

## Article

# Product Innovation and Design Strategies for 5G Technology in China's Home Appliance Companies

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**Abstract:** With the continuous evolution of mobile communication systems, 5G technology has become a key driver for a smart home appliance ecosystem. Fifth-generation technology may create opportunities and threats for the home appliance industry in the stock market, and so companies that do not actively engage in product innovation activities will eventually be eliminated from the market because their products are not on trend. This study investigates Chinese household appliance industry firms to identify their innovation strategies, applied to cope with global competition and gain a competitive advantage, and explores the correlation and operation mode between innovation strategies and design strategies. For this study, we administered a questionnaire to analyze three innovation clusters for Chinese household appliance firms. Interviews were conducted to further understand the design strategies and priorities of Chinese home appliance companies in response to 5G technology, to explore the relationship between innovation strategies and product design strategies, and to provide a reference for the product design strategies of home appliance companies in response to global competition.

**Keywords:** home appliances; 5G technology; innovation strategy; design strategy



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## 1. Introduction

With the breakthroughs in mobile communication technologies, the fifth generation of mobile communication technologies has become one of the most exciting and challenging topics in the research field today [1]. The limitations of 4G technology indicate that the arrival of 5G is an inevitable trend, and 5G technology will further optimize the Internet of Things [1]. According to Cisco, by 2030, 5G applications will bring about USD 1.3 trillion of growth in global GDP, and more than 500 billion devices will be connected to the Internet. These devices will be embedded with IoT modules, and IoT applications will be deployed in all areas, including smart cities [2,3], smart transportation [4], smart agriculture [5], smart homes [6], etc. Maeng (2020) [7] argued that 5G mobile communication not only brings great convenience to people's daily lives, but also profoundly affects all aspects of social production, developing new markets and industries. Ericsson's Mobile Trends report shows that 94% of business respondents believe that next-generation mobile networks are critical to the strategic development of their business [8]. As the next generation of mobile technology, 5G will create value for a wide range of industries and society as a whole [1].

Mavromoustakis [9] stated that 5G mobile technologies will revolutionize end products, leading to a reorganization of the entire industry chain. Abbosh and Downes [10] stated that new 5G technologies will lead to the emergence of new disruptors, which will cause sudden disruptions for unprepared companies. Harold and Kamijima-Tsunoda [11] noted that China, Japan, the United States, and many other countries have made 5G technology development a national strategy and are currently leading in 5G research and deployment [1]. Many studies have also pointed out that the development of 5G mobile

technology is a global R&D program involving academia and industry [12–14]. Haizar [15] demonstrated that 5G technology has a direct impact on smart product development in the face of disruptive forces that drive digital change in the industry. Based on the above statements, it is evident that 5G technology is a key factor that cannot be ignored and is a reference for companies to generate sustainable revenue.

We are in an era of competition where consumers are tempted to choose new products every day, and high quality and a good customer experience have become important directions for the development of home appliances. How should we respond to the trend of 5G technology for home appliances? In recent years, the success of Xiaomi, Huawei, and Haier in smart manufacturing has verified that smart home appliances can be a driving force for companies' innovation [16]. Soldani and Illingworth [17] suggested that 5G technologies will accelerate the implementation of immersive experiences and help to enhance the user experience of products. For example, Xiaomi's product design has been widely recognized by users in more than 90 markets around the world for its commitment to providing consumers with an excellent experience through technological innovation. For the home appliance industry, the revenue momentum of traditional products has slowed down, but the market for smart products has just begun [18]. Fifth-generation technology will drive the global economy and the development of the industrial chain [19], and the impact of 5G on the innovation of home appliances in China will be enormous. In other words, in order to succeed in the market today, home appliance companies must have consumers engage with the smart service experience of home appliance products [20]. If companies do not actively engage in product innovation activities, they will eventually be eliminated from the market because their products will not be in line with the trend [21]. Therefore, in order to maintain a competitive advantage, the R&D departments and product designers of these companies must continuously respond to the challenges of the changing market environment [22,23].

From the above studies, we see that 5G technology is an important reference for product innovation and differentiation, and a hot topic in industry and academia. Although there have been many studies on 5G technology, most of them focus on the integration of the work environment, communication facilities, medical education, etc. Lee and Yoo [24] argued that the competitiveness of enterprises depends on their ability to utilize technological resources or differences in response to changes, as well as the scale of resources and technologies they possess. In a study of home appliances, Hsu [23] found that there is a relevant design strategy for home appliance manufacturers to design and innovate their products in response to technological changes. Most previous innovation studies were conducted from management and economics perspectives, while the correlation between product innovation and design strategy and the operation mode of home appliance products has rarely been investigated. Therefore, this study uses 5G technology as a design strategy to create market differentiation and enhance the core competitiveness of enterprises, and explores the operation mode and relevance of the innovation and design strategies of the Chinese home appliance industry in response to 5G technology. With this in mind, the main objectives of the study are as follows:

- (1) To explore the innovation and design strategy models of Chinese home appliance companies in response to 5G technology in order to understand their design implementation behaviors and practices;
- (2) To analyze the correlation between product innovation strategies and design strategies of Chinese home appliance companies in response to 5G technology, in order to summarize the differences in product development types, product design demands, and priorities;
- (3) The relationship between 5G innovation strategy and design strategy will provide a reference for global home appliance companies to build a design model for product innovation in response to the 5G technology trend.

## 2. Literature Review

### 2.1. Design Strategy

Product design strategy refers to the way in which a company conducts new product design [25–27]. Crawford [28] stated that design strategy refers to how to design new products under the guiding principles of the overall corporate strategy. Olson [29] considered that design strategy is an effective way to allocate and coordinate design resources to accomplish a company's goals. Therefore, Oakley [30] stated that “design strategy and corporate strategy are interdependent” [31]. Furthermore, Porter [32] cited three basic strategies in competitive strategy to describe the objectives of design strategy, including design for cost reduction, design for corporate image, and design for specific markets. It can be seen that design strategy has a crucial impact on the competitiveness of a company, and it can help companies to effectively establish communication channels between partners up and down the value chain [33–36].

Design is a major driver of innovation in the manufacturing and service industries [37–39]. Design strategy is the key to brand differentiation [40], and over the years, the strategic significance of design has been noticed and acted upon. In addition, Johnson & Johnson, PepsiCo, and Philips have acquired user experience consulting firms [41]. Therefore, design strategy is crucial [37,42], and Micheli [41] argued that companies can benefit from design strategy in terms of brand building, innovation, and differentiation. For example, Xiaomi Group has been selected three times for BCG's Top 50 list of the world's most innovative companies for its design innovation [43]. Oakley's study identified four different types of strategies in practice: absence strategy, misguided strategy, reactive strategy, and proactive strategy. Mozota [31] considered that design strategies can be classified into four types: enhancing R&D capabilities, reducing production costs, ensuring product quality, and enhancing corporate image. In addition, Kelley [44] studied product success stories and proposed a “strategic palette” in which 12 strategic factors make up the design strategy. Teng [45] argued that design strategy originates from the formation of organizational design activities within the enterprise. By integrating Kelley's design strategy factors, Teng identified 10 strategic attributes and defined design strategy as a series of product design strategy attributes related to decision making to achieve product design innovation goals and provide a firm with the unique design competitive advantage it needs. Therefore, design strategy is a way to achieve product innovation goals, analyze customer needs and competitor influence, match the core competencies of the company's research and development, and execute tasks through a design team to achieve the company's performance goals [46].

In a cross-country comparative study of design strategy, the DIG (Design Innovation Group) found that the tested companies had long-, medium-, and short-term strategies and implemented strategies such as (1) cost reduction strategies, (2) new products, product improvement, and redesigned product strategies, (3) improved market-based strategies, and (4) information-gathering strategies to improve the production of new or redesigned products, etc. [47]. It is also emphasized that each company's strategy use is not a single type, but involves cross-over and repeated use of various strategies.

From the above study, it can be seen that design strategies have been applied in different industry sectors in response to technological changes, and design strategies can enhance companies' awareness of the complex market environment and help them innovate in the 5G technology trend, which can help strengthen their overall competitiveness. Therefore, this study will explore the product design strategy objectives adopted by Chinese home appliance manufacturers to understand how they are developing products to meet challenges in the highly competitive market.

### 2.2. Innovation Strategy

Innovation strategy refers to the creation of an innovative and creative environment in which a company can differentiate itself from its competitors by offering unique products or services to its customers [48]. A firm can use its resources and technologies in various

combinations to generate different innovation strategies to guide the firm's development and use of innovation in order to implement corporate strategies and improve performance [49–52]. Porter [53] defines innovation strategy as a way for firms to develop and use technology. When developing an innovation strategy, companies must take into account the industry conditions, the company's capabilities, and the underlying competitive strategy. Kuczmarski [54] also argues that companies need to create new market spaces to develop attractive new products, create and implement technologies through the use of knowledge, and incorporate innovative strategies such as the use of new management methods and systems of management, so that companies can consider innovation as a new way of thinking about the operation of corporate strategies. Borowski [55] suggests that innovation strategies can help to encourage, motivate, stimulate, and achieve technological or service progress. Many studies have also shown that innovation strategies help firms to differentiate themselves from their competitors by offering unique products or services to their customers [46,56]. Therefore, scholars generally believe that innovation strategies help firms to pursue superior performance with higher brand equity, gain better partners, and attract highly skilled personnel by setting more ambitious goals [57,58]. Thus, it can be seen that, through innovation strategy, companies focus on developing and launching innovative products or services that can lead the market, and thus the firms can lead the market [59–63]. Therefore, innovation strategy has been widely recognized as one of the effective competitive strategies for firms to pursue superior performance [58,64,65].

According to Hsu [46], this study classifies innovation strategies into three categories: (1) technological innovation strategies, including the ratio of R&D expenses to total revenue, which is higher than that of other industries [66]; active investment in the application of trademarks, publications, and patents [67]; frequent introduction of new technologies to improve products or processes; and continuous improvement of production process efficiency to achieve corporate goals. (2) Business model innovation strategy, which is characterized by: enterprises proposing new products or services; improving or updating existing products, extending existing products or new product lines; and changing the sales targets and re-segregating the target customer groups. (3) Management innovation strategy, the characteristics of which include: the enterprise, at any time, in response to changes in the external environment, taking appropriate strategies to respond to, build, and manage distribution channels; engaging in timely and effective communication to resolve customer complaints; actively implementing new management methods to improve organizational performance; adopting a salary or welfare system to encourage staff innovation; and using performance measurement to motivate R&D staff innovation.

Product innovation requires the cooperation of all strategic levels of the company to implement the overall corporate strategy. The company will combine the objectives set by the innovation strategy with the actual product design work, integrate the innovation resources of the company, and complete the new product through cross-organizational communication and coordination.

### 2.3. Application of 5G Technology

Fifth-generation mobile communication technology (5G) is a wireless mobile communication technology being developed after 4G to meet the rapid spread of smart terminals and the high-speed development of mobile Internet, and is a wireless mobile communication system designed to meet the needs of the information society in the coming years [68]. At the 23rd ITU-RWP5D meeting held by the International Telecommunication Union, the ITU identified three main application scenarios for future 5G: enhanced mobile broadband communication, high and low reliability and low-latency communication, and large-scale machine-like communication. Sarraf [69] concluded that 5G applications will revolutionize the way of life of human beings and have disruptive effects on the fields of work, education, and healthcare. Sarraf also argued that R&D must be reviewed to take into account global economic forecasts in the post-epidemic era to leverage the value of 5G technology and eliminate resistance [70].

As the Industry 4.0 era advances, the home appliance industry is leveraging technologies such as the Internet of Things and big data to collect increased data from users and smart devices. Aheleroff, Xu [71] pointed out that the home appliance industry is one of the pioneers in the use of cutting-edge technologies including the Internet of Things and 5G communication. According to Yang and Liang [72], real-time monitoring of smart cities in the 5G era will no longer be just a buzzword but will address the challenges of demographic processes and promote urbanization [73]. Since 2009, China has become the second most R&D-intensive country in the world [74], in the sense that it is moving away from other emerging economies and approaching advanced industrialized economies known for their innovative capabilities [75]. Smart home appliance systems can optimize functionality and reduce costs while maintaining consumer satisfaction [71]. In addition, users can manage smart home appliances by voice commands.

In summary, design strategy can provide an effective way to achieve product innovation in enterprises. Through design strategies, companies can achieve cost control in product development and play an innovative and integrated role in defining customer needs and differences among competitors through the planning of product design strategies [76]. Chinese home appliances have modern product forms, innovative features, and excellent quality, and have launched many well-recognized products and brands on the global market [77,78]. Gudem and Steinert [26,79] discuss the influence of product design strategy factors. Design teams can utilize the core competencies of the firm to execute design strategies by analyzing customer needs and competitor influences in order to achieve the performance goals of the firm. Therefore, this study adopts the design strategy perspective proposed by Hsu [46,79] to investigate the most appropriate design strategy for Chinese home appliance companies in response to the 5G technology trend. It is important to understand how companies can use their current strengths and resources to respond to the challenges caused by 5G technology by adopting different product design strategies.

### 3. Methodology

According to the direction and characteristics of this study, the research method was mainly questionnaires and case study interviews. The survey was conducted to understand the application of 5G development strategies in the home appliance industry in China. The survey results were analyzed and in-depth interviews were conducted to further explore the application of design strategies and the actual content, and to collect relevant case data to understand the innovation strategies and design strategies in the home appliance industry in China.

#### 3.1. Stage 1

The purpose of the questionnaire was to understand the product development strategies adopted by the Chinese home appliance industry in response to 5G technology, in order to determine how to implement product development strategies in response to global competition. This study used the design-oriented innovation strategy model framework proposed by Hsu (2017) as the questionnaire design for this survey [46]. The product development strategy questionnaire for this study was developed using a seven-point Likert scale, with 1 representing strongly disagree and 7 representing strongly agree, for a total of seven attitude scales. The survey was conducted between August 2020 and February 2022, using a sample of 2000 product development departments from a database of companies in the household appliance industry in China. The survey was conducted in three dimensions: technology innovation, product innovation, and management innovation. Hefei Industrial Design Association and Yangtze River Delta Industry Alliance were commissioned to send the survey by WeChat and Email, and 620 questionnaires were collected (31% of all questionnaires distributed). The study analyzed the application of existing innovation strategies for home appliances through SPSS and extracted four components using factor analysis: market mastery, aggressive innovation, corporate technology innovation, and opportunity innovation.



### 3.2. Stage 2

The interviewees were selected from the three clusters summarized by the cluster analysis. First, industry experts were invited to discuss and analyze the enterprises in their clusters, and nine typical enterprises were selected by the experts according to their size and business type in the three clusters for further interviews according to the nature of the enterprises and the performance effect of their products in the market. Based on the size of enterprises in the Chinese home appliance industry, enterprises with capital over 200 billion yuan were categorized as large enterprises, those with capital between 50 billion and 200 billion yuan were categorized as medium-sized enterprises, and those with capital below 50 billion yuan were categorized as small enterprises. As shown in Tables 1 and 2, the main targets were selected randomly from the group of companies with high willingness to cooperate with the interview, and after confirming the willingness and degree of cooperation of each company through telephone interviews, a total of nine companies with actual products to be launched in 2021 were selected to participate in in-depth case interviews on their design innovation strategies in response to 5G technology, targeting industrial designers and R&D design department heads. The interviewees, their titles, and the time and location of the interviews were as follows.

**Table 1.** Information of the interviewed companies.

Date	Firm	Department	Title	Locations
2022/04/30	Midea	Lifestyle Design Department	Design Manager	Hefei
2022/03/15	Haier	Industrial Design Department	Design Director	Qingdao
2022/04/19	Gree	Industrial Design Department	Design Director	Zhuhai
2022/06/07	Xinbao	R&D Center	Design Manager	Foshan
2022/04/30	Xinfei	Technical Department	Product Manager	Xinxiang
2022/05/25	ECHOM	Industrial Design Department	Product Manager	Hefei
2022/06/23	BEAR	Product Design Department	Senior Designer	Foshan
2022/05/10	Huawei	Consumer Product Design Department	Intermediate Designer	Shenzhen
2021/05/23	Xiaomi	Industrial Design Department	Design Manager	Beijing

**Table 2.** Business type and size information of interviewed companies.

Project Information	Midea	Haier	Gree	Xinbao	Xinfei	ECHOM	BEAR	Huawei	Xiaomi
Year Established	1968	1984	1991	1995	1958	1997	2006	1987	2010
Business Form	OBM	OBM	OBM	ODM	ODM	ODM	OBM	OBM	OBM
Enterprise market value (billion)	3350	1908	1873	190	15	24	75	20,000	1973
Main product category	Ice Wash	•	•	•				•	•
	Kitchen Appliances	•					•		•
	Other	•	•	•	•	•	•	•	•
Staff	101,826	87,447	81,900	25,000	6000	5060	4013	195,000	33,427

Note: • represents the main product type of the enterprise.

**Survey questions:** Semi-structured questionnaires were used to prepare the questions to be discussed in the interview. The survey covered topics such as innovation strategies, impact on competitors' product design strategies, strengths and policies to deal with competition in the market, etc.

**Interview process:** Each company to be interviewed was called in advance to make an appointment and to ensure that the respondents clearly understood the purpose of the interview and provided the data needed for the study. The data recorded during the interviews and the notes taken were first converted into text and tables, and then analyzed and derived from the company's basic data, product design, and product development strategy.

#### 4. Analysis of Innovation Strategies of Home Appliance Companies

Through principal component analysis, four factor constructs were extracted from the 20 innovation strategy variables by scaling down and factor extraction, which cumulatively accounted for 69.54% of the total variance. These four factor constructs were sufficient to represent the original 20 variables. To simplify the factor constructs and clarify them, the Varimax orthogonal rotation method was chosen to explain these four factors, which had eigenvalues greater than 1. Table 3 presents the factor analysis of the existing innovation strategies of the home appliance companies.

**Table 3.** Factor analysis of existing innovation strategies of home appliance companies (spooled).

Factor Name	Factor Loadings			
	Factor 1	Factor 2	Factor 3	Factor 4
M1. Have a good intellectual property rights management system	0.790			
M2. Spending a higher percentage of total revenue on R&D than other companies in the same industry	0.787			
M20. Have a customer complaint handling program to effectively resolve customer complaints	0.763			
M4. Have enough key technologies and patents (5G)	0.680			
M12. The speed of commercializing new technologies is fast compared to the industry (5G)	0.678			
M9. Innovative 5G products or services introduced that meet customer needs better than competitors	0.675			
M18. Performance measurement system that can effectively measure the innovation results of R&D staff		0.762		
M17. Pay and reward system is adopted to motivate employees to innovate		0.748		
M5. Will try to improve manufacturing and R&D work procedures to accelerate the achievement of company goals		0.585		
M8. Will introduce new technologies to improve and upgrade products or processes (5G)		0.570		
M6. Flexible and fast production and delivery according to customers' temporary and urgent requests		0.556		
M3. Actively invest in trademark, copyright, and patent applications (5G)		0.554		
M7. The number of R&D staff employed has gradually increased in the past three years		0.539		
M15. Being a leader in the new product market			0.767	
M16. The new products or technologies introduced are often imitated by competitors			0.698	
M11. Can launch new products quickly (5G smart home appliances)			0.634	
M10. Has an original new product with a high degree of innovation (5G smart home appliances)			0.574	
M19. Will always respond to changes in the external environment and adopt appropriate innovation strategies to cope			0.530	
M13. Can expand the existing product line quickly				0.810
M14. The speed of improving and upgrading the quality of existing products is fast				0.610
Rotary axis squared load capacity				
Eigenvalue	4.813	3.982	3.429	1.684
Percentage of variance explained	24.06	19.90	17.14	8.42
Cumulative variation percentage	24.06	43.97	61.12	69.54
Cronbach's $\alpha$	0.932	0.904	0.918	0.796

#### 4.1. Strategy Component 1: Mastering Technical Response

From the characteristics of the variables in Figure 1, we can see that this structure contains six factors, including M1, M2, M20, M4, M12, and M9, among which M20 and M12 are management innovation and product innovation variables, respectively, while the other three factors are technological innovation variables. According to the above literature, the variables are characterized by strategic adjustment of business practices in response to environmental changes, attempts to use critical technology research and development, and the use of technologies that do not yet exist in the industry to develop original new products, provide new technology products to new markets, and protect their research and development results by patenting new technologies. Innovative activities among operating members affect the technical systems of their organizations, the equipment and methods of converting materials into finished products or services, including the adoption of new concepts in new products or services, and the introduction of new elements in the organization's production processes and operations. In summary, this structure is focused on the development of new technologies and provides good management of the technical resources. The focus is on the new technology level, so the name of the factor is "mastering technology response."

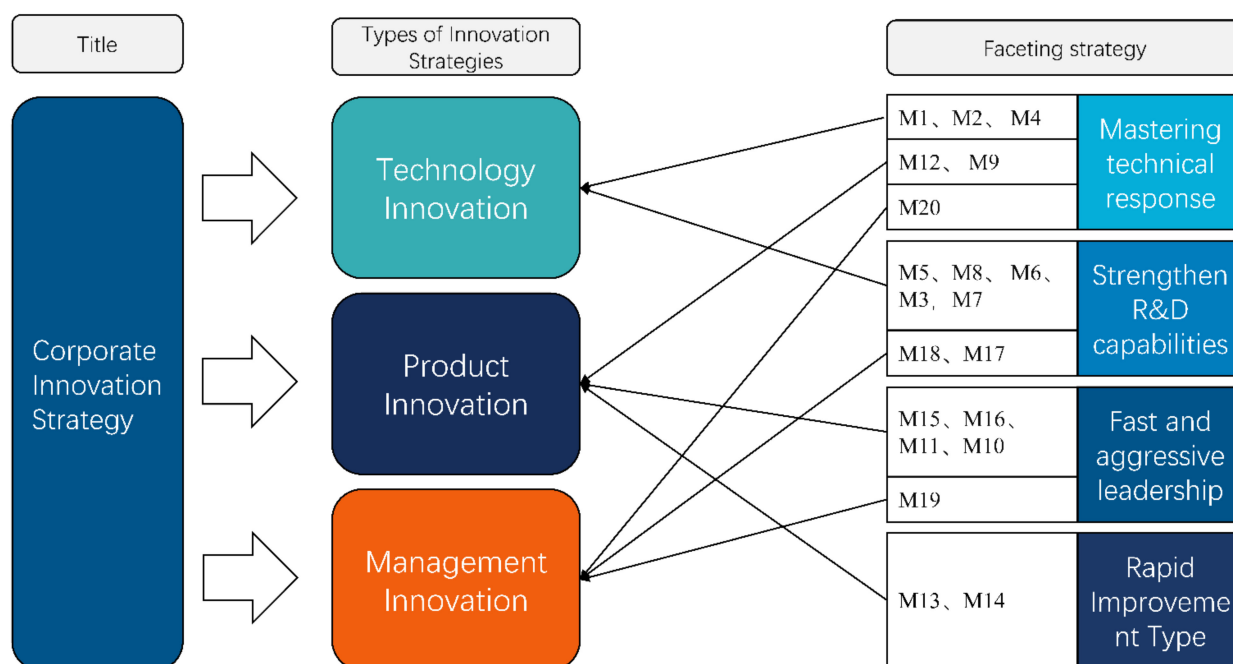


Figure 1. Corporate innovation strategy profile.

#### 4.2. Strategy Component 2: Strengthening R&D Capabilities

From Figure 1, we see that this dimensional variable contains seven factors, M18, M17, M5, M8, M6, M3, and M7, among which technical innovation is the most measured variable, followed by management innovation. This variable is characterized by the use of its resources to establish a new system relative to the company itself and to cultivate the organization's innovation capability. This innovation activity is able to quickly meet the needs of customers according to the flexible demand and will affect the company's future competitive advantage. Companies will try to introduce new technologies to improve and upgrade their products or research and development processes to achieve their corporate goals. New technologies are patented to protect their R&D results. Through management, the company will influence the innovation activities among members, including norms, roles, procedures, and the structure of communication among members. This includes the introduction of new management systems, management processes, and the development of colleague capabilities; all this does not directly provide new products, but indirectly



influences the introduction of new products. In summary, this structure indirectly influences the future innovation of the company from the perspective of personnel management, while focusing on the research and development of new technologies and applying for the protection of the technical resources, which are focused on the new technology level; therefore, Factor 2 is “strengthening R&D capability”.

#### 4.3. Strategy Component 3: Fast and Aggressive Leadership

From Figure 1, we see that this dimension contains five factors, M15, M16, M11, M10, and M19, among which the measurement variable of product innovation is the most common. According to the previous literature, this variable is characterized by the design approach to interpret hidden innovations, discovering the product innovation through the user’s behavior, and attempting to become a leader in the field. The company is able to launch new products quickly at the early stage of product development, and places great emphasis on product development and technology leadership; in order to maintain the flexibility of innovation, few economies of scale exist, and the business risk is high. It will adjust its innovation strategy in time due to external key changes. From the above, it can be found that this sector is mainly for companies that want to improve their business performance in a short period of time, create new products with new technologies, develop new products for new markets, or create new products that are different from existing products by combining existing technologies through design techniques. The abovementioned substructures are all aimed at improving business performance and creating new products in a short period of time, so Factor 3 is named “fast and aggressive leadership”.

#### 4.4. Strategy Component 4: Rapid Improvement Type

From Figure 1, we see that this profile includes two factors that enable companies to expand existing product lines quickly (M13) and improve existing products and improve quality quickly (M14). Both are product innovation variables. According to the previous literature, it is found that the variables are characterized by strategic adjustment of business practices in response to environmental changes and process innovation, which means that the business faces lower risk and has the characteristics of incremental innovation, followership, and imitation. Therefore, we named Factor 4 “rapid improvement”.

#### 4.5. Features of the Product Design Strategy Group of Home Appliance Companies

This study employed a two-stage cluster analysis. Using the factor scores of each strategy group, these firms were first classified using Ward’s method, excluding some clusters that contained only one observation. In the second stage, three clusters were selected from the 620 sample data points, in which the K-means method of nonstratified cluster analysis was used. In addition, the samples were reallocated to the nearest seed points based on the Euclidean distance of the three groups obtained in the first stage, and finally three innovative strategy groups were realized.

In order to further understand whether the four common factors in China’s home appliance manufacturing industry have different orientations or perceptions, we conducted a cluster analysis of the factor scores of the four common components of the surveyed home appliance manufacturing enterprises to examine whether several homogeneous groups could be identified and to investigate the characteristics of the members and strategic behaviors of the home appliance companies in each group. The analysis method used was Ward’s method of hierarchical cluster analysis, in which the percentage increase in the cohesive coefficient was used to determine the optimal number of clusters, which was three.

Among the surveyed home appliance manufacturing companies, 270 (43.5%) were in Strategy Group 1, 140 (22.5%) were in Strategy Group 2, and 210 (33.8%) were in Strategy Group 3. The three strategy groups were analyzed and identified based on the average scores of each factor for each strategy group (see Table 4). No significant differences were found between the companies in the same strategy group in terms of number of employees, number of brands, type of products, and type of business. In order to understand how each

group differs in terms of each factor component or the distinctive characteristics of each group, and to give each group an appropriate name, this study used the strategy groups as independent variables and the four common factor components as dependent variables. One-way ANOVA was conducted, and the results show that the Wilks' Lambda statistic reached a significant level of 0.01. The results show that the three groups had significant differences in the four common factor components, and then, based on the average scores of each group on each factor component, the factor components that were particularly important to each group were identified, as shown in Table 5.

**Table 4.** Percentage of innovation strategy groups for home appliance companies.

	Group 1	Group 2	Group 3	Total
Company sample size	270	140	210	620
Percentage of ownership (%)	43.5%	22.5%	33.8%	100%

**Table 5.** The results of ANOVA of strategic groups in product development performance criteria.

Factor Dimensions	Average Factor Score in Each Factor			F	p-Value
	Strategic Group 1	Strategic Group 2	Strategic Group 3		
Factor 1: Mastering technical response	0.4780 (0.5963)	−0.7060 (0.6163)	−0.2715 (10.1239)	24.097	0.000 **
Factor 2: Strengthening R&D capabilities	−0.5291 (0.5209)	−0.5771 (0.4075)	10.0539 (0.5334)	42.764	0.000 **
Factor 3: Fast and aggressive lead	0.4016 (0.6792)	−1.0859 (0.5814)	0.2394 (0.7944)	53.974	0.000 **
Factor 4: Rapid improvement type	−0.0338 (0.8271)	−0.2114 (1.1644)	0.2482 (0.6107)	9.252	0.000 **

Notes: \*\* indicates that the *p*-value is less than the 0.01 significance level. The numbers in parentheses represent the ranking of each group on each variable.

From the analysis of the previous literature, we can see that, although some studies consider design or design strategy as an integrated resource, a mechanism for product integration, and a key link in the overall innovation value chain of a company, these papers are mostly case studies or individual conceptual expositions, lacking theoretical integration and no further empirical evidence on the relationship between these design-related variables.

From the perspective of product design strategy, the measures taken by the appliance manufacturing industry in mainland China in response to the changing market environment of the 5G technology trend can be simplified into four factors: mastering technology response, strengthening R&D capability, fast and aggressive leadership, and fast improvement. In addition, using cluster analysis, China's home appliance manufacturers can be divided into three strategic groups: strengthening R&D, seeking opportunities, and responding quickly.

## 5. Analysis and Discussion

### 5.1. The Relationship between Innovation Strategy and Product Design Strategy

Through the cross-analysis of the innovation strategy and design strategy of the group, it was found that the case company with the strengthening R&D strategy as the main strategy type was mainly OBM in its business form, and its products were mainly large household appliances, followed by kitchen appliances. In the overall design strategy, the company's approach to technology research and development, the introduction of new technologies, and the development of unique product features are emphasized, and because of its own brand, the company attaches great importance to the market and brand image, so the innovation strategy is market leading.

The main strategic type of the ODM-based company is the opportunity seeking strategy, with a wide range of products, including small home appliances and kitchen appliances. The overall design strategy emphasizes the change from "cost-driven" to

“value-driven,” emphasizing product function and manufacturing technology, and the low-cost, high-quality business positioning of the company; it also places great emphasis on customer value management. Therefore, the innovation strategy belongs to the type group of rapid flexibility, which is named active improvement.

The case company with the rapid response strategy as the main strategy type, in terms of business form, is mainly OBM; the types of products developed are more focused, mainly smart products and consumer electronics, and its 20 design strategies together adopt a total of 15 practices, mainly to respond to the concentration of superior resources, to provide high-performance products with strong functional integration, and to pay attention to user experience. The overall design strategy is based on the ecological chain to reduce the production cost of products and achieve 5G intelligent technology, the strengthening of technical cooperation, the development of unique intelligent products, and the enhancement of corporate brands.

### 5.2. The Relationship between Design Strategy Groups and Product Design Focus

From the aggregation of case design strategy groups in Figure 2, we see that the product innovation tendency of home appliance companies includes strengthening R&D, seeking opportunities, and rapid response, all accounting for nine points each. Its product innovation tendency is enhanced R&D, and corresponding to its design strategy group of technology R&D, its product development type is based on the new product platform S1. The product design demand is mainly intelligent, with functionality as the main design focus; presumably, the approach mainly involves applying existing technology to provide the best deployment and simplify external costs, enhancing the quality of product functions with intelligence to meet the mass market.

Strategy Groups	Code	Product innovation tendency			Product Development Type				Product Design Request				Product Design Focus		
		M1	M2	M3	S0	S1	S2	S3	P1	P2	P3	P4	D1	D2	D3
Technology R&D	A11	●				●			●				●		
	A12	●				●						●	●		
	A13	●				●								●	
	A21	●			●						●		●		
	A22	●				●					●		●		
	A23	●			●					●			●		
	A31	●				●			●						●
	A32	●				●				●			●		
	A33	●					●			●				●	
Aggressive improvement	B22		●					●				●			●
	B33		●			●			●				●		
	B12		●					●	●						●
	B32		●					●		●					●
	B31		●					●	●				●		
	B11		●					●				●			●
	B13		●				●				●		●		
	B21		●				●		●				●		
	B23		●				●			●				●	
Technology intensive	C12			●	●				●					●	
	C23			●		●				●				●	
	C32			●	●					●			●		
	C22			●	●					●			●		
	C13			●		●					●			●	
	C21			●			●				●			●	
	C11			●	●						●			●	
	C31			●		●					●			●	
	C33			●	●					●				●	

Note: ● means classified as the item  
 Product innovation tendency: strengthen R&D (M1), seek opportunities (M2), respond quickly (M3)  
 Product development type: new product (S0), new product platform (S1), existing product derivative (S2), existing product improvement (S3)  
 Product design requirements: simplicity (P1), intelligence (P2), user experience (P3), emphasis on special features (P4)  
 Product design focus: function (D1), interaction (D2), appearance (D3)

**Figure 2.** Relationship between design strategy groups and product innovation tendencies, product development types, product design aspirations, and product design priorities.

In cases where product innovation tends to involve active improvement, and the corresponding design strategy group is looking for opportunities, product development is mainly based on the improvement of existing products and the derivation of existing products, and product design demands are mainly simple, with function and appearance being the most important to product design. It is presumed that the approach involves redesigning the appearance or enhancing the function of the existing product structure in order to enhance the user experience, stimulate the market, and maintain the competitiveness of the product line.

In the case of the product innovation tendency of technology leadership, the design strategy is to respond quickly, and the product development type is mainly new products (S0), so its product design demands a high realization rate based on user experience. The main focus of the product design is on functionality and interaction, and it is assumed that the approach involves developing new smart home appliances through a new product platform to achieve a high-quality user experience and open up new market segments.

### 5.3. Relevance of Innovation Strategy and Design Strategy

1. The innovation strategy entitled “strengthening R&D” has its main focus on mastering key technology. Its characteristics include focusing on market share and brand image, the business type is mainly OBM companies, and the design strategy approach shows a diversified and positive attitude, being willing to try all kinds of innovation. Of 20 design strategy items, there are a total of 17 which share the same approach regarding the four factors. This design strategy trend is named “technology development”.
2. The innovation strategy entitled “seeking opportunities” is mainly focused on technology research and development and strengthening product innovation. Its characteristics include comprehensive innovation, whether internal technology innovation, product innovation, system management innovation, or innovation in response to external reactions, etc., the business type is mainly ODM companies, and the design strategy approach involves reducing the production cost of products and making them easy to manufacture. In terms of design strategy, we place the most emphasis on reducing product production costs, improving the ease of manufacturing, and implementing maintenance. Ten out of the twenty design strategy items share the same approach in terms of the four factors, and we named this design strategy trend “active improvement”.
3. The innovation strategy entitled “rapid response” attaches great importance to product research and development and technology leadership, is characterized by active breakthroughs and flexible responses to the market, and mainly involves OBM companies in terms of business type. Fifteen out of the twenty design strategy items share the same approach, and this design strategy trend is named “technology leadership”.

### 5.4. Design Strategy Groups and the Application of Design Strategies

For the strengthening R&D design strategy group, seventeen out of twenty design strategies were adopted, and the design strategies used were C1, C2, C3, C4, C6, C7, C8, C9, etc. This shows that the market leader tends to be diversified and active in its design strategies, is brave enough to try innovative and smart products, and attaches great importance to brand positioning.

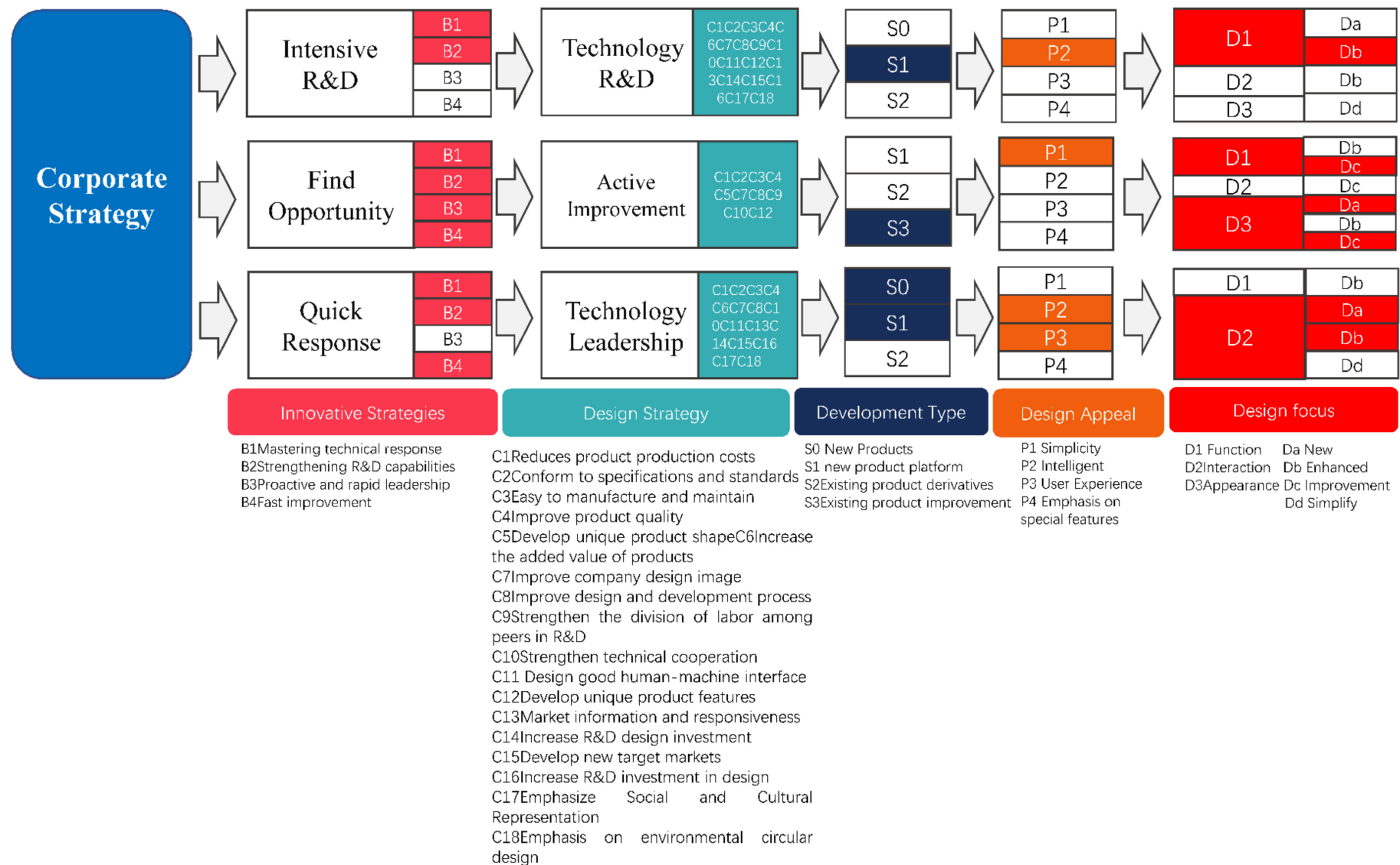
For the aggressive improvement design strategy group, 10 out of 20 design strategies are adopted, such as C1, C2, C3, C4, C6, C7, C8, C9, C10, etc. This shows that aggressive improvement tends to place the most emphasis on reducing product production costs, ease of manufacturing, and maintenance in design strategy.

For the technology-intensive design strategy group, 15 of the 20 design strategies are adopted: C1, C2, C3, C4, C6, C7, C8, C10, C11, C13, etc. This shows that the technology concentration in the design strategy tends to focus on technology research and development, and it emphasizes product function and smart manufacturing technology.

## 6. Conclusions

The purpose of this study was to investigate the innovation strategy and design strategy model of Chinese home appliance companies in response to 5G technology, further analyze the relevance of the product innovation strategy and design strategy of Chinese home appliance companies in response to 5G technology, and determine the relationship between generalized 5G innovation strategy and design strategy. As shown in Figure 3, we found that when the product innovation group is strengthening R&D, the design strategy tends to be technology R&D, the type of product development is mostly in the form of a new product platform, the design demands are mainly developed in the form of user experience, and the product design focuses on simplifying functions. When the product innovation group is seeking opportunities, the design strategy tends to be active improvement, the product development type is mainly improvement of existing products, the design demands involve simplicity and an emphasis on special functions, and the product design focuses on strengthening function and new appearance. When the product innovation group is rapid flexibility, the design strategy tends to be technology leading, the product development type is mainly new products and a new product platform, and the design demands are enhancing user experience. The main development is to enhance user experience, and so the product design focuses on strengthening function and new, optimized interaction. In the highly competitive global market for home appliances, only companies with the ability to innovate and react quickly and flexibly can leverage new technologies to gain a new market share. Therefore, when an industry is facing similar technological changes, this study on the innovation and design strategies of Chinese home appliance companies in response to 5G technology can provide a reference for global companies to develop innovation and design strategy plans.





**Figure 3.** Innovative design models for home appliance companies.

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