

# Analysis and Comparative Study of Industrial Design Patent Layouts of Automobile Manufacturers in Overseas Markets

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## ABSTRACT

In the context of globalization, the international development of the automotive industry has become an inevitable trend. As China has become the world's largest automobile exporter, automotive companies are gradually shifting from product export to technology export. During this transition, the protection of industrial design patents, which are crucial for brand image and market competitiveness, becomes particularly important. This study focuses on the layout of industrial design patents, a key area of intellectual property in the automotive industry's international expansion. It examines major global automotive markets and key regions for Chinese automotive brands' international ventures. We selected 23 automotive manufacturers from the Fortune 2023 Global 500 list as research subjects and developed a comprehensive analysis system encompassing key indicators such as patent family size, number of authorized countries, and major countries/regions of patent layout. Through a co-linearity relationship network matrix and visual analysis using Gephi software, this study provides an in-depth analysis of the design patent layout of automotive companies. The aim is to offer robust theoretical support and practical guidance for the intellectual property strategy of Chinese automotive brands in the global market, further advancing their internationalization process.

## KEYWORDS

Automobile brands going global; Automotive industrial design patents; Patent layout

## 1. INTRODUCTION

In the context of globalization, the international development of the automotive industry has become an inevitable trend. More and more automotive brands are actively expanding into overseas markets, striving to secure a foothold in the global market. According to statistics from China's General Administration of Customs, in 2023, China's automobile exports reached 5.221 million units, surpassing Japan and becoming the world's largest automobile exporter. Currently, the development of China's automotive industry has gradually shifted from merely exporting automotive products to exporting technology. In this process, appearance design, as a critical component of an automotive brand's image and competitiveness, plays a crucial role in patent protection. Appearance design not only affects the consumer's first impression but also reflects the core competitiveness of a company. Therefore, how to effectively lay out design patents in international markets has become a significant challenge faced by China's automotive enterprises in their international development.

This paper focuses on the major automobile production and sales regions worldwide, as well as key regions for the international expansion of Chinese automobile brands. It selects key Chinese and foreign automobile enterprises as the research subjects, analyzing the current status and strategies of their design patent layouts. By comparing the patent layouts of domestic and international automobile enterprises, this paper offers optimization suggestions for Chinese automobile companies. The aim is

to provide valuable references for the patent layout of Chinese automobile enterprises in the global market, offer theoretical support and practical guidance for the internationalization of Chinese automobile brands, and promote the process of Chinese automobile exports.

## **2. SAMPLE DATA**

### **2.1. Selection of Automobile Enterprises**

This paper selects the automobile manufacturers listed in the "2023 Global 500" published by *Fortune* magazine as the research subjects, totaling 23 companies, to ensure the research reflects the strategies and practices of leading enterprises in the industry regarding design patent layouts.

### **2.2. Scope of Design Patent Data Collection**

The patent search database used in this study is the global automobile patent big data platform independently developed by the China Automotive Technology Research Center, which includes over 150 million automotive and related patents from 104 countries worldwide. Patents related to automobile appearance design were retrieved from the database using keywords and the Hague classification codes for appearance design, with the search period from January 1, 2012 (when China's automobile exports exceeded 1 million units, according to the China Association of Automobile Manufacturers) to June 30, 2024. Due to the lag in patent publication, data from 2023-2024 is for reference only.

## **3. ANALYSIS OF AUTOMOBILE ENTERPRISES' DESIGN PATENT LAYOUT**

### **3.1. Analysis of Major Scale Indicators**

A patent family refers to a set of patent documents with the same priority, filed and published in different countries or regions, that share identical or nearly identical content. Traditionally, patent families refer to invention patents, but with globalization, especially through agreements like the Hague Agreement, design patents can be filed in multiple countries, expanding the meaning of patent families. In this paper, the term "patent family" specifically refers to a set of design patents that have the same priority and are filed and published in different countries or regions.

The scale of a patent family, as an important indicator of patent layout breadth, effectively reflects the geographical coverage of patent applications and their international influence. Therefore, this paper uses the patent family as the core unit of analysis to explore the current state of patent layout in the field of appearance design for automobile companies.

The patent family statistics of the 23 sample automobile companies are summarized in Table 1.

#### **3.1.1. Average Patent Family Size**

The average size of a patent family not only reveals the global layout of automobile companies' design patents but also indirectly reflects the company's international development strategy and market expansion capabilities. By comparing the patent family sizes of different automobile companies, we can gain deeper insights into their competitive positioning and growth potential in the global automobile market. The number of patents in a family reflects the breadth of the patent layout for that design, with a higher number indicating that the design has entered more countries or regions. This indicator is an effective tool for measuring the importance of patents held by a company and its product market layout. Typically, if an automobile company plans to produce and sell in a particular

country or region, it must file for design patents in that area to secure protection. Therefore, the layout of design patents can reflect the markets that an automobile company has entered or plans to enter.

**Table 1.** Summary of Patent Family Information for Major Global Automobile Enterprises

No.	Global Ranking	Company Name	Abbreviation	Country	Revenue (Million USD)	Patent Quantity	Average Patent Family Size	Number of Authorized Countries	Major Layout Countries/Regions
1	15	Volkswagen Group	VW	Germany	293,684.70	40863	3.92	50	China, United Kingdom, United States
2	19	Toyota Motor Corporation	Toyota	Japan	15,223.20	10093	1.96	32	China, Japan, United States
3	31	Stellantis Group	Stellantis	Netherlands	188,887.50	13627	3.03	50	United States, Argentina, China
4	46	Ford Motor Company	Ford	United States	158,057	8743	3.22	21	China, United States, Brazil
5	47	Mercedes-Benz Group	MB	Germany	157,781.70	6515	3.37	21	China, United States, United Kingdom
6	50	General Motors Company	GM	United States	156,735	3922	1.92	33	United States, China, Canada
7	57	BMW Group	BMW	Germany	149,991.30	8668	10.79	17	European Union, United Kingdom, China
8	70	Honda Motor Co., Ltd.	Honda	Japan	124,912.20	15527	4.41	50	Japan, United States, China
9	84	SAIC Motor Corporation Limited	SAIC	China	110,612.30	1941	1.03	6	China, United Kingdom, EPO
10	85	Hyundai Motor Company	Hyundai	South Korea	110,411.70	8284	2.04	27	South Korea, China, WIPO
11	131	China FAW Group Corporation	FAW	China	5,704.90	3054	1.01	13	China, Russia, Chile
12	152	Tesla, Inc.	Tesla	United States	81,462	442	2.14	12	United States, Japan, Australia
13	160	Nissan Motor Co., Ltd.	Nissan	Japan	78,287.10	7716	3.03	28	Japan, China, United States
14	165	Guangzhou Automobile Industry Group Co., Ltd.	GAC	China	77,344.70	2102	1.02	7	China, United States, Russia
15	188	Dongfeng Motor Corporation	Dongfeng	China	68,415.60	3550	1.04	19	China, WIPO, Vietnam
16	193	Beijing Automotive Group Co., Ltd.	BAIC	China	67,282.20	3127	1.02	11	China, United Kingdom, WIPO
17	196	Kia Corporation	Kia	South Korea	67,054.60	8171	2.08	27	South Korea, China, WIPO

No.	Global Ranking	Company Name	Abbreviation	Country	Revenue (Million USD)	Patent Quantity	Average Patent Family Size	Number of Authorized Countries	Major Layout Countries/Regions
18	212	BYD Company Limited	BYD	China	63,040.80	3643	1.60	35	China, EPO, United Kingdom
19	225	Zhejiang Geely Holding Group	Geely	China	60,395.80	7206	1.29	31	China, EPO, United Kingdom
20	286	Renault	Renault	France	49,923.80	4090	1.50	28	China, India
21	307	Volvo Group	Volvo	Sweden	46,828	7643	3.74	44	China, United States, EPO
22	337	Tata Motors (India)	Tata	India	43,661.30	6951	4.07	31	India, United States, United Kingdom
23	441	Suzuki Motor Corporation	Suzuki	Japan	34,291.90	2486	1.42	35	Japan, Indonesia, China

German automotive companies, including Volkswagen, Mercedes-Benz, and BMW, demonstrate strong international market layout capabilities, with average patent family sizes of 3.92, 3.37, and 10.79, respectively. Notably, BMW has an extensive design patent layout that covers numerous countries and regions.

Similarly, Japanese automaker Honda has also shown strong global patent layout capabilities, with an average patent family size of 4.41. In contrast, although Toyota and Nissan have also made some international market arrangements, their average patent family sizes are relatively lower, at 1.96 and 3.03, respectively. This may indicate that they have adopted more concentrated layout strategies in specific markets.

Among U.S. automotive companies, Ford and General Motors have average patent family sizes of 3.22 and 1.92, showing that Ford has a broader global market layout. As a leader in the electric vehicle sector, Tesla's average patent family size is 2.14, suggesting that it is gradually expanding its patent protection scope in international markets.

In comparison, Chinese automobile companies generally have smaller average patent family sizes, such as SAIC and FAW, which may be related to their relatively late entry into international markets and their development strategies that focus more on the domestic market. However, some Chinese companies, such as BYD and Geely, are actively improving their patent layouts in international markets, with average patent family sizes of 1.6 and 1.29, respectively, reflecting their efforts and progress in global market expansion.

### 3.1.2. Number of Authorized Countries

The "number of authorized countries" is an important indicator for measuring the degree of internationalization and the breadth of patent layout. By comparing the number of authorized countries across different companies, we can gain deeper insights into their competitive position and development potential in the global market, as well as their patent coverage and market competitiveness.

From the data, it is evident that Volkswagen, Stellantis, and Honda stand out, each having patents authorized in 50 countries. This figure not only reflects their strong capabilities in design patents but also highlights their extensive market coverage and international development strategies. The fact that these companies have obtained patent authorizations in so many countries demonstrates that their

product designs are recognized and protected globally, providing strong intellectual property support for their competition in the global market.

In contrast, some automotive companies have fewer authorized countries. For example, Tesla has patents authorized in 12 countries, and FAW in 13, which may be related to their focus on specific regional markets or relatively late entry into international markets.

It is noteworthy that some automotive companies, while having a smaller average patent family size, excel in the number of authorized countries. For example, BYD and Suzuki have average patent family sizes of 1.60 and 1.42, respectively, but their patents are authorized in 35 countries. This indicates that these companies have a flexible product and patent layout strategy in international markets, which may involve different models launched in various markets, enabling them to achieve wide international coverage within a limited patent family size.

### 3.1.3. Main Layout Countries/Regions

By comparing the layout situations of different companies, we can gain a deeper understanding of their market penetration strategies, regional preferences, and the breadth and depth of their international development.

From the data, it is evident that Volkswagen, Stellantis, and Honda have layouts in regions that include China, the United States, and another key market (such as the UK or Argentina). This layout reflects not only their broad coverage in the global market but also their in-depth development strategies targeting specific regions. Particularly, the Chinese market, as a significant growth point for automotive consumption in recent years, has received special attention from these companies. Companies like Toyota, Ford, and Mercedes-Benz have also demonstrated similar layout strategies, focusing on China, the U.S., and one or more other key markets. This "tri-country dominance" or "multi-country progress" layout helps mitigate market risks and seize growth opportunities in different regions.

It is worth noting that some automotive companies, while having a smaller average patent family size, make highly precise choices in their layout regions. For example, BYD and Suzuki's main layout regions are China, European Patent Office (EPO), UK, Japan, China and Indonesia. This shows that these companies have a flexible product and patent layout strategy in international markets, enabling targeted layouts based on the characteristics and demands of different markets.

Additionally, Chinese companies like SAIC and FAW are actively seeking international development. Their main layout regions, in addition to China, include the UK, EPO, Russia, and Chile, showing China's automotive companies' determination and actions in their overseas expansion strategies.

## 3.2. Patent Family Co-linearity Network Analysis based on Gephi

To further analyze the global patent layout of appearance design by Chinese and foreign automobile enterprises and to compare the gap between Chinese and overseas automobile companies, this paper constructs a co-linearity relationship network matrix (23 \* 74, two-dimensional network) based on the aforementioned search data, linking automobile companies with their layout countries/regions. A co-linearity network graph is then drawn using the Gephi tool for visual analysis. In the co-linearity network graph, the size of the nodes represents the number of design patents held/applied for by that node, and the thickness of the connections between nodes reflects the layout of design patents in the region, with thicker connections indicating more patents in that region.

### 3.2.1. Overview Analysis

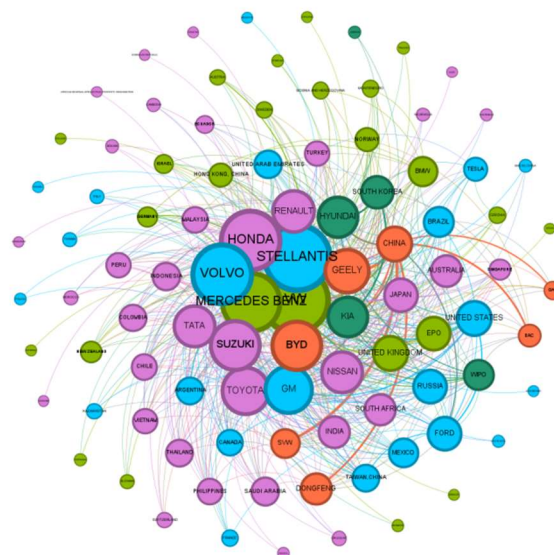
From the perspective of layout countries, the design patent layout of automobile enterprises is primarily concentrated in economically developed countries with strong automotive industrial foundations and emerging markets. Traditional automobile powerhouses like Germany, Japan, and the United States remain key regions for design patent layouts. These countries not only have well-

established patent protection systems but also host a large number of automobile enterprises and component suppliers, creating a robust automotive industry ecosystem. Additionally, emerging markets such as India, South Africa, and Brazil have become important targets for patent layout, highlighting the vibrant and immense potential of the automotive markets in these regions.

It is worth noting that with the rapid global expansion of Chinese automakers such as BYD and Geely in recent years, their design patent layouts in emerging markets like Southeast Asia, South America, and Africa have shown strong growth. This trend not only reflects the rising prominence of Chinese automobile enterprises on the international stage but also signals the changing landscape of global automotive design competition in the future.

From the perspective of corporate layout strength, internationally renowned automobile companies such as Stellantis, Volvo, Honda, Volkswagen, and Mercedes-Benz have clear advantages in both the number of countries they have patents in and the quantity of patents. This success is due in part to their long corporate histories and strong brand foundations, as well as their global strategic vision and powerful resource integration capabilities. These companies have established solid patent barriers for appearance design in traditional automobile powerhouse countries while proactively laying out patents in emerging markets to ensure their continued leadership in the global automotive market.

At the same time, we can also observe that there is still a gap between Chinese automobile companies and foreign enterprises in terms of design patent layouts: 1) The global layout is incomplete. Compared to the deep penetration of foreign companies in developed countries and regions such as Europe and the U.S., Chinese automakers have a weaker patent layout in these areas. For example, over 95% of the design patent applications from companies like FAW, Dongfeng, SAIC, BAIC, and GAC are in China. This localized layout strategy undoubtedly limits the competitiveness of Chinese automobile companies in the global market. 2) Chinese automobile companies are less active in filing patents with the World Intellectual Property Organization (WIPO) and the European Patent Office (EPO). There is a lack of awareness regarding the use of international agreements such as the Hague Agreement for patent layout, which limits the scope and efficiency of their patent protection.



**Figure 1.** Collinear Network Analysis of Design Patents of Major Global Automotive Companies

### 3.2.2. Analysis of Appearance Design Layout in Major Global Automotive Sales Markets

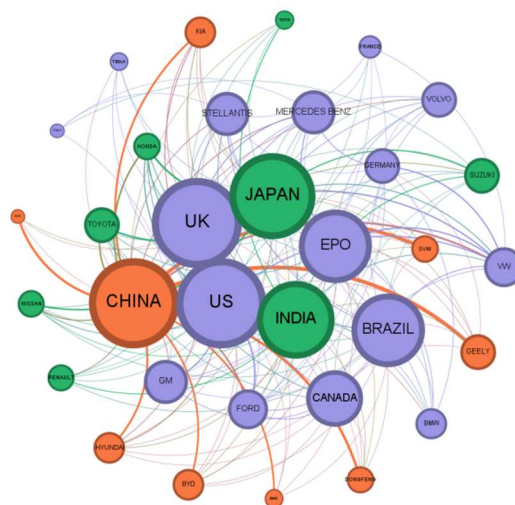
According to statistics from the International Organization of Motor Vehicle Manufacturers (OICA), the top ten countries in global automobile sales in 2023 were China, the United States, India, Japan, Germany, Brazil, the United Kingdom, France, Italy, and Canada. Analyzing the design patent layout

of automobile companies in these major global automotive sales markets is of significant importance for understanding the competitive landscape of the international automotive industry and optimizing the patent layout strategy and innovation path of Chinese automobile companies as they expand globally.

**Table 2.** 2023 Global Automotive Market Sales (Top 10)

No.	China	Asia	Sales (10,000 units)
1	United States	North America	3009.37
2	India	Asia	1600.93
3	Japan	Asia	508.00
4	Germany (EPO)	Europe	477.91
5	Brazil	South America	320.43
6	United Kingdom	Europe	230.87
7	France (EPO)	Europe	226.37
8	Italy (EPO)	Europe	220.91
9	Canada	North America	179.47
10	China	Asia	176.45

The patent layout for appearance design in major global markets shows significant localization characteristics. In the Chinese market, local automakers such as Geely (5207 patents), Dongfeng (2249 patents), BAIC (3034 patents), and FAW (3025 patents) have the most extensive patent layouts, demonstrating the high level of importance and protection that Chinese automobile companies place on the domestic market. At the same time, foreign automobile companies like Volkswagen (2461 patents) and Ford (2046 patents) also have a notable presence in China's design patent layout, reflecting the importance that both Chinese and foreign automobile companies place on the Chinese market.



**Figure 2.** Collinear Network Analysis of Design Patents in Major Global Automotive Markets in 2023

In the U.S. market, American companies such as Ford (1719 patents) and General Motors (1184 patents) dominate, with a relatively high concentration of patent layouts. Foreign automakers such as Volkswagen and Toyota are also actively laying out patents, striving to expand their market share. In the European market, Volkswagen (1415 patents) and Mercedes-Benz (900 patents) lead in patent layout, emphasizing the local advantage in Europe.

Although Chinese automobile companies have a competitive advantage in the domestic market, there remains a significant gap in the quantity and breadth of their patent layouts compared to foreign automakers, placing them still in the early stages. For example, in the U.S. market, BYD has only 69 design patents, while Geely and SAIC have no patent layouts in this region. In the European market, Dongfeng and GAC do not have any records of layout with the European Patent Office (EPO). Similarly, in markets like India and Brazil, Chinese automakers have relatively limited patent layouts. In India, BYD has only 16 design patents, while Dongfeng, FAW, and other companies have no layouts, whereas Suzuki has 626 design patents in India. In Brazil, Volkswagen (619 patents) and Stellantis (478 patents) dominate, while Chinese automobile companies have fewer patents in this market; for instance, BYD has 70 patents, but SAIC, BAIC, and Dongfeng have no patent records.

This layout gap may be caused by multiple factors, including Chinese automobile companies' insufficient understanding of different national markets, differences in market sales strategies, lack of focus on intellectual property strategies, and the high costs and complexity of international patent applications and maintenance.

### 3.2.3. Appearance Design Layout Analysis for Major Export Destinations of Chinese Automobiles

According to data from the China Passenger Car Association, in 2023, the top 10 export destinations for Chinese automobiles were Russia, Mexico, Belgium, Australia, the United Kingdom, Saudi Arabia, the Philippines, Thailand, the United Arab Emirates, and Spain.

**Table 3.** 2023 China Automotive Export Destinations (Top 10)

No.	Country	Region	Export Volume (10,000 units)
1	Russia	Europe	90.9
2	Mexico	North America	41.5
3	Belgium (EPO)	Europe	21.7
4	Australia	Oceania	21.5
5	United Kingdom	Europe	21.4
6	Saudi Arabia	Asia	21.4
7	Philippines	Asia	17.3
8	Thailand	Asia	17.1
9	United Arab Emirates	Asia	16.0
10	Spain (EPO)	Europe	13.9

From the statistical data and co-linearity network analysis graph, it is evident that, compared to foreign automobile companies, Chinese automobile companies' design patent layouts are significantly lacking. Taking Russia, the largest export destination for Chinese automobiles, as an example, foreign automakers such as Volkswagen, Stellantis, Toyota, and Nissan have over 200 patents in the region,



### 3.3. Overall Analysis and Recommendations

Based on the comprehensive analysis of the key scale indicators for design patents and the co-linearity network analysis graph of major global automobile enterprises, the following conclusions can be drawn:

- 1) Internationally renowned automobile companies such as Volkswagen, Stellantis, and Honda excel in design patent layout, with higher patent family sizes and numbers of authorized countries. This indicates their strong international market penetration and awareness of patent protection. These companies have particularly extensive patent layouts in major global automotive sales markets such as China, the U.S., and Europe, and also lead in emerging automotive markets like Russia, Mexico, and Thailand, as well as major Chinese export destinations. This reflects their global development strategies and keen ability to seize market opportunities.
- 2) The global market's design patent layout shows clear regional characteristics. In the Chinese market, both domestic and foreign companies have dense patent layouts, creating intense competition. In the U.S. market, local automakers dominate, and foreign companies' layout strategies are more cautious. In the European market, especially in the EU region, German automakers hold a significant advantage, with Chinese companies' layouts being more scattered. Emerging markets like India and Brazil show that Chinese companies' design patent layouts are relatively weak, posing potential legal risks during market promotion and sales.
- 3) Compared to foreign automobile companies, Chinese automakers still face gaps in their design patent layouts, with most patent families being smaller in size, and the number of authorized countries is limited, predominantly focusing on the domestic market. While this localized layout strategy strengthens competitiveness in the domestic market, it restricts their influence and competitiveness in the global market. Furthermore, Chinese automobile companies show insufficient awareness and action in utilizing international platforms such as WIPO and EPO for patent layout, which limits their patent coverage.

Recommendations for Chinese Automobile Companies:

- 1) Enhance patent layout awareness by actively utilizing international platforms like WIPO and EPO. Companies should increase their patent applications and protection efforts in developed automotive countries (such as Europe, the U.S., and Japan) and emerging markets.
- 2) Optimize patent strategies by focusing on key markets. Companies should develop targeted patent layout strategies based on the consumption demands and legal environments of different markets. Special attention should be paid to China, the U.S., and Europe, while also expanding patent layouts in emerging markets like India, Brazil, and Southeast Asia to improve global patent coverage and protection.
- 3) Strengthen patent layout capabilities by investing in patent talent development and recruitment to enhance companies' patent layout capabilities and internationalization levels. Companies could also leverage market data forecasting and technologies like artificial intelligence to optimize patent layout predictions and decision-making, improving efficiency and effectiveness.

## 4. CONCLUSION

This paper innovatively uses Gephi to conduct patent co-linearity network analysis and provides an intuitive view of the global distribution of automobile enterprises' design patents. Through the study of the current state of patent layouts, the paper delves into the patent strategies of global automobile companies in international markets. The findings show that automobile companies from developed countries like Germany, the U.S., and Japan have broad global layouts, with deep coverage in both developed and emerging markets. In contrast, Chinese automobile companies have relatively limited

international patent layouts, mainly concentrated in the domestic market, and lack engagement with international patent agreements like the Hague Agreement. However, the study also reveals that some Chinese companies, such as BYD and Geely, have shown positive progress in global market layouts, especially in emerging markets like Southeast Asia and South America. This paper not only provides strategic recommendations for optimizing patent layouts but also offers theoretical support for the globalization process of Chinese automobile companies and enhancing their international competitiveness.

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