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Research on a Competitive Strategy for Innovative Design in China

The Research Group of the *Innovation Design Competitiveness*

Abstract: Based on China's strategic transformation from a manufacturing country into a creative country, this paper outlines the characteristics, trends, and value of Design 3.0 in the era of the knowledge network. It further discusses the factors and implications of competitiveness in innovative design. On the basis of the three indices of design benefit, design capability, and design environment, the authors construct a three-in-one evaluation system for design competitiveness that comprises national-, urban-, and enterprise-based competitiveness in innovative design. This study divides various countries, cities, and enterprises into data samples and carries out a pilot evaluation. The authors then summarize policy recommendations and specific measures to enhance China's innovative design competitiveness.

Keywords: Design 3.0; innovative design; design competitiveness

1 Introduction

In August 2013, the Chinese Academy of Engineering commenced a major consulting project, the *Innovative Design Development Strategy Research*, which was jointly undertaken by the Chinese Academy of Engineering and the Chinese Mechanical Engineering Society. This project brought together more than 20 academicians and 100 experts from higher education institutions, research institutes, and key enterprises from across the country and organized them into project groups to conduct in-depth research on the definition and implications of innovative design, its value and role, related development trends, key generic technologies, and other topics. In February 2015, the report on the *Recommendations for the Vigorous Development of Innovative Design* served as an important achievement of the *Innovative Design Development Strategy Research* and attracted a high level of government attention as well as widespread public interest. An important measure for increasing the innovative capacity of China's manufacturing industry is "increasing innovative design capability," which was included in the "Made in China 2025" national strategic plan. The *Design Competitiveness Research* consulting project is an extension of *Innovative Design Development Strategy Research* and involves in-depth survey studies and empirical analysis at the national, urban, and enterprise levels [1,2].

The project advances the notion that, as an important measure of the level of innovative development, design capability has significantly increased China's overall competitiveness. The evaluation of innovative design competitiveness can assist in the objective analysis of design policies and the status of industrial innovative development in different countries, as well as the realization of an international comparative analysis. This not only carries theoretical significance for the improvement of national overall competitiveness but also plays a practical and guiding role in increasing urban and enterprise design competitiveness. Hence, on the basis of intensive and in-depth domestic and overseas investigations, the project groups supporting the *Innovative Design Competitiveness Research* refer to the existing index systems for competitiveness developed by other countries and examine the index systems of national-, urban-, and enterprise-based innovative design competitiveness. Based on the characteristics of these indices and the sampling differences, this

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study constructs a hierarchical index system of innovative design competitiveness and conducts a pilot evaluation.

2 Implications of innovative design competitiveness

Design refers to the prior conception, planning, and development of intentional creations and innovative activities. It transforms information, knowledge, technology, and creativity into the precursors of and preparations for products, processes, equipment, and operational services, determining the quality and value of manufacturing and services. Design has driven the advancement of civilizations. Having experienced the stage of traditional design during the agricultural era (the "Design 1.0" era) and the stage of modern design during the industrial era (the "Design 2.0" era), we are now advancing into a new stage of innovative design in the age of knowledge networks (the "Design 3.0" era) (Fig. 1). Innovative design is a comprehensive extension of design, covering areas that include industrial design, material design, product design, process design, engineering design, and service format design, among others. In the context of the knowledge network age, innovative design is primarily characterized by green and low-carbon features, network intelligence, openness and integration, co-creation, and sharing. It provides systematic services for complete product and industrial processes and integrates technological, product, and service innovation into a single entity. Innovative design is key to the transformation of scientific and technological achievements and the generation of new market demands. It is also crucial to driving enterprise transformation and upgrading, promoting changes in the modes of economic growth, leading new industrial revolutions, and elevating national core competitiveness [3–5].

National innovative design competitiveness has become a major index for evaluating a country's investment environment and economic competitiveness. As cities are important components of a country, improving urban innovative design competitiveness is an important measure for increasing national innovative design competitiveness. Furthermore, enterprises are the practitioners of innovative design, as well as the fundamental components of industrial and national competitiveness. By developing their innovative design capability, enterprises are able to gain advantages from external cultures, technologies, and enterprise resources, and comprehensively leverage them. These advantages are primarily reflected in the economic benefits, management strategies, and resource endowments of enterprises. Thus, research on innovative design competitiveness draws on national-, urban-, and enterprise-level R&D investment in innovative design, talent development, public services, and brand value as its input factors; these enable the comprehensive evaluation of the effectiveness of innovative design to enhance innovative capabilities and efficiency. Through empirical analyses of certain samples, this study constructs an effective and scientific evaluation index system for innovative design competitiveness.

3 Status quo of research on innovative design competitiveness

Innovative design competitiveness occupies a unique position and role in the national innovation systems. Since 2002, research institutes, including the Seoul Metropolitan Government, the International Council of Design, the Cambridge Institute for Manufacturing, the Hong Kong Design Centre, the University of Art and Design Helsinki, INSEAD, and the Science and Technology Policy Institute, selected several key competitiveness factors related to design; some of these input factors were R&D investment, talent development, public services, and brand value, as well as the output factors of scale of profits and level of

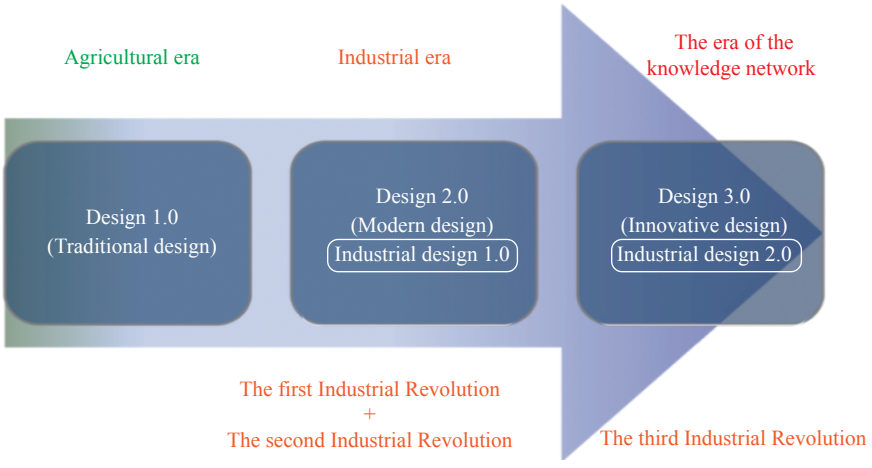

Fig. 1. Design evolution: traditional design – modern design – innovative design.

taxation. Using these factors, these institutes conducted design competitiveness evaluations at national and municipal levels (see Table 1) and published a number of reports including *Global Design Competitiveness Research Report*, *Survey on Global Design*, *International Design Scoreboard*, *Asian National Design Competitiveness Report*, *Seoul Design Survey*, and *Hong Kong Design Index*. These reports unanimously note that countries and regions such as the United States, Germany, and Sweden have developed manufacturing industries, diversified economic patterns, and are characterized by substantial innovative design competitiveness. In particular, the Global Design Competitiveness Ranking, published by Aalto University Design Innovation Center in Finland, ranked China as 35th in the world for design competitiveness, lower than China's overall global competitiveness ranking of 29th in the same year. In general, research on design competitiveness evaluation focuses on three aspects: the in-depth investigation of design systems and design policies, adequate consideration of the differences in development models and status quo as well as the frameworks of design systems among the samples, and the accessibility of data and scientificity of calculations.

4 Evaluation index system of innovative design competitiveness

4.1 Construction of the evaluation index system of innovative design competitiveness

The selection of competitiveness indices is the primary factor that determines the scientific strength of the evaluation system.

Table 1. Overview and comparative analysis of domestic and foreign research on design competitiveness.

Name	Publishing organization	Key factors	Characteristics	Shortcomings
Seoul Design Survey Index	Seoul Metropolitan Government	• Policy support for design • Environment of design culture/ education resources • Status of Seoul's design industry	• A large number of indices and broad coverage • Quantitative indices • Widespread and reliable data sources	• Relatively low operability and inapplicability to regional, national, and international research • Difficult-to-achieve indices of design policies
Asian Design Survey Index	International Council of Design and Seoul Metropolitan Government	• Comparison of the status quo of the design policy, design industry, design education, and design culture in different cities	• Simple indices, highly operable • Combination of quantitative evaluation of open data and qualitative analysis of descriptive indices	• Insensitive qualitative indices that fail to show the disparities among cities • Incomplete survey data
International Design Scoreboard	Cambridge Institute for Manufacturing	• Design policy environment in different countries • Investment in design education in different countries • Output and profits of the design industry in different countries	• Quantitative indices with highly accessible data and high operability • The use of absolute and relative indices for more reasonable comparisons among the countries	• Difficulty of obtaining data on national policy
Hong Kong Design Index	Hong Kong Design Centre	• Human resources in Hong Kong's design industry and relevant industrial investment • Industrial framework and market demand • Social culture and landscape of intellectual property rights	• Comprehensive and detailed index system • Indices designed to demonstrate and increase the social recognition of design	• Excessive index classification and overemphasis on details • Limited applicability of indices
Survey on Global Design	University of Art and Design Helsinki	• Design industry development and market scope • Corporate R&D investment and production process • Industry value chain and customer orientation	• Emphasis on comparisons of design industry competitiveness • Representation of the relationship between national competitiveness and design competitiveness	• Highly abstract indices and complex data processing
National Innovation Index	INSEAD	• Design organizations, institutions, and infrastructure in different countries • Design education and human capital of different countries • Market conditions and innovation outputs in different countries	• Wide coverage of indices for comprehensive measurement • Emphasis on national infrastructure and market conditions	• Low index operability; a great variety of data required
Innovation Assessment Index	Science and Technology Policy Institute	• National capital investment in innovation	• Combination of quantitative comparisons and qualitative analysis	• Overly subjective indices for qualitative analysis • Indices with abstract connotations

An innovative design competitiveness evaluation is a comprehensive measurement and analysis of the innovative design capabilities of countries, cities, and enterprises. The evaluation index system used in this study is a comprehensive and complex system which includes multiple interconnected evaluation indices with different emphases. Hence, this study adopts methods such as content analysis, cluster analysis, benchmarking, and factor analysis to extract the evaluation indices. Emphasis is placed on the content and composition of indices as well as the determination of factor categories. This allows the extraction of the key dimensions of an innovative design competitiveness evaluation, to demonstrate the values and characteristics of the Design 3.0 era, while also ensuring that the index system is standardized, comparable, operable, and provides targeted measures for resolving prominent issues in national innovation, regional development, and enterprise transformation.

The evaluation index system of innovative design competitiveness is divided into national, urban, and industrial (enterprise) levels. The index system at each level is established on an independent and comprehensive theoretical basis and research foundation, and follows a progressive process. Overall, the development of the index system involves stages which include a literature review, index pool establishment, expert interviews, and the construction, assessment, and rectification of the index system (Fig. 2). As nation-, urban-, and enterprise-based innovative design competitiveness differs in terms of definition, categories, and relationship with national competitiveness, the index systems for the three levels are established on the basis of a shared process and method while also exhibiting different characteristics. This study establishes a pool of design competitiveness indices based on the factors involved in existing evaluation systems, which are relatively comprehensive. In accordance with the overall principles of index establishment integrated with experts' guiding opinions, the first-class indices of design competitiveness are reselected and reorganized. This study confirms that the first-class indices of innovative design competitiveness are design benefits, design capability, and design strategy.

Design benefits are primarily represented by R&D achievements, new products, and new service models related to innovative design. Among these, R&D achievements entail indices such as the value added by knowledge-intensive industries as a percentage of the global total, major patent contributions, the number of world famous brands, the intensity of resource and energy consumption per unit value during the product life cycle, and market share. New product and service models include indices such as the percentage of the "Internet Plus" models in all business models, product quality, and user satisfaction. Design capability (potential) is primarily manifested as the level of design education, design-related R&D investment, and design technologies and tools. The level of design education includes indices such as the growth rate of design personnel and the number and quality of designers. Design-related R&D investment includes indices such as the input and growth rate of R&D funds, design investment, and the value added by the design service industry as a percentage of GDP. Design technologies and tools include indices such as digitalized design, the prevalence of

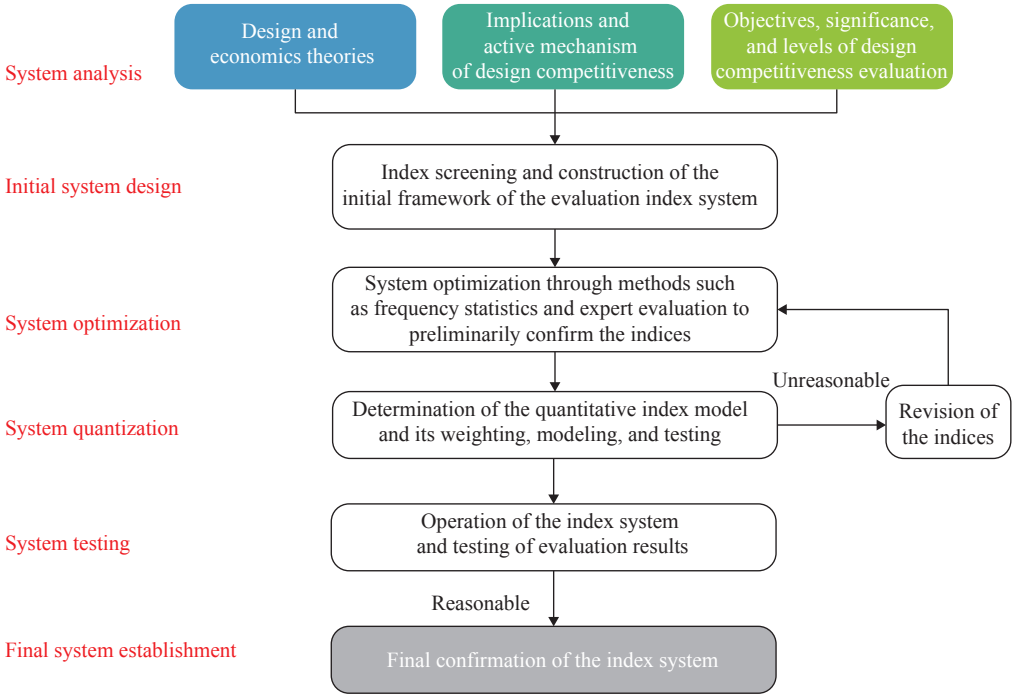

Fig. 2. Innovative design competitiveness assessment index system.

tools, the penetration rates of advanced technologies such as big data, and the numbers of incubators, laboratories, and technological innovation parks. The index of design strategy is primarily composed of policy support, which includes advanced national strategies, the rigor of protections for intellectual property rights, and policies supporting new products; and design culture, which includes industrial and product innovation culture.

4.2 Evaluation indices of national-, urban-, and enterprise-based design competitiveness

As national-, urban-, and enterprise-based innovative design competitiveness differs in terms of definitions and categories, the construction of the index systems at the three levels retains the commonality and coordination among the first-class indices, while taking into account the characteristics and differences in the second- and third-class indices. Figs. 3, 4, and 5 show the compositions of the innovative design competitiveness indices at the national, urban, and enterprise levels, respectively.

5 Evaluation of national-, urban-, and enterprise-level design competitiveness

5.1 Analysis of national innovative design competitiveness

With regard to national innovative design competitiveness, the contribution rate of innovative design towards the country's economic growth is on the rise, in accordance with technological advancements. According to the *Global Competitiveness Report* published by the World Economic Forum, the world's most competitive countries, Finland, Germany, Japan, the United States, and Switzerland, are also considering the improvement of their innovative design competitiveness as an important means of increasing their national competitiveness. In addition, each of these countries has established a strategic system for innovative design development and has upgraded it to the level of national strategy. In this study, G20 nations and Finland, Singapore, and Switzerland are selected as the samples for evaluation of national design competitiveness. Their rankings in terms of national design competitiveness are shown in Fig. 6. The overall rankings show the classification of countries based on their national innovative design competitiveness; the first group is composed of highly competitive nations. The United States is further ahead of other countries in the sample in terms of the advantages it possesses. Due to its well-developed and open market economic system and world-class scientific research institutes, talents, and resources, the United States also has the highest level of R&D investment and the highest innovation conversion rate in the world. The favorable domestic environment for development has also provided never-ending vitality for innovative design and guaranteed the country's leading position in innovative design competitiveness.

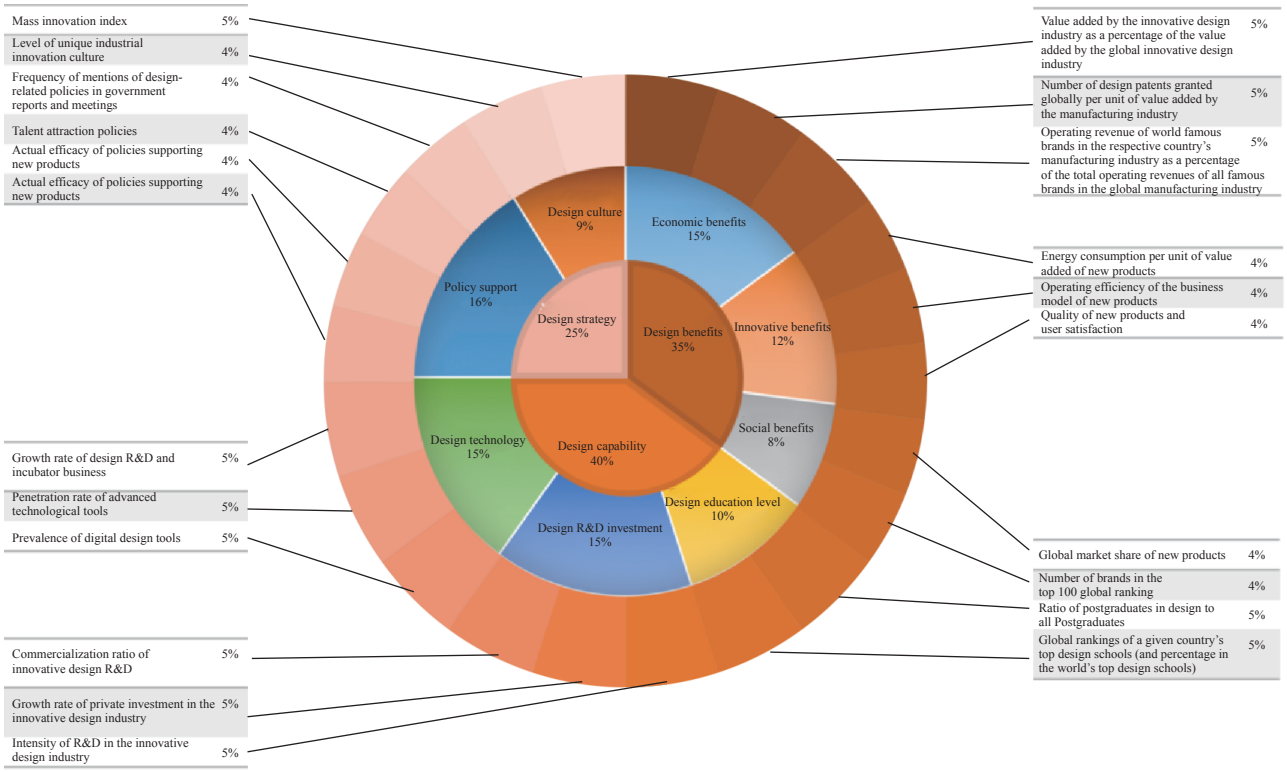

Fig. 3. Composition of national innovative design competitiveness.

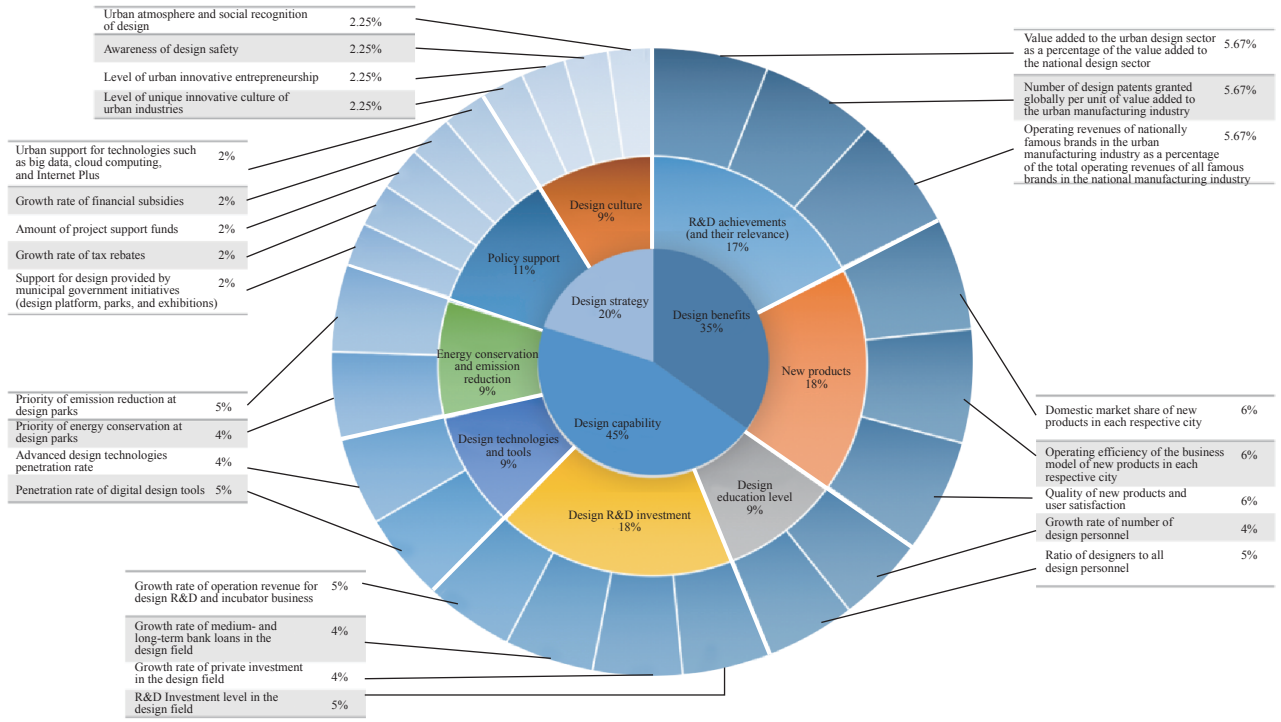

Fig. 4. Composition of urban innovative design competitiveness.

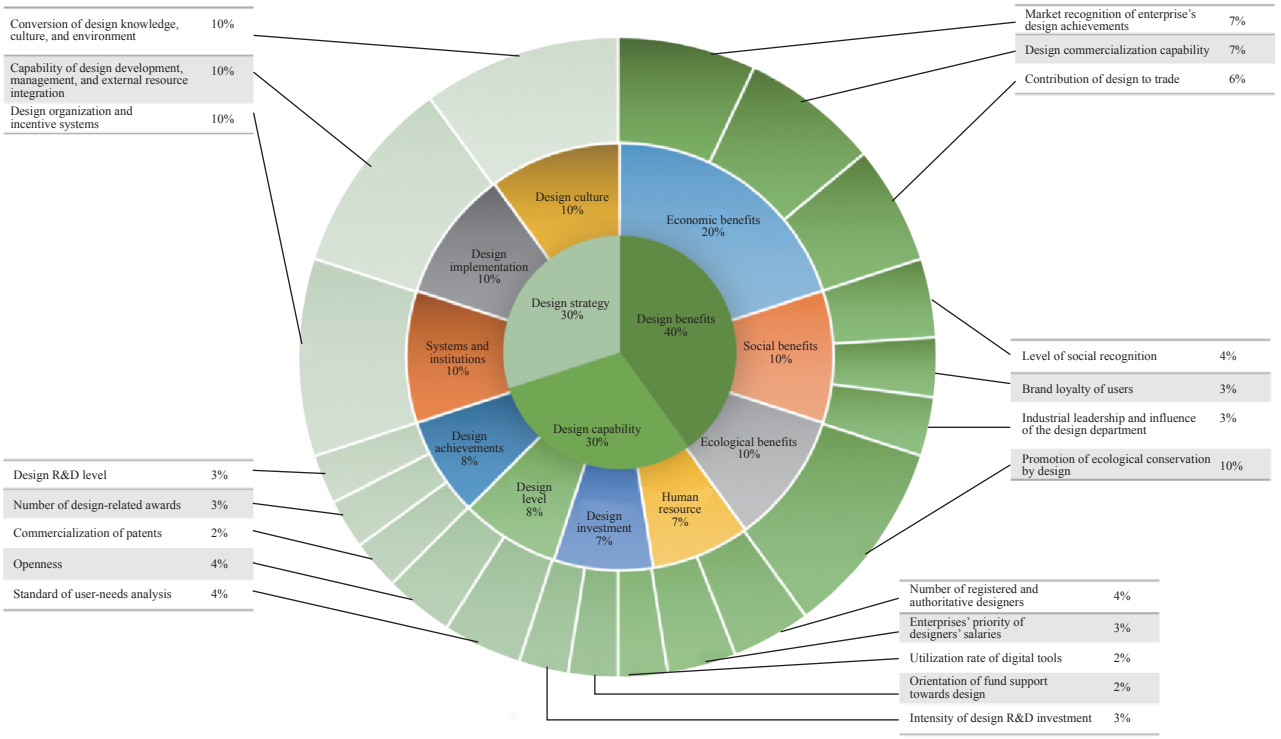

Fig. 5. Composition of enterprise innovative design competitiveness.

The evaluation scores of the innovative design competitiveness of Germany, Finland, and Japan are relatively high. While the current conditions and driving factors of innovative design development vary across these countries, they all belong to the second group. The third group is composed of Switzerland, the United Kingdom, France, Italy, South Korea, Singapore, Canada, and Australia, all of which perform well in terms of innovative design competitiveness. The fourth group consists of countries

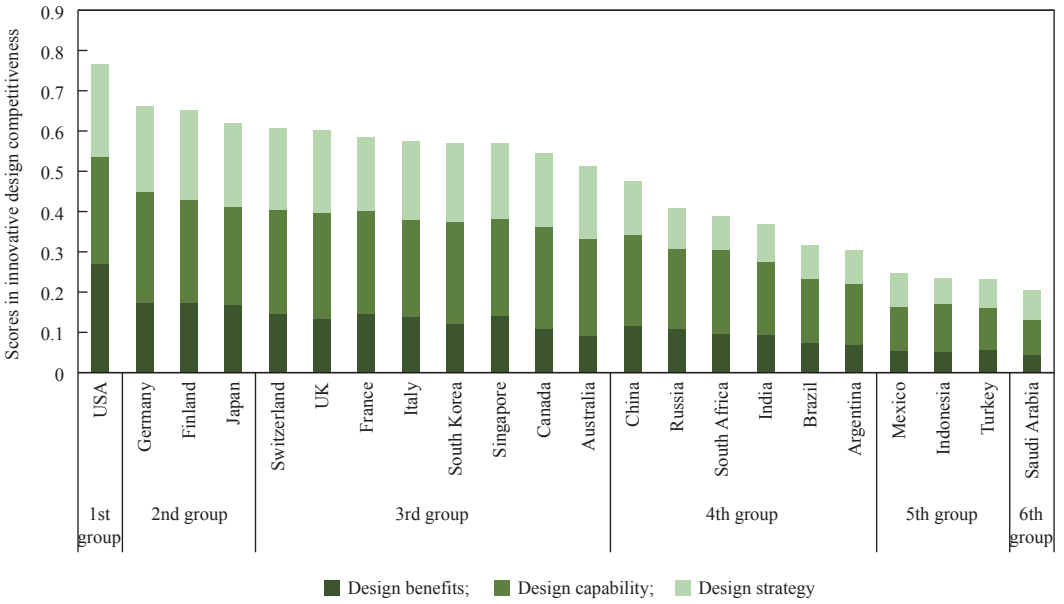

Fig. 6. Scores in national innovative design competitiveness.

with average innovative design competitiveness. These include China, Russia, South Africa, India, Brazil, and Argentina. This is followed by the fifth group, which is composed of countries with relatively low innovative design competitiveness, such as Mexico, Indonesia, and Turkey. The sixth group consists of countries with very low innovative design competitiveness, such as Saudi Arabia. With the exclusion of the European Union, countries ranking from the 1st to the 7th are in a highly advantageous position, those ranking from the 8th to the 14th are in a moderately advantageous position, and those ranking 15th and lower are in a disadvantageous position.

5.2 Analysis of urban innovative design competitiveness

Urban innovative design competitiveness is a new research topic that emerged in the era of constant urban expansion, continuous increases in productivity, and never-ending economic growth. A new wave of technological innovation poses immense challenges for further urban development, but it is also a rare opportunity. The sample cities selected in this study consist of 32 domestic cities which are represented by provincial capitals and directly-controlled municipalities, and major overseas cities, represented by the G20 nations.

The innovative design competitiveness of the 32 Chinese cities is analyzed based on the first-class indices of design benefits, design capability, and design strategy (Fig. 7). The results show that Hong Kong, Beijing, Guangzhou, Shanghai, Shenzhen, and Hangzhou are prominently driven by design benefits. Cities that are driven by innovative design capability include Shanghai, Hong Kong, Shenzhen, Guangzhou, Hangzhou, and Beijing. Those that are driven by innovative design strategy include Shenzhen, Shanghai, Guangzhou, Hangzhou, Beijing, Nanjing, Chongqing, Hefei, Chengdu, and Xi'an. A comprehensive assessment of the cities' performance in the three index systems reveals that Hong Kong, Shanghai, Shenzhen, and Guangzhou have excellent scores in all three of the first-class indices, and their development is prominently driven by integrative driving forces.

With regard to the scores in innovative design competitiveness of non-Chinese cities (Fig. 8), Berlin, London, Paris, Rome, Seoul, and Moscow have similar development modes and are more equally driven by design benefits, design capability, and design strategy. Mexico City and Ottawa are less driven by design strategy than the other two first-class indices, while New York, Tokyo, and Sydney are less driven by benefits than design capability and design strategy. Through cluster analysis, the 50 Chinese and non-Chinese cities in our sample are compared and classified into four categories. Cities such as Paris, Seoul, Shanghai, Shenzhen, Tokyo, New York, Beijing, and Hangzhou have similar development modes and are prominently driven by benefits, design capability, and design strategy. This indicates that they have the strongest performance in terms of the three first-class indices of innovative design competitiveness among all the categories; these cities are the design leaders. They are followed by two categories of cities which are propelled by different driving forces. The first category includes benefit-driven cities such as Mexico City, Jakarta, and Istanbul. The second category includes strategy-driven countries, represented by Kunming, Xi'an, Hefei, and Sydney. Lastly, the underdeveloped category includes cities with the weakest performance in all three of the first-class indices, represented by Rio de Janeiro, Mumbai, Shenyang, Nanchang, Lanzhou, and Harbin.

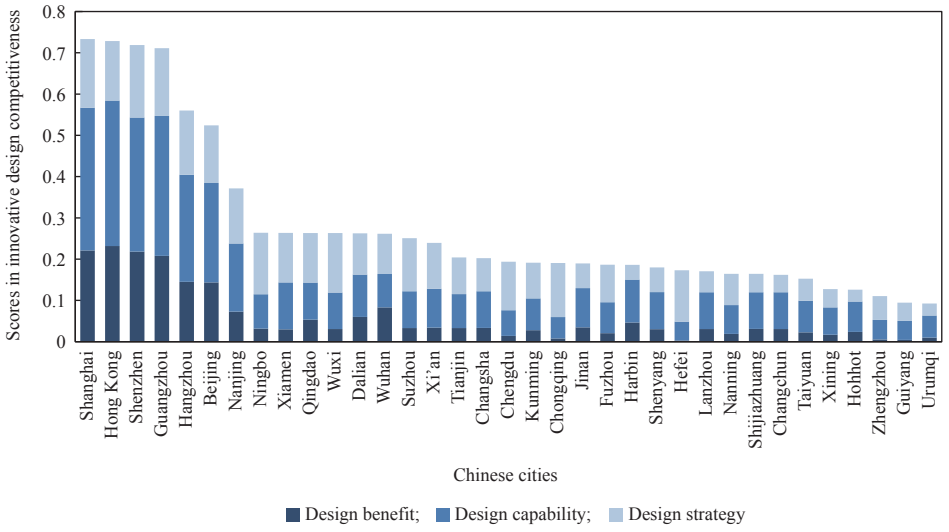

Fig. 7. Scores of 32 Chinese cities in innovative design competitiveness.

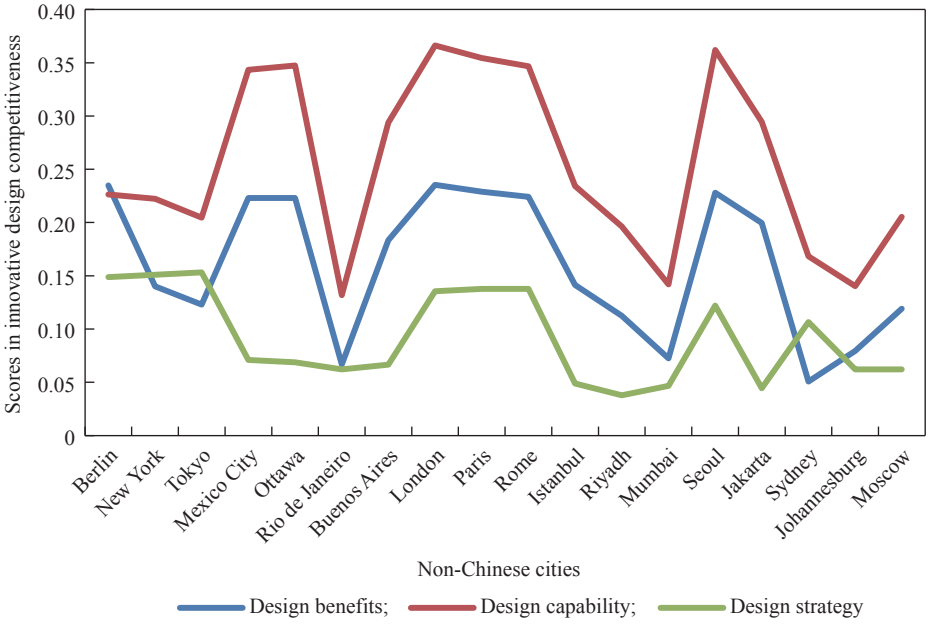

Fig. 8. Scores of non-Chinese cities in innovative design competitiveness.

5.3 Analysis of enterprise innovative design competitiveness

Innovative design is an important component of the national strategy of *Made in China 2025*, which was published in 2015. It plays an important role in enhancing China's national competitiveness and the comprehensive global competitiveness of its industries, improving China's position in the global value chain, and promoting the "Three Transformations." This section adopts evaluation indices of enterprise innovative design competitiveness from the perspective of Design 3.0 to analyze and evaluate the design competitiveness of key areas, such as construction machinery, marine engineering equipment and shipbuilding, electrical equipment, and home appliances.

5.3.1 Evaluation of innovative design competitiveness of construction machinery enterprises

The construction machinery industry is an important component of the equipment manufacturing industry. It is a technology- and capital-intensive pillar industry which has made substantial contributions to the national economy, and has a high number of industrial linkages as well as a strong ability to absorb employment. This study investigates the innovative design competitiveness of seven typical domestic enterprises. Their scores in enterprise innovative design competitiveness are listed in Fig. 9. XCMG Group, Sany, and Zoomlion are China's most competitive construction machinery enterprises. In terms of design benefits, these three enterprises have outperformed the other

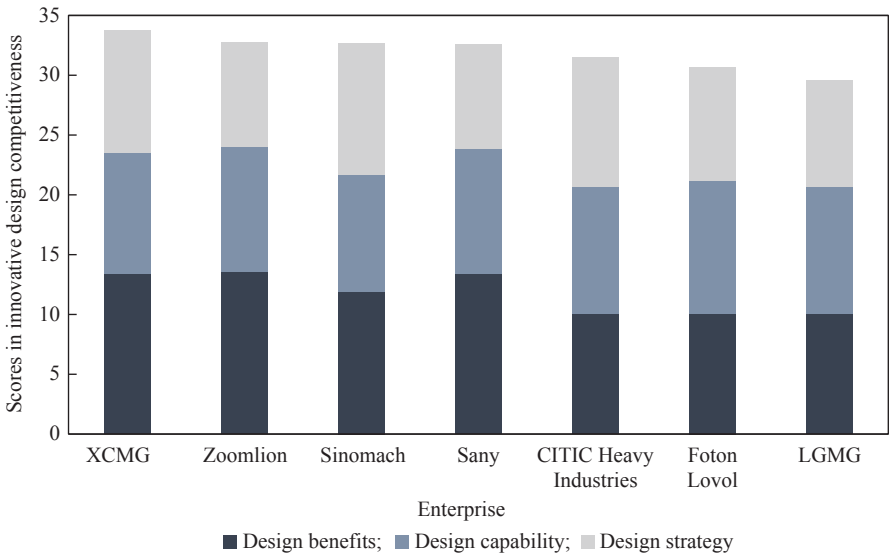

Fig. 9. Scores of construction machinery enterprises in innovative design competitiveness.

four enterprises. In terms of design capability, XCMG, Sany, and Zoomlion are the top three enterprises in the industry, mainly because of their high-quality design technicians. In terms of design strategy, XCMG ranks fourth in the industry, while Zoomlion and Sany performed poorly, ranking sixth and seventh respectively. XCMG has constructed a unique globalized R&D platform within the industry by coordinating its global resources [6].

5.3.2 Evaluation of design competitiveness of marine engineering equipment and shipbuilding enterprises

The marine engineering equipment and shipbuilding industry is a strategic industry associated with national security and national economic development. It promotes industrial structural upgrading and provides the main equipment for national defense construction, shipping and transportation, aquaculture and fishery, marine development, and other areas. In this study, seven major marine engineering equipment and shipbuilding enterprises in China are selected for analysis and evaluation of enterprise innovative design competitiveness (Fig. 10). With regard to design benefits, Offshore Oil Engineering Co., Ltd. (OOEC) ranks first in the industry, ahead of Zhenhua and the China State Shipbuilding Corporation (CSSC). OOEC has vigorously developed its international markets, and the percentage of foreign revenue in its total revenue has increased continuously, recently exceeding 30% for the first time. With regard to design capability, CSSC and OOEC rank second and third in the industry, respectively, while Zhenhua only ranks fifth. CSSC's high scores in design capability can be attributed to its substantial design achievements. The total number of its valid patents has grown by 342%. The 3000-metre deep-water semi-submersible oil platform it designed, "Ocean Oil 981," can operate at a maximum depth of 3 050 meters and drill to a maximum depth of 12 000 meters. Its major operational indices have achieved the international standard of an advanced operation. In terms of design strategy, Zhenhua demonstrates excellent management capability within a design organization. It employs the approach of "establishing three projects, creating four environments, and mastering five major technologies" in order to achieve the strategic goal of promoting leapfrog development in the marine engineering equipment industry through informatization.

5.3.3 Evaluation of innovative design competitiveness of electrical equipment enterprises

The electrical equipment industry is a basic industry that supplies stable and secure power and sustains the healthy development of the national economy. In this study, 12 major electrical equipment enterprises in China are selected in order for their design competitiveness to be analyzed and evaluated. In terms of design benefits, the electrical equipment industry is currently faced with tough challenges, including production overcapacity and changing market demands. Shanghai Electric, which outperforms other enterprises in terms of design benefits, has actively adapted to the "new normal" of China's economy. With regard to design capability, XD Group outperforms Shanghai Power and Dongfang Electric. Its high scores in design capability are based on its heavy emphasis on the cultivation of design talents and high levels of technological investment. Due to its design personnel and investment of scientific research funds, XD group has brought about multiple achievements with regard to independent innovation and has achieved breakthroughs in emerging areas such as ultra-high voltage technology, flexible power transmission, and new energy. In terms of design strategy, the top-ranking companies are, in descending order, XJ Group, Baiyun Electric Group, and Harbin Electric (Fig. 11).

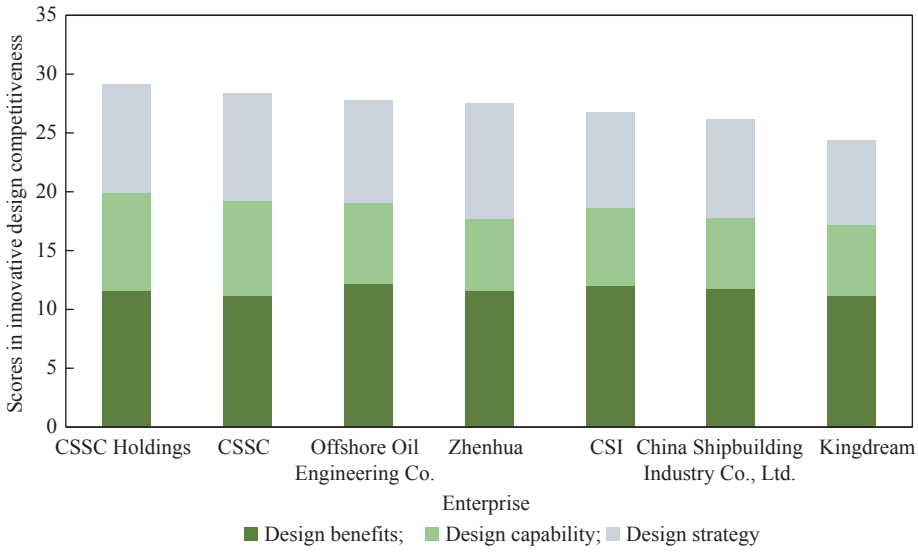

Fig. 10. Scores of marine engineering equipment and shipbuilding enterprises in innovative design competitiveness.

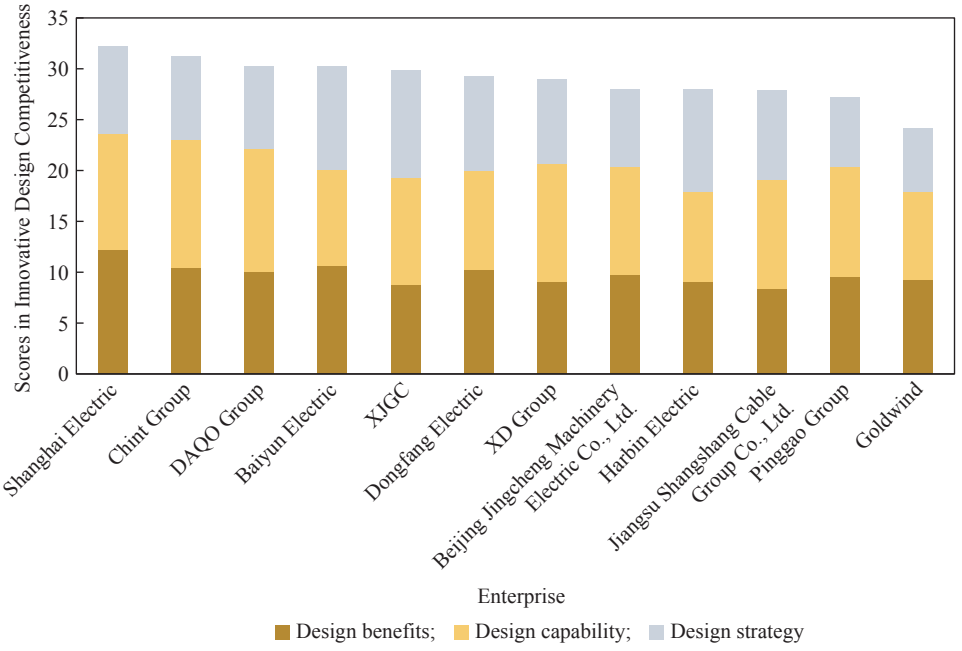

Fig. 11. Scores of electrical equipment enterprises in innovative design competitiveness.

5.3.4 Evaluation of innovative design competitiveness of home appliance enterprises

The home appliance industry is among the industries with the most market competition, the most complete industry chain, and the most distinct competitive advantages. It not only occupies an immense market share in the domestic market but also possesses a significant share in the global market. Under the "new normal" of China's economy, the home appliance industry faces significant pressure of an economic downturn. The major problems currently faced by the industry include severe product homogenization, a low level of brand differentiation, and a lack of technological and functional integration innovation. From the perspective of supply, traditional home appliance enterprises with a high level of inventory produce and stock mid- to low-end products; however, their supply of mid- to high-end products is inadequate. Hence, they are unable to adapt to the changes among their consumers, which has affected the consumers' purchase intentions.

With regard to the scores in design benefits, the top three home appliance enterprises are Gree Electric (or "Gree"), Midea Group, and Haier (Fig. 12). Gree, with a high level of brand influence and recognition in China, receives the highest score in

design benefits. It also ranks first in design capability, demonstrating its strategy for improving its design capability, which considers the cultivation of design talents as the basis and the mastery of key technologies as the core. In terms of design strategy, Haier ranks higher than Midea Group and Gree. Haier is exploring a business model in which the enterprise is transformed into a platform and the staff become makers to deliver personalized services for the users. The role of the staff shifts from employees and executors to entrepreneurs and dynamic partners to optimize the customer experience ecosystem for the community and satisfy the personalized needs of the users.

6 Suggestions for improving innovative design competitiveness

The key to improving innovative design capability is to update one's way of thinking, optimize the design environment, strengthen the design foundation, achieve educational reforms, and cultivate a design culture. This study presents the following five suggestions for accelerating the improvement in China's global competitiveness in innovative design as well as its ability to achieve sustainable development and global leadership.

(1) China should reshape its ways of thinking. It should respect the principles of design and develop a full understanding of the role of innovative design in guiding products, processes, and operational services. It should master the key factors and new characteristics of innovative design capability, including "green and low-carbon features, network intelligence, openness and integration, co-creation, and sharing." In addition, it should lead the promotion and acceleration of the transformation of "made in China" into "created in China," "Chinese speed" into "Chinese quality," and Chinese products into Chinese brands.

(2) China should optimize its environment. Given that innovative design has already been included in *Made in China 2025*, China should establish an action plan for the development of innovative design in the manufacturing industry. It should also refine the political and legal environment and take concrete measures to safeguard intellectual property rights. The same preferential tax rates enjoyed by high-technology enterprises should be applied to design enterprises as well. Meanwhile, a zero-tariff policy should be implemented for the import and export of design services. China should adopt a market-oriented approach for reforming its mechanism of innovation resource allocation, equity sharing systems, and design evaluation systems. It should take advantage of the guiding roles of organizations and units such as the Chinese Academy of Engineering, the Chinese Society of Mechanical Engineering, and the Innovative Design Alliance of China to optimize an enterprise-centered innovation environment in which the industry, academia, research institutes, users, and the financial sector are coordinated and deep civil-military integration is achieved. China should also commence the election of candidates for awards such as the China Good Design Award, the Guanghua Longteng Award, and the Red Star Award, while organizing activities such as design exhibitions, competitions, and forums. Design villages, design innovation parks, and domestic and overseas design parks should be constructed to optimize the design environment and encourage mass entrepreneurship and innovation.

(3) China should strengthen its design foundation. While continuing to increase its investment in fundamental and frontier R&D projects to accumulate knowledge and build technological foundations for independent innovation, different departments and units should strengthen their investment in innovative design, establish innovative design foundations, and strengthen

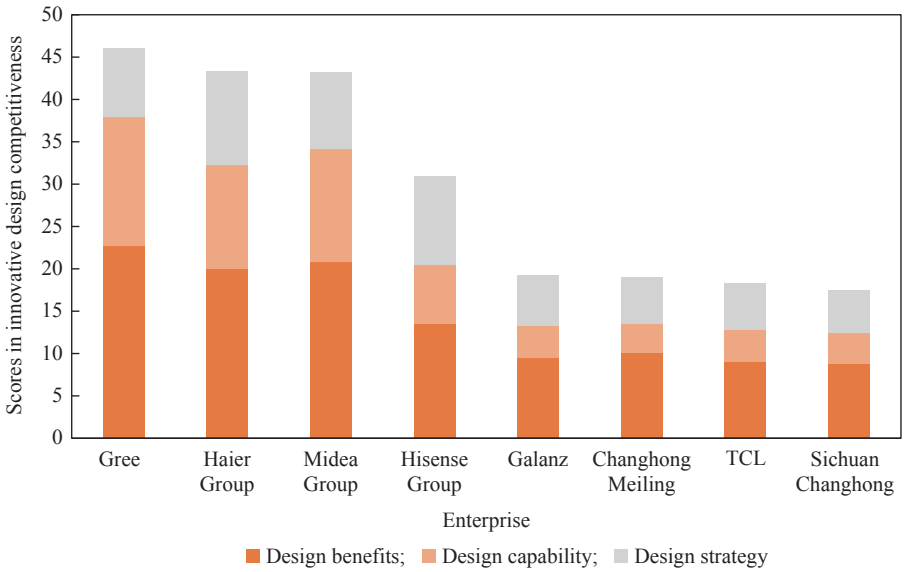

Fig. 12. Scores of home appliance enterprises in innovative design competitiveness.

their human capital as the basis for innovative design. China should construct and recognize a number of technology service centers for innovative design and strengthen its market-oriented basic technology support systems and industrial clustering platforms. It should also vigorously improve the level of independent innovation, prevalence, and resource sharing related to advanced design theories, design tools, embedded software, computing methods, and big data platforms, while strengthening the technological basis for digitalized, network-connected, intelligent, and green design. Finally, China should construct a world-class, open, shared, highly efficient, and secure information network and physical computing environment and participate actively in the establishment of advanced international industrial standards.

(4) China should reform its design education. Innovative design originates from practices and the understanding of the current and future market demands and social needs. The primary mission of design education is to guide the establishment of advanced scientific thinking and values, cultivate the spirits of innovative entrepreneurship and craftsmanship, develop people's interests and confidence in design creation and practices, and stimulate their imagination and creativity. Innovative design necessitates the cross-disciplinary integration of new knowledge about sciences and technologies, socioeconomics, humanities and arts, ecology, the environment, and other domains. It requires mathematical methods and computing skills for analyzing and interpreting big data. It also calls for the cultivation, attraction, and clustering of cross-disciplinary talents and the ability to design and construct co-creation and sharing platforms, networks, and mechanisms, to allow the acquisition of global resources for innovative design through crowdsourcing and create a globalized education environment.

(5) China should establish a design culture. An innovative design culture determines the characteristics and style of innovative design. During industrialization and modernization, different countries developed design cultures with their own unique characteristics. The United States emphasizes investment in fundamental and frontier R&D projects and encourages independent exploration, innovation, and creation, thereby forming an innovation-led design culture. Germany is a manufacturing power that emerged later than the others. It relies on its distinctive natural sciences, engineering, vocational education, and advanced industrial standards, which have cultivated a design and manufacturing culture based on high quality and trustworthiness. Both France and Italy have a rich cultural and artistic history, which has given rise to a design culture of elegance and grandeur. Japan has developed an exquisite and practical design culture. To transform itself into a manufacturing power, China must cultivate an advanced innovative design culture with Chinese characteristics, one which meets current demands, respects innovation and creation, pursues excellence, operates according to principles of integrity and cooperation, and advocates co-creation and sharing.

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