & Technology Progress and Policy*, Vol.37(2020), No.22, p.99-105.
- [9] X.T.Liu: Is Higher Industrial Agglomeration better for Industrial Growth and Economic Development? --Based on the Empirical Evidence of Jiangsu Manufacturing Industry, *Jiangxi Social Sciences*, Vol.35(2015), No.12, p.43-47.
- [10] Q.C.Yang, J.X.Wang: Measurement of Shanghai's Position in the Global Innovation Network--Evidence from the World's Top Ten Innovative City Clusters, *Forum on Science and Technology in China*, 2023, No.1, p.109-118.
- [11] L.Lin, X.Z.Cao, G.Zeng: Innovation Paths of Heavy Industry Cluster under the Influence of Technology Authority: A Case of Shanghai Lin'gang Equipment Manufacturing Cluster, *Journal of East China Normal University(Humanities and Social Sciences)*, Vol.51(2019), No.2, p.152-162+188.
- [12] L.C.Huang, Q.Liang: A Study on the Upgrading Path of Industrial Cluster Based on the Perspective of Quality Reformation: A Case of Shunde World-class Household Appliance Industry Cluster, *Industrial Economic Review*, Vol.12(2021), No.1, p.104-114.
- [13] Z.X.Chen, G.L.Ren: Evolution of Clusters, Industry Transfer and the Upgrade of Manufacturing Industry Cluster: Taking the Appliance Industry Cluster in Cixi as an Example, *Journal of Nantong University(Social Sciences Edition)*, Vol.30(2014), No.6, p.31-38.
- [14] X.H.Zhang, B.Wu: Motivation and Direction of Cluster Firms' Inter-Regional Relocation--Case Study Based on Chinese Home Appliances Industry Clusters, *Science and Technology Management Research*, Vol.32(2012), No.22, p.202-206.
- [15] W.Liu, X.LI, Q.S.OU: Informal Ties in Industrial Cluster and its Impact on Technological Innovation: A Case Study of Household Appliance Cluster in Shunde, *Geographical Research*, Vol.32(2013), No.3, p.518-530.