VALUENEX IP ANALYTICS
FOR INVESTMENT

THEMATIC RESEARCH

Discontinuous Innovation to Fuel Auto Industry's Greatest Revolution in a Century

A MITSUBISHI UFJ MORGAN STANLEY REPORT
POWERED BY VALUENEX TOOLS AND ANALYTICS

VALUENEX
intellectual innovator

Japan Equity Research

October 4, 2016

Mitsubishi UFJ Morgan Stanley

Thematic Research

Discontinuous innovation to fuel auto industry's greatest revolution in a century (Overview)

In-depth report: Using patent information to reveal new technology trends and companies' survival strategies

Discontinuous innovation to have deep impact

Over the last century or so, automotive industry players have been competing to leverage economies of scale as they undergo continuous innovation centered mainly on gasoline and diesel engines. However, new technology trends such as electric vehicles, carbon fiber and other advanced materials, and autonomous driving are fostering discontinuous (disruptive) innovation on parallel tracks, and this will likely cause tremendous structural changes. There is no guarantee that even the current market leaders will be able to maintain their strength. In this report we discuss some of the major trends occurring in the auto industry, based on our analysis of worldwide patent information.

Condition for victory in an environment of continuous innovation

The main condition for market success in an environment of continuous innovation is economies of scale with overall optimization. In fact, Toyota, VW, and GM have leveraged sales of over 10mn vehicles to enhance their competitiveness. However, Europe's mega suppliers in the auto parts business are eyeing the 20mn-unit club and represent a growing threat. European automakers are coming more under the control of their suppliers, but still utilize their economies of scale. Japan's automakers have arrived at a crucial crossroads that will ultimately determine whether they maintain their unique business model or come under the control of suppliers.

Discontinuous innovation strengthens the dominance of suppliers

Based on our analysis of patent information, technological development seems to be driven mainly by suppliers in Europe, but mainly by automakers in Japan. It is clear that the business model of Toyota Motor is self-sustenance within its corporate group, complemented by suppliers such as Denso. Our cluster analysis of patent information is broadly divided into four domains (engine and drive systems, body and interior, ICT and control systems, batteries and materials), but new players are emerging in fields like autonomous driving and the development of new materials related to next-generation power sources, so the traditional industry powers are rapidly losing their dominance. It is clear to us that the industry is at the threshold of a major reorganization.

Major Industry reorganization

Factors likely to trigger this reorganization include (1) changes in the rules of competition and the players competing, and (2) a shortage of resources as competition spreads over more regions and domains. Even industry leader Toyota may have to change its business model, eliminate group inefficiencies, and form alliances aimed at reaching a scale of 20mn vehicles in order to survive. The speed of change will become more important than ever, and we therefore believe companies will have to undertake bold reforms that potentially include even adopting a holding company structure.

1.Mitsubishi UFJ Morgan Stanley Securities Co., Ltd. ("MUMSS") is currently acting as financial advisor to Toyota Boshoku Corporation ("Toyota Boshoku") in relation to its announced consideration that Shiroki Corporation and Aisin Seiki Co., LTD. will transfer the parts for seat frame business or assets to Toyota Boshoku..
Toyota Boshoku has agreed to pay fees to MUMSS for its financial advisory services.
2.Mitsubishi UFJ Morgan Stanley Securities Co., Ltd. ("MUMSS") is acting as financial advisor to Mitsubishi Motors Corporation ("MMC") in relation to the capital and business alliance with Nissan Motor Co., Ltd. ("Nissan") including its allocation of new shares to Nissan as announced on May 12, 2016. The proposed transaction is subject to regulatory approvals and other closing conditions.
This report and the information provided herein are not intended to solicit support for the transaction or to otherwise provide advice to investors.
MMC has agreed to pay advisory fees to MUMSS for its financial advisory services.

Contents

Overview: Who will be the auto industry's future champions?

1. Technological innovation will drive the auto industry's greatest structural revolution in a century

1-1. Competition in the century-long era of "continuous innovation"

Reflecting on the history of the automobile, it has now been 108 years since the famous Ford Model T was introduced for sale in 1908, resulting in the birth of automobile mass production systems. The automobile has evolved dramatically over these 108 years, and is now virtually indispensable to daily life.

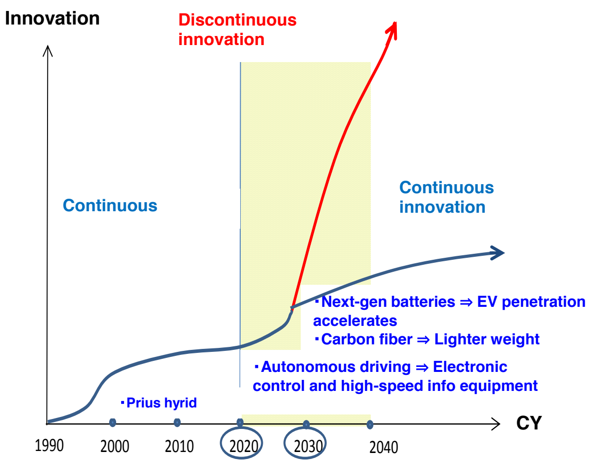
However, the evolution of automotive technology over the past century has been characterized by "continuous innovation", or gradual advancements in existing technology. It has not been a case of innovation stemming from new technological trends, so-called "discontinuous (disruptive) innovation" that arises from entirely different fields. When we look at today's most popular vehicle models, we see that all (1) run on liquid gasoline or diesel fuel, which have high energy density; (2) are powered by reciprocating engines; and (3) are made principally of steel, which is cheap and easy to process.

With respect to the technological advancements that have occurred within this "continuous innovation" process, over the 100-plus years since the birth of the Ford Model T, competition has been limited mainly to specific domains such as gasoline-powered cars or diesel-powered cars, and it is probably fair to say that the main condition for victory has been an ability to generate profits through sales volume (i.e., economy of scale).

Volume-centric business strategy must be abandoned

Over the last century, "reducing unit input costs by increasing sales volume" was a vital business strategy, and to increase sales volumes, automakers pursued development strategies that emphasized aesthetic design along with differentiation versus rivals' models in terms of safety and fuel efficiency. Among the automakers that were successful in selling popular models, those that were also successful in selling models of superior quality (few defects) saw their brand status and customer trust increase, which resulted in repeat sales and relatively stable earnings. However, we are nearing the end of "tranquil times" in which changes to business models were not required. Going forward, we can expect existing earnings structures to collapse under the weight of "discontinuous (disruptive) innovation" from multiple fronts.

Figure 1-1: Technological advancement through discontinuous innovation



Source: MUMSS

1-2. Discontinuous (disruptive) innovation starting from multiple fronts

The era of continuous innovation in gasoline and diesel-fueled automobiles will likely continue, supported mainly by demand growth in emerging markets. However, we highlight the concurrent startup of discontinuous (disruptive) innovation from separate directions that does not represent mere improvements of existing technology. Examples include the following:

(1) The emergence and future advancement of electric vehicles, which employ an entirely different type of motive power and are better for the environment

(2) The commercial use of carbon fibers and other advanced materials other than steel

(3) Trial runs of self-driving vehicles facilitated by advancements in information and communication technologies

"Continuous innovation" champions will not necessarily be the "discontinuous innovation" champions

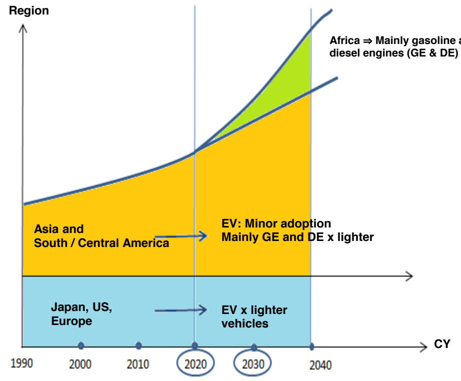
To state the obvious, champions in the "continuous innovation" era will not necessarily be the champions in the era of "discontinuous (disruptive) innovation". Google, for instance, is already conducting road tests of self-driving cars, and challengers from a variety of different industries are targeting the electric vehicle market. Discontinuous innovation that cannot be achieved simply by improving upon existing technologies can also be called "disruptive innovation" that can destroy existing earnings structures in a single stroke.

In the consumer electronics industry, the method of recording and listening to music evolved from open reel tape decks, to cassette tapes, to MD players, to hard disks, to SSD (semiconductors), and finally to on-demand listening via the Internet, and during this process, the industry's original champions were gradually eliminated by the disruptive force of discontinuous innovation.

Even Toyota, Daimler, BMW, VW, and other highly profitable automakers face the risk of their earnings structures collapsing if they do not respond effectively to "discontinuous innovation".

That said, considering the ongoing growth in global automobile demand, existing technology will not disappear immediately. In Africa and other emerging markets where demand for cars is growing and roads and electric power infrastructures are in poor condition, sales of advanced models of conventional gasoline and diesel-fueled vehicles can be expected to increase. In developed markets, on the other hand, sales of electric cars, self-driving cars, and other new models born from "discontinuous innovation" will likely explode from 2020 onward. Accordingly, automakers and automotive component suppliers will have to simultaneously employ multiple strategies to deal with (1) both market regions (developed markets and emerging markets), and (2) both technology development tracks (next-gen and conventional technologies).

Figure 1-2: Regional market strategies amid global competition



Note: GE=gasoline engines, DE=diesel engines
Source: MUMSS

2. Auto industry reorganization ramping up; firms use alliances and M&A to access complementary technologies

2-1. Global alliances seeking complementary technologies

New players from different industries are changing the industry structure

Changes in automotive technology trends have accelerated the entrance of new players from the electronic components, materials, and information & communication industries, among others, and this is driving a structural realignment that could dramatically alter the industry structure.

As mentioned above, in developed nations where new technologies are needed for electric vehicles, self-driving cars, and other emerging areas, electric component makers are rapidly entering the automotive industry fray. Electronics technology has thus taken priority over mechanical technology, and communications technology has been introduced to integrate and control the two. With respect to braking/steering technology and power control technology, the key elements of driving control in autonomous vehicles, even component makers that excel in existing mechanical technologies may not survive unless they fuse their technology with advanced electronics and communications technologies. As a result, more and more companies are looking to supplement their current technologies through global alliances and/or M&A.

2-2. M&A activity heating up in the auto parts industry

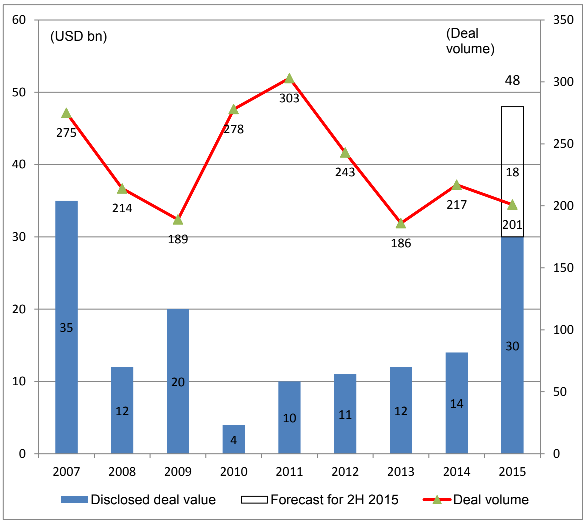
In emerging markets where conventional technology still dominates, growth in scale is more important than ever

In emerging markets where conventional technologies can still be utilized, volume growth will be more essential than ever in order to minimize production costs. Consequently, global-scale M&A activity is heating up as companies try to survive in existing fields. Firms must also streamline development that has multiple objectives.

Although the current earnings structures of automakers and parts suppliers were perfected in an environment of continuous innovation, improving those structures to handle an environment of discontinuous (disruptive) innovation, in which new regions and new technologies will be increasingly important, will require companies to further strengthen their strong points while supplementing their weaknesses. We believe this is where new business opportunities will arise.

Figure 2-1 shows the trends in supplier M&A activity. It appears that the trend in recent years is increasing bipolarization between small cases that target elemental technologies, and traditional large cases that target market supplementation (growth).

Figure 2-1: Global M&A activity in the automotive parts industry



Source: MUMSS, from PWC Consulting data

During the M&A boom of the mid- to late-1990s, the development of technology for designing and assembling over 20,000 individual components as modules drove industry reorganization that targeted peripheral components necessary for modularization. North American auto parts suppliers played the central role in this and saw their market presence increase.

Today, however, although M&A activity among traditional auto parts suppliers is also increasing, as we see in the aggressive M&A activity of companies like motor maker Nidec, electrical equipment makers looking to expand into new fields are utilizing their abundant cash resources to strategically expand their business at an even faster pace than traditional auto parts makers.

1990s M&A deals ultimately failed due to poor ROIC

Incidentally, during the 1990s M&A boom, companies that increased their scale as module suppliers by using M&A to access peripheral components were initially successful in boosting their sales, but few deals produced synergies such as cost savings or increased value added, and most ultimately ended in failure. This is because companies were generally unable to realize adequate returns on their invested capital, which swelled due to the goodwill costs generated by large-scale M&A.

As a result of M&A, companies' returns on invested capital (ROIC) actually declined, preventing them from creating adequate levels of economic added value (ROIC<WACC; WACC = weighted average cost of capital). Consequently, their share prices slumped during that period. After US auto demand finally peaked out, firms ultimately split up as they concentrated on their core business lines, a trend characterized by the Delphi bankruptcy. Today, companies are instead targeting next-generation technologies, but the results could ultimately be the same, and activities should therefore be monitored closely.

2-3. Firms black-boxing knowhow through use of IoT

In-house production technology is one secret behind the manufacturing strength of Japanese automakers

The auto industry's greatest intellectual property is (1) proprietary production technology, and (2) manufacturing equipment/facilities that cannot be easily replicated by competitors. Within the semiconductor industry, there are semiconductor production equipment makers that sell similar SPE all over the world. In the auto industry, however, automakers buy generic machine tools, robots, etc. from outside vendors, but they add in vital proprietary production technology in-house. Toyota Motor's Teihou plant and Honda's Honda Engineering unit produce manufacturing equipment that incorporates proprietary knowhow. Some of this equipment that features Japanese knowhow is transferred to overseas production facilities, and due to increasing local procurement and localization of equipment maintenance, some proprietary knowhow is leaking out overseas.

The greatest expectation with respect to IoT is that it will allow companies to boost production efficiency while prudently controlling information. However, in order to survive under stiffer competition, companies will have to take IoT a step further, and use it to prevent the leakage of knowhow by consolidating the control of production equipment information in Japan. In other words, it may require a radical change in thinking, such as the black-boxing of proprietary technology.

The key is implementing a strong intellectual property (IP) strategy to black-box the production technology and production equipment knowhow born from new technology trends, and keep it from easily falling into the hands of rival firms.

2-4. Expansion into robotics, etc.

The evolution of the automobile will facilitate expansion into new industries such as AI and robotics. Companies like Toyota are investing in cutting-edge R&D with an eye toward expanding into such fields. There have previously been examples of companies expanding from the automotive field into fields such as aircraft and engines for other applications, but expansion into the robotics industry, which has the potential to be even larger than the automobile industry, would likely create new earnings opportunities for automakers.

Instead of cars as simply a mode of transportation, the concept of autonomous driving envisions cars with the ability to think and make decisions, and such technology would naturally spread to non-automotive fields as well. Honda and Toyota are already working on humanoid robots, and considering the huge potential demand, we believe this is the most promising field beyond the auto business.

2-5. Where is the automotive industry headed?

As the auto industry adjusts course, the technologies that define competitiveness will also change

As we discussed earlier, the 100-plus-year history of the automobile industry has been characterized by continuous innovation, and that ceaseless process of improvement was absolutely essential to sustained competitiveness. In this sense, Japan’s cultural and ethnic background probably helped make Japan an automotive superpower by fostering assiduous improvement through close collaboration among the automakers, suppliers of more than 20,000 individual components, and the materials industries that support them.

However, there is no guarantee that the Japanese auto industry, which has heretofore leveraged its strength in traditional integrated manufacturing centered on mechatronics, will necessarily be able to maintain its advantage in an environment of discontinuous innovation.

The evolution of vehicle control, from manual operation by the driver, began with the addition of driver-assist features utilizing various sensors and actuators, and has now advanced to preparations for autonomous driving by connecting cars with the external environment (e.g., the internet, other cars, etc.). Eventually cars will have the capacity for fully autonomous driving.

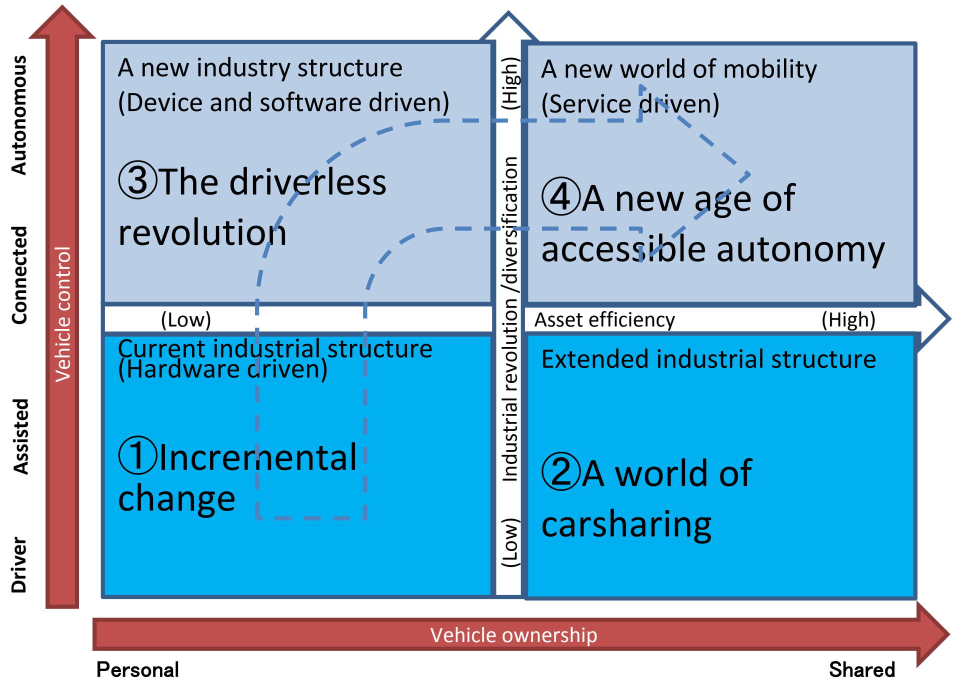
On the other hand, a shift in the mode of vehicle ownership is also conceivable—for instance, a shift from individual ownership to sharing, which would make cars more akin to a public utility or infrastructure amenity. Such a shift is more likely in developed nations where automobile diffusion rates are already high, and, in fact, the desire to own a car is declining sharply among the younger generation.

In Figure 2-2 we summarize these trends in matrix format. In an industry that has remained relatively stable in the era of continuous innovation (1), the lineup of key players that create added value in vehicles will probably change as the utilization of electronic devices and software leads to dramatic advances in vehicle performance (3).

Moreover, if the mode of vehicle ownership also changes, the value criteria for automobiles would change significantly, and the automotive business’s core value creators might shift to the software and service industries from the hardware industry.

There are predictions that by 2045, AI will start to surpass human intelligence and usher in the so-called age of singularity. It hypothesized that in such a world, cold fusion, superconductivity, and other theoretical technologies would become reality, and all of humankind's environmental and resource problems would be solved. Although it would be impossible to devise an investment strategy for such a scenario, we believe it is fair to assume that we are nearing the point at which a major step in discontinuous innovation is definitely possible.

Figure 2-2: Evolution of the auto industry as a result of discontinuous innovation



Source: MUMSS, based on *The Future of Mobility* (Deloitte University Press)

3. Conditions for hegemony in an environment of continuous innovation

3-1. Smile curve of profit margin versus sales volume

Relationship between scale and profitability at the world's major automakers is represented by the smile curve

As shown in Figure 3-1, automakers' sales volumes and profit margins are not proportional; in fact, those with high margins are generally at the ends of the smile curve. In one group, plotted in the upper right-hand quadrant, are automakers with annual sales of around 10mn units and high profit margins (e.g., Toyota and GM; note that VW's profitability has declined temporarily due to the emissions data falsification scandal). In the other group, plotted in the upper left-hand quadrant, are unique automakers with sales of 2mn vehicles or less and high profit margins (e.g., Fuji Heavy Industries, BMW, Daimler).

Automakers with low profit margins plotted near the middle of the smile curve have sales volumes of around 4mn to 6mn vehicles and include names like Honda and Ford.

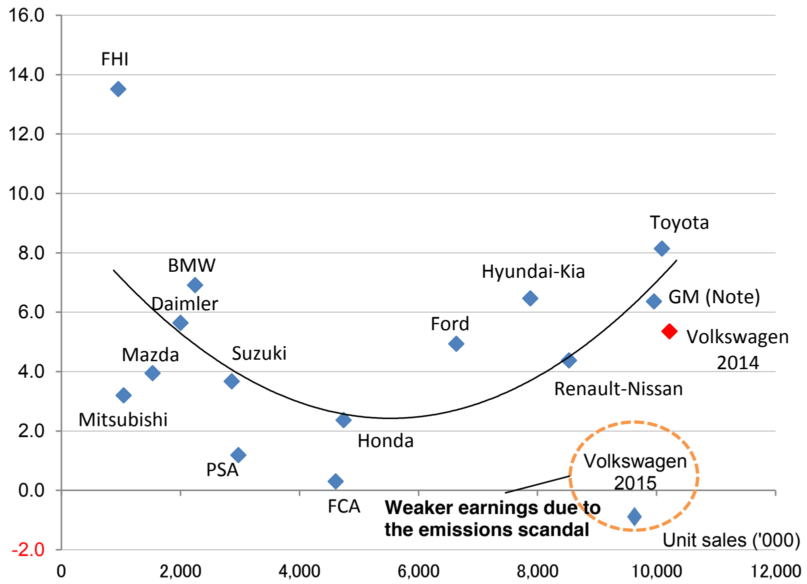
High margins reflect either economies of scale or elevated ASP due to brand strength

In the environment of continuous innovation, the middle tier, which is less profitable than the 10mn club, which generates high margins thanks to global volume scale, cannot realistically adopt a strategy of scaling back sales volume. This means they have to try to increase their sales volumes, but this is difficult if they continue to compete in existing technologies.

A characteristic feature of the 2mn vehicles club, headlined by Daimler and BMW, is their focus on luxury models with high sticker prices. As for Fuji Heavy Industries, the company's Subaru brand, which features AWD and a unique horizontally-opposed engine, has garnered broad popularity particularly in the US, and generates high profit margins thanks to low sales incentives. Mazda is pursuing a similar strategy with its SKYACTIV technology.

For Japanese automakers with high profit margins, their main rivals are principally German brands—specifically VW in the 10m vehicles club and BMW and Daimler in the 2mn club.

Figure 3-1: Automakers' sales volumes versus NP margins (FY2015)



Note: In FY12/15 GM booked deferred tax assets (reversal of assessed reserves) of USD3,957mn related to its European operations. We estimate that GM's NP margin would have been 3.8% excluding this item. To derive the approximation curve, for Volkswagen we use 2014 data and exclude 2015 data.

Source: MUMSS, based on individual company data

3-2. R&D investment trends

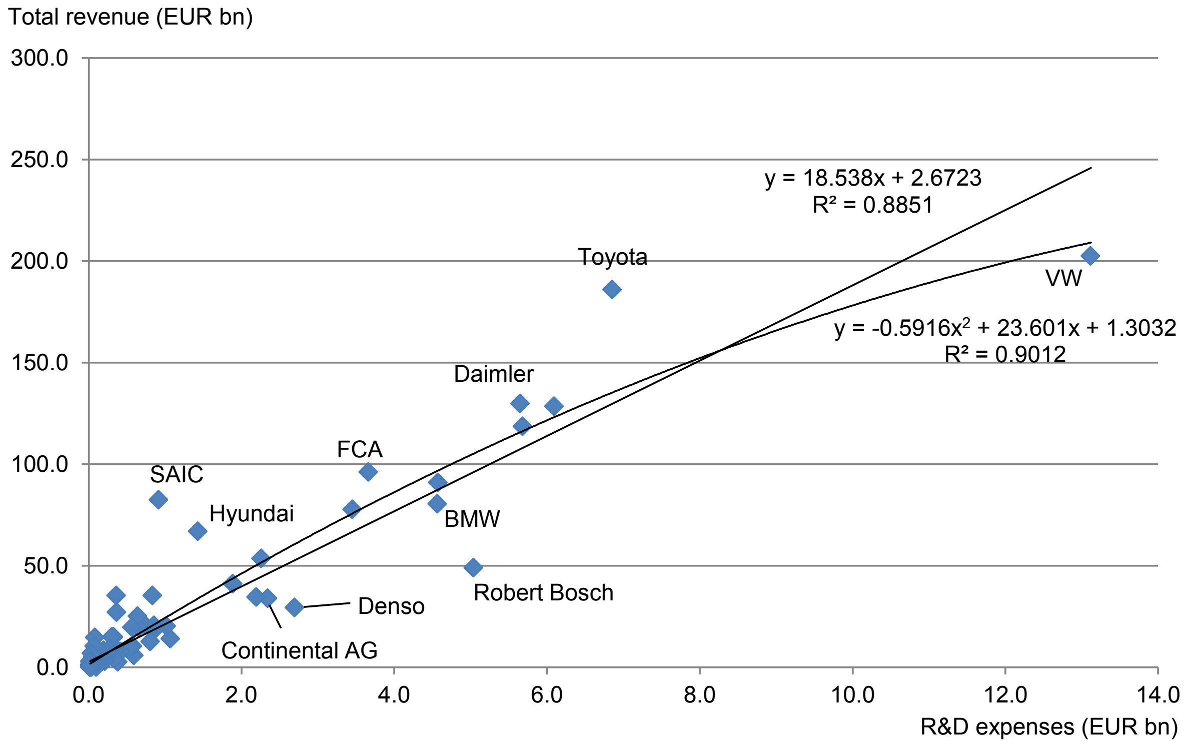
Analyzing the relationship between profit margin and sales volume, the smile curve shows the bipolarization of automakers with high profit margins. In Figure 3-2, we examine the relationship between business scale and R&D investment, which funds the new technology that is ultimately the wellspring of an automakers' enterprise value.

At Toyota, Daimler, and BMW, for instance, the amount of capital available for investment in R&D is limited by the level of sales, with the ratio of R&D expenditures to sales generally around 4–5%. However, R&D spending is much higher at VW, whose ratio of R&D investment to sales is 6–7%. Conversely, Hyundai Motor, which is chasing the leading automakers, spends only around 2% of sales on R&D investment.

As for suppliers, Bosch and other leading European suppliers spend roughly 10% of their sales on R&D, followed by Continental at around 6% and Denso at around 9%. On the other hand, suppliers like JCI and Hyundai Mobs, which lag behind in technology development, have considerably lower ratios of R&D spending to sales. In short, the degree of variance in R&D investment levels tends to be greater among automotive parts suppliers.

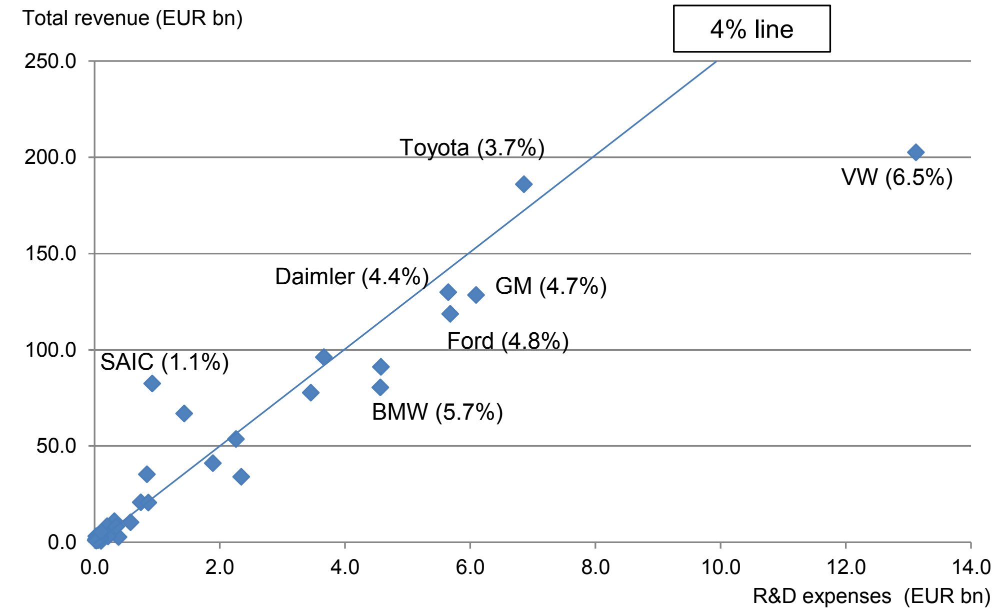
Although a high ratio of R&D investment to sales does not necessarily guarantee success in developing cutting-edge technology, companies with higher ratios clearly have a greater probability of success than firms with lower ratios. Although R&D details are typically black boxed, our approach here is to infer companies' R&D activities from publicly available patent information.

Figure 3-2: Global automotive companies' sales and R&D expenditures (FY2014)



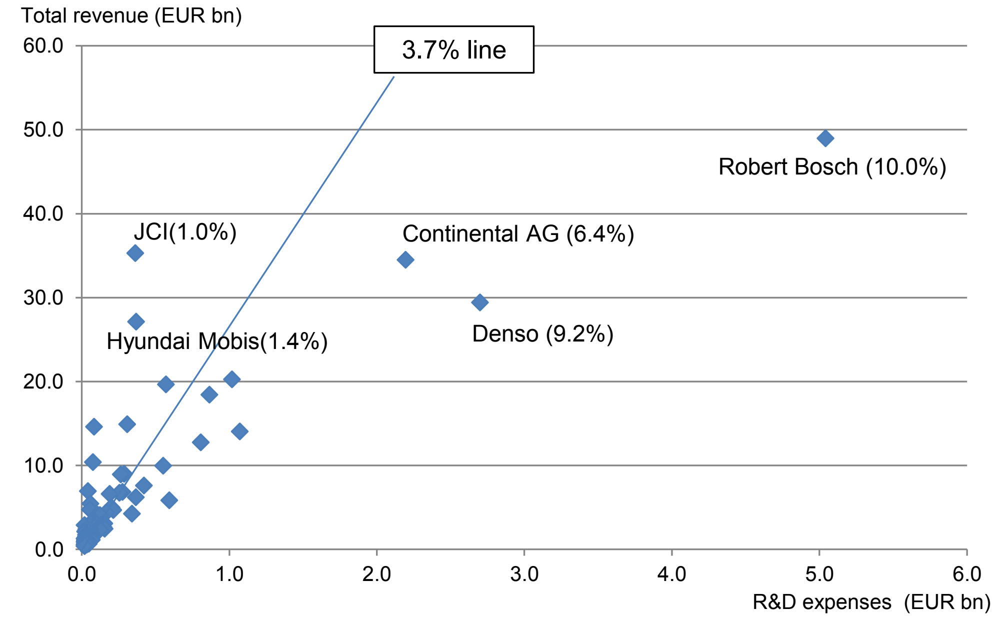
Source: MUMSS, from *The 2015 EU Industrial R&D Investment Scoreboard* (European Commission)

Figure 3-3: Global automakers' sales and R&D expenditures (FY2014)



Note: In billion euros; figures in parentheses are ratios to sales
Source: MUMSS, from *The 2015 EU Industrial R&D Investment Scoreboard* (European Commission)

Figure 3-4: Global auto parts suppliers' sales and R&D expenditures (FY2014)



Note: In billion euros; figures in parentheses are ratios to sales
Source: MUMSS, from *The 2015 EU Industrial R&D Investment Scoreboard* (European Commission)

3-3. In Germany, suppliers taking the lead in technology development

In Europe, suppliers have extremely high technological expertise

With respect to technology development, the relationship between European suppliers and German automakers, which have used continuous innovation to consistently maintain their technological advantage, is characterized by a high level of dependence on suppliers.

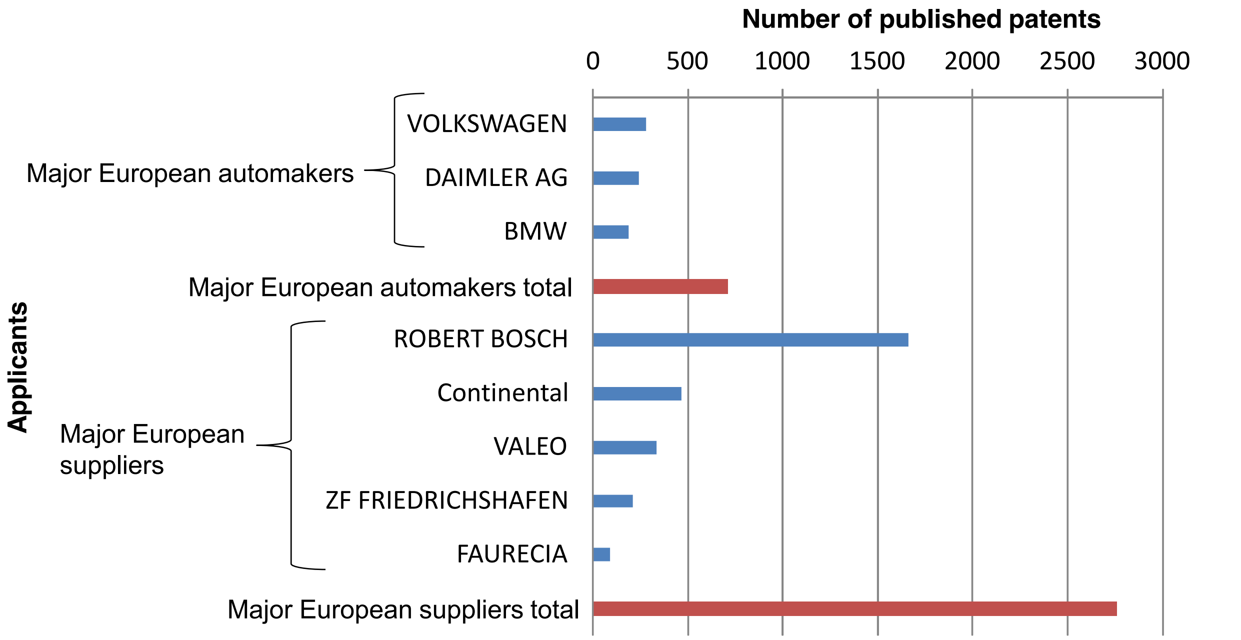
Using numbers of patents published in Japan, Europe, and the US to compare technology development scales, we see that suppliers—headlined by Bosch—overwhelm the German automakers (see Figure 3-5). Meanwhile, Figure 3-6 shows that, in terms of development comprehensiveness, suppliers tend to carry out technology development more densely and on a broader scope (see page 18 onward for a detailed explanation our technology patent map).

To conceal their activities, firms often do not submit patent applications for cutting-edge and manufacturing technologies

The majority of patent registrations are for technology patents; registrations of manufacturing patents are extremely rare. Accordingly, the reason VW has relatively few technology patents despite its extremely large R&D investment is probably that it is developing highly confidential technology, possibly in the area of level-4 autonomous vehicles. It is also possible that VW is conducting multiple R&D projects related to manufacturing engineering (e.g., its MQB platform), although we cannot confirm this.

Regardless, with respect to the key devices that largely determine vehicle performance, Bosch and other system suppliers in Europe continue to increase their influence and competitive superiority over automakers. Against this backdrop, we believe the development activities of Bosch, which dominates in terms of number of published patents, merit close attention (Figure 3-7).

Figure 3-5: Automotive-related patents of major European automakers and suppliers (total number published in Japan, Europe, and US)

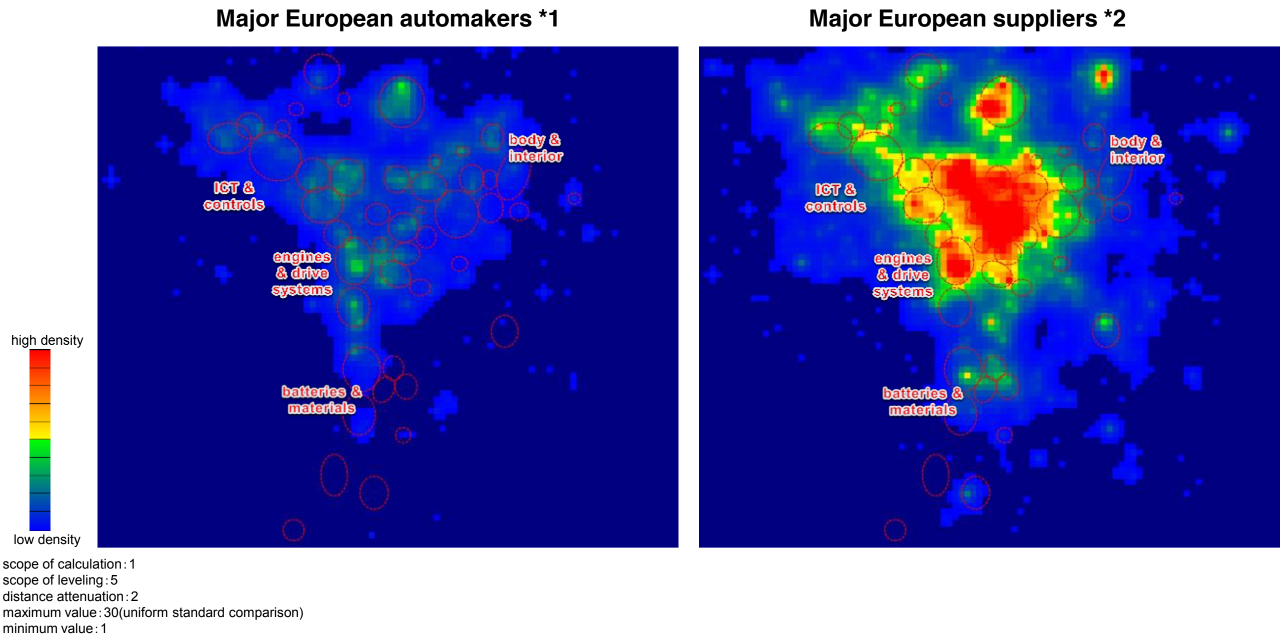


Source: Joint research by Valuenex and MUMSS

Autonomous vehicles, a key driver of discontinuous (disruptive) innovation, will particularly encourage the advancement of automotive electronics and further enhance Bosch's status as a system supplier. Meanwhile, modularization through the adoption of the architecture concept in vehicle design is accelerating, but Bosch's competitive advantage as a system supplier is increasing in this regard as well.

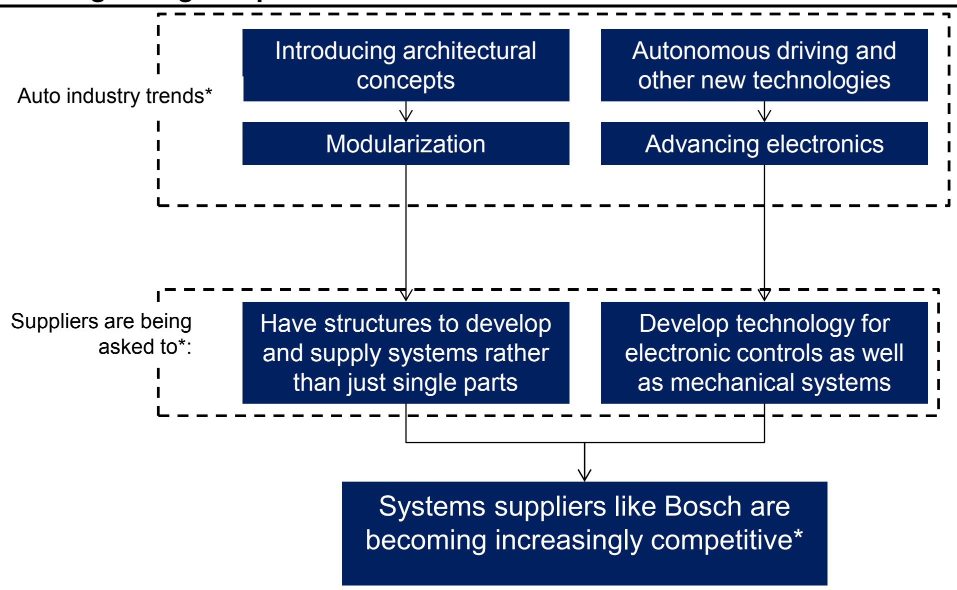
In short, the nucleus of automotive technology development in Europe is shifting from German automakers to key suppliers such as Bosch. As a result, the kind of vertical integration that still permeates the auto industry in Japan (see Figure 3-8) is collapsing, and we believe the industry is moving toward a structure in which suppliers will actually exert control over the automakers.

Figure 3-6: Automotive-related patents of major European automakers and suppliers



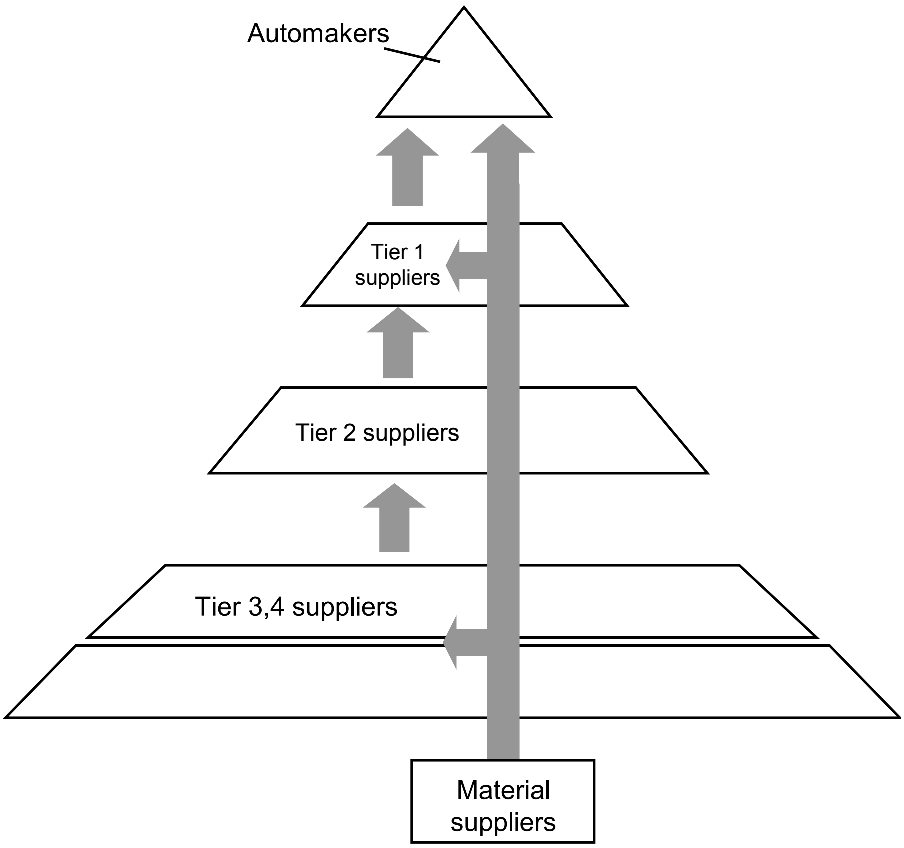
Notes: *1: Totals for VW, Daimler, and BMW; *2: Totals for Bosch, Continental, Valeo, ZF, and Faurecia
Source: Joint research by Valuenex and MUMSS

Figure 3-7: Advancement of modularization and electronics, and Bosch's growing competitiveness



Note: * From 22 July 2015 METI report on structural changes affecting the automobile industry
Source: Joint research by Valuenex and MUMSS

Figure 3-8: Vertical integration model of the automotive industry



Relationship between automakers and auto parts suppliers are changing

Past: Automakers lead → auto parts makers follow
Now: Auto parts makers lead → automakers follow

"A car model can't be competitive without this part"

Competitive abilities needed to survive

1. Outstanding capability to develop new technology (environmental, safety, information, production equipment)
2. Outstanding capability for low-cost production (Japan-centric → emerging countries-centric, e.g., in Asia
3. Sales prowess that can withstand price competition
4. Development expertise in materials (resins, carbon fiber, precious metal alternatives)
5. Ability to secure profits and fully utilize production facilities in emerging countries
6. Ability to cultivate new customers
7. Resilience to risk (country, China, currency, carbon)
8. Ability to respond to and use discontinuous (disruptive) innovation

Source: MUMSS

3-4. Toyota's business model built on group self-sufficiency

Pyramid structure, with finished autos at the top, is exemplified by Toyota and is the traditional industry structure in Japan

Compared with European firms, the technology development strategies employed by Japanese firms are more diverse, and Toyota's strategy differs substantially from those of its rivals.

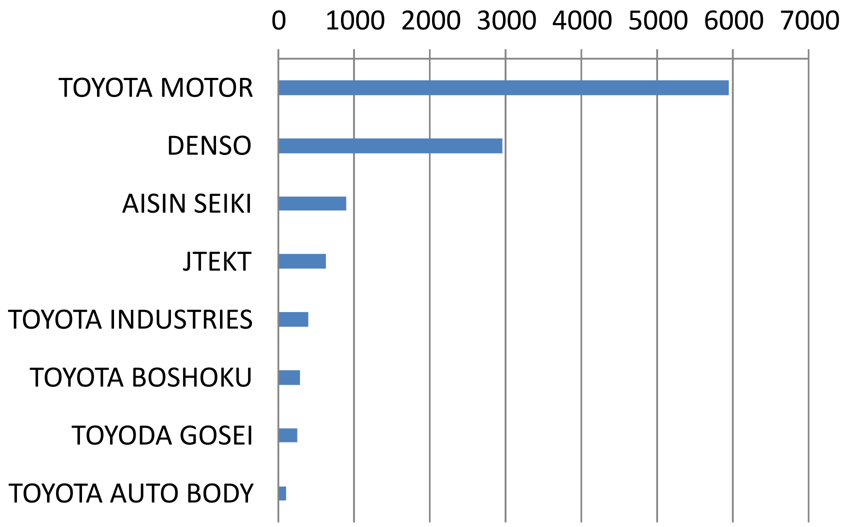
The technology development strategy of industry-leader Toyota Motor can be described as follows: Toyota plays the central role in technology development, with Toyota Group suppliers, led by Denso, supplementing development in areas Toyota is unable to cover itself, and in this way the group as a whole covers virtually every existing technology domain.

Meanwhile, Toyota Motor and Denso account for the overwhelming share of published patents for the group (Figure 3-9).

This is also true of patents related to advanced materials and EV, core fields of discontinuous (disruptive) innovation, where the number of Toyota patent applications is rising sharply (see Figures 3-10, 3-11, and 3-12). This suggests that Toyota's development strategy remains in line with its traditional business model.

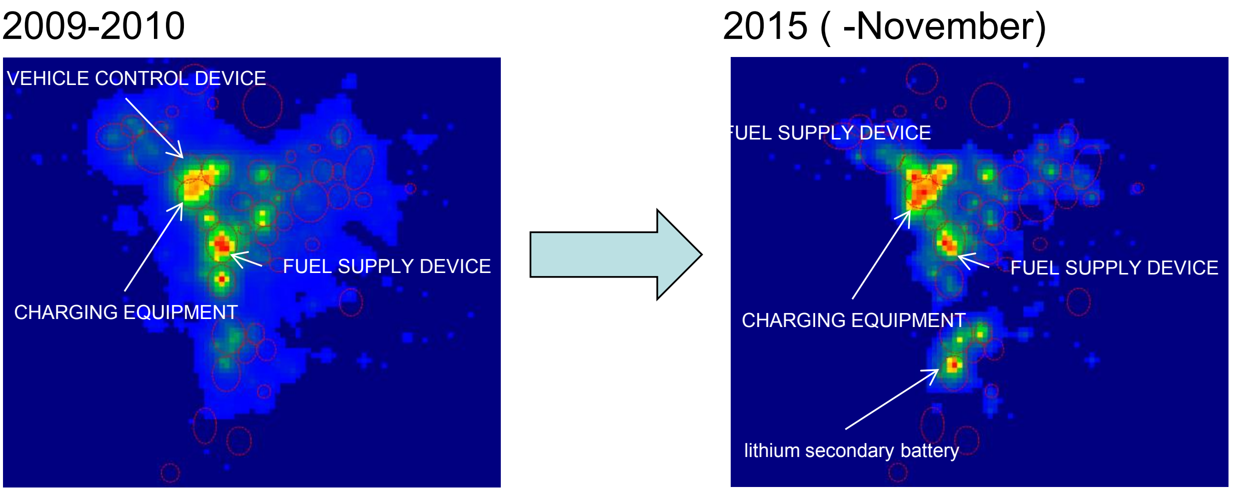
However, as we discuss later in this report, Toyota is gradually starting to abandon its penchant for self-sufficiency, as evidenced by its collaboration with a US research institution in the field of AI. In fact, it is actually Toyota Group suppliers, which were previously able to easily generate profits thanks to Toyota's production volume, that now appear unprepared for discontinuous (disruptive) innovation and are thus at risk of being negatively impacted by the coming structural changes.

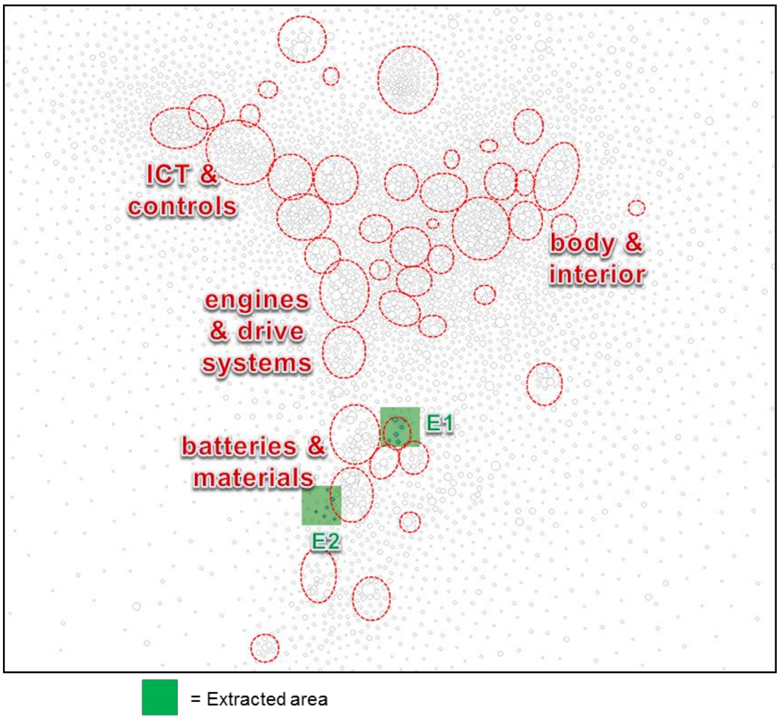
Figure 3-9: Published automotive patents of Toyota and its key suppliers



Source: Joint research by Valuenex and MUMSS

Figure 3-10: Areas in which Toyota's patent applications are up sharply (fields highlighted in green)





Nascent technology domain extraction parameters

- **Mesh size:5**
- **Patent publication incidents in mesh: 15+**
- **Slope of regression line of patent publication incidents since 2005: 0+**
- **Percentage of patent publication incidents since 2011: 60%+**
- **Patent publication incident peak observed in 2014-15**

Source: Joint research by Valuenex and MUMSS

Figure 3-11: Areas in which Toyota's patent applications are up sharply (E1)

■ Sample title (JP2015179760A)

Semiconductor module

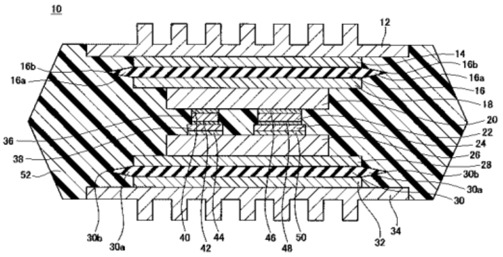
■ Coincident terms

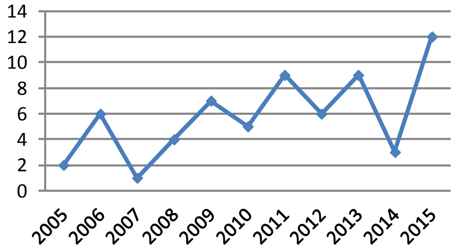
substrate, semiconductor layer, trench, semiconductor device, semiconductor substrate

■ Description (Excerpts or machine translations of Japan Patent Office publications)

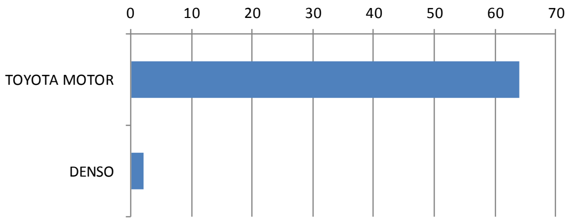
A damage-resistant ceramic substrate for semiconductor modules

■ Diagram





Number of patent publications in the domain range



Number of patent publications in the domain range by applicant

Source: Joint research by Valuenex and MUMSS

Figure 3-12: Areas in which Toyota's patent applications are up sharply (E2)

■ Sample title (WO2015037490A1)

Method for producing sulfide solid electrolyte

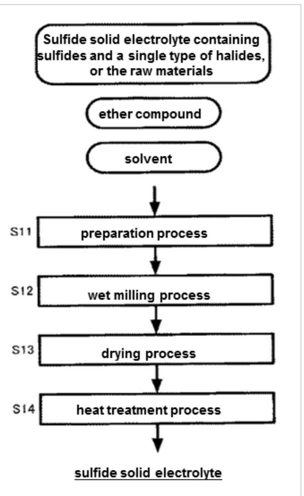
■ Coincident terms

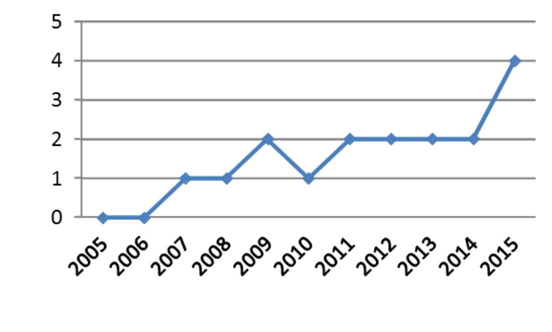
sulfur, electrolyte, electrode, ion conductor, lithium

■ Description (Excerpts or machine translations of Japan Patent Office publications)

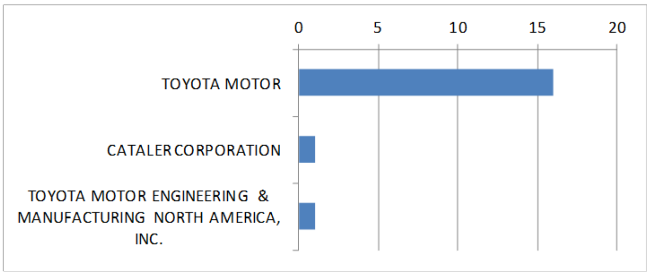
A sulfide solid electrolyte manufacturing method that is able to maintain high productivity and recovery rates during the manufacture of sulfide solid electrolyte with enhanced ionic conductivity.

■ Diagram





Number of patent publications in the domain range



Number of patent publications in the domain range by applicant

Source: Joint research by Valuenex and MUMSS

4. Who will control discontinuous innovation? A birds-eye view of technology patents in Japan, Europe, and the US

Discontinuous (disruptive) innovation is getting closer by the day, but what are automakers and automotive parts suppliers doing to prepare? And who will emerge victorious when discontinuous innovation arrives?

To tackle this large topic, we use global patent information to present an overview of the various strategic approaches of automotive companies. The principal objective of this report is not necessarily to predict whether certain companies' share prices will rise or fall. Neither is it our objective to predict the kinds of vehicles that are being developed and likely to be on the market in five years, nor whether those vehicles are likely to sell or not.

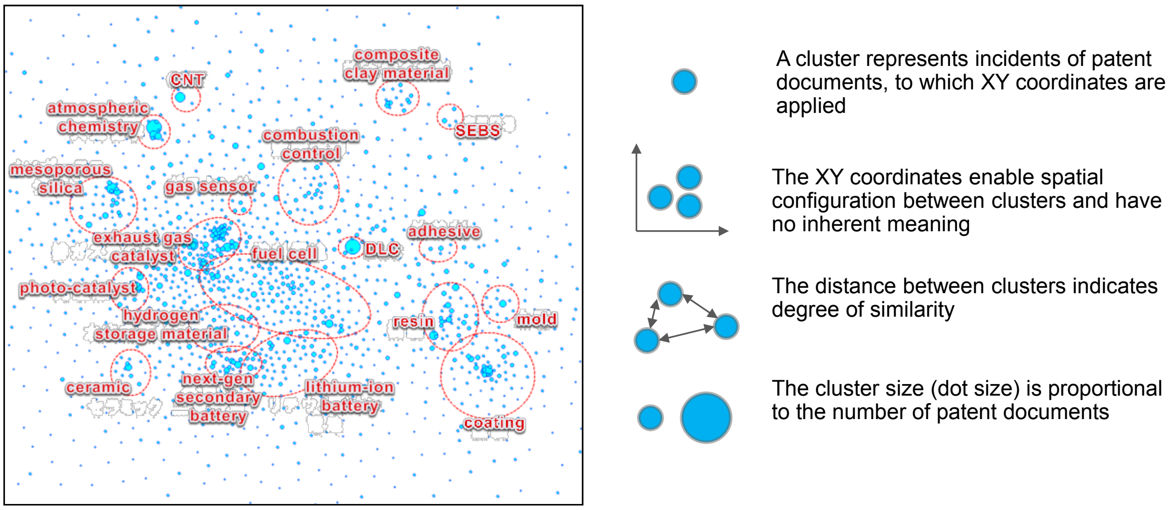
Instead, by presenting an overview of the new technologies that will likely be incorporated in future automobile development, this report is intended as a reference paper for discussing and evaluating the direction of the auto industry over the next 5–10 years, the technology development strategies of the various players, and the differences in those strategies.

4-1. Using US, Japanese, and European patent information to plot a technology map

Using patent information to plot an automotive technology map and summarize general industry trends, individual company strategies, and companies' strengths and weakness in specific technology domains

Based on automotive-related patent information registered in Japan, the US, and Europe, we attempt to plot an automotive technology map and analyze it by time, manufacturer, and function. For this analysis, in which we received the full cooperation of Valuenex, we conducted a random sampling of roughly 100,000 patent documents (from a universe of over 2mn), categorized them by content similarity, and created a birds-eye patent map for two-dimensional visualization. The map shows a general overview of the technology fields included in our patent sample, as well as the linkages among those various fields of technology. Additionally, along with showing the fields in which large numbers of patents have been filed, the map simultaneously shows the areas in which there is relatively little patent application activity.

Figure 4-1. Interpreting the technology patent map



Source: Valuenex

Patent information is represented as clusters by dots. Cluster size (dot size) indicates the number of patent documents in the related field of technology, while the spacing between clusters indicates the degree of similarity and/or linkage between those technologies. Accordingly, as shown in the samples in Figure 4-1, the X and Y axes have no bearing whatsoever on the overall dispersion of clusters in the map; clusters are merely arranged in “clumps” according to the mutual association of the technology patents.

By next conducting a time-series analysis of the data, we get a general idea of how the auto industry’s focus with respect to technology development has shifted. Since the normal vehicle model cycle is around five years, cars currently in development are slated to be released for sale five years from now. Accordingly, this technology map likely represents the technologies that companies are working on (investing in R&D) for products that will hit the market in 5–10 years.

Overlapping clusters (dots) indicate the degree of technology concentration, and by coloring the dots according to degree of concentration, we can turn our 2-D map into a 3-D map. Because this improves the visual clarity of the map, we use it sequentially in this report as well.

Meanwhile, in addition to a birds-eye map of the industry as a whole, we can also create technology maps for individual companies and maps for inter-company comparisons in order to more easily visualize differences in R&D direction, differences in technology coverage, and also characteristics by country and corporate group.

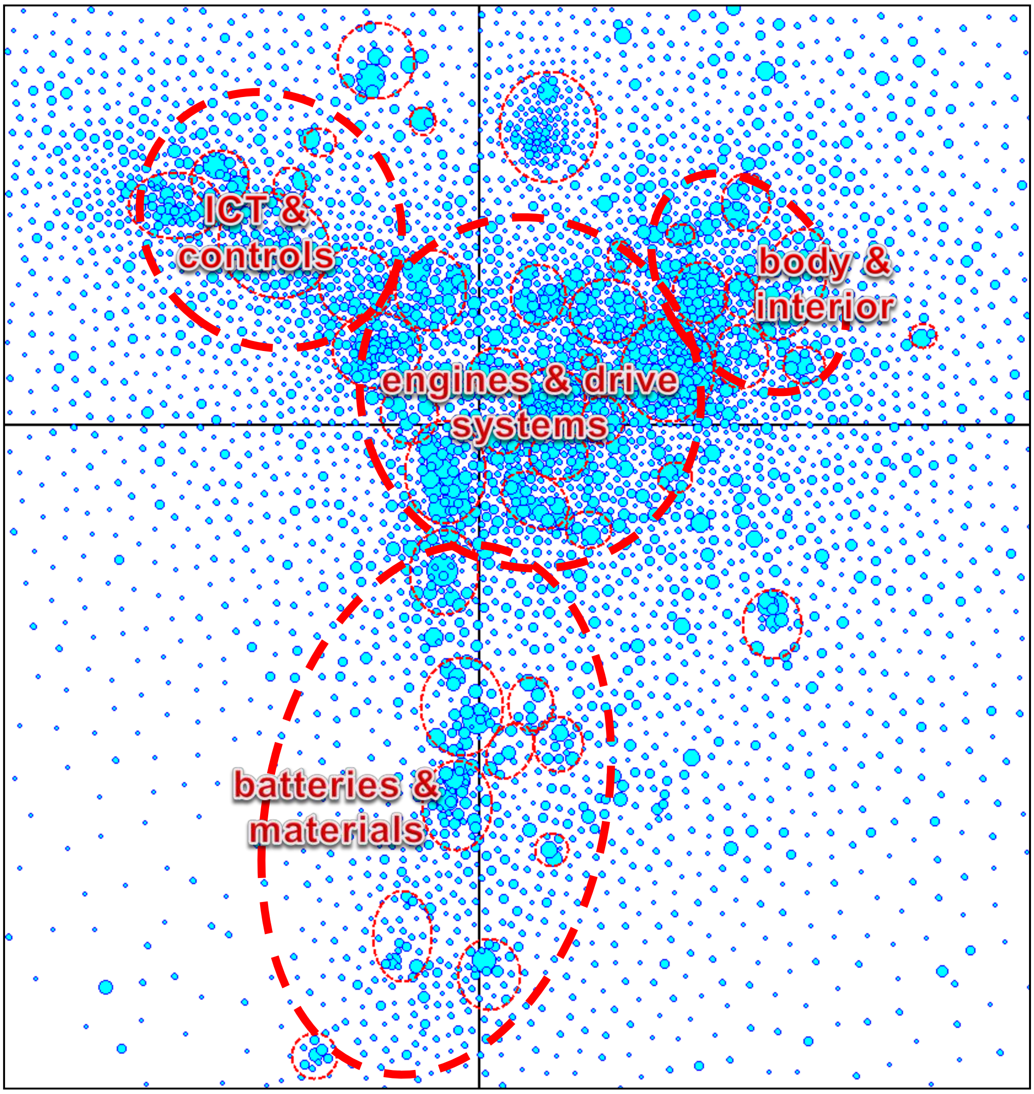
In the following pages, we attempt this multifaceted analysis and present our outlook for future developments.

4-2. Automotive technology map can be divided into four domains

Overview of the past decade's automotive-related patents

Conducting a birds-eye analysis of automotive-related patents filed in Japan and overseas over the past decade, it is our impression that automotive technology can be broadly divided into four major domains (engines & drive systems, body & interior, ICT & controls, batteries & materials), and the map itself actually looks incredibly similar to a map of the Americas (Figure 4-2).

Figure 4-2. Birds-eye view of automotive technology patents



Source: Joint research by Valuenex and MUMSS

ICT and control-related technology is concentrated in the area corresponding to Alaska on a map of North America, and this shows not only that the number of patent filings in this domain has risen sharply in recent years, but also that the number of players from non-automotive industries has increased sharply as well.

On the other hand, technology is also increasing in the batteries and materials domain, whose position corresponds to the location of Central and South America, and patent registrations for primary and secondary batteries, as well as for related materials, are up dramatically. The keys to rapid advancement of electric automobiles are reducing battery production costs and improving their energy density, and therefore patent application activity related to materials technology necessary to accomplish those objectives is something that should be monitored closely going forward. In fact, three of the five technology clusters with the sharpest increase in published patent counts in recent years fall within the batteries and materials technology domain, which indicates that this domain is currently the target of vigorous development activity.

In Figure 4-3 we present a heat map version of this birds-eye view by adding colors to represent cluster density. Individual company heat maps can be represented in two forms: “uniform standard for all companies”, which is calculated based on the distribution of absolute counts under a uniform density standard; and “individualized standard”, which is calculated in relative terms with each individual company’s maximum density level as the standard.

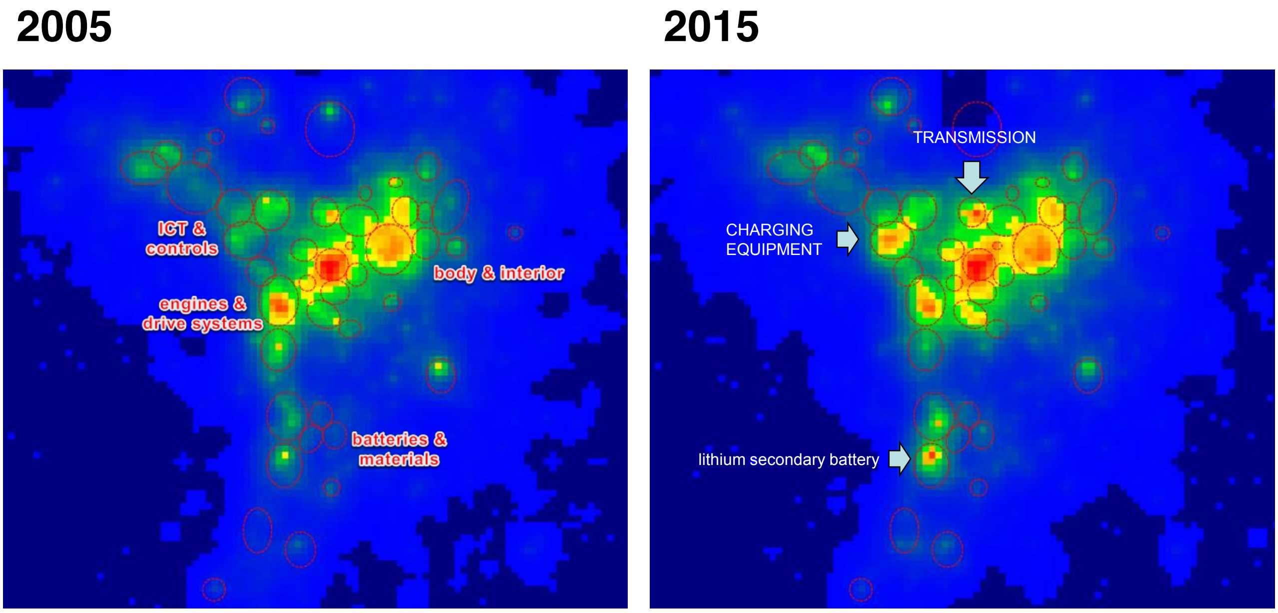
Additionally, by conducting a time-series analysis of the technology birds-eye view, we can see which technology domains are attracting increased activity, and we can confirm these trends for the industry as a whole as well as for individual companies.

In the second half of the 2000s, activity was particularly high in the engines and drive systems domain, especially in the areas of electric valves and fuel supply devices, but so far this decade, particularly since 2012, we have seen a dramatic uptick in development activity in charging equipment, lithium secondary batteries, and other technologies related to electric vehicles. The overall number of registered PHEVs and EVs has been rising steadily since around 2011, and we assume the number of related technology patent applications is also rising as a result.

Generally speaking, the focus of technology development is expanding outward from traditional domains like mechatronics to fields such as ICT, communications, and new materials, and we think this is driving the increase in development manhours at automakers (= increased R&D costs), which is recently mentioned as a serious issue.

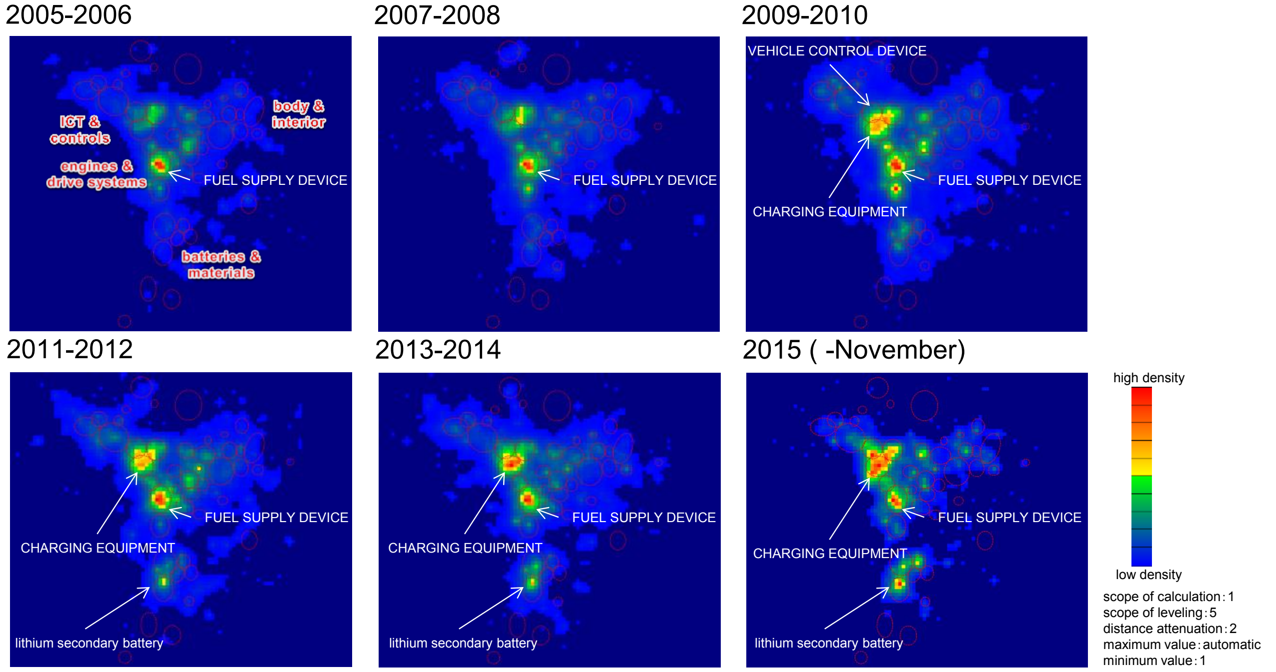
Meanwhile, in Figure 4-4 we show how Toyota’s development focus has changed over time. The focus of Toyota’s patent activity has clearly shifted from engines and drive systems to batteries, charging equipment, and materials. Recently, Toyota’s patent density has increased particularly in the ICT and control technology domain.

Figure 4-3. Increasing diversity of automotive-related technology



Source: Joint research by Valuenex and MUMSS

Figure 4-4. Case study: Birds-eye view (heat map) of Toyota's patent activity (shift in focus area)



Source: Joint research by Valuenex and MUMSS

4-3. Technology development trends among Japanese and European automakers and suppliers

In Europe, technology development spearheaded by suppliers rather than automakers

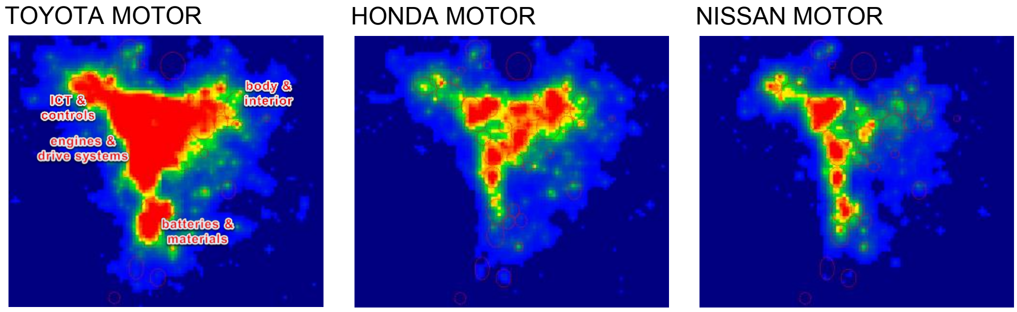
A key difference in the auto industry structures of Japan and Europe can be seen in the respective complementary relationships between major automakers and their suppliers with respect to technology development. In Japan, automakers and their affiliated parts suppliers typically oversee the bulk of technology development themselves. In Europe, however, automakers do not conduct omnidirectional technology development themselves; instead, the bulk of development is handled by suppliers, including independent suppliers.

4-4. Major Japanese, German, and US automakers

Toyota focusing on fuel supply devices; Honda evenly in most domains; Nissan less active in body/interior domain

Japan's three largest automakers (Toyota, Honda, Nissan) generally carry out development across all technology fields (omnidirectional development). If we compare the three based on a uniform standard, we see that Toyota, which has the most published patents, has by far the most extensive development coverage (Figure 4-5).

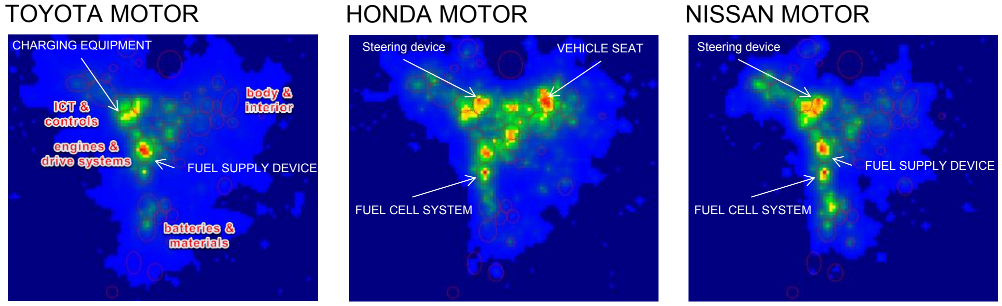
Figure 4-5. Technology coverage of Toyota, Honda, and Nissan (uniform standard)



Source: Joint research by Valuenex and MUMSS

When we compare them based on an individualized standard, however, each automakers' unique characteristics come into view. While Toyota's principal focus is on technologies related to fuel supply devices, Honda's development activities tend to be broader in scope. Nissan also tends to carry out development across a relatively wide range of technology domains, but is relatively inactive in the auto body and interior domain.

Figure 4-6. Technology coverage of Toyota, Honda, and Nissan (individualized standard)

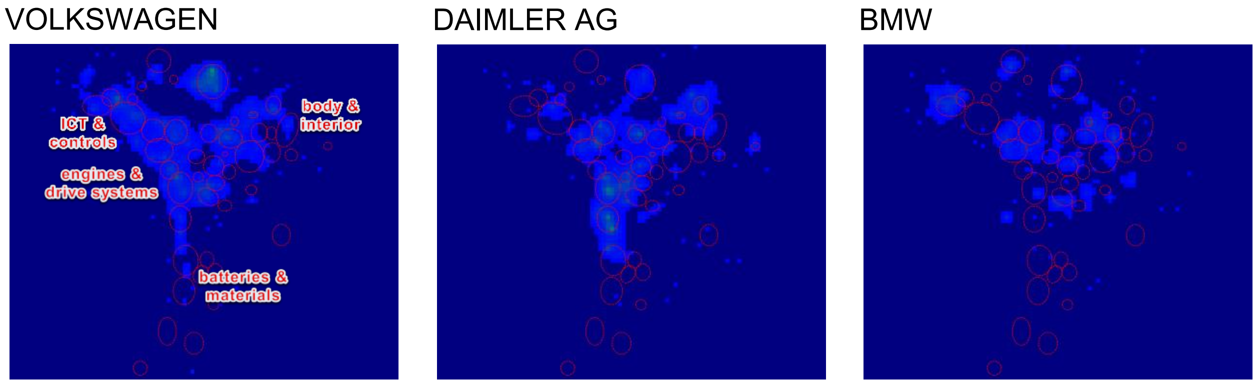


Source: Joint research by Valuenex and MUMSS

In Germany, development approaches differ by automaker

The development approaches of Germany's three largest automakers (VW, Daimler, BMW) are similar to Honda's in that they all have good coverage over a broad spectrum of technology domains, but owing in part to low absolute patent counts, differences are difficult to see based on the uniform standard (Figure 4-7).

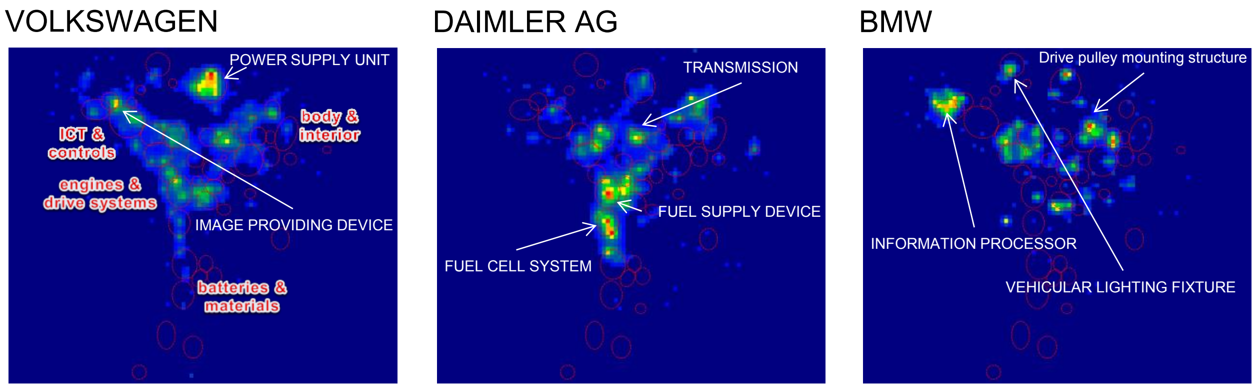
Figure 4-7. Technology coverage of VW, Daimler, and BMW (uniform standard)



Source: Joint research by Valuenex and MUMSS

On the other hand, the differences become clearer when we compare the automakers based on the individualized standard (Figure 4-8). Here, we see that VW's focus is on power supply units and image providing devices; Daimler's focus is on fuel supply devices and fuel cell devices; and BMW is focused on information processors.

Figure 4-8. Technology coverage of VW, Daimler, and BMW (individualized standard)

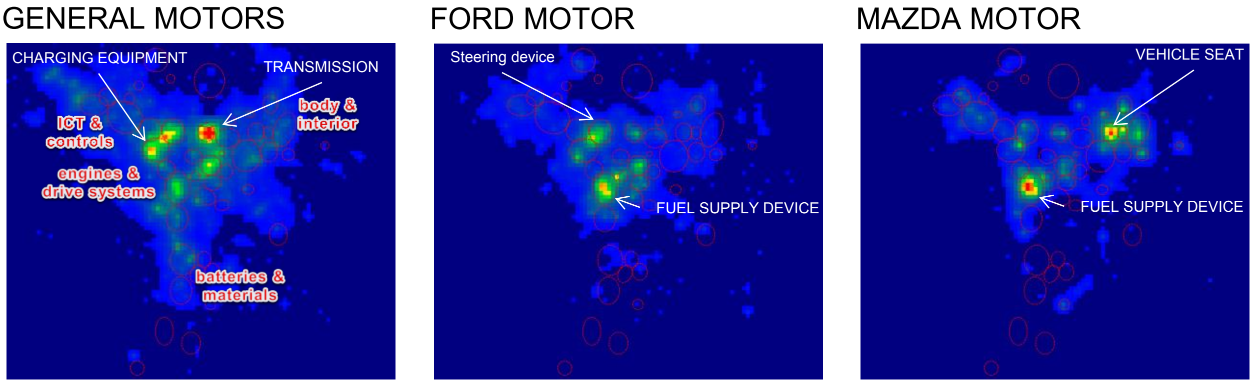


Source: Joint research by Valuenex and MUMSS

Areas of focus differ among US automakers as well

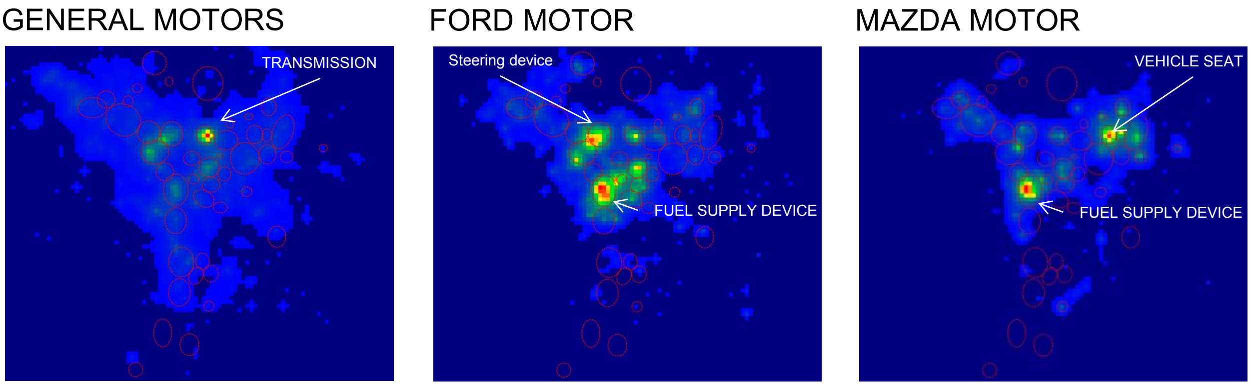
Major US automakers GM and Ford, along with Japanese automaker Mazda, all have different areas of focus. GM's main field of emphasis is transmissions. Ford and Mazda are both focusing particularly on the field of fuel supply devices, but Ford is also focusing on steering devices while Mazda's other area of emphasis is vehicle seats.

Figure 4-9. Technology coverage of GM, Ford, and Mazda (uniform standard)



Source: Joint research by Valuenex and MUMSS

Figure 4-10. Technology coverage of GM, Ford, and Mazda (individualized standard)



Source: Joint research by Valuenex and MUMSS

4-5. Toyota Group exhibits strength in all technology domains

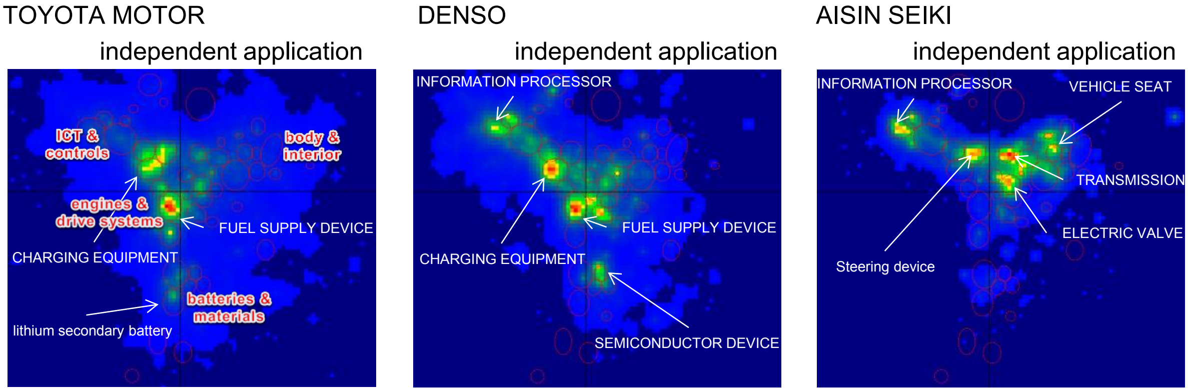
The Toyota Group's technology coverage is extremely broad. Meanwhile, in priority domains, we see great potential by leveraging Denso's unique strengths

On a group level (including affiliated suppliers), there is some overlap in the development activities of individual Toyota Group suppliers and the broad technology development coverage of Toyota Motor, but on the whole, group development activities are generally complementary.

Patent applications filed solely by Toyota Motor are concentrated in the fuel supply devices and charging equipment domains, so there is significant overlap with applications filed solely by Denso. On the other hand, applications filed solely by Aisin Seiki are largely concentrated in the transmissions and electric valves domains.

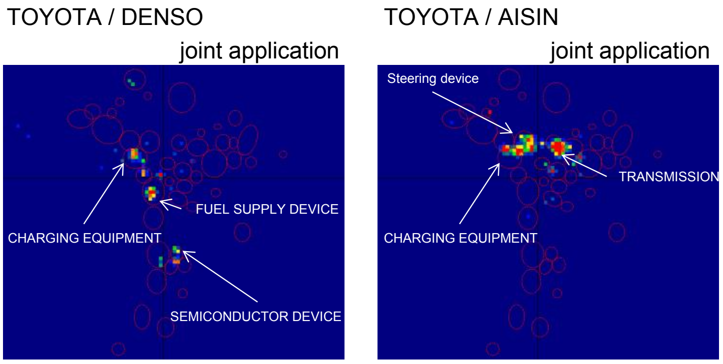
Both Denso and Aisin Seiki have independently filed numerous patent applications in the information processor domain, particularly navigation devices. Recently, however, Denso's focus is mainly on dynamic mapping technology such as map difference data distribution devices, and human-machine interface (HMI) technology such as communication delay prediction devices, while Aisin Seiki is focused mainly on parking assist and driving support systems.

Figure 4-11. Tech development coverage of Toyota, Denso, and Aisin Seiki (Individualized standard)



Source: Joint research by Valuenex and MUMSS

Figure 4-12. Toyota, Denso, and Aisin Seiki's joint patent applications (individualized standard)



Source: Joint research by Valuenex and MUMSS

Patent applications filed jointly by Toyota Motor with Denso or with Aisin Seiki are mainly limited to the fuel supply devices and transmission domains. In fields such as lithium secondary batteries, Denso and Aisin Seiki have filed few applications independently, suggesting that this is a technology domain in which Toyota prefers to maintain control.

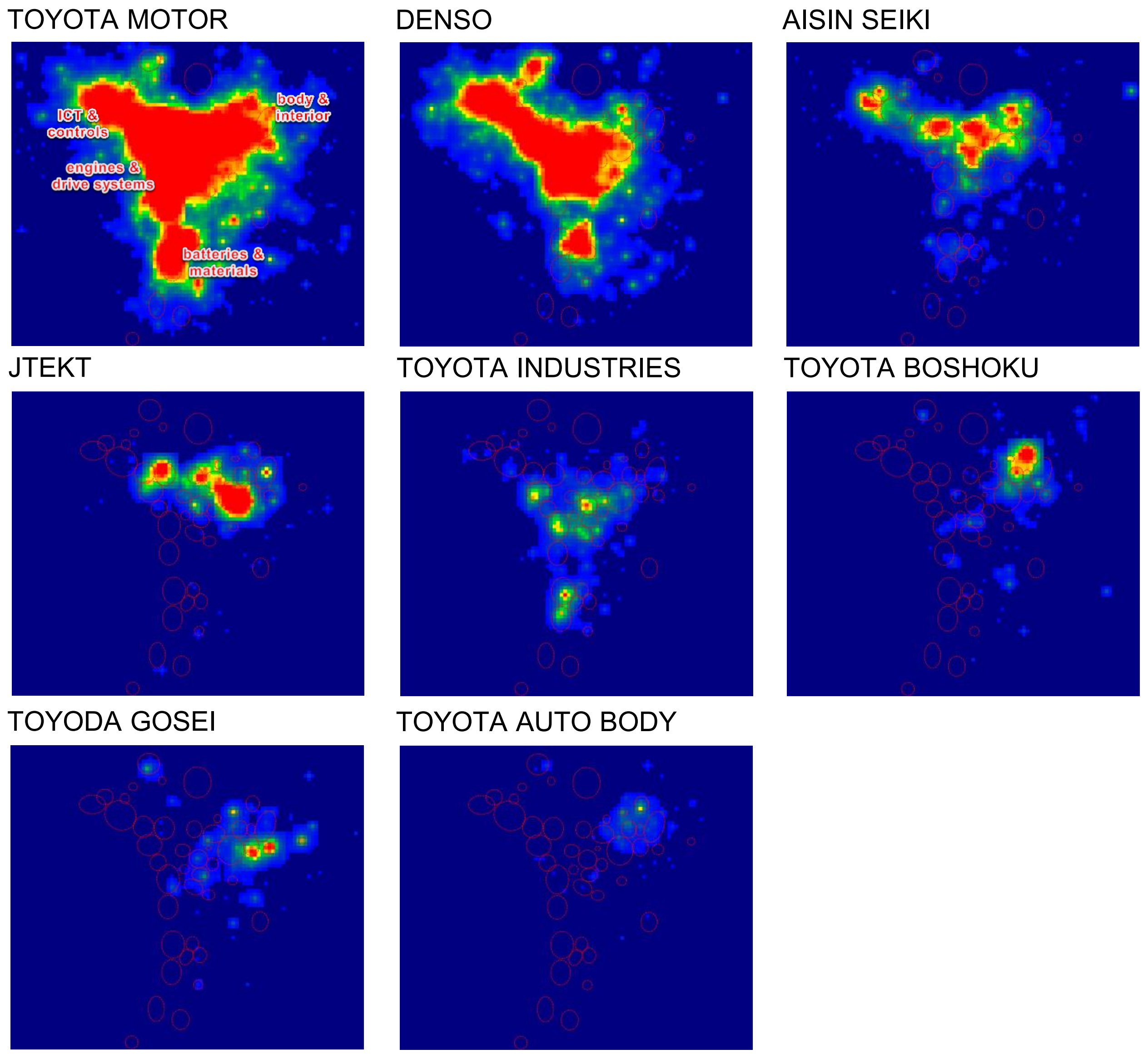
In short, the Toyota Group is characterized by broad technology coverage coupled with depth in fields deemed particularly important, and in terms of technology development competitiveness, we believe Toyota is a step or two ahead of other global automotive groups.

However, such a conclusion is possible only if one assumes that Toyota Group suppliers have the affinity to cooperate fully and Toyota has a system in place for this kind of cooperative and complementary relationship to continue going forward.

Among certain suppliers, overlapping existence is allowed within the group, which hinders efficient management. The Toyota Group has a history of skillfully managing the delicate balance between “centripetal force”, with Toyota Motor as the nucleus, and “centrifugal force”, aimed at leveraging economies of scale through the growth of non-Toyota businesses. Unfortunately, there is no guarantee that this management strategy will continue to be effective in an era of mega-competition.

At the very least, in an environment of discontinuous innovation, an entirely different set of players could completely change the rules of the game—or even the game itself, and will likely establish new standards featuring state-of-the-art devices and software. For example, if Google or Microsoft were to standardize an automobile OS much like cell phone OS, then develop/select devices and applications that fully utilize that OS, thus creating a world in which the level of manufacturing value added in the auto industry is reduced in relative terms, the status of the world's traditional automakers—including the Toyota Group—could be threatened.

Figure 4-13. Technology development emphasis of Toyota and its key suppliers (uniform standard)

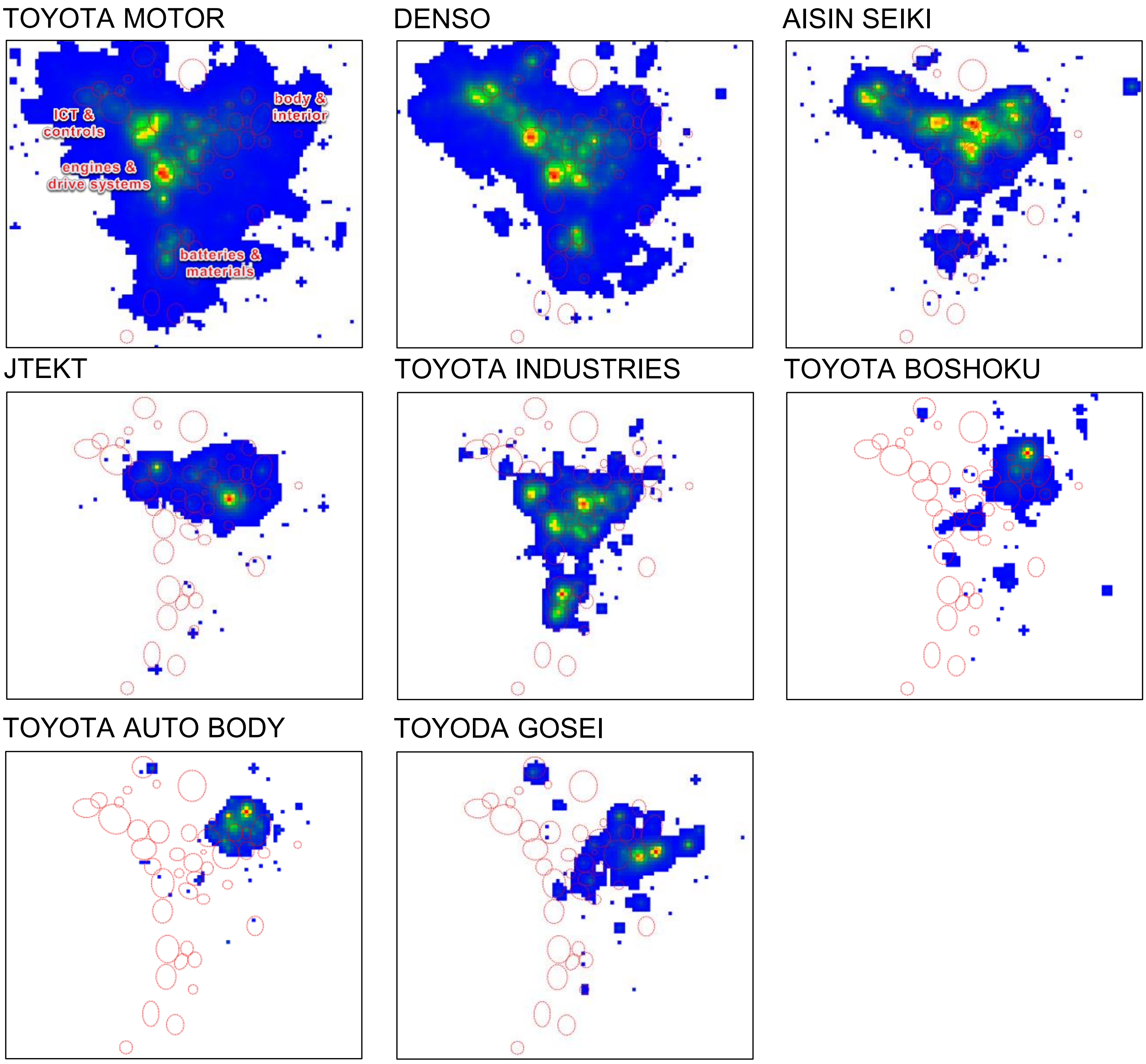


Source: Joint research by Valuenex and MUMSS

Even if the breadth of coverage of the Toyota Group's combined technology map, which aims to attain group self-sufficiency, and its depth of coverage in priority domains give Toyota a relative competitive advantage, the value of that advantage will not be worth much unless the organic fusion of those elements produces a chemical reaction to generate sufficient energy to create a new world.

In this sense, an extremely important question going forward is what kind of group strategy the Toyota Group needs to pursue in order to thrive in an era of mega-competition. This, along with the internal reorganization moves recently announced by Toyota Motor, should be watched very closely.

Figure 4-14. Technology development emphasis of Toyota and its key suppliers (individualized standard)



Note: Here we use a white background (instead of blue) to emphasize the areas in which technology development is concentrated.
Source: Joint research by Valuenex and MUMSS

4-6. Honda Group's strength is not omnidirectional

Honda's areas of focus overlap with those of its affiliated suppliers

Regarding the Honda Group, on the other hand, the group's scope of technology development is broad, but it is our impression that its relative competitiveness is limited mainly to traditional technology domains. Meanwhile, as there is not much division of labor or complementary development between Honda and its suppliers, the group employs a top-down, centralized development structure headed by Honda R&D Co., Ltd.

In other words, Honda's Achilles heel is the development capacity of Honda R&D, which ultimately hinges on Honda's topline growth momentum. Over the past decade, Toyota has increased its global sales volume from 4mn vehicles to 10mn, but Honda's sales volume is basically stuck at around 4mn vehicles. Accordingly, with respect to scale of R&D investment, Honda has now fallen far behind Toyota.

We are skeptical whether Honda's development approach that lets affiliated suppliers specialize in R&D of applications while Honda itself carries out basic research is sufficient for Honda to survive in the era of mega-competition.

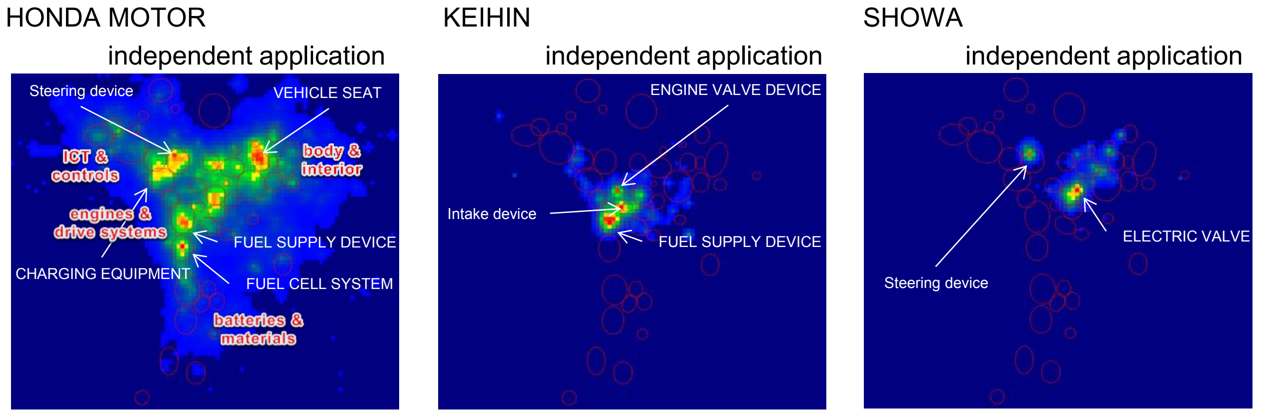
If a company is forced to be selective and limit its R&D activity to fields with the greatest prospects for commercialization, it risks falling way behind in technology/product development and losing its relative competitiveness in the event the market moves in an unexpected direction.

We will be watching to see whether, going forward, Honda maintains a closed development architecture like the Toyota Group's, or decides to follow the lead of Nissan, which has adopted a European-style open development architecture through its collaboration with Renault.

Honda's sole patent applications span a broad spectrum, from fuel cell systems and fuel supply devices, to vehicle seats and steering devices. Keihin's and Showa's areas of emphasis tend to overlap Honda's, with Keihin focusing mainly on fuel supply devices and Showa on electric valves and steering devices.

Neither Keihin nor Showa have a significant number of joint applications with Honda.

Figure 4-15. Tech development coverage of Honda, Keihin, and Showa (individualized standard)



Source: Joint research by Valuenex and MUMSS

4-7. Nissan: Focused on priority domains, with complementary development within group and by independent suppliers

Nissan shares development responsibilities with affiliated suppliers

Nissan Motor's sole patent applications are broad in scope, ranging from fuel cell systems and fuel supply devices to steering devices, but it has filed relatively few patents in the auto body and interiors domain. Calsonic Kansei's applications tend to be concentrated in areas where Nissan itself has few applications, including vehicle cooling systems, intake devices, and electric valves, so there is little overlap with Nissan. Similarly, most of JATCO's patent applications are related to transmissions, another area in which Nissan has relatively little coverage.

We were unable to find any joint applications by Nissan and Calsonic Kansei. Most of the applications filed jointly by Nissan and JATCO are related to transmissions.

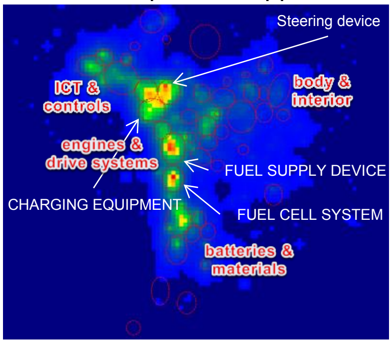
In addition to sharing development responsibilities with Renault, Nissan Motor also outsources development of certain key devices to Nissan Group suppliers or major independent suppliers, and in this way has established a relatively efficient system for supplementing technology.

On the other hand, once the era of discontinuous innovation arrives, there is no guarantee that Nissan will be able to incorporate the resulting state-of-the-art technology solutions into its own vehicles faster than its rivals can. Looking back on Renault's slow start in adopting next-generation diesel engines from 2000 onward, we believe this risk merits constant consideration, and thus it will be essential for Nissan to establish and maintain close relationships with its outside suppliers.

Figure 4-16. Technology development coverage of Nissan, Calsonic Kansei, and JATCO (individualized standard)

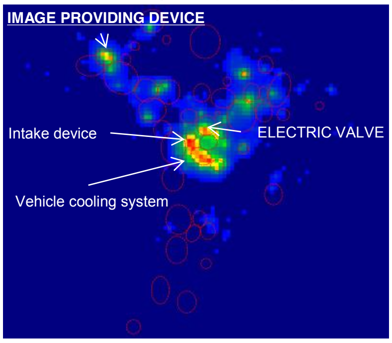
NISSAN MOTOR

independent application



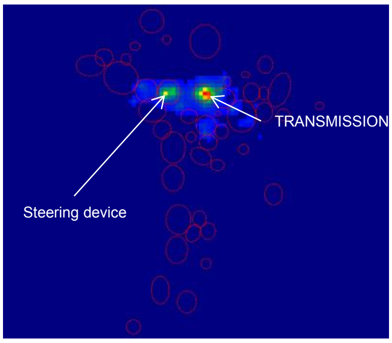
CALSONIC KANSEI

independent application



JATCO

independent application



Source: Joint research by Valuenex and MUMSS

4-8. Major US automakers and suppliers

Like Japanese automakers, GM and Ford also carry out omnidirectional development

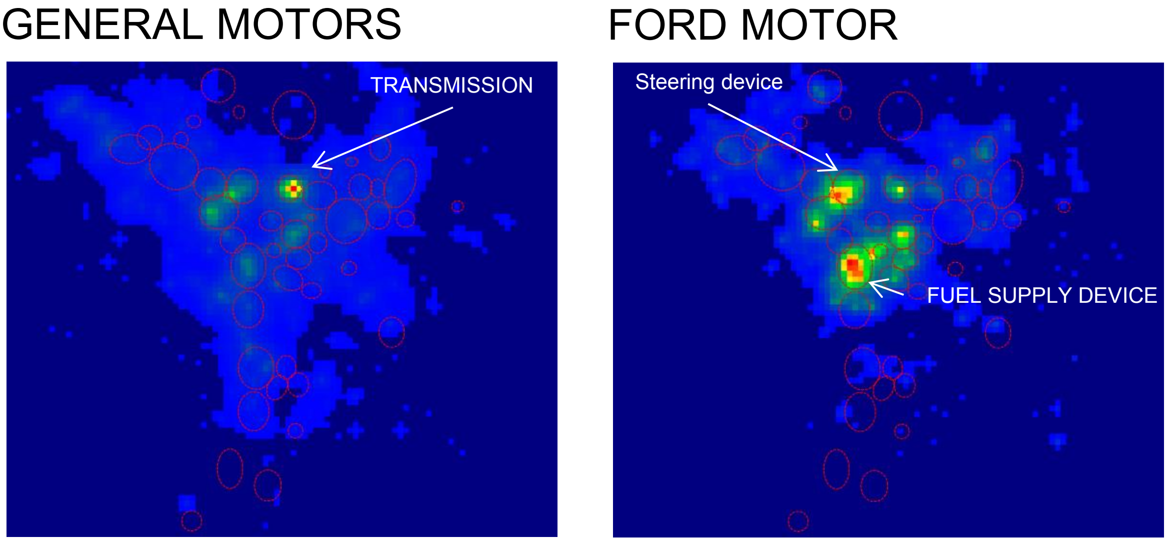
Like their Japanese counterparts, the two major US automakers (GM and Ford) also carry out omnidirectional technology development, and this is particularly true of General Motors.

Both automakers have particular areas of emphasis, with GM focusing mainly on transmissions while Ford is focused particularly on fuel supply devices and steering devices.

In certain technology domains, suppliers supplement development

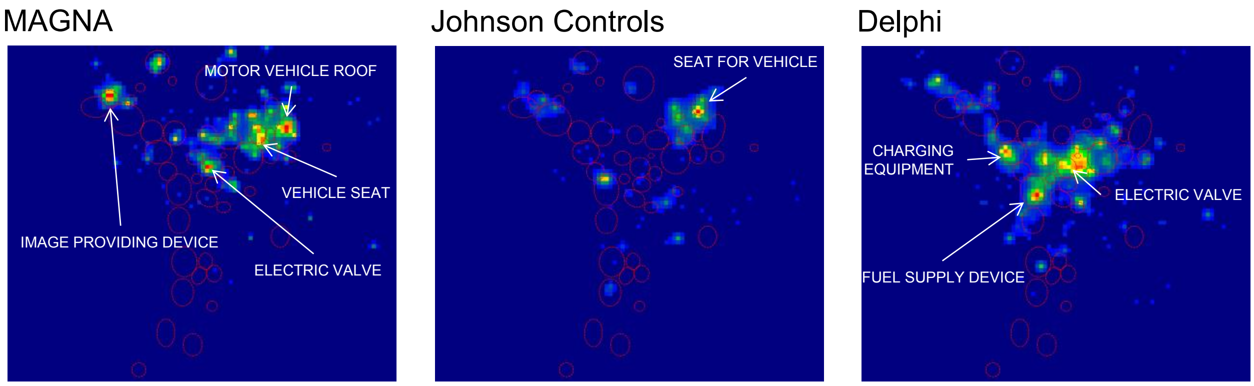
Compared with their suppliers, US automakers—like Japanese automakers—tend to be stronger in omnidirectional technology development, but in certain domains suppliers supplement automakers' technology development activities.

Figure 4-17. Technology development coverage of GM and Ford (individualized standard)



Source: Joint research by Valuenex and MUMSS

Figure 4-18. Technology development coverage of MAGNA, Johnson Controls, and Delphi (individualized standard)



Source: Joint research by Valuenex and MUMSS

4-9. Major European automakers and suppliers

VW, Daimler, and BMW have less technology development coverage

In terms of omnidirectional technology development, three major European automakers (VW, Daimler, BMW) trail behind their US and Japanese counterparts. This is particularly true of BMW, which has sparse patent application coverage in several technology domains.

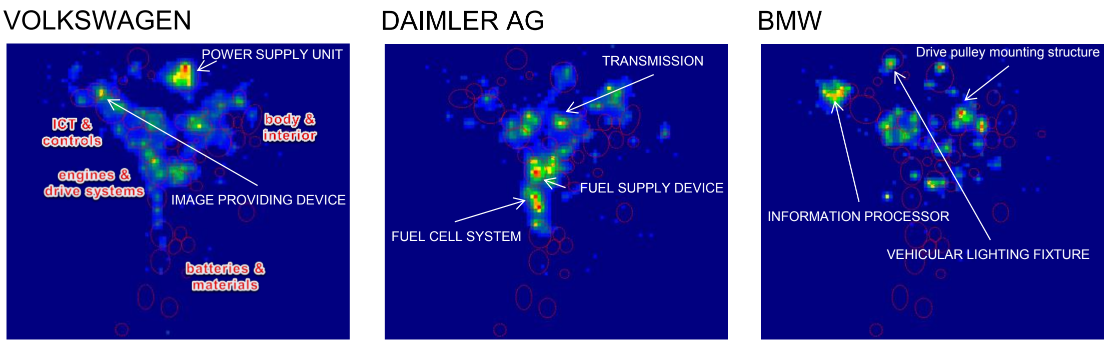
Bosch contributes omnidirectional technology development

On the other hand, some major European suppliers, most notably Bosch, carry out broad-ranging technology development to supplement the development activities of Europe's major automakers.

European firms take different approach to technology development

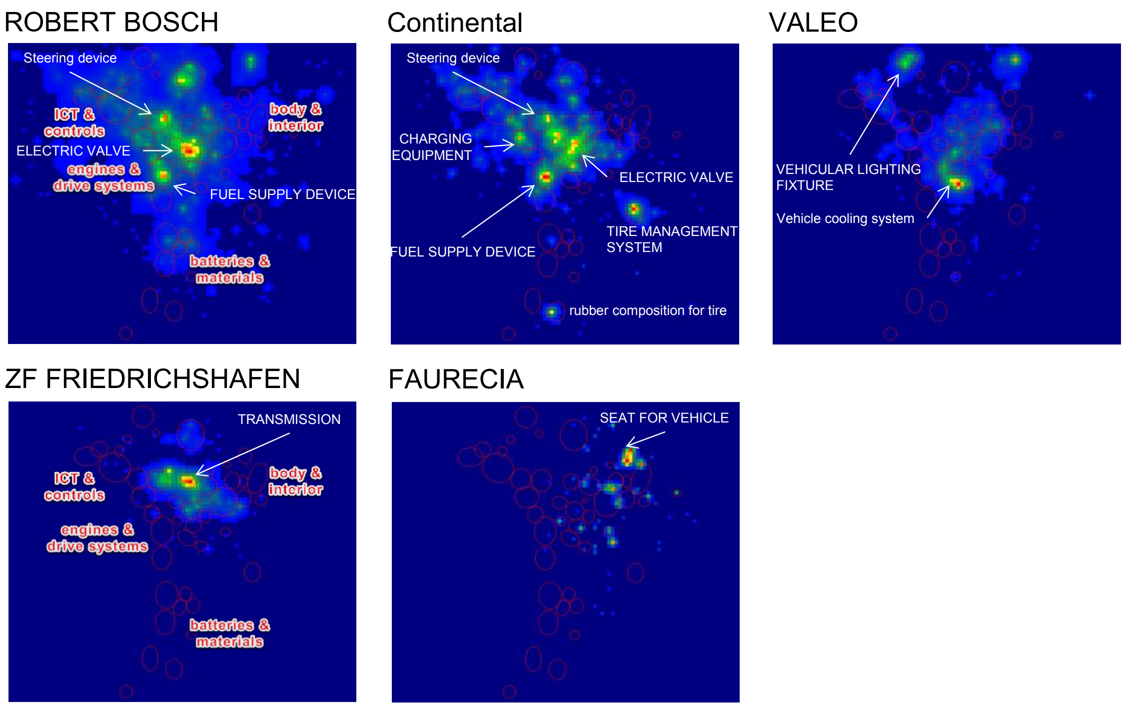
In short, while US and Japanese automakers tend to be directly involved in many different fields of technology development, the situation is different in Europe's auto industry, where automakers typically do not engage in omnidirectional development themselves, but instead rely on mega suppliers (including independent suppliers) to supplement technology development.

Figure 4-19. Technology development coverage of VW, Daimler, and BMW (individualized standard)



Source: Joint research by Valuenex and MUMSS

Figure 4-20. Technology development coverage of European suppliers (individualized standard)



Source: Joint research by Valuenex and MUMSS

4-10. Toyota vs. the European auto industry

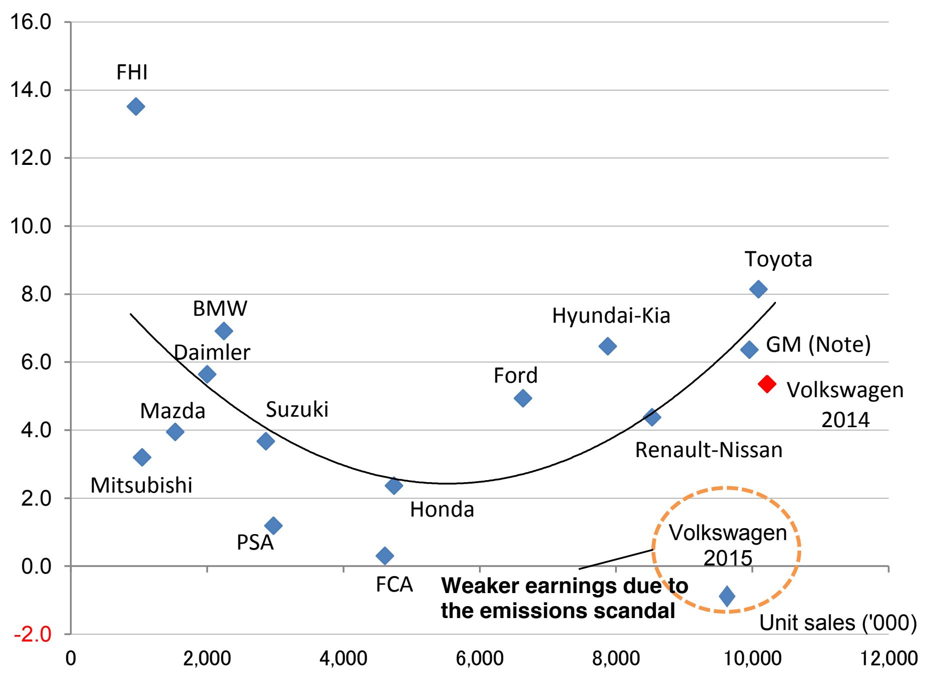
From Toyota's perspective, competitors with high profit margins are VW, BMW, and Daimler

Automakers with high profit margins basically fall into two distinct groups: those with annual sales of at least 10mn vehicles (10mn Club; right-hand side of the figure), and those with sales of around 2mn vehicles (2mn Club; left-hand side).

Considering that Mazda and Fuji Heavy Industries—two members of the 2mn Club with high profit margins—both have deep relationships with Toyota Motor, then it is fair to say that from Toyota's perspective, its only true rivals with high profit margins are European automakers like VW, BMW, and Daimler.

Here we examine the focus of technology development in the European auto industry, and clarify the key areas in which they potentially pose a threat to Toyota.

Figure 4-21: Automakers' sales volumes versus NP margins (FY2015)



Note: In FY12/15 GM booked deferred tax assets (reversal of assessed reserves) of USD3,957mn related to its European operations. We estimate that GM's NP margin would have been 3.8% excluding this item. To derive the approximation curve, for Volkswagen we use 2014 data and exclude 2015 data.

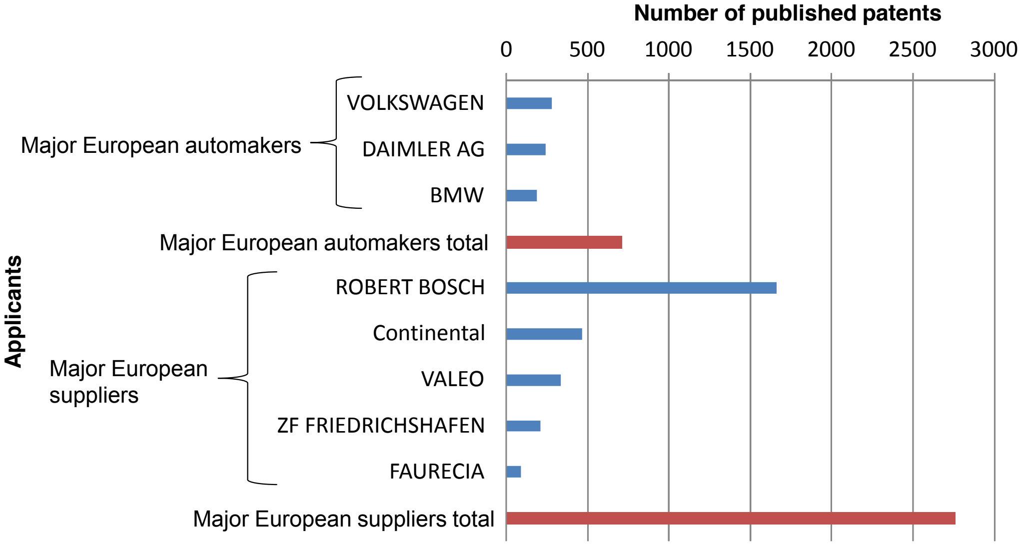
Source: MUMSS, based on individual company data

4-11. Bosch plays a key role in automotive technology development in Europe

In Europe, suppliers file far more patent applications than do automakers

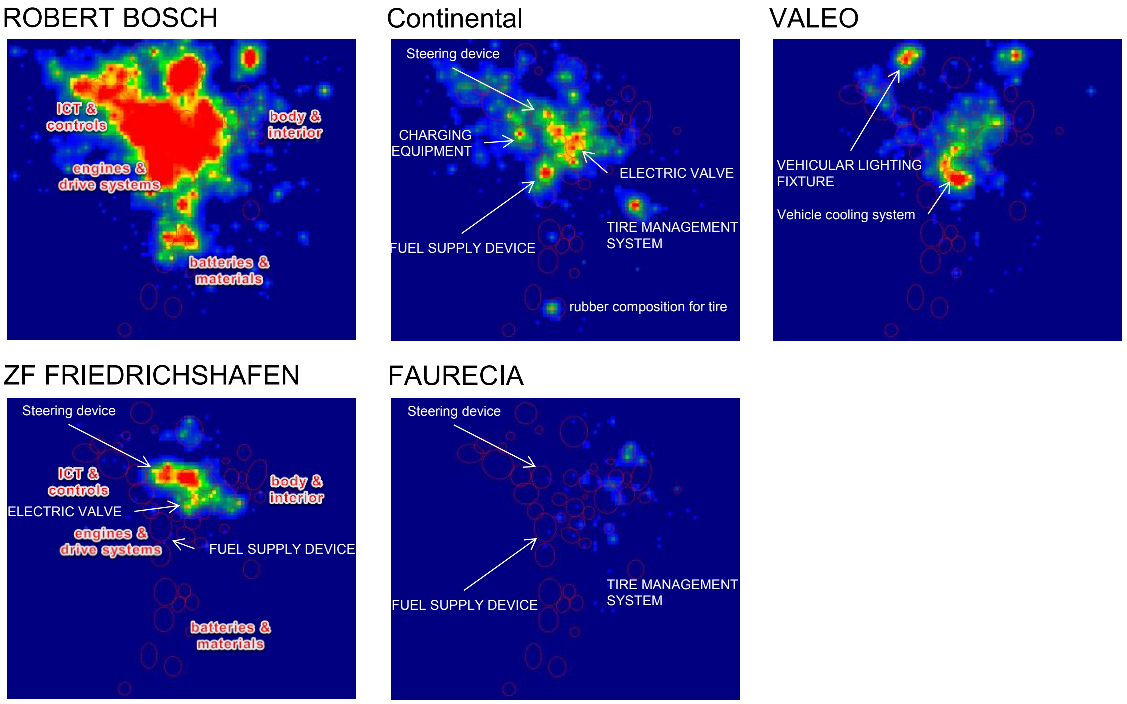
In Europe, the number of patents published by major suppliers far surpasses those published by the major automakers. Bosch has a particularly large number of published patents, and its coverage of technology domains is extensive as well. As such, we can say that Bosch plays the leading role in technology development in the European auto industry.

Figure 4-22: Published automotive patents by major European automakers and suppliers



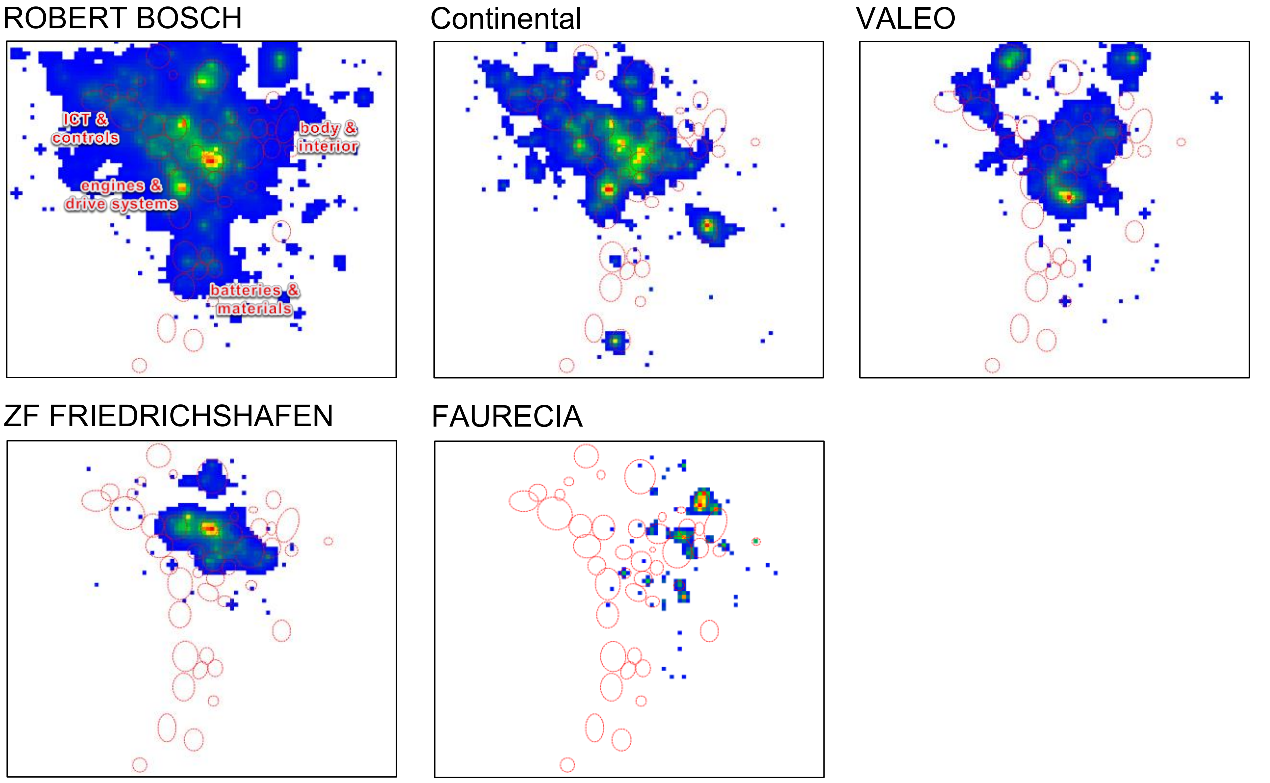
Source: Joint research by Valuenex and MUMSS

Figure 4-23. Technology development coverage of major European suppliers [uniform standard]



Source: Joint research by Valuenex and MUMSS

Figure 4-24. Tech development coverage of major European suppliers [individualized standard]



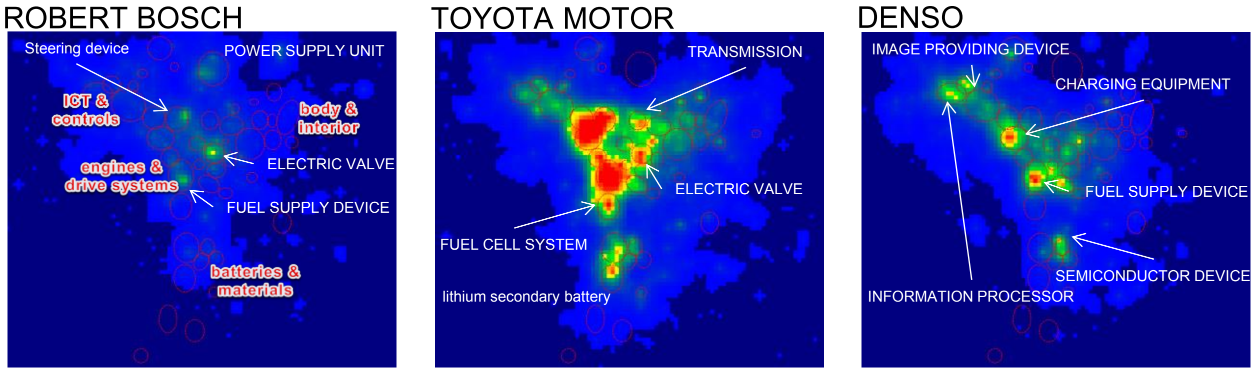
Note: Here we use a white background (instead of blue) to emphasize the areas in which technology development is concentrated.
Source: Joint research by Valuenex and MUMSS

4-12. Technology domains in which Bosch dominates

Bosch has wealth of technology in power supply units and electric valves

In terms of sheer numbers of patent filings, Toyota and Denso have a significant advantage in the vast majority of technology domains.

Figure 4-25. Technology development coverage of Bosch, Toyota, and Denso (uniform standard)

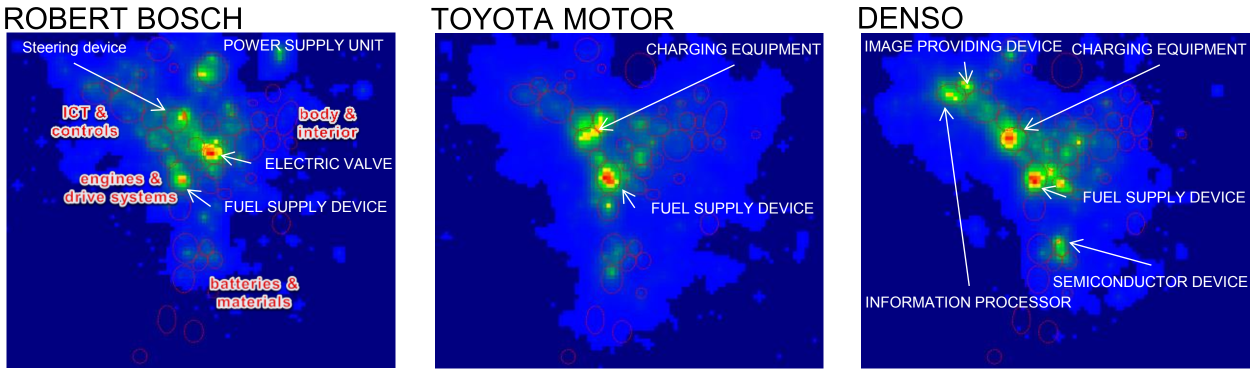


Source: Joint research by Valuenex and MUMSS

However, when we compare areas of emphasis based on the individualized standard, we notice the following characteristics:

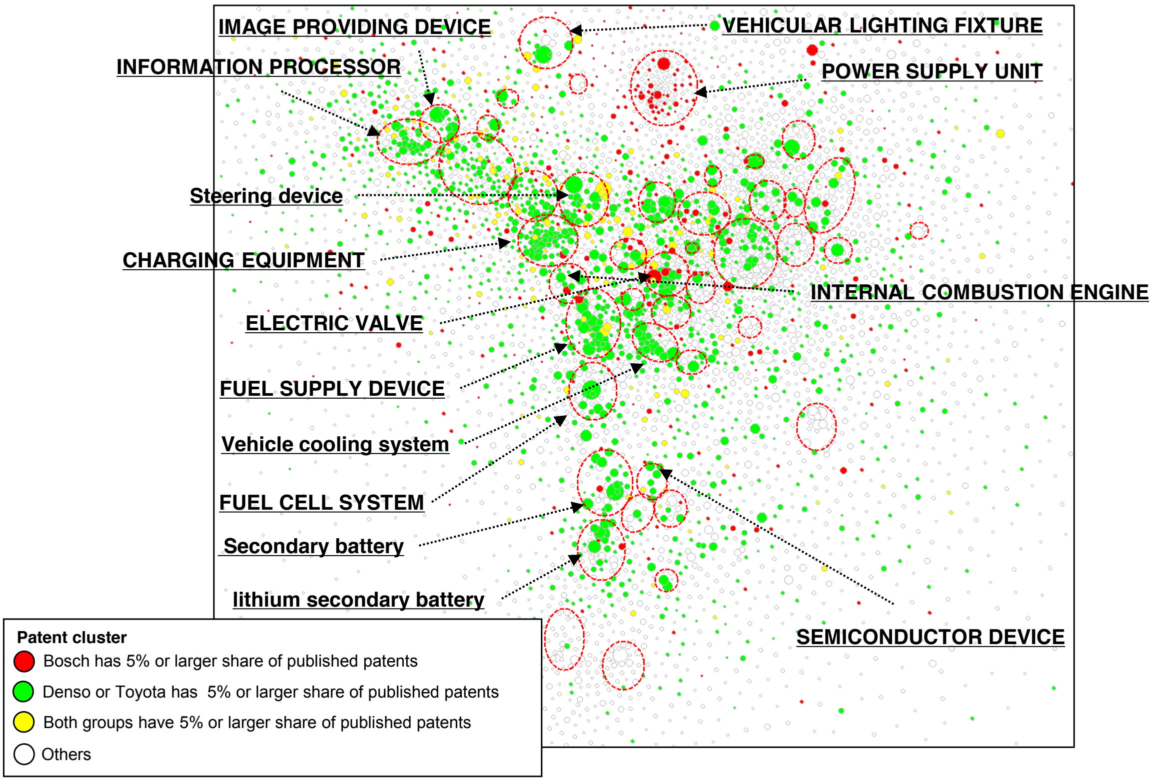
- Bosch places greater emphasis than Toyota and Denso on the electric valves domain and power supply units domain;
- Toyota is focusing particularly on lithium secondary battery technology; and
- Denso is focusing particularly on the fields of information processors and semiconductor devices.

Figure 4-26. Technology development coverage of Bosch, Toyota, and Denso (individualized standard)



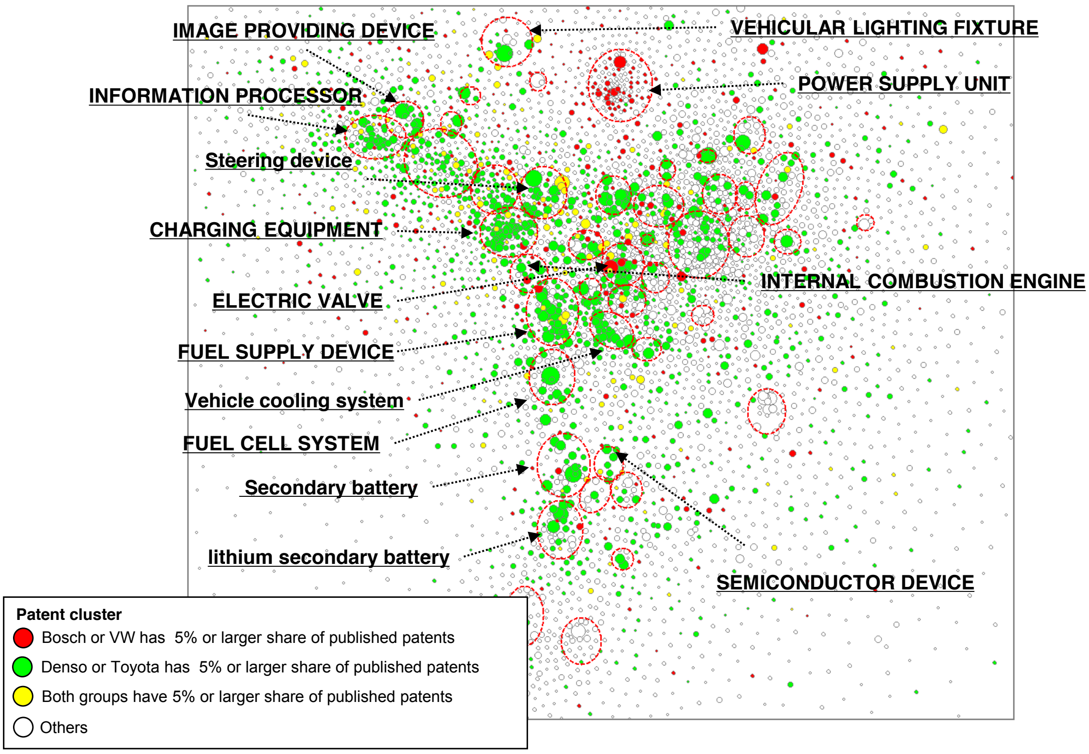
Source: Joint research by Valuenex and MUMSS

Figure 4-27. Technology domains dominated by Bosch, Toyota/Denso



Source: Joint research by Valuenex and MUMSS

Figure 4-28. Technology domains dominated by Bosch/VW, Toyota/Denso



Source: Joint research by Valuenex and MUMSS

Bosch versus Toyota/Denso alliance

Figure 4-27 shows the areas in which Bosch and the Toyota/Denso alliance hold competitive advantages, based on the data in Figure 4-26.

Bosch/VW alliance versus Toyota/Denso alliance

Figure 4-28, similarly, compares the Bosch/VW alliance with the Toyota/Denso alliance.

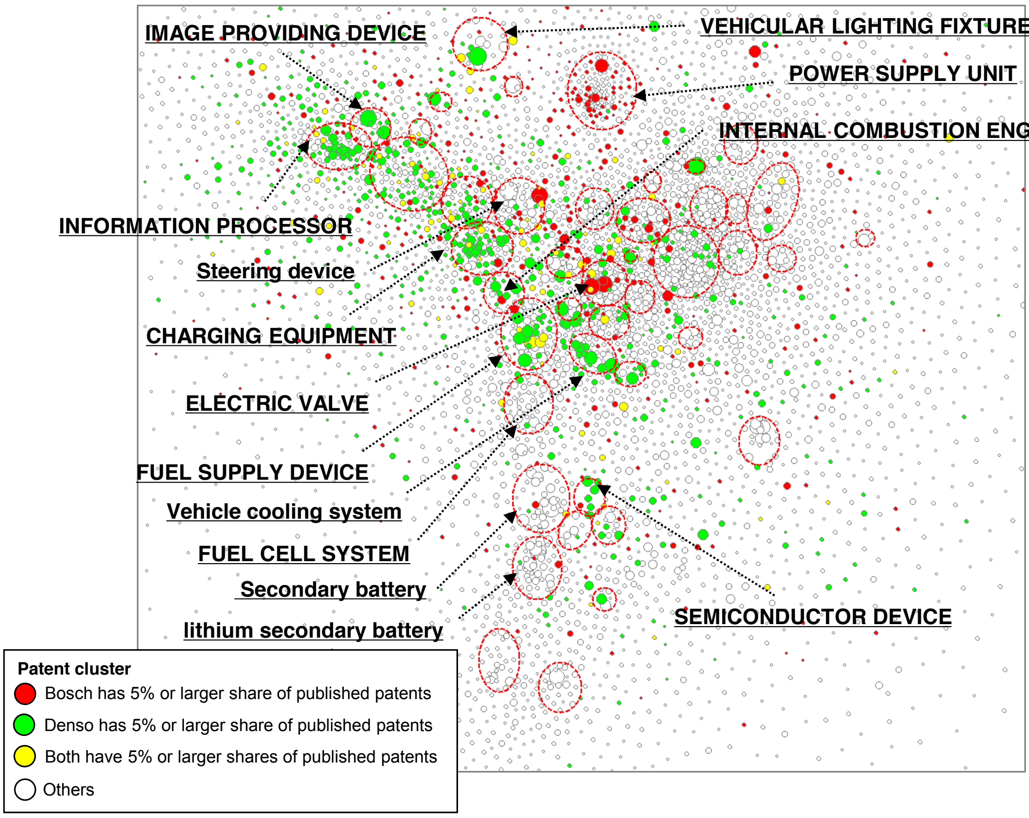
As shown, the addition of VW does not change the layout much. Toyota and Denso tend to have an advantage over Bosch/VW in virtually all technology domains except power supply units and electric valves.

Bosch versus Denso

While Figure 4-27 looks at Bosch versus the Toyota/Denso alliance and Figure 4-28 looks at the Bosch/VW alliance versus the Toyota/Denso alliance, in Figure 4-29 we compare Bosch against Denso. We note that in this case, the number of fields dominated by Bosch (represented by red clusters) increases.

Denso still has an advantage over Bosch in fields such as information processors, vehicle cooling systems, and semiconductor devices, but Bosch holds the advantage in domains such as electric valves and power supply units. However, we believe it is noteworthy that in addition to domains with high concentrations of next-generation technologies such as steering devices and charging equipment, Bosch also has a relatively high level of accumulated technology in more traditional domains such as internal combustion engines.

Figure 4-29. Technology domains dominated by Bosch, Denso



Source: Joint research by Valuenex and MUMSS

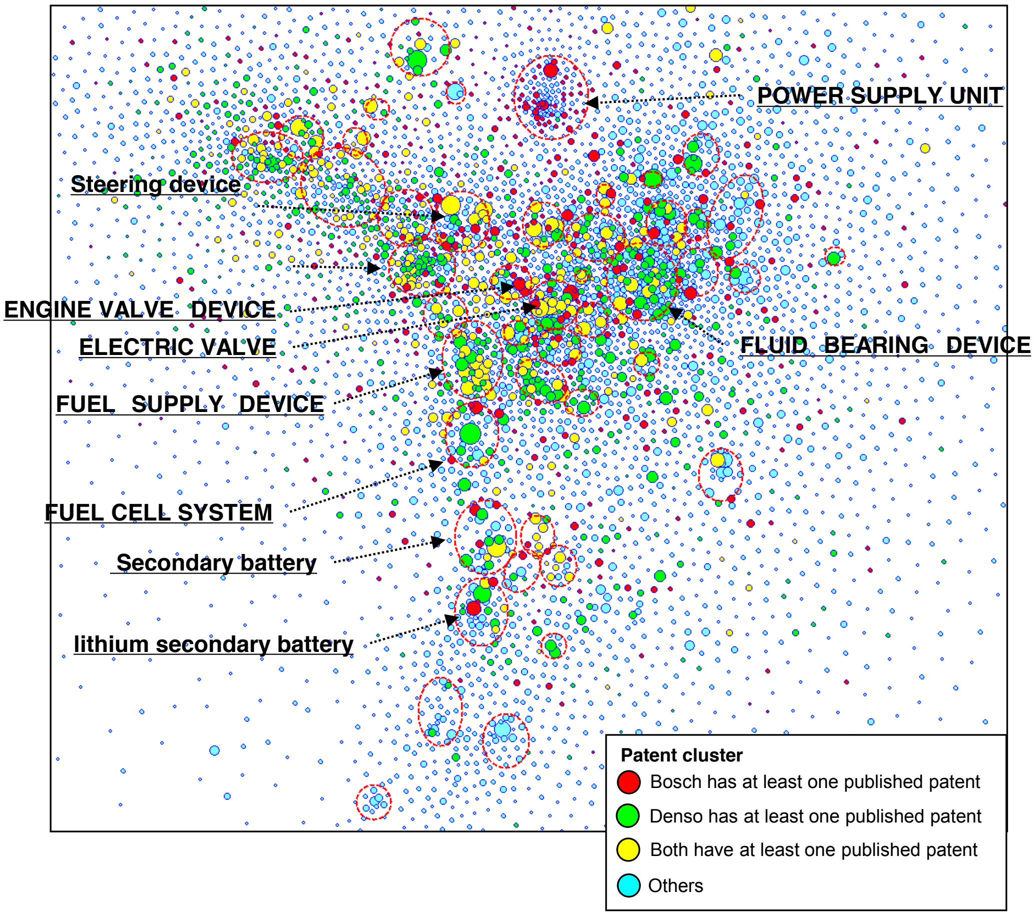
Comparing Bosch and Denso based on a looser standard

In Figures 4-27 through 4-29, we compared clusters in which the respective companies have 5% or larger shares of published patents. In Figure 4-30, in order to account for the differences in absolute numbers, we show all clusters in which the respective companies have as few as one published patent.

Based on this standard, the number of areas in which Denso dominates, represented by green clusters, declines significantly, and many of the clusters that were previously green are now yellow, denoting areas in which both firms have published patents. Meanwhile, the number of areas dominated by Bosch, represented by red clusters, increases dramatically. Those red clusters increase particularly in domains like secondary batteries, fuel cell systems, engine valve devices, and fluid bearing devices, outside the domains on which Bosch has traditionally focused (e.g., electric valves and power supply units).

As differences in absolute numbers of patent filings might owe to the secretive nature of European players, we think it would be unwise for Denso to remain complacent.

Figure 4-30. Technology clusters in which Bosch is leading



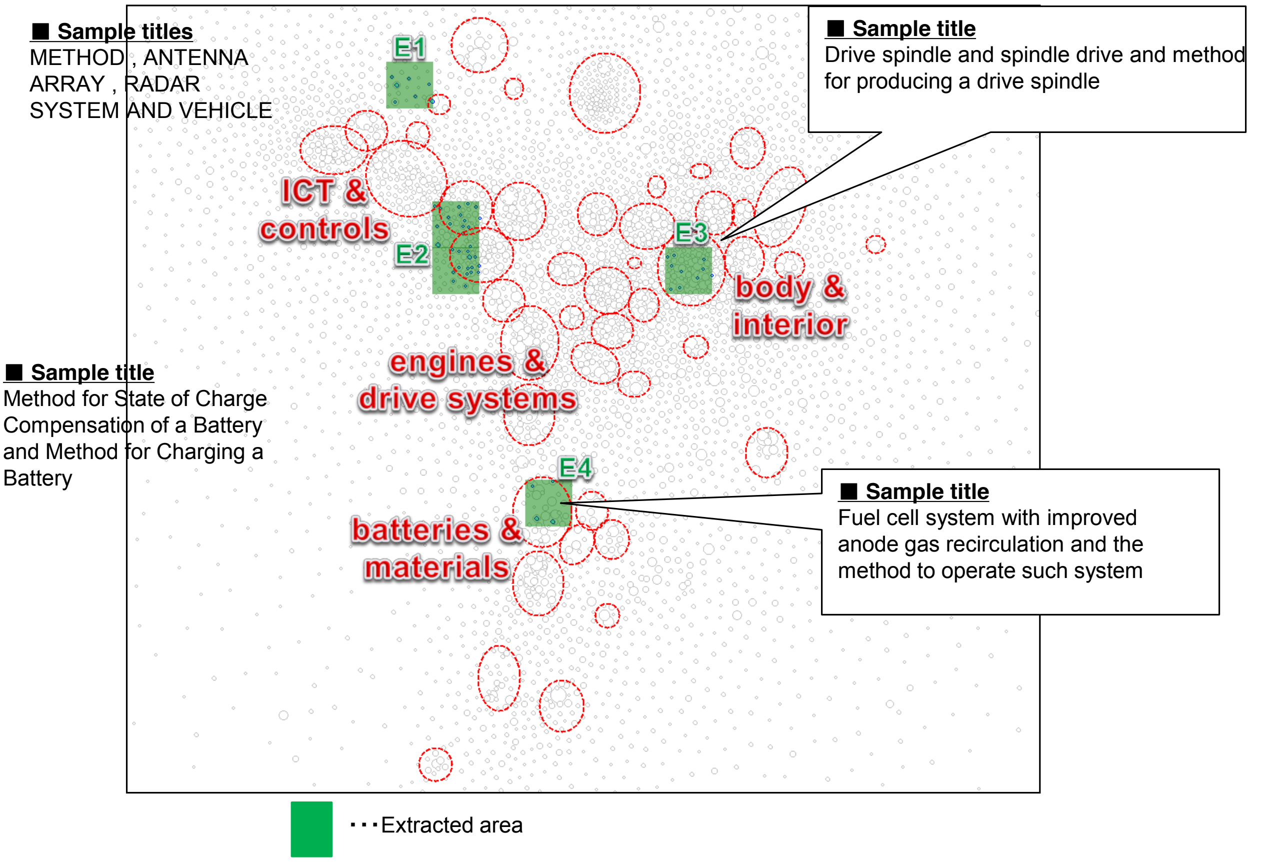
Source: Joint research by Valuenex and MUMSS

Domains in which Bosch's patent applications are increasing sharply

Figure 4-31 shows the technology domains in which Bosch's patent applications have increased dramatically. E1 represents domains related to method, antenna array, radar system and vehicle, etc., and the number of published patents in these domains rose sharply in 2015. E2 represents a domain related to "method for state of charge compensation of a battery and method for charging a battery", and the number of published patents in this domain surged in 2013. E3 represents a domain related to "drive spindle and spindle drive and method for producing a drive spindle", and the number of published patents in this domain rose sharply in 2012. Finally, E4 represents a domain related to "fuel cell system with improved anode gas recirculation, and method for operating fuel cell system", and the number of published patents in this domain rose sharply in 2012. We believe Bosch's future development activities, including in the above domains, merit further scrutiny.

Incidentally, we are unable to confirm the domains in which Denso's patent applications are increasing based on the same criteria.

Figure 4-31. Technology domains in which Bosch's patent applications have increased sharply



Source: Joint research by Valuenex and MUMSS

4-13. Bosch closing in on Toyota and Denso

Power supply units decline; more activity in electric valves and charging equipment

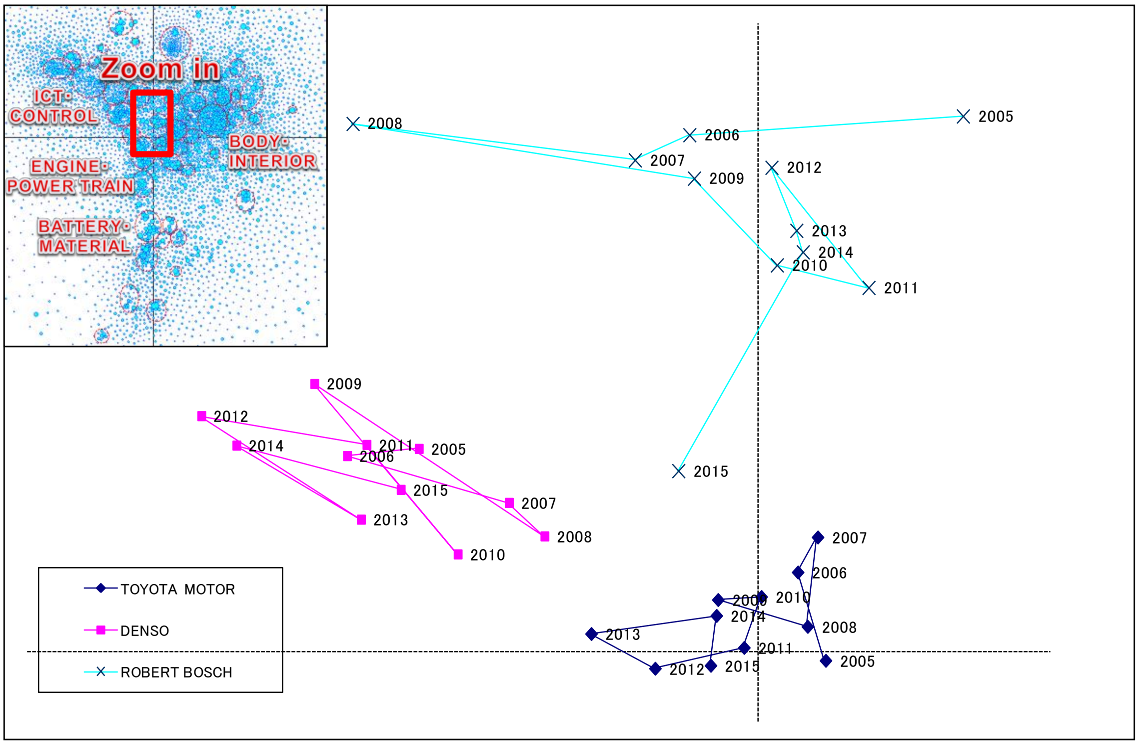
The focus of Bosch's technology development has recently approximated that of Toyota and Denso, suggesting that the level of competition may be increasing (Figure 4-32). Electric valves and charging equipment are domains that should be watched particularly closely by Toyota and Denso.

Since 2013, the center of gravity of Bosch's technology development has shifted from midway between the "ICT and control" domain and "body and interior" domain, to a point closer to that of Toyota and Denso. This reflects a drop in activity in the area of power supply units and other domains of emphasis in 2014–15, and instead more robust development activity in domains such as electric valves and charging equipment (Figure 4-33).

On the other hand, as shown in Figure 4-34, the focus of Denso's technology development activity has not changed significantly in recent years. In 2014 and 2015, Denso was particularly active in four domains: charging equipment, vehicle cooling systems, fuel supply devices, and image providing devices.

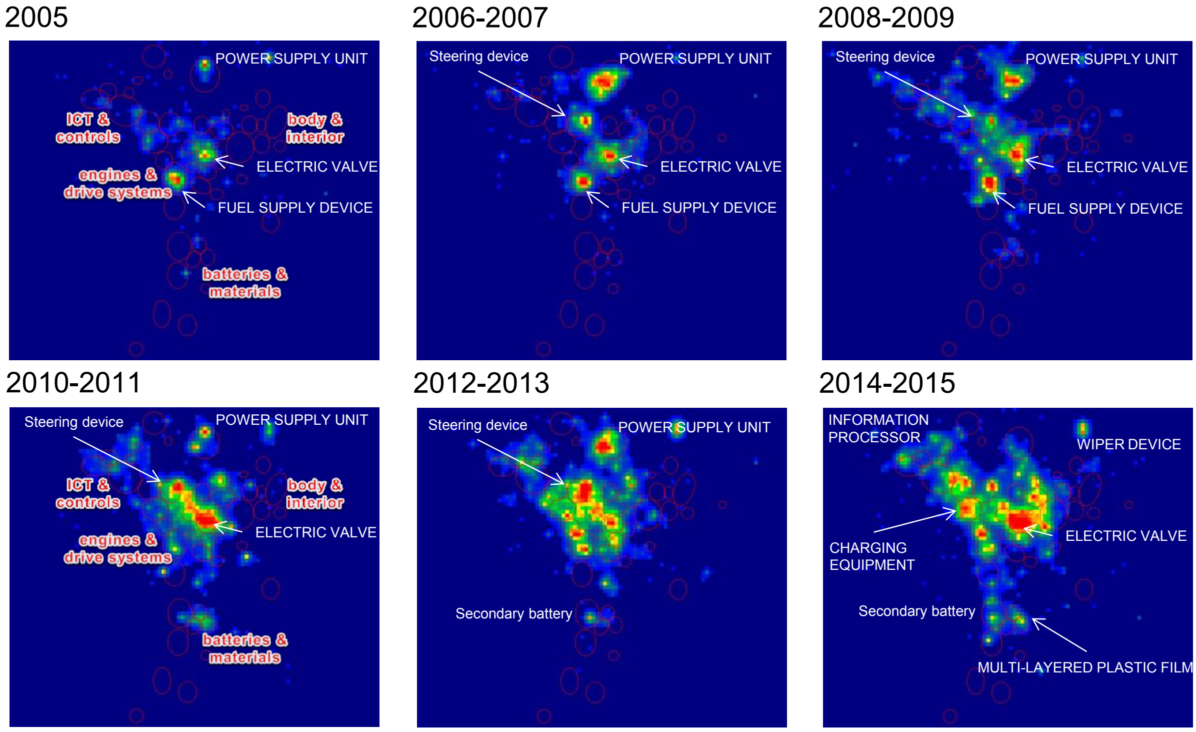
Finally, as shown in Figure 4-35, Toyota's development activity in domains related to batteries and materials started picking up around 2008–09. In 2014 and 2015, Toyota was particularly active in the charging equipment, fuel supply devices, and lithium secondary battery domains.

Figure 4-32. Changes in development focus of Toyota, Denso, and Bosch



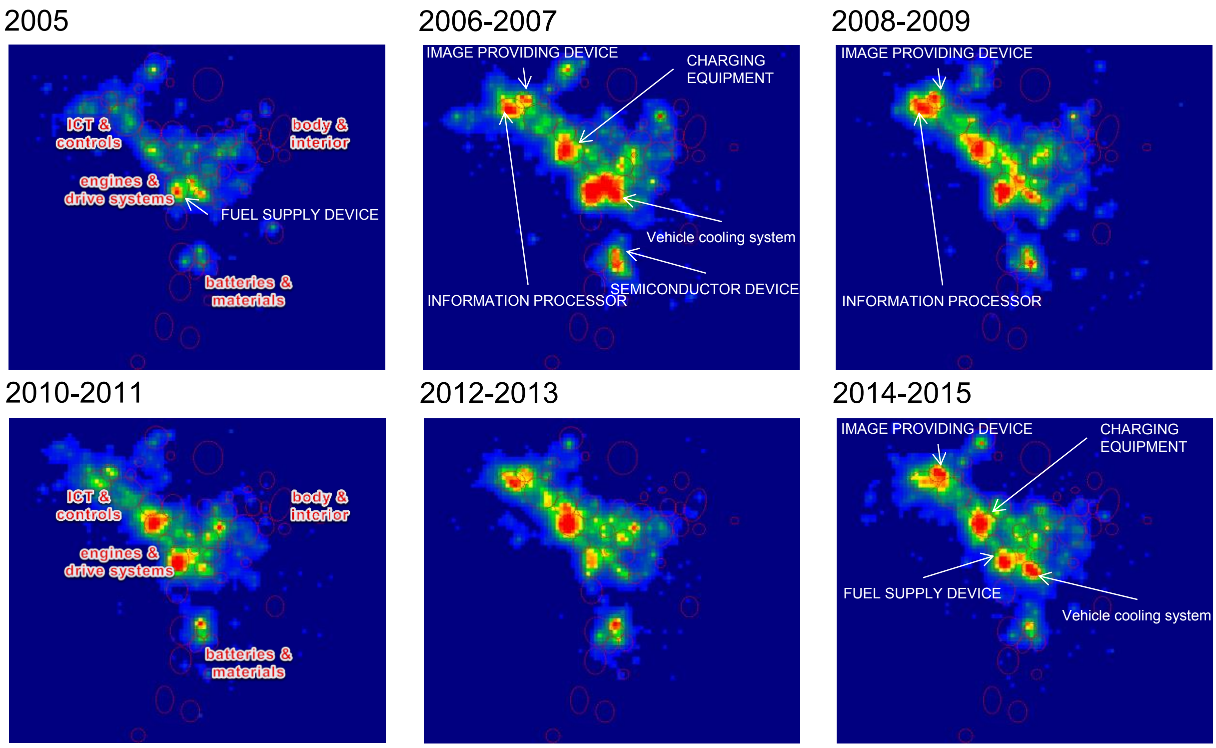
Source: Joint research by Valuenex and MUMSS

Figure 4-33. Evolution of Bosch's tech development emphasis (uniform standard for each year)



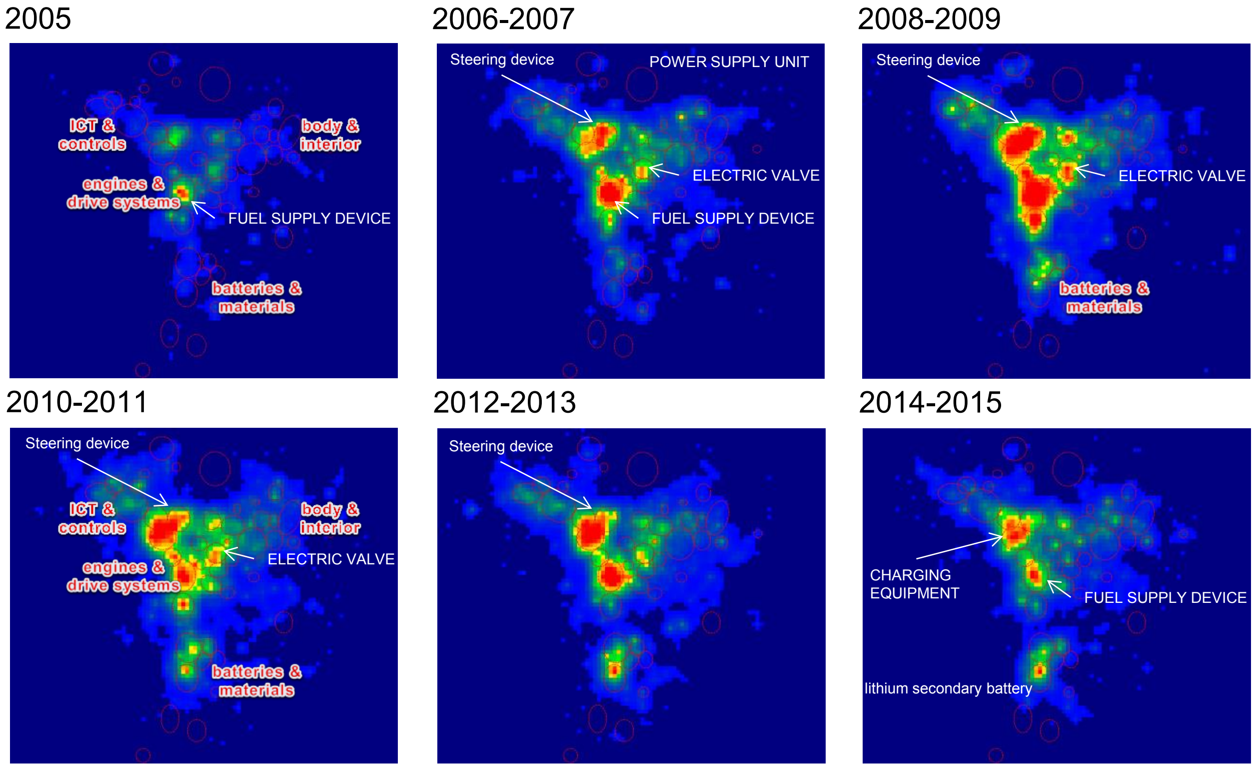
Source: Joint research by Valuenex and MUMSS

Figure 4-34. Evolution of Denso's tech development emphasis (uniform standard for each year)



Source: Joint research by Valuenex and MUMSS

Figure 4-35. Evolution of Toyota's tech development emphasis (uniform standard for each year)



Source: Joint research by Valuenex and MUMSS

4-14. Bosch technology domains that Toyota and Denso should monitor closely

Electric valve and charging equipment domains

Comparing Toyota and Denso with Bosch, we believe Toyota and Denso need to be particularly cautious about the following two domains:

(1) Electric valves

(2) Charging equipment

First, technology development trends indicate that Bosch's development focus is getting closer to that of Toyota and Denso. The main factors, which Toyota and Denso should watch closely, are the electric valves and charging equipment domains.

Toyota/Denso have overall advantage, but Bosch's accumulated technology in electric valves merits close attention

With respect to accumulated technology, Toyota and Denso have an overall advantage versus Bosch. However, Bosch has the advantage in the power supply unit domain, and the electric valve domain also merits close attention given Bosch's wealth of accumulated technology in that field.

With respect to power supply units, Toyota and Denso have not filed any patent applications in this domain. However, we have noticed several technologies here that are similar to the fuel supply device domain, where Denso has a clear advantage. Moreover, Bosch's patent applications in the power supply units domain have declined in recent years. Accordingly, this domain may not be all that important for measuring the overall intensity of competition between Bosch and Toyota/Denso.

Bosch's latest patent application could be applicable to closely-watched HCCI engines

Incidentally, Bosch's recent patent applications relate to the following topics. In the electric valve domain, Bosch filed an application related to an elastic diaphragm for a pressure-measuring device for ascertaining pressure in a combustion chamber of a self-ignition type internal combustion engine (US20150135811A1). Because it is for self-ignition type internal combustion engines, this technology could likely also be utilized in HCCI (homogeneous charge compression ignition) engines, which are attracting much attention recently as a next-generation automobile engine.

Technologies to improve charging infrastructure convenience and FCV fuel efficiency

Regarding technology for non-contact charging of energy storage cells within the charging equipment technology domain, this could likely be utilized for improving the convenience of charging infrastructure necessary for the wide dissemination of PHEV and EV (US20150222140A1).

Within this same domain, technology for heating/cooling a vehicle's interior by utilizing the endothermic and exothermic reactions of the vehicle's regenerative fuel cells could potentially lead to improved fuel efficiency in rechargeable FCVs (WO2015162017A2).

4-15. Denso also appears to be at a crossroads

Lags behind in ADAS, autonomous driving, 48V technology

Comparing numbers of patent application filings, Toyota and Denso hold the advantage in the vast majority of technology domains. However, owing in part to differences in attitudes about patent filings in Japan versus overseas, we need to look at domains as well as absolute numbers. Accordingly, in Figure 4-31 we compare technology domains alone, and on this basis Bosch's presence increases substantially.

Considering its high level of R&D expenditures, it is difficult to imagine Bosch lagging behind numerically. In fact, while Denso and other Japanese suppliers have a lead in FCV and HV technologies, it is our impression that they currently trail behind European players in fields like ADAS, autonomous driving, and 48V technology, in part because Toyota tends to be cautious about adopting new technologies.

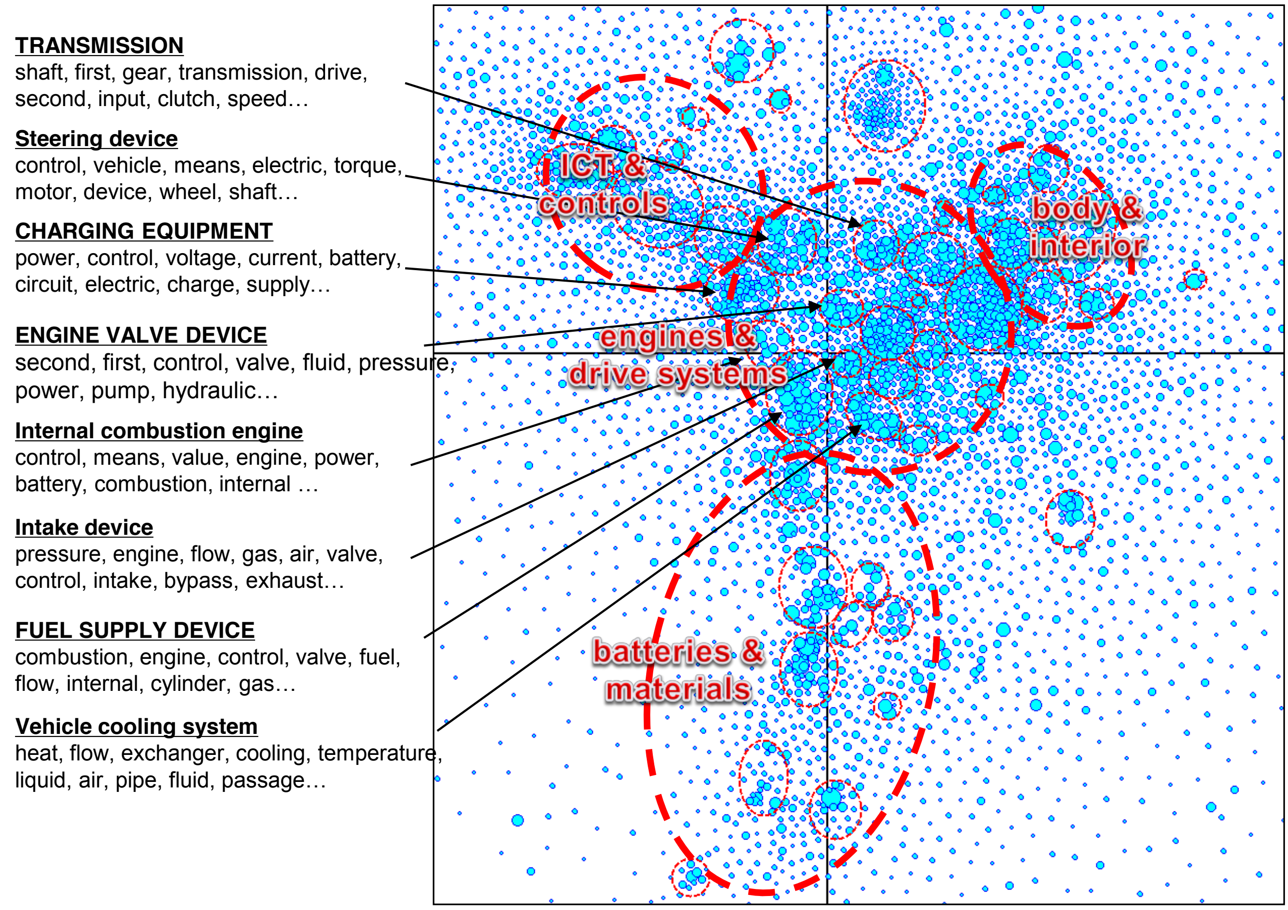
As stated earlier, the center of gravity of Bosch's technology development has recently shifted to a point closer to that of Toyota and Denso. In addition to this, the two Japanese firms should also be monitoring the emergence of Bosh's patent filings in key future technology domains. Even Denso, which has consistently maintained a principle of self-sufficiency, has since 2012 become more proactive in forming alliances in fields such as image processing, with an eye toward autonomous driving vehicles, but we think it has now reached a stage where even deeper strategic M&A deals will be necessary.

4-17. Reference materials

Detailed patent map for each automotive technology domain

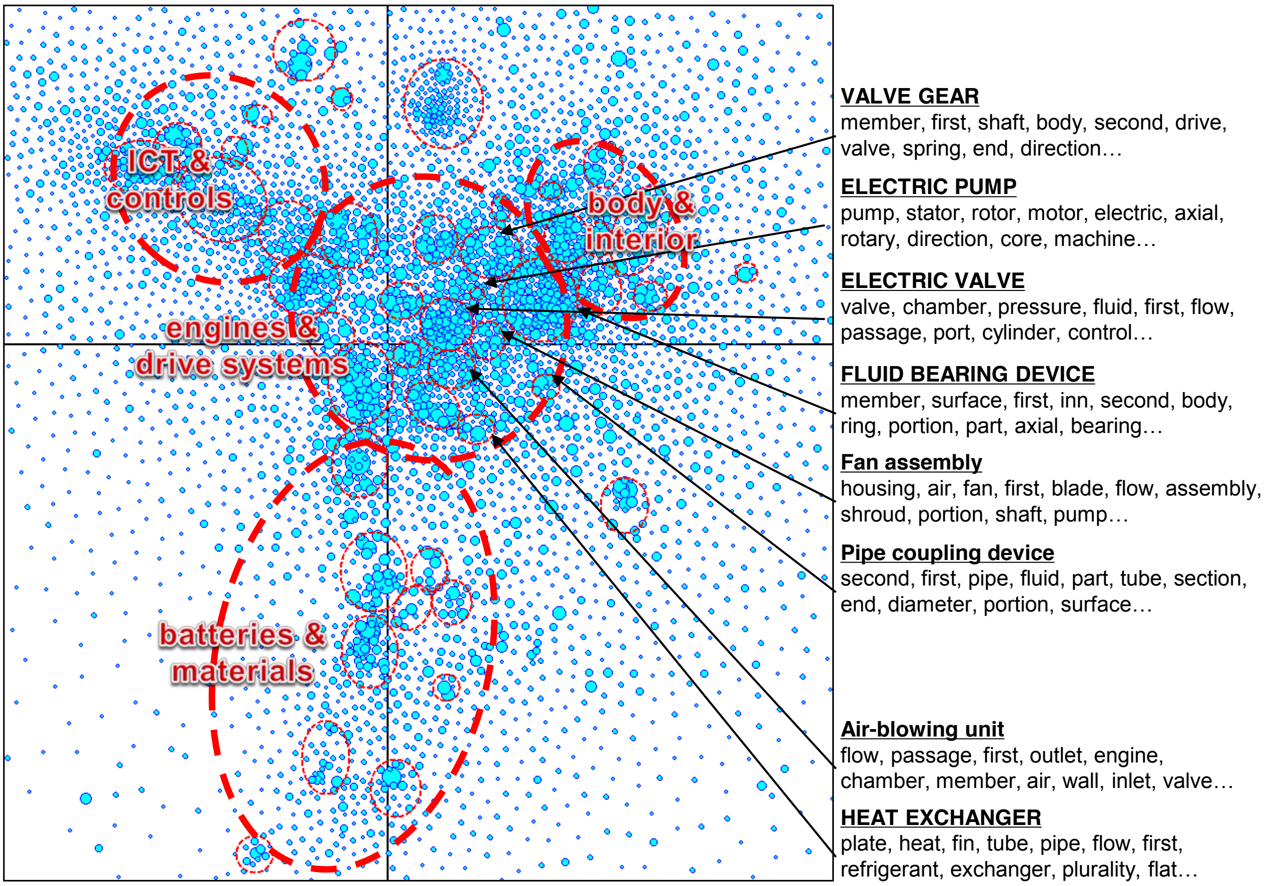
(1) Engine and drive systems domain

Figure 4-36. Detailed patent map of engine and drive systems domain (1/2)



Source: Joint research by Valuenex and MUMSS

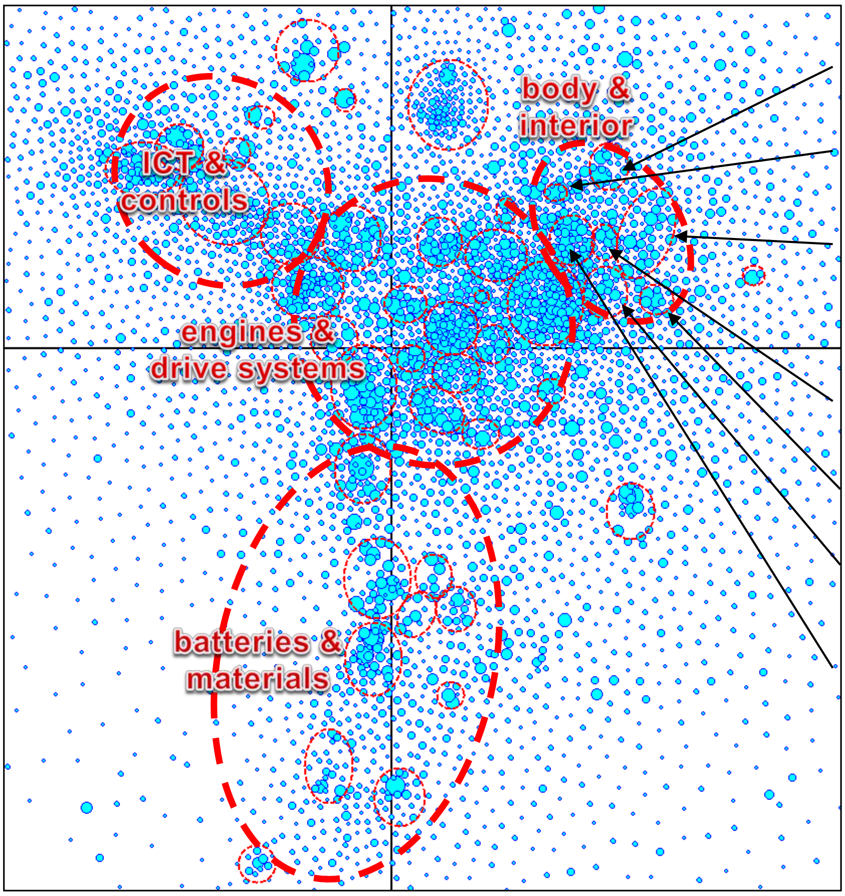
Figure 4-37. Detailed patent map of engine and drive systems domain (2/2)



Source: Joint research by Valuenex and MUMSS

(2) Body and interior domain

Figure 4-38. Detailed patent map of body and interior domain



SEAT FOR VEHICLE
seat, vehicle, frame, rear, member, back, assembly, position, portion, front…

Door device for vehicle
member, portion, door, position, body, vehicle, part, closing, frame, panel…

MOTOR VEHICLE ROOF
member, body, vehicle, portion, rear, front, first, panel, end, structure…

CABLE ASSEMBLY
member, part, first, second, portion, end, support, body, plate, assembly…

AIRBAG DEVICE
portion, body, part, side, panel, member, airbag, bag, air, inflate, inflator…

Connector
member, portion, end, part, body, screw, first, locking, hole, diameter, shaft…

member, portion, first, support, body, end, second, side, frame, upper…

Source: Joint research by Valuenex and MUMSS

(3) ICT and control systems domain

Figure 4-39. Detailed patent map of ICT and control systems domain

ANTENNA DEVICE
signal, transmission, transmit, circuit, first, wave, element, antenna…

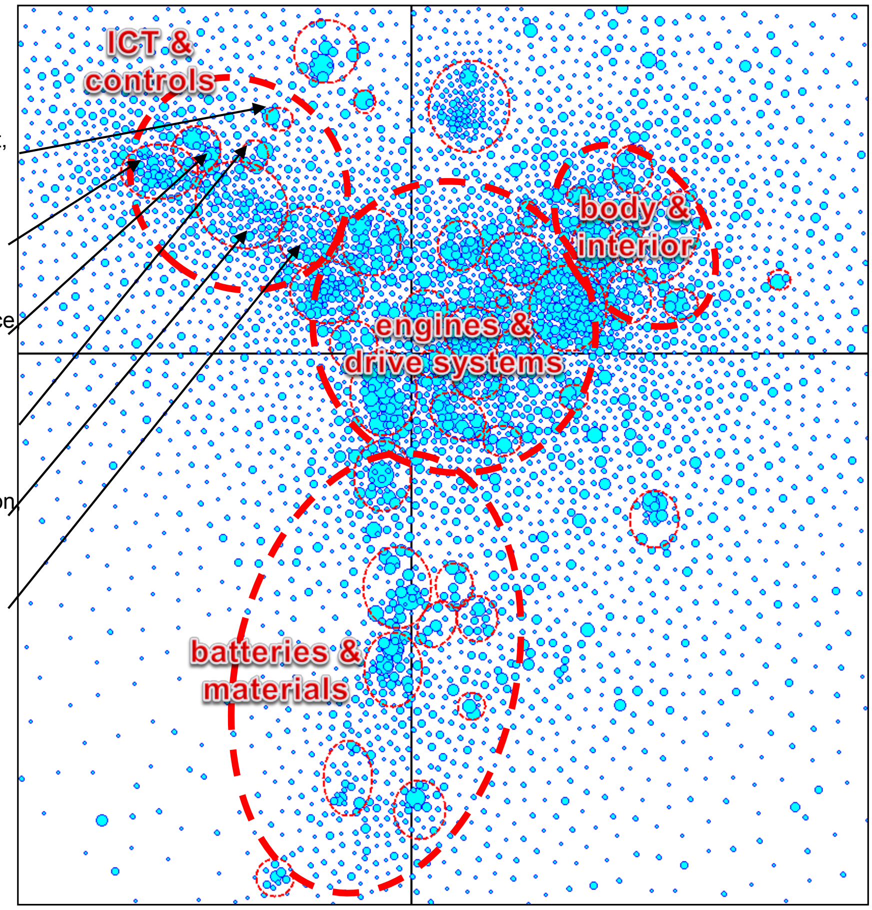
INFORMATION PROCESSOR
information, datum, vehicle, means, system, device, signal, receive …

IMAGE PROVIDING DEVICE
vehicle, information, image, means, device, datum, display, displayed…

Parking support device
means, vehicle, control, device, system, target, park, space, parking…

DRIVING SUPPORT DEVICE
vehicle, signal, control, means, information, device, system, determine …

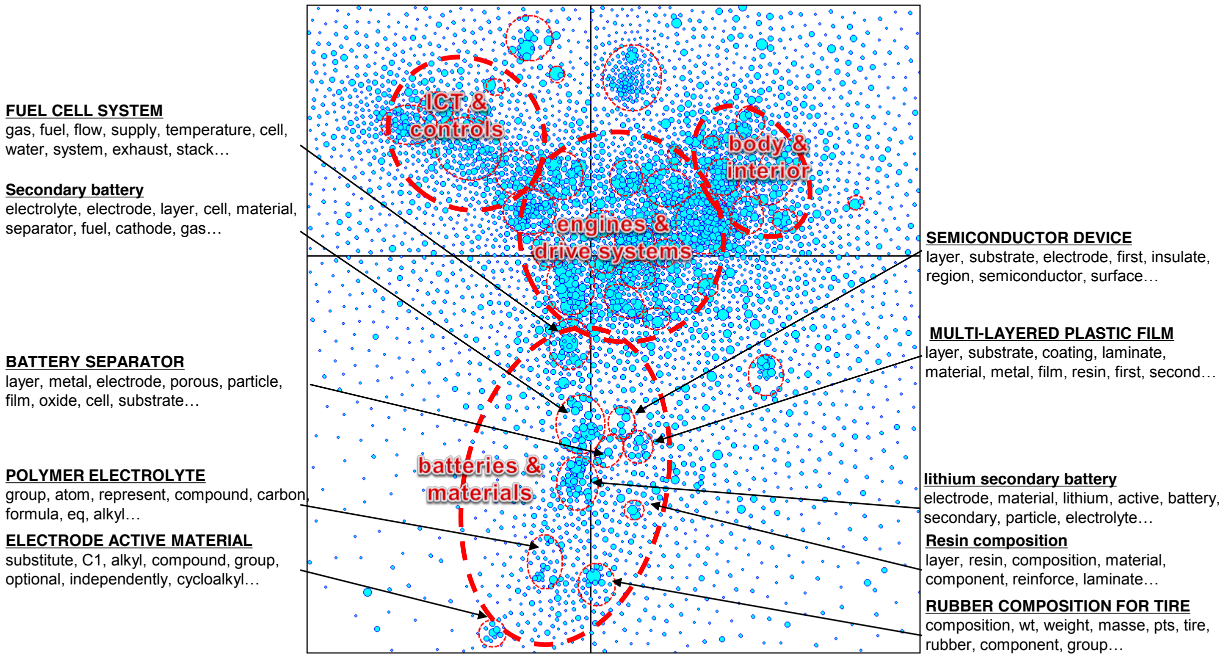
VEHICLE CONTROL DEVICE
control, means, speed, value, vehicle, calculate, target, engine…



Source: Joint research by Valuenex and MUMSS

(4) Batteries and materials domain

Figure 4-40. Detailed patent map of batteries and materials domain



Source: Joint research by Valuenex and MUMSS

5. Major reorganization scenario

5-1. Greatest revolution in a century underway

The auto industry has started undergoing the greatest revolution in a century. We highlight the following key aspects of this transformation.

(1) Changes in the identity of competitors and the rules of competition

(2) Multi-polarization of regions/fields of competition

Figure 5-1. The automotive industry has entered an era of major transformation

Greatest revolution in a century underway

⇒ Changes in the rules/fields of competition and the identity of competitors

⇒ Firms need to establish new earnings structures

■Powertrain-related innovations

①Shift from era of gasoline/diesel engines to EV era is underway

～EV market would presumably take off after the appearance of next-generation batteries in around 2030

②Hybrids and plug-in hybrids to see extended transition period

～More fuel cell vehicles to be launched as well, see brisker market growth from around 2030

③Innovations to lead to rivalry in gasoline and diesel engines getting 40km/L

～Vehicles with reciprocating engines to survive past 2030

■Innovations in new materials and ICT

①Further demands for lighter vehicles → Greater use of carbon fiber and other materials

②Increased integration of ICT support and safety-related innovations

→ Auto-braking → Auto-driving (Would advent of crash-free car bring changes in safety-related demands?)

③Use of next-generation batteries and fuel-cell vehicles

→Need to watch for negative impacts of discontinuous innovation

■Shift in profitable regions

①Lower demand growth in developed areas～ Contraction in areas where population declining (e.g., Japan and Europe)

②Faster demand growth in emerging economies～ Spike in demand in Asia, Latin America, and Africa

③Earnings structures transformed by use of lower-priced vehicles

■Change in competitors

①Weaker automakers weeded out as "survival of fittest" plays out

→ Keys will be meeting market needs on price, technology, quality

②Entrants from electronics and materials industries → Careful choice of partners

③Local makers to gain more prominence in emerging markets (e.g., China, India, Russia)

■Technological developments to accelerate

①Leap in abilities to collect/analyze data → Shorter times until later entrants catch up

②IP to become even more important → Patents, production, technologies to be guarded more closely

Source: MUMSS

1) Changes in identity of competitors/rules of competition caused by shift in auto production expertise

Initiative shifting from automakers to parts suppliers

The advance of new technologies like electric vehicles, autonomous vehicles, and new materials (carbon fiber) will add discontinuous (disruptive) innovation to a world of continuous innovation. The rules of competition will clearly change as a result.

The established practice is a vertically integrated earnings structure in which, due to the benefits of volume, the automakers control affiliated parts suppliers organized in tiers (Figure 3-8). Under discontinuous innovation new rules will apply, robbing the automakers of their technical development edge.

New key technologies will emerge to add to conventional component technology. Examples include information/communications, electronic components (like semiconductors and sensors), new materials (like carbon fiber), and electric vehicle batteries. Automakers do not have any decisive advantage in these areas.

Bottom-up control from new players

The advantage will instead lie with companies in the ICT industry, electronic components industry, and materials industries (chemicals, fibers, nonferrous metals). Venture-backed players could also emerge in some technical fields. Armed with these new technologies, parts suppliers and material producers could start exercising bottom-up control over automakers backed by the volume benefits of components making use of these decisive technologies.

We will examine this hypothesis in more detail using the examples of the commercial use of carbon fiber and the production of an autonomous electric vehicle.

Plants producing gasoline-engine cars with sheet-steel bodies

Production at existing plants

In the era of continuous innovation, iron was the core component of the materials used to form car bodies. Automakers produce cars in the key plants (i) through (iv) below and ship the finished product after the final inspection in point (v).

(i) Stamping plant: Body components (roofs, hoods, doors, floors, etc.) are produced from sheet steel using stamping presses including transfer presses and tandem presses.

(ii) Welding plant: Vehicle skeletons (body-in-white) are produced by welding the body components together.

(iii) Coating plant: The body-in-white and components are coated (anti-corrosion, undercoat, middle coat, top coat).

(iv) Assembly plant: The vehicle is completed by installing in order tens of thousands of components, including dashboard modules (comprised of subcomponents), and engines and transmissions produced in separate plants.

(v) Inspection: The finished vehicle is inspected.

The full use of carbon fiber in the car body is currently impeded by the required manufacturing time and costs. Once these hurdles are cleared, however, the plant breakdown would look like the following.

Change in plant structure for carbon fiber-bodied autonomous electric vehicle

Plant structure in the near future

(i) Injection molding plant: Expertise regarding dies would still be needed, but injection molding machines will take the place of stamping machines. It is even possible that the entire body could be formed in one giant molding machine.

(ii) Adhesion plant: Steel bodies are welded together, while aluminum bodies are bonded together. Carbon fiber requires expertise in a new technical field, namely adhesion.

(iii) Coating plant: The anti-corrosion coating step is no longer needed because carbon fiber does not rust. It is possible that the overall coating process could become simpler with the addition of color to carbon fiber. It is also possible that in addition to spray coating (which has been used for many years on steel bodies), seal coating (which is starting to be used) could be used on the body as a whole to ensure uniform surface quality.

An autonomous electric vehicle would entail the following changes.

(iv) Assembly plant: The three main components of an electric vehicle–the motors, inverters, and batteries–are all large. Moreover, the modules with autonomous driving functionality added (integration of key safety systems like steering and braking) would be assembled as a package. The assembly line will be simplified as a result.

(v) Inspection: An inspection process for autonomous driving would be added. This could include on-the-road testing, which would require test courses.

These major changes would mean the elimination of the key technologies and expertise held by the automakers.

Loss of automaker expertise and emergence of new processes and technologies

Automaker-specific technology no longer necessary

(i) Expertise in developing, designing, and producing core systems (engine and transmission) would become unnecessary.

(ii) Expertise in maintaining high precision in mass production-level stamping and welding operations would become unnecessary. Die technology and the use of robot technology would remain, however.

(iii) Large-scale coating processes using conveyors would become more straightforward. The more simple and flexible processes would improve coating plant productivity. Accordingly, the coating process would no longer be a limiting factor on an auto plant's production capacity. There could be a marked improvement in direct run rates due to the elimination of the impact of the manual retouching of spray coating defects.

(iv) Further progress with modular assembly processes would shorten assembly lines and expand the assembly work done by robots. This would reduce the number of processes requiring multi-skilled shop floor workers with expertise in assembling various specific components.

2) Multi-polarization of regions/fields of competition: Lack of resources will become major issue

Continuous innovation proceeding in emerging nations, discontinuous innovation arising in advanced nations

From now on we look for continuous innovation to proceed mainly in emerging nations, as discontinuous innovation arises in advanced nations simultaneously.

(i) Earnings structure transformations to bring about required low-cost production in emerging nations

Seeking volume benefits through overall optimization

Auto sales volume will grow most strongly in emerging markets. The key strategy will be commercializing low-priced products that can spark demand. This will likely spur on efforts to maximize volume benefits by pursuing common architectures geared toward overall optimization, as well as unconventional reforms such as the formation of alliances in particular component categories not tied to particular automakers. It will not be possible to survive the fierce competition in emerging markets without these kinds of earnings structure transformations.

(ii) Speed in new technology development and commercialization required for advanced nations

Management agility key

Advanced nations will be directly impacted by discontinuous innovation through the increase in sales of products like autonomous electric vehicles. The industry's center of gravity could shift as a result. The key in this respect is advanced technology not previously used in automobiles (like ICT, new material technologies, and electric energy technology). Taking a lead in the development phase and in commercialization/mass production will become extremely important strategically. The true value of corporate managers' ability to rapidly make the correct decision will be put to the test.

Major issue is lack of resources

The diversification of the regions and technical fields in which competition occurs will have a severe impact on automakers and parts suppliers. Attempting to cope with diversification on two different fronts will stretch resources like development personnel and funding.

Automakers and parts suppliers will need to strictly define their strategic priorities and effectively use the resources they have available. In this context, we expect to see moves toward increased use of common parts/homogenous platforms that go beyond conventional approaches as companies try to improve efficiency.

(i) Open architecture predicated on joint development

Distinguishing between collaboration and competition

Taking software development as an example, we think the idea of open architecture will spur increased commonality in areas where there is no real competition between companies, leading to an increased likelihood of a general use of basic software. The possibility that joint development will gain widespread traction will mean automakers and parts suppliers will need to narrow down their own development fields. In the area of on-board software, AUTOSAR, a consortium formed mainly by European manufacturers in July 2003, is making headway in establishing basic software standards.

(ii) Bolstering weak areas through collaborations

Strategic tie-ups important

Because it is not possible for all automakers to compete in all regions and all technical fields, companies will need to examine their strengths and weaknesses by region/field and pursue strategic collaborations to shore up weak areas.

As this process unfolds, as we will discuss later, we can expect a major reorganization of the auto industry to occur that radically changes the relationships between automakers, parts suppliers, and new industry entrants.

5-2. Shakeout starts with bottom-up control strategy of global mega-suppliers

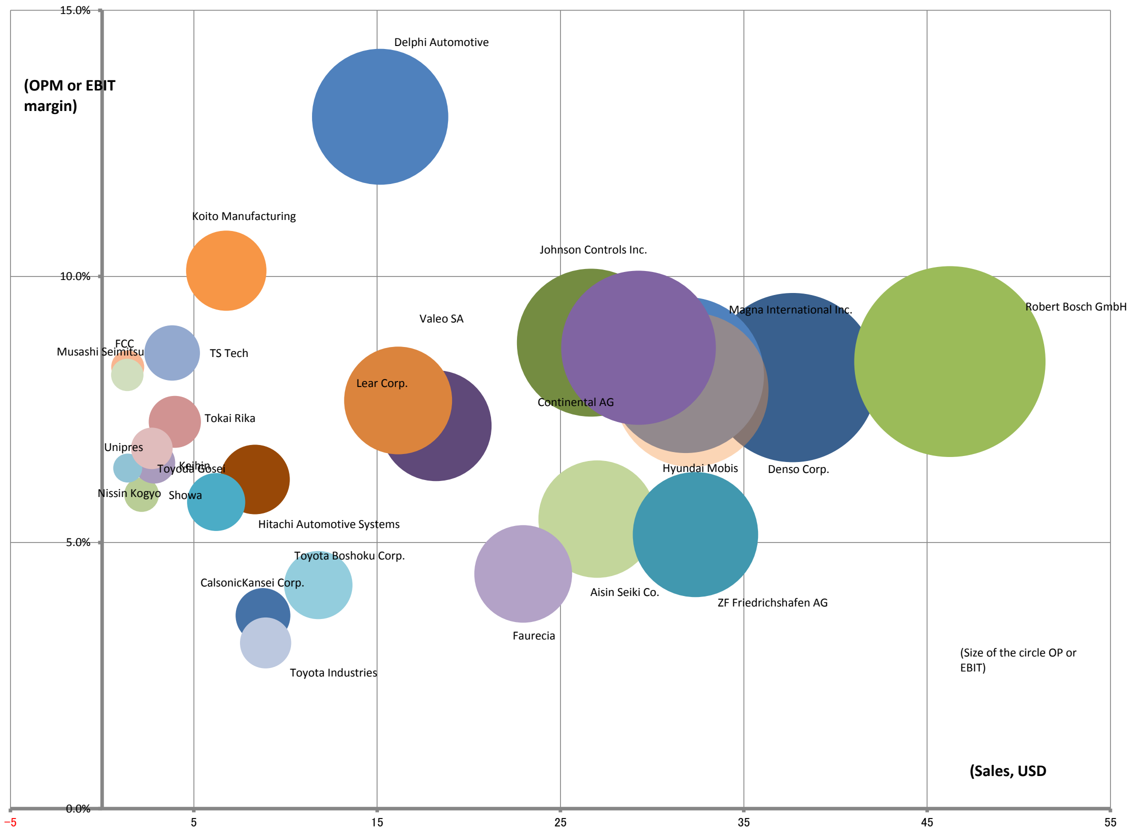
In terms of vehicle output, Toyota, VW, and GM are the three members of the 10mn club. Meanwhile, the global mega-suppliers are aggressively consolidating component counts to gain volume benefits for core components (well over 10mn units). Bosch and Continental are already pursuing a management strategy targeting the 20mn club, beyond the scope of control by a single automaker. In our view, this could signal the start of parts suppliers using massive volume benefits as a tool to exert bottom-up control over automakers.

As discussed earlier, brisk M&A activity among parts suppliers is being driven by an intent to form the 20mn club. This trend is gathering pace in a variety of component categories.

In such conditions, Japan's automakers and parts suppliers will need to undergo a major reorganization in pursuit of volume benefits if they are to survive. We could even see the emergence of a nationwide approach incorporating government strategy.

Below, we take a speculative look at the reorganization scenario for the major automakers.

Figure 5-2. Major global suppliers' sales and profitability (FY2015, adjusted for extraordinary factors)



Note: Size of circles represent scale of OP or EBIT
Source: MUMSS, from company data; EBIT for Bosch, Continental, and Magna International

5-3. Major reorganization driven by Toyota Motor

TNGB = Toyota New Global Business Structure (our name)

Toyota aiming for all-Japan 20mn club through strategic tie-ups

If mega-suppliers continue their strategic expansion, even the Toyota Group, a 10mn club member, will find it difficult to maintain an advantage. However, we see zero possibility of Toyota surrendering to the European mega-suppliers and becoming part of a bottom-up control framework. This is because developing world-leading vehicles requires an automaker to commercialize world-leading technology before competitors do, and the European mega-suppliers would offer new technology to European automakers before Toyota.

Accordingly, there would be a need for a Toyota Motor-driven industry reorganization and a reform of the Toyota Group's business model.

We will refer to this as TNGB (Toyota New Global Business) Structure

To counter the mega-supplier-controlled framework in terms of volume would call for a base strategy of establishing a Japan-wide 20mn club. This would involve not only the 10mn units of the Toyota Group (Toyota Motor, Daihatsu Motor, Hino Motors), but also the volume of other producers like capital alliance partner FHI, technical alliance partner Mazda, and Suzuki, which, although independent, is attractive for its solid base in India and its strong ability to compete on costs.

Reforms needed to address inefficiencies within the Toyota Group

TNGB would be built around addressing the inefficient production systems that still remain within the Toyota Group's part procurement framework while also garnering the substantial volume benefits of the 20mn club. Failing to achieve this could undermine not only the Toyota Group's suppliers, but also the profit structure of Toyota Motor itself.

There would be seven main impediments to TNGB.

1) A lack of a sense of crisis among Toyota Group employees
2) Insistence on self-sufficiency and Toyota standards deeply embedded within Toyota Motor and the Toyota Group
3) The after-effects of the Prius success within Toyota Motor
4) The lack of an eye for opportunities within the development and procurement divisions
5) Bureaucracy and proud attitudes within Toyota Motor
6) Resistance to change and reorganization within the Toyota Group
7) A domestic sales system exposed to long-term structural changes in society

1) Lack of sense of crisis among Toyota Group employees

Toyota Motor has grown into one of the world's largest companies. There are probably virtually no employees of Toyota Motor or other Toyota Group companies who are concerned that the company could start struggling in the near future. However, the approaching era of discontinuous (disruptive) innovation could suddenly unseat Toyota Motor from the preeminent position it has enjoyed in the continuous innovation era.

Introduction of seven-company structure demonstrates CEO's sense of crisis

Toyota Motor is not currently the global front runner in the core fields of discontinuous innovation. The company is trailing rivals in areas like electric vehicle commercialization and autonomous driving, including the commercialization of automatic emergency braking systems that is a prerequisite for autonomous vehicles.

Toyota Motor CEO Akio Toyoda, at least, is steering the company with an appropriate sense of crisis. Believing that the pre-existing management structure would not allow the company to overcome the upcoming shock, the CEO introduced a seven-company structure in April 2016. The company and group have not yet fully adapted to this change, but we think the move demonstrates agile top-down decision making on the part of the management team.

A patient who acknowledges they are ill may still die if they don't seek treatment. The first step of TNGB would be spreading the sense of urgency among all Toyota Group employees.

Figure 5-3. Toyota Motor's new seven-company management structure

Vehicle type-based companies
-Total management from planning to production-

Toyota Compact Car Company	
President	Kazuhiro Miyauchi, Senior Managing Officer
Business area	Compact cars
Subsidiaries and plants	Toyota Motor East Japan
Est. 2015 sales	2.7mn units

CV Company	
President	Keiji Masui, Senior Managing Officer
Business area	Minivans and CVs
Subsidiaries and plants	Toyota Auto Body, Honsha and Tahara plant
Est. 2015 sales	2.6mn units

Mid-size Vehicle Car Company	
President	Moritaka Yoshida, Senior Managing Officer
Business area	Passenger cars
Subsidiaries and plants	Motomachi, Takaoka, and Tsutsumi plant
Est. 2015 sales	3.25mn units

Lexus International Co.	
President	Tokuo Fukuichi, Senior Managing Officer
Business area	Lexus
Subsidiaries and plants	Toyota Motor Kyushu, Motomachi and Tahara plant
Est. 2015 sales	0.65mn units

Overall R&D functions

Advanced R&D and Engineering Company	
President	Kiyotaka Ise, Senior Managing Officer
Business area	R&D for advanced technologies

Power Train Company	
President	Toshiyuki Mizushima, Senior Managing Officer
Business area	Engines and transmissions

Connected Company	
President	Shigeki Tomoyama, Senior Managing Officer
Business area	"Connected" cars

Note: Toyota Motor also established the Frontier Research Center (headed by Mitsuhisa Kato, executive vice president), the Corporate Strategy Division (Shigeki Terashi, executive vice president), and companywide support functions (Takahiko Ijichi, executive vice president) under the head office. 2015 sales units are MUMSS estimates.

Source: MUMSS, from Toyota Motor's press release

Figure 5-4. Toyota Group's former management structure

Directly managed by the group

- TNGA Planning Division
- Product & Business Planning Division

Business units

- Lexus International (Lexus business)
- Toyota No.1 (North America, Europe and Japan)
- Toyota No.2 (China, Asia & Middle East, East Asia & Oceania; Africa, Latin America & Caribbean)
- Unit Center (engine, transmission and other "unit"-related operations)

Regional groups

- Japan Sales Business Group
- North America Region
- Europe Region
- China Region
- East Asia & Oceania Region
- Asia and Middle East Region
- Africa Region
- Latin America & Caribbean Region

Source: MUMSS, from Toyota Motor's press release

2) Insistence on self-sufficiency and Toyota standards deeply embedded within Toyota Motor and the Toyota Group

Taking scalpel to inefficiencies stemming from insistence on self-sufficiency

Toyota Motor and the Toyota Group have a strong preference for their own technologies and products and have proprietary standards designed to keep quality high. None of this is bad. That said, being so beholden to in-house technologies that an attitude of looking down on other companies' technologies develops can only be harmful. Moreover, insisting on quality that is above the industry average by a clearly unnecessary margin could lead to losing out due to cost competition if the quality standards are not adjusted to more suitable levels.

Toyota Motor expanded its use of global procurement in the 1990s. This was when the company migrated from its own CAD system (Integrated CAD) to CATIA, the prevailing system among overseas suppliers. Toyota Motor and Toyota Group suppliers who did a lot of work for Toyota Motor had been using the Integrated CAD. The decision to move to CATIA, the prevalent global platform, was seen as a way to overcome the barriers imposed by a focus on self-sufficiency during a period of globalization. In our view, the current situation calls for a scalpel to be taken to the inefficiencies stemming from inward-looking attitudes with an even greater sense of urgency than during the 1990s.

Tailoring Toyota standards to particular regions

Similarly, reviewing the excessive application of Toyota standards will be essential for the idea of a common architecture under the Toyota New Global Architecture (TNGA). It will likely be necessary to revise standards to levels suited to each region (this applies to commodity component standards rather than to standards that drive product differentiation like in the case of Lexus-level quality). However, any change in standards would need to be done after careful testing, including of deterioration with age, because any error would run the risk of large-scale recalls.

3) After-effects of the Prius success within Toyota Motor

How long will Toyota cling to Prius technology?

It is difficult for any company to move on from past successful experiences. Toyota Motor's most successful experience was the Prius hybrid. The Prius burst onto the scene almost 20 years ago in December 1997 with the advertising tagline "just in time for the 21st century." Before launching the Prius, although Toyota was Japan's largest automaker, from the perspective of engine development and other technical capabilities the company was seen as lagging rivals like Nissan, known for its technical prowess, and Honda, known for its CVCC technology. Toyota had earned its leading position because its sales capabilities and service coverage compensated for the lack of a decisive edge on the technology front.

The CEO of Toyota Motor when the Prius was launched was Hiroshi Okuda, who was well-versed in the technical deficiencies of Toyota vehicles thanks to his background at Toyota Motor Sales. With the launch of the world's first commercial hybrid, Mr. Okuda succeeded in changing the public perception of Toyota Motor to that of an environmentally conscious automaker with cutting-edge technology. The first Prius models had a lot of defects, mainly with the NiMH batteries, but the impact was softened by Toyota's service capabilities and hybrid technology gradually gained a foothold.

The current Prius hybrid system is essentially unchanged from the first iteration developed during Mr. Okuda's tenure. That is, the technology is already outdated. Toyota has used the technology as a basis for producing a plug-in hybrid, but there is likely a limit on how much technical progress is possible. Other automakers have started to launch electric vehicles and plug-in hybrids using new technology that overcomes the wall of patents Toyota built around Prius technology. The approach that stands out in particular is technology that uses the engine as an electric generator. Toyota Motor is approaching the point where it needs to move on from the after-effects of the Prius success, but there is not enough post-Prius technology visible at the moment.

4) Lack of an eye for opportunities within development and procurement divisions

Lack of vision risks fatal management errors

There have been examples where the lack of an eye for opportunities in Toyota Motor's development and procurement division have led to the company passing on offers of superior cutting-edge technology developed by suppliers. The suppliers subsequently offered the technology to other automakers who gained an edge over Toyota by commercializing the new technology. This is the kind of management misstep that could prove fatal.

A good recent example is Denso's development of a new type of injector that allowed compression ratios not previously thought possible. This technology ended up in Mazda's Skyactiv engines, which offer improved fuel efficiency. We believe Denso must have offered this technology to Toyota first. The benefits of the new technology are evidenced by the performance of the Mazda engines and similar engines subsequently developed by Toyota.

The tandem solenoid starter developed by Denso, a key component in start/stop systems that allow a running engine to be stopped and immediately restarted when required, was first commercialized by Daihatsu, followed by Suzuki.

So far, it has been possible to catch up after being slow to adopt new technology, but we think it is safe to conclude that in the future it will be more common for the first company to market to stay out in front. Missing opportunities due to a lack of judgment is not something that can be allowed given the risk of business defeat.

In our view, the company could benefit from thoroughly reviewing why it missed opportunities to gain an advantage and applying those lessons in the future. We see a pressing need to follow through with reforms based on the following.

(i) Fully engaging in dialogue with suppliers from an early stage

(ii) Using leaders with a good eye to develop junior employees' ability to spot opportunities

(iii) Expediting the adoption of new technology by delegating more authority to the shop floor level

(iv) Establishing a company culture that is unafraid of the risk of failure as well as a management framework and systems that offer losers a second chance.

5) Bureaucracy and proud attitudes within Toyota Motor

Position of strength calls for humility

Toyota Motor has grown into a huge organization. This has resulted in large numbers of employees who are highly capable, but have a bureaucratic mindset. Unfortunately, this may be because employees who joined the company with the conviction that the world's largest automaker should make the world's best cars are now largely outnumbered by employees who joined because they saw the company as a safe bet where their academic record would count.

While Hiroshi Okuda was CEO, the company embarked on business reform efforts and slimmed down its organization. However, we think it is not unreasonable to conclude that the organization and its staff members have become more bureaucratic over the intervening 15 years. In our view, another round of efforts to improve employees' mindsets and streamline the organization may be called for.

Toyota Motor is a leader of both the auto industry and the Toyota Group. As far as suppliers are concerned, Toyota Motor's procurement, development, and production technology divisions are effectively kings of each area. This situation can have the adverse effect of arrogant attitudes toward the suppliers creeping in as a result of pride. We have heard of examples of Toyota Motor employees only realizing this after leaving to work for a supplier. It is necessary to instill the idea in all executives and employees that strength should be tempered with humility.

6) Resistance to change and reorganization within the Toyota Group

The key to the success of TNGB would be eliminating the efficiencies within the Toyota Group suppliers. There are many obstacles, including dilution of volume effects due to traditional purchasing from multiple suppliers, work being secured as a result of personal relationships within the Toyota Group (impeding optimal procurement from superior suppliers), and barriers due to vested interests among parts suppliers. Given the need for speed, the major reforms that we think are called for would need to eliminate these issues in one sweep.

The core concept of TNGA is a common architecture that allows a shift from the previous locally optimized approach to auto development and production to company-wide optimization that transcends automobile grade and model divisions. Not many examples of TNGA in action have actually been disclosed, but we understand the new seat frames produced by Toyota Boshoku are one such example.

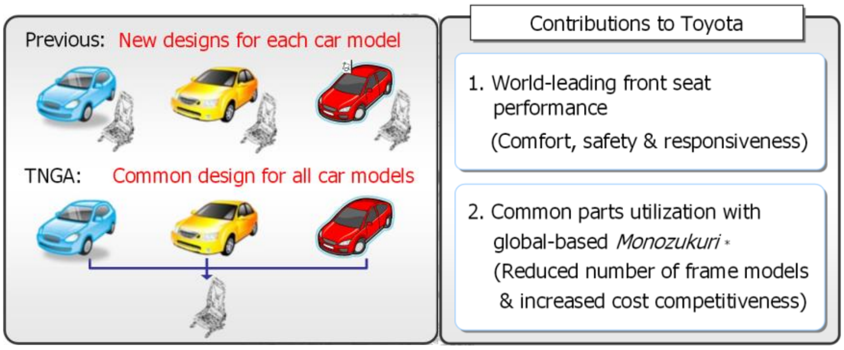
The new seat frames are used in the TNGA seats installed in the new Prius launched in December 2015. The TNGA seats are around 20% lighter than the previous TBK4-based models. They are also stronger, thanks to the use of high tensile-strength materials, and greater suitability for common use, thanks to the elimination of bolting points. We believe the new models also have larger margins. A reorganization involving the transfer of Shiroki and Aisin Seiki’s mechanical seat frame component ops gave Toyota Boshoku end-to-end production capabilities. This move sharply reduced intermediate inventory and transportation costs. We think there was likely opposition to these reforms. However, from the perspective of realizing overall optimization capable of delivering new seats that allow Toyota Motor and the Toyota Group to compete globally, this kind of unfounded opposition is something that needs to be completely suppressed.

Even just within the Toyota Group there are still plenty of latent examples of duplication of purchasing and of inefficient production systems. We see a need to use the realization of TNGA as an opportunity to push ahead with across-the-board productivity improvements and consolidation of part procurement in existing domains governed by continuous innovation.

On the discontinuous innovation front, it will be necessary to develop new efficient production and procurement systems. This will require an aggressive Toyota Motor-led reorganization of suppliers, including those outside the group. In our view, Toyota Motor’s management will need to approach these structural reforms with strong resolve.

Moreover, in the interests of becoming less insular and adding complementary technologies, we think Toyota Motor and Toyota Group companies will be served by engaging in wide-ranging M&A activity, an area that Toyota is not known for. Specifically, M&A activity in the ICT and new materials field must be initiated by Toyota Motor, as this would not be possible from the position of a supplier.

Figure 5-5. TNGA seat initiatives and contributions to Toyota



Source: MUMSS, from company data

7) Domestic sales system exposed to long-term structural changes in society

Sales network already larger than necessary

Toyota Motor, like most Japanese automakers, has shifted to a business model that generates more profit overseas than in Japan. Since cars started to become widespread in Japan in the late 1960s, Toyota has been supported by its domestic sales network.

The company has five sales channels: Lexus, Toyota, Toyopet, Corolla, and Netz. Daihatsu-badged mini-vehicles can be counted as a sixth channel.

Auto sales volume in Japan is likely to decline as a result of demographic changes, including a decrease in younger populations. This implies a need to revamp a domestic sales structure that has so many channels. In Toyota's case, however, many of the sales companies in the network are independent. Accordingly there has been little progress in reforming the network to date.

In our view, reforming the sales network will become inevitable as the impact of discontinuous innovation spreads to auto sales.

(i) Autonomous electric vehicles will shorten replacement cycle, depress residual values

From sales to leasing

The battery technology used in electric vehicles is progressing rapidly, as are technical innovations geared toward autonomous vehicles. When these technologies are commercialized, the gap versus conventional technologies is likely to be substantial. It is therefore likely that the residual values of used vehicles with older technology will be undermined when new vehicles featuring these new technologies are launched. Moreover, we think the vehicle replacement cycle is likely to shorten because technology will become obsolete more quickly in the electric vehicle/autonomous age than it did in the gasoline engine era. A shorter replacement cycle would be beneficial for domestic sales, but lower trade-in values stemming from the undermining of used car residuals would leave consumers needing to find additional funds when purchasing their next cars. This could lead to an increase in leasing agreements that allow consumers to drive new cars at lower initial costs than outright purchasing. The business model for domestic sales would likely change as a result.

(ii) Fewer models can be developed

Loss of channel individuality

Limitations on development resources at automakers and suppliers will make it impossible to launch as many models on the Japanese market as in the past. Toyota Motor is already selling strong sellers like the Prius through all its sales channels. There is a risk that such examples could become more common, with a consequent erosion of channel individuality. This would lead to channel integration further down the line.

(iii) Advent of autonomous driving would remove need for consumer ownership

Thinking about how to survive in self-driving era

If self-driving cars are commercialized, then time sharing (consumers using cars only when and for as long as needed) could become the primary mode of use. For example, booking a pick-up outside one's home at 7am then releasing the vehicle at 6pm after being dropped off back at home. This use model would require domestic sales companies to transition to a business model based on the leasing, operating, and service/maintenance of autonomous vehicles. Sales expertise and the replacement cycle would no longer be relevant. It is likely that society will shift in this direction over the long term, meaning domestic sales companies will need to be prepared for the transition. Toyota Motor will naturally be called upon to provide backing to this reform and reorganization of the sales structure.

5-4. Toyota Motor's future management structure

1) Seven-company structure is only the start of structural reforms

Goal is more agile management

As mentioned earlier, Toyota Motor updated its management structure in April 2016 with the introduction of a seven-company system. As managers of an operating company, Toyota Motor's management team continues to exert overall control while monitoring the operating performance of the seven companies across defined areas and frameworks. Similarly, the changes are not particularly wide-ranging with regard to suppliers (an area where we think major reorganization is needed), with equity stakes being maintained at previous levels. The aim of this round of changes was to allow more agile management.

2) Uncertainty inherent in management structure that relies on personal relationships

High reliance on personal relationships

There is still an insufficient level of management control under the new structure, however. This is because the connections within the Toyota Group still depend to a large degree on interpersonal relationships. Such a management system works efficiently when these personal relationships are good, but it is very possible that these personal relationships could become counterproductive if future large reorganization results in movements of capital and transfers of responsibility among companies.

3) Transition to holding company structure could be called for

Reorganization and shift to holding company structure

Drastic ideas could be called for if the company sets its sights on implementing a major reorganization of parts suppliers and finding subsequent roles for them, as well as on new collaborations with automakers in the future. This could include a shift in management structure, built around a transition to a holding company (an idea deemed to be ahead of its time when Hiroshi Okuda was CEO), and the formation of a Japan-wide alliance with the Toyota Group at its core.

Toyota Motor has for many years maintained the same management structure, centered on a strong business core. In our view, however, it will be necessary to break with tradition to handle the demands of global business expansion and the approaching era of discontinuous innovation.

Growing beyond manufacturing is a future issue

Another future management issue for Toyota Motor is growing beyond manufacturing. Naturally, manufacturing will still play the most important role as a source of profit within Toyota Motor and the Toyota Group. That said, there may come a time when the company will call itself simply Toyota instead of Toyota Motor, as a result of growth in non-manufacturing fields in line with changes in society. In our view, it is likely that a holding company structure will offer the best balance of management control over these changes.

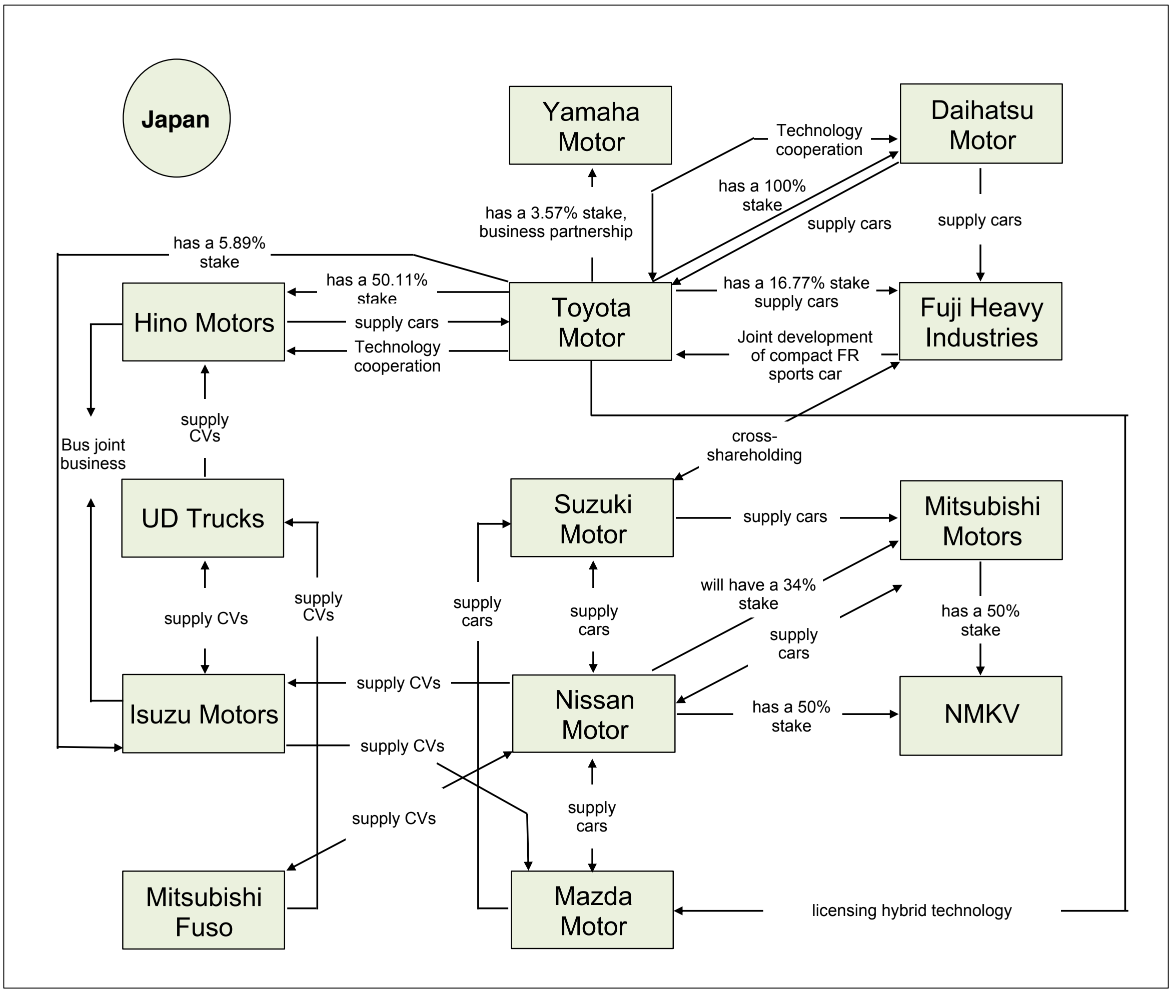
4) Denso's possible role

Denso could be ace up Toyota's sleeve

If Toyota Motor's high stakes in some parts suppliers could cause concern among the other automakers, then a possible alternative would be making Denso the principal in a holding company structure for the parts business. Denso is a good candidate among the suppliers due to its technological superiority as evidenced by the wealth of patent holdings.

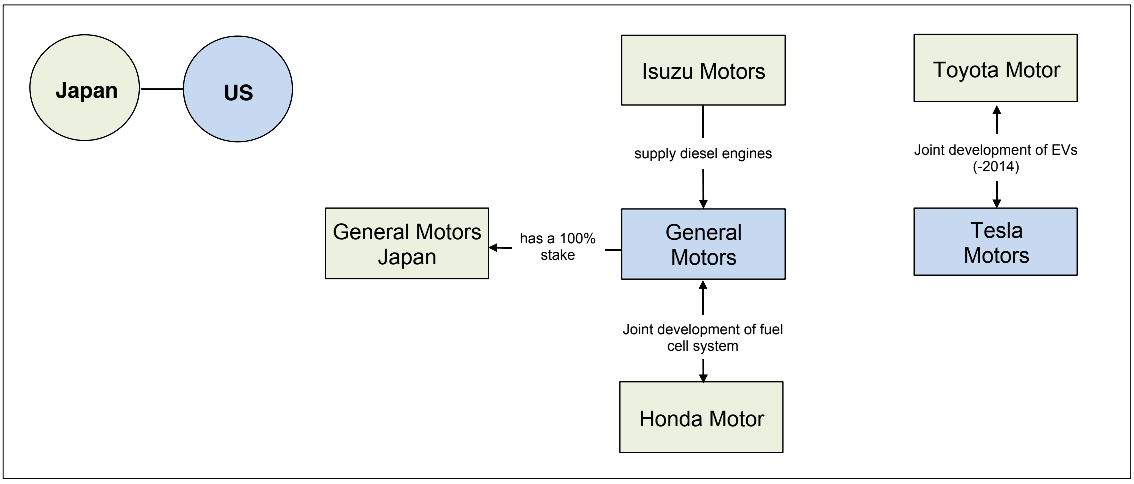
For example, Advics is one supplier who has technology that will be key to autonomous vehicles in the future, but Aisin Seiki has a larger stake in the supplier than Denso. In our view, a more favorable arrangement would result if Advics was under Denso's umbrella and Toyota Motor provided support by sending key officers.

Figure 5-6. Capital and business alliances by Japanese automakers



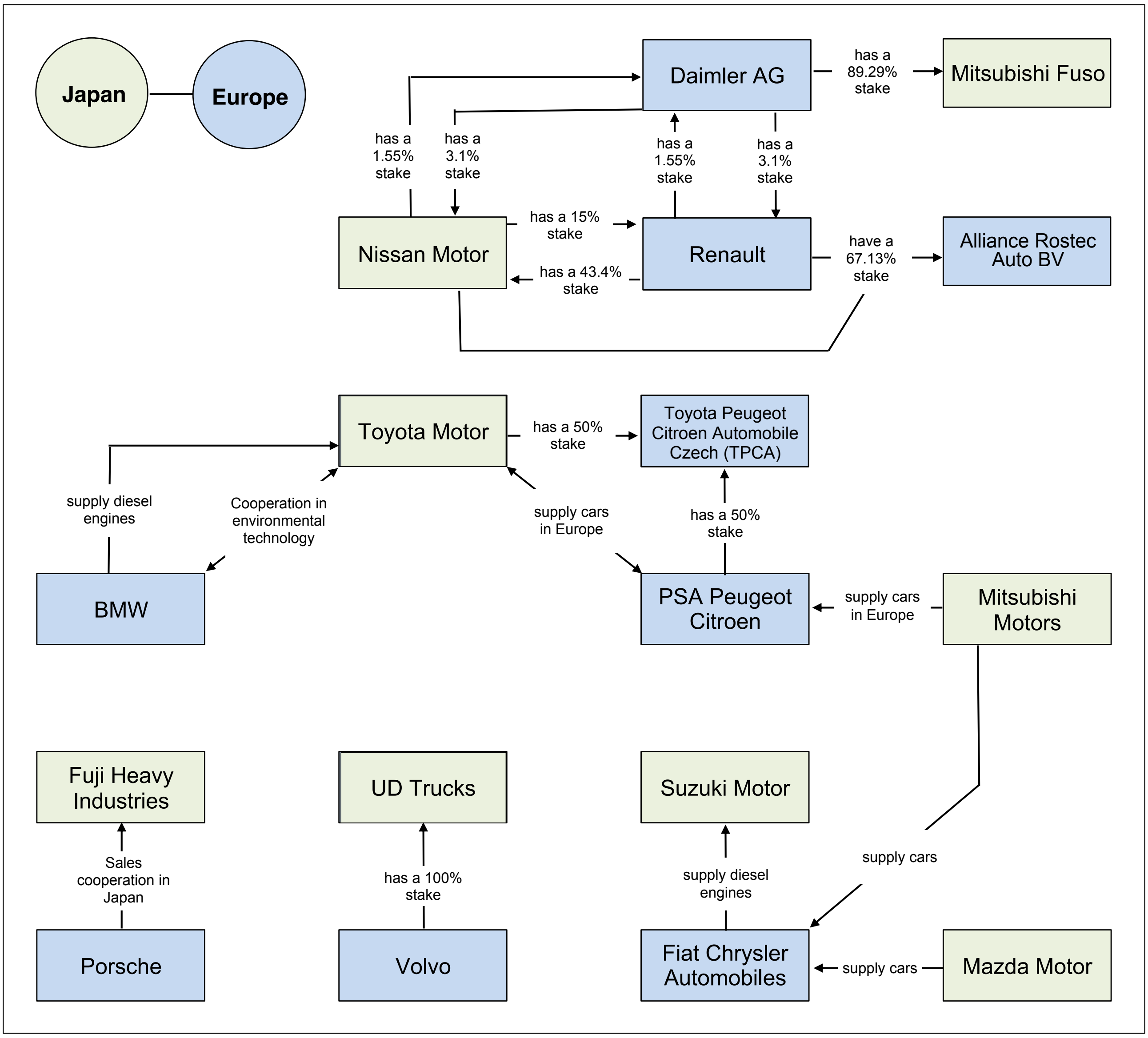
Source: MUMSS, from company and JAMA data

Figure 5-7. Capital and business alliances between Japanese and US automakers



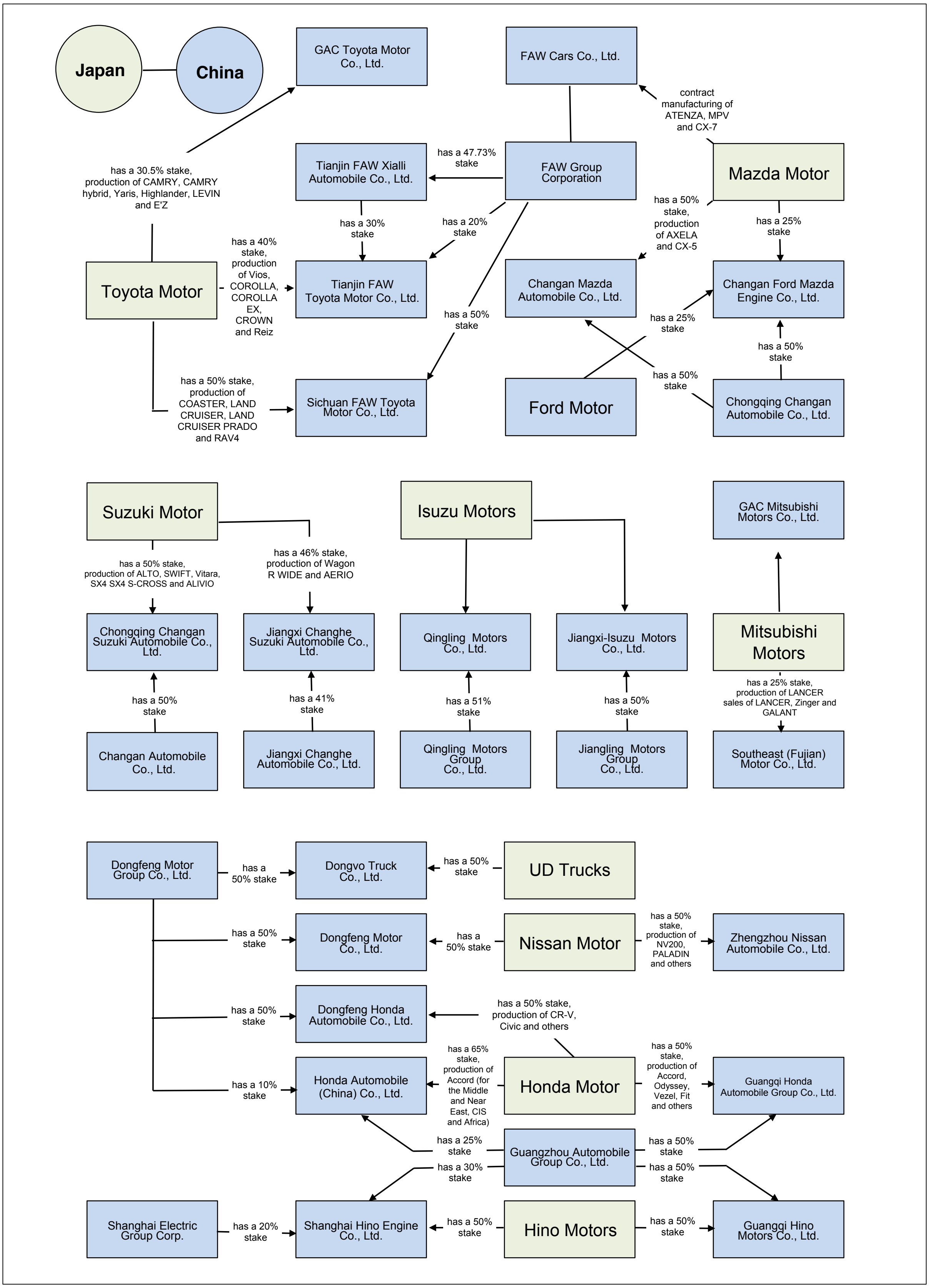
Source: MUMSS, from company and JAMA data

Figure 5-8. Capital and business alliances between Japanese and European automakers



Source: MUMSS, from company and JAMA data

Figure 5-9. Capital and business alliances between Japanese and Chinese automakers



Source: MUMSS, from company and JAMA data

Figure 5-10. Equity holdings among Toyota Group affiliates

(more than 20%)

(%)	Toyota	Daihatsu	Hino	Toyota Ind.	Denso	Aisin	Tsusho	Gosei	Boshoku	Aisan	Rika	Koito	Aichiko	JTEKT
OWNER														
7203 Toyota	8.8	51.1	50.1	23.5	22.2	22.2	21.5	42.6	39.2	28.8	31.1	20.0	23.7	22.4
7262 Daihatsu														
7205 Hino														
6201 Toyota Ind.	6.6			3.5	7.8	7.0	11.1		4.1	7.6			6.8	2.2
6902 Denso	2.5			9.0	10.3	4.3			5.4	8.7	9.3	1.8		5.3
7259 Aisin				2.0	1.4	3.8								
8015 Toyota Tsusho				4.6					2.3					1.7
Towa Fudosan				4.9	3.7	2.1			9.7				2.3	
7282 Toyoda Gosei														
Aioi Nissay Dowa Insurance				1.5			1.1							
3116 Toyota Boshoku									1.0					
7283 Aisan Kogyo														
6995 Tokai Rika											3.2			
7276 Koito Mfg.														
5482 Aichi Steel														
6473 JTEKT														
Employee stock ownership plan					1.3			0.8	1.3	1.9	1.1			
Total As of 3/16	**17.9**	**51.1**	**50.1**	**49.0**	**46.7**	**39.4**	**33.7**	**43.4**	**63.0**	**47.0**	**44.7**	**21.8**	**32.8**	**31.6**

(less than 20%)
Toyota's ownership

(%)	Akebono	Futaba	KYB	Ichiko	Toyo RB	T-RAD	NOK	FHI	Yamaha	Owari	Isuzu	KDDI
As of 3/16	**11.3**	**12.2**	**7.6**	**6.1**	**3.7**	**4.4**	**3.9**	**16.4**	**3.5**	**9.9**	**5.8**	**11.0**

Source: MUMSS

Figure 5-11. Equity holdings among Honda Group affiliates

(more than 20%)

(%)	Honda	Yutaka Giken	Keihin	Nissin Kogyo	Yachiyo Industry	Showa	Musashi Seimitsu	Tanaka Seimitsu	H-One	TS Tech	FCC	G-TEKT
OWNER												
7267 Honda		69.6	41.3	34.6	50.3	33.4	26.2	24.3	21.3	22.5	20.6	29.6
7229 Yutaka Giken												
7251 Keihin												
7230 Nissin Kogyo												
7298 Yachiyo Industry												
7274 Showa												
7220 Musashi Seimitsu												
7218 Tanaka Seimitsu												
5989 H-One												
7313 TS Tech												
7296 FCC											4.6	
5970 G-TEKT												
7212 F-Tech												
Employee stock ownership plan		2.3	1.3		1.7	2.1		11.3	4.1		1.7	
Total **As of 3/16**		71.9	42.6	34.6	52.0	35.5	26.2	35.6	25.4	22.5	26.9	29.6

(less than 20%)
Honda's ownership

(%)	F-Tech	Imasen	Nippon Seiki	Nittan Valve	Mitsuba	Ahresty	Nippon Konpo	Hi-Lex
As of 3/16	**16.5**	**5.0**	**6.1**	**4.2**	**3.6**		**3.5**	**2.2**

Source: MUMSS

Figure 5-12. Equity holdings among Nissan Group affiliates

(more than 20%)

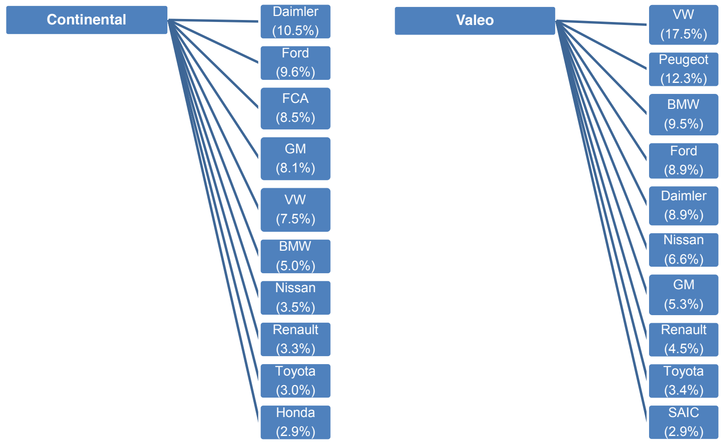
(%)	Nissan	Nissan Shatai	Calsonic
OWNER			
7201 Nissan		43.0	40.6
7222 Nissan Shatai		5.9	
7263 Aichi Kikai			
7248 Calsonic			1.9
Employee stock ownership plan		1.7	
Total As of 9/15		50.6	42.5

(less than 20%)
Nissan's ownership

(%)	Unipres	Mitsuba
As of 9/15		3.8

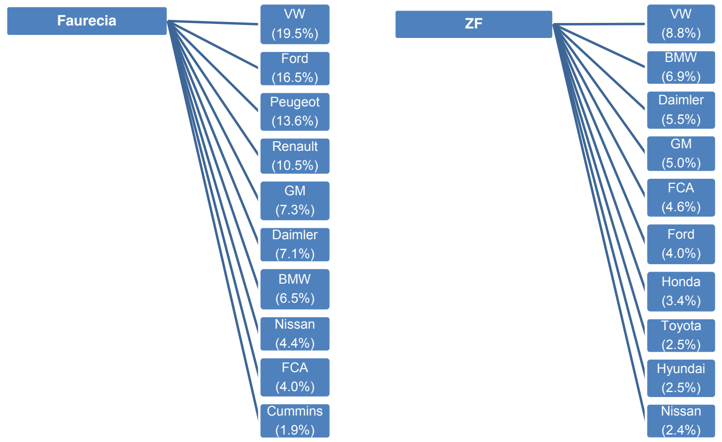
Source: MUMSS

Figure 5-13. Top 10 customers (by sales) for European suppliers (1)



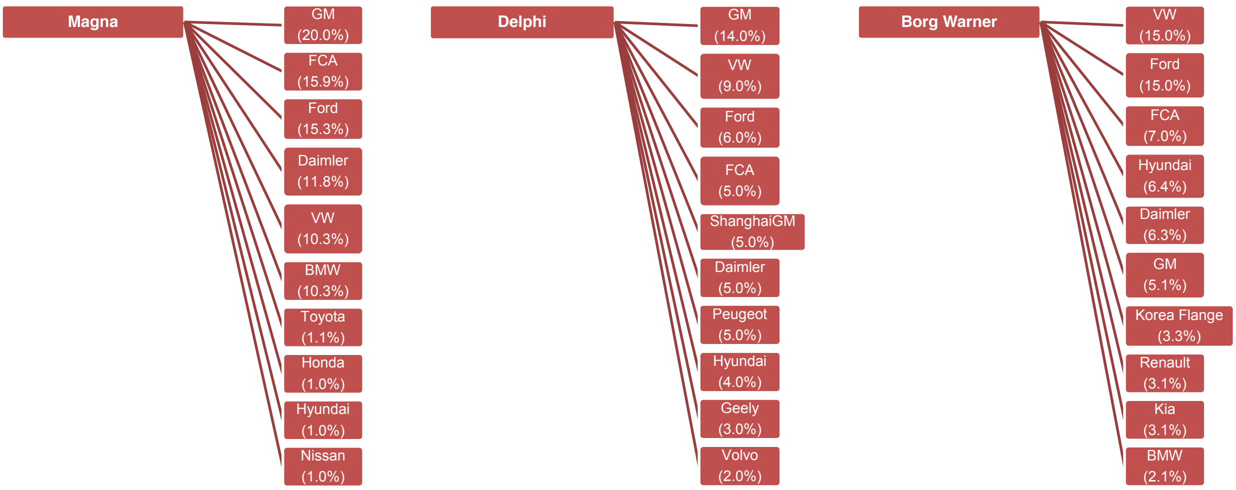
Source: MUMSS, from Bloomberg

Figure 5-14. Top 10 customers (by sales) for European suppliers (2)



Source: MUMSS, from Bloomberg

Figure 5-15. Top 10 customers (by sales) for North American suppliers



Source: MUMSS, from Bloomberg

Appendix A

Analyst Certification

The analyst(s) mentioned on the cover of this report hereby certify(ies) (or, where multiple analysts are responsible, individually certify with respect to each security that the analyst covers in this report) that the views expressed in this report accurately reflect their personal views about the subject company(ies) and its (their) securities, and also certify(ies) that they have not been, are not, and will not be receiving direct or indirect compensation in exchange for expressing any specific recommendation(s) or view(s) in this report.

Required Disclosures

Mitsubishi UFJ Morgan Stanley Securities Co., Ltd. ("MUMSS") and/or its affiliate(s) beneficially owns 1% or more of any class of common equity securities of TOYOTA BOSHOKU, NIDEC, DENSO, NISSAN MOTOR, TOYOTA MOTOR, HINO MOTORS, CALSONIC KANSEI, KEIHIN, AISIN SEIKI, Mazda Motor, HONDA MOTOR, SUZUKI MOTOR, Fuji Heavy Industries, SHOWA.

MUMSS and/or its affiliate(s) beneficially owns 0.5% or more of any class of common equity securities of TOYOTA BOSHOKU, NIDEC, DENSO, NISSAN MOTOR, TOYOTA MOTOR, HINO MOTORS, CALSONIC KANSEI, KEIHIN, AISIN SEIKI, Mazda Motor, HONDA MOTOR, SUZUKI MOTOR, Fuji Heavy Industries, SHOWA.

Calculations for companies within one month of a public listing of shares may be based on the Offering Memorandum.

Within the past 12 months, MUMSS and/or its affiliate(s) did manage or co-manage a public offering of securities of DENSO, NISSAN MOTOR, TOYOTA MOTOR, AISIN SEIKI.

Within the past 12 months, MUMSS and/or its affiliate(s) received and/or entered into an agreement to receive compensation for investment banking services from NIDEC, DENSO, NISSAN MOTOR, TOYOTA MOTOR, AISIN SEIKI.

Within the next 3 months, MUMSS and/or its affiliate(s) expects to receive or intends to seek compensation for investment banking services from TOYOTA BOSHOKU, NIDEC, DENSO, NISSAN MOTOR, TOYOTA MOTOR, HINO MOTORS, CALSONIC KANSEI, KEIHIN, AISIN SEIKI, Mazda Motor, HONDA MOTOR, SUZUKI MOTOR, Fuji Heavy Industries, SHOWA.

Mitsubishi UFJ Morgan Stanley Securities Rating System:

Definitions of individual stock ratings

Overweight (OW)	The analyst expects the stock to outperform other stocks in the subsector as classified by MUMSS
Neutral (N)	The analyst expects the stock to have a neutral performance relative to other stocks in the subsector as classified by MUMSS
Underweight (UW)	The analyst expects the stock to underperform other stocks in the subsector as classified by MUMSS
NR	Not Rated. Stock rating, target price have not been assigned
RS	Rating Suspended. Stock rating, target price have been suspended.

Definitions of small cap stock ratings

Buy	The analyst expects the share price to rise in absolute terms
Hold	The analyst expects the share price to fluctuate modestly in absolute terms
Sell	The analyst expects the share price to decline in absolute terms
NR	Not Rated. Stock rating, target price have not been assigned
RS	Rating Suspended. Stock rating, target price have been suspended

Unless otherwise specified, the time frame for target prices included in this report is over the next 12 months.

Distribution of ratings on individual stocks (updated as of 3 October 2016).

Rating category	Coverage universe	Investment banking relationships*
Buy (Overweight, Buy)	37.4%	31.0%
Hold (Neutral, Hold)	51.4%	30.0%
Sell (Underweight, Sell)	7.7%	13.2%
Others	3.5%	29.4%

Based on the MUMSS stock rating system, with “Buy” equated to “Overweight” for individual stocks and “Buy” for small caps, “Hold” equated to “Neutral” and “Hold”, and “Sell” equated to “Underweight” and “Sell”.

* Investment banking relationships is weighting by rating category, based on data for the past 12 months.

Additional Required Disclosures

MUMSS has established organizational and administrative arrangements such as appropriate policies and procedures to monitor activities and/or communication between the research department and other business areas of MUMSS and to monitor correspondence and personal brokerage accounts of all those involved in the production of research.

MUMSS policy prohibits its analysts, persons reporting to analysts, and members of their households from owning securities of any company in the analysts' area of coverage or from serving as an officer, director, or advisory board member of such company. Individuals who are involved in the production of research who have knowledge of the timing or content of research which is not publicly available are prohibited from undertaking personal transactions in financial instruments to which the research relates (or in any financial instruments) until the intended recipients of the research have had a reasonable opportunity to act on it.

Analysts are paid in part based on the profitability of MUMSS, which includes investment banking revenues.

MUMSS and/or its affiliate(s) may have holdings in other financial interests or other products issued by the companies named in this report. MUMSS and/or its affiliate(s) may have a short or long position in respect to these financial interests or other products.

An officer (or officers) of MUMSS (member of the board, executive director or auditing officer as stipulated by the Company Act of Japan (Law no. 86 of 2005, as amended, the Company Act)) serve(s) as an officer (or officers) in Mitsubishi UFJ Financial Group, Kabu.com Securities, Mitsubishi Logistics

For disclosure information on this report, please refer to our Disclosure site at the following link.
https://www.er.sc.mufg.jp/disclosure/disclosure.php

Disclaimers

This report has been prepared by MUMSS solely for the purpose of supplying information to the clients of MUMSS and/or its affiliate(s) to whom it is distributed. This report is not, and should not be construed as, a recommendation, solicitation or offer to buy or sell any securities or related financial products.

Any references in this report to MUMSS are based only on publicly available information. The authors of this report are prohibited from using or even obtaining any insider information. As a subsidiary of Mitsubishi UFJ Financial Group, Inc. ("MUFG"), MUMSS does not, as a matter of corporate policy, cover MUFG for investment recommendation purposes.

This report has been prepared by MUMSS solely from publicly available information. The information contained herein is believed to be correct and reliable but has not been independently verified. This report does not purport to contain all the information that a prospective investor may require. MUMSS and/or its affiliate(s) do not make any guarantee, representation or warranty or accept any responsibility or liability as to the accuracy, reliability, completeness, adequacy or appropriateness of such information. Information contained herein may not be current due to, among other things, changes in the financial markets or economic environment. Opinions reflected in this report are subject to change without notice. MUMSS and/or its affiliate(s) have no obligation to update the opinion and information contained in this report. MUMSS has prepared and published this report wholly independently of any of its affiliates, and thus any comments, views, outlook, ratings or target prices expressed in this report may differ substantially from any similar reports issued by affiliates which may be based upon different sources and methodologies.

Regarding the stocks mentioned either directly or indirectly in this report, there is risk that investors may, upon a sale of investments, receive less than the originally invested capital due to factors including fluctuations in share price, changes to issuers' management and/or financial profiles, related changes to external evaluations, and changes in interest and/or foreign exchange rates.

This report does not constitute, and should not be used as a substitute for, tax, legal or investment advice. The report does not constitute a personal recommendation and has been prepared without regard to the individual financial circumstances, needs or objectives of persons who receive it. The securities and investments related to the securities discussed in this report may not be suitable for all investors. Readers should independently evaluate particular investments and strategies, and seek the advice of their own professional and financial advisers as to the legal, business, financial, tax and other aspects before making any investment or entering into any transaction in relation to the securities mentioned in this report.

MUMSS and/or its affiliate(s) shall not be liable in any manner whatsoever for any consequences (including but not limited to any direct, indirect or consequential losses, loss of profits and damages) of any reliance on or usage of this report and accepts no legal responsibility to any investor who directly or indirectly receives this material. The final investment decision must be made by the investor and the responsibility for the investment must be taken by the investor.

Past performance should not be taken as an indication or guarantee of future performance. Unless otherwise attributed, forecasts of future performance represent analysts' estimates based on factors they consider relevant. Actual performance may vary. Consequently, no express or implied warranty can be made regarding future performance.

MUMSS or any other company affiliated with MUFG or any of their directors, associates, connected parties and/or employees may deal in or otherwise have a financial interest in securities referred to in this report, or derivatives of such securities or other securities issued by companies mentioned in this report, for their own account or the accounts of others, may enter into transactions contrary to any recommendations contained herein, may act as market maker or may supply or seek to supply a wide range of financial services to the issuers of such securities or to their affiliates. In reviewing this report, an investor should be aware that any or all of the foregoing, among other things, may give rise to real or potential conflicts of interest. MUMSS is prohibited under Article 135 of the Company Act from dealing in the shares of MUFG for its own account.

The securities referred to in this report may not be eligible for sale in all jurisdictions or to all categories of investors. This report is not directed to, or intended for distribution to or use by, any person or entity who is a citizen or resident of or located in any locality, state, country or other jurisdiction where such distribution, publication, availability or use would be contrary to any law, regulation or rule.

United Kingdom/European Economic Area(EEA): This report is distributed in the United Kingdom, by MUFG Securities EMEA plc. ("MUS(EMEA)"), a member of MUFG, contact number +44-207-628-5555. MUS(EMEA) is authorised by the Prudential Regulation Authority ("PRA") and regulated by the Financial Conduct Authority ("FCA") and PRA in the UK (FS Registration Number 124512). For the avoidance of doubt this report is prepared for a "professional client" or "eligible counterparty" and not intended for a "retail client" as those terms are defined in the FCA rules and should not be passed on to any such persons. This report may be distributed to professional investors (or equivalent) in other member states of the EEA by MUS(EMEA). This report has been prepared in accordance with MUS(EMEA)'s organisational and administrative arrangements for managing conflicts of interest. Such arrangements include

Mitsubishi UFJ Morgan Stanley Securities Co., Ltd.
Equity Research Division
Otemachi Financial City Grand Cube, 1-9-2, Otemachi, Chiyoda-ku, Tokyo 100-8127, Japan
Tel.03-6627-5340 Fax.03-6627-5344

VALUENEX
intellectual innovator

www.valuenex.net
customer@valuenex.com

PLEASE NOTE:

This document is distributed by VALUENEX. This document is the MUMSS report containing the results of VALUENEX-powered analytics and joint research by VALUENEX and MUMSS.

Contact

EMAIL: customer@valuenex.com

TEL (JP): +81 3 6902 9833

TEL (US): +1 650 319 8015