An Empirical Study of the Partnership Network Structure of Automakers under CASE

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Abstract

The purpose of this research is to analyse empirically the effect of the ongoing and radical change in the business environment in the automotive industry called CASE (Connected, Autonomous/Automated, Shared, Electric) on the network structure of the partnerships of automobile manufacturers. Traditionally, partnerships in the automotive industry have been dominated by dense network structures. On the other hand, according to previous studies in other industries, network structures suitable for radical innovation involve weak ties, structural holes, and betweenness centrality, etc. This study's methodology used actual data on the partnerships of automobile manufacturers around the world which were analysed using a social network analysis method. The analysis results showed a significant correlation between the degree of approach to CASE and the number of weak ties and the size of structural holes. In addition, some case studies show significant differences in network structure between new technology venture companies and existing legacy technology companies. The discussion highlights the insight that the network structure of the automobile industry could change significantly in the future due to technological innovation. Future work should acknowledge that changes in the industry structure due to CASE are still in progress, and continuous research is needed.

Keywords: partnership network, social network analysis, technology change, automobile industry
JEL classification: M11

Paper type: Research article
Received: Feb 12, 2020
Accepted: Jun 5, 2020

Introduction

The purpose of this study is to empirically analyse the effects of radical technological change on the network structure of corporate partnerships. Network structures related to corporate partnerships vary depending on the industry characteristics and product structure to which the company belongs. Changes in technology will affect both industry characteristics and product structure, such as component configuration, and the optimal partnership will change. This study focuses on the automotive industry, which is currently facing dramatic technological change, known as CASE (Connected, Autonomous, Shared & Services, and Electric) (Houdek & Schmerler, 2017). The term CASE was originally coined by Daimler, but is widely used today in the automotive industry.

In the traditional automotive industry, a closed and strong partnership network structure with a specific group of companies has been selected. In the choice of a consumer for a car, the customer value of the car is greatly influenced by its individual characteristics such as concept and brand value; these of course differ for each vehicle. Therefore, in order to realise the individuality of each car, a product individual to each car has been developed for the main parts and materials of cars. A single car is made up of tens of thousands of parts and materials, and in order to realise the concept and design of the car, integrated adjustments between many parts and materials is important. For this reason, each automobile manufacturer develops, designs, and manufactures products in close cooperation with specific parts and material manufacturers. Each automaker must flexibly exchange vital intellectual property, development, and design information with its partners, while preventing leakage to non-partners. For this reason, they have strengthened human and capital relationships with limited and unique partners, and have formed strong partnerships over time. As a result, a vertically integrated, closed, and cohesive ecosystem (Iansiti & Levien, 2004) has been formed in the automotive industry, centred on vehicle manufacturers.

On the other hand, for example, in the IT industry, a network structure of a relatively open and ad hoc weak partnership has been selected. Interface specifications for computers and the Internet are being standardised, many of which are open to the public free of charge, and the modularisation of components is progressing. This has enabled various players to enter the market and has encouraged the creation of countless venture companies specialising in certain technologies. Furthermore, it is easy to improve product performance, add new functions, or reduce costs, and cost performance for customers is rapidly increasing. In addition, so-called platformers (or platform leaders) have emerged that specialise in limited technology, expand partnerships with various companies, and dominate in certain business areas. In the IT industry, platformers play a central role in forming an ecosystem that is both open and horizontally collaborative.

However, the development of CASE, the subject of this research paper, is causing radical changes in traditional automobile products and industry structure, which may predict that the automobile product structure will resemble that of IT products. For example, “connected” means that an automobile is converted to an information communication device. "Autonomous driving" will transform the core technology of automobiles into IT, and the traditional value of driving for fun will be lost. If all cars become like buses and taxis by "sharing", the value of the customer by owning the cars, such as the appearance, design, and status of luxury cars, will be meaningless. The total number of vehicles sold will decrease drastically due to the sharing of automobiles, and their value will shift from hardware to services. In addition, the adoption of "electric vehicles" will simplify the structure of the car and

greatly reduce the number of parts, reduce the need for integrated adjustment between parts, and significantly reduce the number of parts manufacturers. In order to prepare for these changes, existing automakers and parts makers are trying to survive and desperately change their strategies. Many companies are attempting to adapt to new technologies and services and build new industry rules around themselves. Others are honing their existing technologies to differentiate and survive. In addition, many emerging automakers are seeking supremacy through the adoption of new business models.

In order to gain insight into these changes, the purpose of this study is to analyse how the network structure of partnerships by automakers is changing due to the impact of the current development of CASE. As data for analysis, we collect actual data on the partnerships of automobile manufacturers and construct a database for analysis. As an analysis method, the characteristics of the network structure of each automobile manufacturer and their relationship with their degree of CASE approach will be analysed based on the compiled database using the aforementioned method of social network analysis.

Previous research

Relationships between organisations in the automotive industry

There has been significant discussion in previous studies as to whether or not conventional inter-organisational relationships will change following the development of CASE. For example, Murasawa (2010) has positioned electric vehicles as a modular development (Baldwin & Clark, 2000). It becomes possible for a small company such as a local car repair shop or an electric shop to develop, produce, and sell an electric car by combining parts that are interchangeable with each other. Iansiti and Lakhani (2017) predicted the "Connected – Car" ecosystem. Three software platforms-Android Auto, Apple CarPlay, and, to a lesser extent, OpenCar-dominate the market for integrating smartphone functionality into vehicles. They constitute powerful bottleneck assets because they have scores of supply-chain partners and they enable other stakeholders to reach consumers. The car features that buyers will care most about—software and networks—will be largely outside the automakers' control, and their price premiums will go down. Saeki (2011), on the other hand, states that the product architecture of an entire electric vehicle has the characteristics of an integral type (Baldwin & Clark, 2000). Even electric vehicles require advanced coordination by car manufacturers and suppliers, including software development.

Network Theory and Innovative Technology Evolution

This argument can be replaced by the question of whether radical innovation is likely to be created by integrated inter-organisational relationships or by decentralised inter-organisational relationships.

According to Granovetter (2005), more novel information flows to individuals through weak rather than strong ties. As close friends tend to move in the same circles, the information they receive overlaps considerably with what is already known. Acquaintances, in contrast, know people in other circles and thus receive more novel information.

Burt (2004) classifies ties into Bridging Ties and Cohesive Ties, and Bridging Ties are defined as ties that connect separated individuals and groups. These can be analysed by indexes such as the number of intervening ties and structural holes. When there is no direct connection between those who are connected to the actor

(ego), a structural hole is said to exist between them. Bridging Ties' strength lies in the widespread dissemination of new, formal, and heterogeneous knowledge, and it is easily linked to radical innovation. On the other hand, if two people who are connected to the actor (the ego) are themselves connected, the three people (the triad) are described as closed. The high network density of the ego represents the degree to which the ego network triad is closed (Phelps et al., 2012). Research papers that analyse CASE in the automobile industry using the method of social network analysis are rare. Nischak and Hanelt (2019) analysed the structure of the entire industry, not the analysis of differences between individual companies.

Platform and Innovation

There are also many previous studies in the case study method, which point out that the dispersion and openness of inter-organisational relationships promote technological innovation. In particular, research into the IT industry in Silicon Valley is prominent, and among them, there are many previous studies on so-called platformers. One of the earliest prominent research studies on platformers is Platformer Leadership by Gawer and Cusumano (2002), as well as their subsequent works. Platforms are the product and service that act as a base upon which multiple complementary companies make a product or provide a service. According to Gawer and Cusumano (2013), external or industry platforms serve as foundations upon which a larger number of firms can build further complementary innovations in the form of specific products, related services, or component technologies. Industry platforms tend to facilitate and increase the degree of innovation in complementary products and services; the greater the innovation in such complementary aspects, the greater the value created for the platform and its users via network effects, thus creating a cumulative advantage for existing platforms. By connecting to the platform, complementors can not only generate complementary innovation, but also gain access, whether directly or indirectly, to the platform's customers (Ceccagnoli et al., 2012; Cennamo & Santalo, 2013).

Integration and Innovation

On the other hand, there are many previous studies that explain the usefulness of integrated inter-organisational relationships, especially when the industry structure is undergoing an innovative transformation.

According to Chesbrough and Kusunoki (2001), integral architecture is mainly used in the early stages of industry. Individual modules that function as semi-autonomous subsystems can flexibly respond to technological changes that can be absorbed inside the module. However, in the early stages of the industry, the interface rules between modules themselves can be ambiguous and subject to change. Companies that have adopted a modular organisational structure are more likely to fail to lead or follow innovative technological changes because they do not have the breadth of knowledge beyond modules.

Wessel et al. (2016) conducted a case study on electric vehicles, pointing out the importance of enhancing Interdependence in the ecosystem for innovative technological evolution. Changes to one part of the car often meant changes throughout the automobile. For that reason, product development requires an interdependent network of partners. The more dramatic the innovation, the more interdependence may be required. As the transition to autonomous driving and electric vehicles progresses, a level of interdependence similar to vertical integration is required.

Research hypothesis

The research hypothesis is derived based on the aforementioned studies. One of the most important issues in the current literature is the breadth of a partnership's network. It is assumed that the size of the partners will increase opportunities for new integration of knowledge and promote innovation. A series of discussions on open innovation in the time since Chesbrough (2003) have made similar claims. According to discussions on dynamic capabilities, such as in Teece (2009), strategic decision-making ability is important at times of technological changes in the environment. If the technology is immature and uncertain, expanding the scope of the partnership will allow multiple technologies, both internal and external, to compete and the better of the two to be chosen. In addition, by cooperating with various partners, it is possible to disseminate the technical specifications of the company and aim for standardisation in the future.

With the development of CASE, automakers need to work on various new technological elements that have not previously been targeted. For example, even considering only electric vehicles, it is necessary to solve not only the development of various technologies related to the vehicle itself such as batteries and motors, but also the solution of infrastructure issues such as charging facilities. There are enormous challenges in autonomous driving, such as the accumulation and analysis of big data, as well as the improvement of road networks for location information and the development of communication technology between vehicles. In addition, issues such as connected and sharing are pushing the transformation of automobile profit models. Instead of increasing the profit margin and sales volume of the car itself, it is necessary to shift to new revenue models such as services and solutions related to mobility. For this reason, there is a need for development targeting the entire transportation and the entire city in cooperation with various companies such as railway and real estate companies.

Hypothesis 1. With the development of CASE, the network of automaker partnerships will expand.

In addition to the breadth of this network, the diversity of partners is important from the viewpoint of innovation. In particular, in order to create radical innovation, it is useful to encounter different kinds of knowledge as far as possible from the knowledge domain owned by the company. Consequently, it is thought that structural holes are likely to work effectively in promoting innovation.

Hypothesis 2. With the development of CASE, the structural holes in automaker partnerships will increase.

On the other hand, as an alternative between Hypothesis 1 and Hypothesis 2, the size of the partner may not necessarily promote innovation. For example, according to the theory of exploration and exploitation (Gupta et al., 2006), if a company becomes too active in external collaboration, this could lead to a decline in its own R&D capabilities. In addition, even if the partners are diversified, the alliance with a partner whose R&D content is very different from the company tends to have a low probability of success (Lane & Lubatkin, 1998). Considering CASE, since the structure of an electric vehicle is significantly simpler than that of a gasoline-powered vehicle, it is conceivable that the number of parts manufacturers traded by one completed vehicle manufacturer may be reduced. In addition, it is assumed that a large amount of management resources will be required if one company attempts to develop a wide variety of issues. Therefore, no company alone may be trying to conduct comprehensive and integrated business activities. Automakers may concentrate their development resources on limited parts of the ecosystem.

Hypothesis 3. With the development of CASE, the partnership network of automakers will not be widened.

Another critical issue in previous research is whether the inter-organisational relationship is horizontally specialised or vertically integrated. This is closely related to the types of relationships between components or services that make up the product/value chain.

One hypothesis is that with the development of CASE, the product structures of automobiles will be closer to the modular types of computers. If the business areas that automakers and related companies need to consider greatly expand with the progress of CASE compared to the existing automobile industry, it may be difficult for a single company to undertake comprehensive innovation. It may instead be advantageous for various companies to autonomously divide innovation. In such a horizontally specialised industrial structure, the core companies in the ecosystem are platformers or platform leaders (Gawer & Cusumano, 2002). With the development of CASE, the automobile industry is likely to be reorganised, and many companies are working toward becoming a platformer.

Hypothesis 4. With the development of CASE, automakers will expand their platform-type partnership network.

Moreover, the platform leader is not necessarily the complete car manufacturer. Platformers often occupy resources that are scarce or difficult to imitate, which can be a source of competitive advantage. It can be a component or material based on a high level of technological accumulation, or it can be information rather than substance. Big data, for example, whose usage value is increased by accumulation, can be an important resource. For instance, in the IT industry, the platform leader is not necessarily a finished product company, but a specific component manufacturer or a company that monopolises valuable big data. In the case of CASE, the source of competitive advantage may be a database of autonomous driving experiments or big data on mobility usage. A supplier company capable of accumulating such big data across the industry can play a role as a platform leader for multiple vehicle manufacturers and their group companies.

Hypothesis 5. With the development of CASE, non-automaker suppliers will expand their platform-type partnership network.

On the other hand, as an alternative to Hypotheses 4 and 5, even if CASE progresses, there is a possibility that the industrial structure will not be modular and the inter-organisational relationship will not be a platform type. As the cause, for example, a cause related to a stage in a product life cycle or a cause due to characteristics unique to an industry can be considered. Many technological developments related to CASE are still in progress, and there are many products and services that will be put into practical use in the future. The scope of technological development is not limited to automobile products alone, but rather covers a wide variety of areas, including transportation infrastructure, residential and commercial facilities throughout the city, and energy issues. Since they interact with each other, complicated adjustments are considered necessary. In the early stage of such a large-scale technological development, it may be more appropriate to promote technology development in an integrated manner while closely cooperating with specific companies than to autonomously promote technological developments by division of labour.

It also needs to take into account the unique characteristics of the automotive industry. As CASE progresses, the complexity and individuality of the car itself may decrease, but the car will respond to the complex and individual demands of each city as part of all means of transportation in the city right. Transportation issues differ

from region to region, such as congested urban areas and depopulated rural areas, advanced and aging countries and countries with immature infrastructure. If individual and optimal solutions are needed to solve each regional issue, it may be desirable in the future for the industry to be integrated and for companies to cooperate and coordinate closely.

Hypothesis 6. Even if CASE progresses, the industrial structure will remain integrated.

Research method

In this study, in order to verify each of the aforementioned hypotheses, we analysed the network structure of partnerships by automakers. The data and method for analysis are as subsequently detailed.

Data

Data on the partnerships required for the analysis were obtained from FactSet's Supply Chain Relationships database (OpenFactset, 2014). FactSet Supply Chain Relationships was accessed as an additional service of Nikkei Telecon. The data of FactSet Supply Chain Relationships is classified into Suppliers, Customers, and Partners, and the data on Partners was obtained from them. As a candidate for the company to be extracted, we refer to the industrial yearbook issued by Fourin (2020), a survey company specialising in the automobile industry, and listed the world's automobile manufacturers. Then, we searched the FactSet Supply Chain Relationships database and obtained the data of all the companies included. The number of companies available was 106 for automakers and 901 for all, including partners.

From the FactSet Supply Chain Relationships database, we obtained information on the names of automobile manufacturers and their partner companies, as well as the patent type and industry category. The types of partnerships were mainly Research Collaboration, Manufacturing collaboration, Joint Venture, In-licensing, Out-licensing, equity Investment, and investors. In addition, there was at least one company in the distribution, marketing, and integrated product offering categorisations.

The Industry category was used to measure the extent to which automakers are collaborating with partner companies on CASE. Since it is difficult to categorise each partnership strictly as a CASE, in this survey, the ratio of partners with the following Industry categories (*) to all partners was used as a proxy variable for the degree of cooperation with partners regarding CASE. Hereinafter, this value is referred to as the "CASE ratio".

(*) Packaged Software, Electrical Products, Internet Software/Services, Telecommunications Equipment, Electric Utilities, Broadcasting, Information Technology services, Semiconductors, Electronics/Appliances, Electronic Equipment/Instruments, Electronic Production Equipment, Major Telecommunications, Electronic Components, Internet Retail, Alternative Power Generation, Wireless Telecommunications, Computer Processing Hardware, Data Processing Services, Computer Communications, Electronics Distributors, Specialty Telecommunications, Cable/Satellite TV, Computer Peripherals

As basic statistics, the average CASE ratio of each automaker was 0.18, and the standard deviation was 0.21. For example, a CASE ratio of 0.18 means that 18% of the number of partner companies belongs to the above industry category. Automakers are working on CASE by themselves, and they have already used many electrical components. However, if the CASE ratio is low, it is assumed that

automakers have not conducted much joint research with their partners on electrical components, etc., and are simply using them as purchased products.

Analysis method

As an analysis method, the collected partnership database was analysed using social network analysis. Various network indices that quantify the characteristics of the network structure of each automobile manufacturer were extracted by the aforementioned analysis. The network indices were selected in accordance with the respective hypotheses, as described later. Subsequently, the relevance of each variable to CASE was verified by correlation analysis with CASE ratio. In addition to the statistical analysis of the overall trend, a case study was conducted on companies with particularly large and small CASE ratios.

The network indices used to test each hypothesis are as follows. For Hypothesis 1, the size of the network is based on the size of the ego network of each car manufacturer. For the structural hole in Hypothesis 2, Constraint was used. Constraint is an index that indicates the degree of constraint of the network. The smaller the value of constraint, the larger the structural hole, indicating that the company is effectively cooperating with various companies. Hypothesis 3 corresponds to the null hypothesis of Hypotheses 1 and 2. For the platform of Hypothesis 4, we used broker and ego betweenness; these are indices indicating the mediation of a certain node, and indicate the ratio of mediating the connection between other nodes on the network. For Hypothesis 5, density was used. This index indicates the degree to which each node on the network is connected to each other, and it is assumed that this index indicates the degree to which the supplier cooperates with multiple corporate groups. Hypothesis 6 corresponds to the null hypothesis of Hypotheses 4 and 5. The network analysis was performed using UCInet ver. 6.6. Borgatti et al. (2002) was referred for the calculation method.

Results

Statistical analysis results

Table 1 illustrates the results of the correlation analysis between the network indices of all automakers and the CASE ratio.

Table 1

Correlation coefficient between network index and CASE ratio

Network index	Correlation coefficient	Related hypothesis (alternative hypothesis)
Size	.348*	Hypothesis 1(3)
Constraint	-.390*	Hypothesis 2(3)
Broker	.245	Hypothesis 4(6)
EgoBetween	.233	Hypothesis 4(6)
Density	-.241	Hypothesis 5(6)

Note: *: 5% significance level

Case analysis results

Of all the automakers, the two companies with the highest CASE ratios and the two with the lowest were selected, and the network indices of each company were extracted (Table 2). As a result, Chinese carmakers NIO and BYD were identified as carmakers with a high CASE ratio. On the other hand, Daihatsu and Subaru in Japan

were identified as low-CASE automakers. Note that each network index is standardised (after subtracting the average value and dividing by the standard deviation), so that it can be easily compared.

Table 2
Network indices of companies with high/low CASE ratios (after standardisation)

CASE ratio	Company	Size	Constraint	Broker	EgoBetween	Density
High	NIO (China)	-1.0	-0.6	0.7	0.9	-0.7
High	BYD	-0.6	-0.6	0.8	1.0	-0.8
Low	Subaru	-0.7	1.2	-1.7	-1.2	1.7
Low	Daihatsu Motor	-0.9	2.0	-1.5	-1.2	1.5

Discussion

Next, each hypothesis is verified based on the results of the preceding analysis. First, from the results of the correlation analysis on the trends of all automakers, the more companies progressing to CASE, the wider and more diversified their partnerships. These results support Hypotheses 1 and 2, and reject Hypothesis 3, an alternative hypothesis. Currently, numerous automakers are expanding their R&D activities by investing proactively in the new CASE domain while maintaining vehicles that are based on existing gasoline engines and maintaining a vertically integrated supply chain. It is inferred that the network with new partners has been expanded for this purpose. In order to expand the number of partnerships and diversify R&D themes, a large amount of resources will be required. In fact, the world's automakers are now actively conducting M&As and expanding their scale in preparation for CASE, and the results of this analysis are consistent with these phenomena. As CASE progresses, the value of owning cars, the source of profits in the existing passenger car industry, may decrease.

On the other hand, as a result of the correlation analysis, horizontal specialisation and platformisation were not correlated with the progress of CASE. These facts seem to indicate that the existing vertical integration of organisational relationships has not changed with the progress of CASE in the overall trend of the automobile industry. This trend was the same for both finished car makers and parts makers. Therefore, the results of the correlation analysis seem to support Hypothesis 6, which is an alternative hypothesis, with Hypotheses 4 and 5 being rejected.

The current overall trend seems to indicate a situation that differs from experiences of the computer industry in the past. The question then arises as to whether the inter-organisational relationship will change in the automotive industry even if CASE progresses. As one possibility, a vertically integrated organisational relationship may be maintained, and joint upfront investment may continue. Or, as another possibility, even if the current inter-organisational relationship is vertically integrated, it may be because technology development for CASE is in the early stages of the life cycle. In other words, a scenario is conceivable in which, as development progresses in the future, many technologies mature, and various technical standards are established, and the inter-organisational relationships will become specialised horizontally.

This is difficult to distinguish from the results of the correlation analysis for the present time alone, but can be suggested from the results of case studies. Of the car

manufacturers extracted as cases, the two companies with the highest CASE ratios were both electric car manufacturers originating in China. NIO (China) is a venture company established in 2011 and is a promising company as a specialised manufacturer of electric vehicles. BYD was established in 2003 as an affiliate of a company engaged in the automotive battery business and is one of the world's largest companies producing and selling electric vehicles. As a partnership, a joint venture company for electric vehicles has been established with major companies such as Toyota. On the other hand, the two companies that were identified as having low CASE ratios were Japanese automakers. All are small-scale companies as manufacturers of completed vehicles, mainly existing gasoline-powered vehicle companies. Although some hybrid vehicles are sold, both companies are under the umbrella of Toyota, and they are assumed to be products that receive technical support from Toyota.

Interestingly, when we compared each of the network indices, the results were opposed except for Size. Individually, the results of the size of the network were small for all four companies. It is assumed that this is because each company is relatively specialised in electric vehicles, which are new technologies, or existing gasoline vehicles. Regarding Constraint, the same tendency was observed as in the overall correlation analysis described previously. It is assumed that the smaller the value of Constraint is, the larger the structural hole is, and it is possible to work more efficiently with various companies on the network. On the other hand, for the Broker, EgoBetween, and density indicators, no clear trend appeared in the overall statistical analysis; however, a comparatively clear trend appeared in the comparison between individual companies. Each of the selected companies is relatively small and almost exclusively engaged in either new or old technology. Therefore, it is inferred that the organisational characteristics of each company are more clearly evident than those of companies engaged in various R&D and business development.

From the results of the case study, it can be inferred that emerging electric vehicle manufacturers with a high CASE ratio are building a partnership network centred on themselves. An automaker is in a position as a platform leader in the network. Since the partners of each company include existing companies and new entrants that have become cooperative with the progress of CASE, it is presumed that a relatively moderate ecosystem has been formed. In other words, it may be an inter-organisational relationship similar to that of the IT industry. On the other hand, conventional car manufacturers with a low CASE ratio form a closed network with a relatively limited number of companies. It is considered that the characteristics of the inter-organisational relationship in the conventional automobile industry are well represented. These two companies are not located at the centre of the network, and are presumed to be located around the network where their giant partner companies are expanding and diversifying their business. If automobiles based on internal combustion engines are going to disappear in the future due to the laws and regulations of each country, the conventional narrow and closed network structure may not be adopted.

Conclusion

The purpose of this study was to empirically explore the impact of technological innovation on network structure between organisations in the automotive industry. A database on the network structure of partnerships by automakers around the world was created and analysed using network analysis techniques, and several useful suggestions were obtained. In response to technological changes called CASE, automakers have increased the size and diversity of their networks. Case studies also show that the inter-organisational relationship in the automotive industry may shift from a closed integrated type to a platform type network structure. As a limitation of this research, CASE is still in progress, and the structure of the corporate inter-organisational network may further change in response to future technological changes. As a remaining issue, continuous investigation is subsequently needed.

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