Service Oriented Cross-industry Innovation as One Category of Open Innovation

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***Abstract*--In open innovation, every company is seeking for external resources for internal innovation activities. Meanwhile, other companies are also in desperate need of the internal resources owned by this company. Such resources can be either engineering technologies or managerial experiences. Hence, open innovation can be performed not only for engineering purpose but also for management purpose, such as business model, product or even service. In this article, we will only focus on one typical kind of open innovation named cross-industry innovation for discussion. Particular attention will be paid to the cases in which services are integrated together with product. By introducing product service system, the advantages of open innovation can be most obviously incarnated. This is only a theoretical research, which is composed based on the foundations of previous researches. This paper will firstly compliment the theory structure of open innovation. And then special attention will be paid on customer integrated cross industry (CICI) open innovation because of its high level of openness. By taking telematics service as an example, this paper will continue to discuss the industrial business model of CICI open innovation.**

I. INTRODUCTION

The concept of open innovation has been pointed out for a long period of time since Henry Chesbrough firstly announced it in his book “Open Innovation”[1]. The concept of open innovation was defined in relative to closed innovation. In closed innovation process, all the concepts or innovative ideas comes only within the boundary of a company or organization, which means the company may own full control over the innovation process. It is much easier to protect technology and patent. In open innovation process, the sources of ideas or knowledge can be either from inside or outside the company. Inside sources include, but not limited to, R&D teams, marketing department or even HR department. The range of outside sources of information and resources can be even wider, for example business partners or competitors from the industry chain, customers from the market, and even companies from another totally different industry. Technology and patent protections are less likely to form any obstacle in creasing innovation efficiency if the innovating companies’ business scopes do not overlap with each other seriously.

Oliver Gassmann and Ellen Enkel [2] has studies the phenomenon on cross-industry innovation but previous researches focused primarily on external sources within the same industrial chain such as customers, suppliers, competitors or cooperation partners, who may share similar knowledge set. The circumstances in which knowledge difference or cognitive distance is greater have drawn less attention. Nooteboom found that increasing cognitive distance would have a positive effect on learning through interaction, which means higher efficiency and better effectiveness in absorbing external resources [3, 4]. But Ellen Enkel and Oliver Gassmann [5] didn’t find any correlation between the cognitive distance and its impact on the innovation result for exploration (breakthrough or disruptive innovation) and exploitation (incremental innovation). Consequently, it can be inferred that cognitive distance may not be the most significant factor in open innovation. The most influential external factor might be business model or business architecture.

Ulrich Lichtenthaler’s research also showed insignificance of industry differences [6]. He also questioned that previous conclusion were conducted based on the studies biased on for example chemicals and pharmaceuticals industries, while the industries for instance automotive or machinery have received comparatively less attention. So we tend to hold the opinion that industry characters is not the most influential external factor, though it may be capable of affecting business architecture or industry structure.

Additionally, industry distance is hard to be universally and qualitatively measured including automotive and chemical industries, hence it is also hard to draw a universally adaptable conclusion in the most precise way. Comparatively, business architecture can be more widely used to analyze open innovation activities for different industries.

We can infer that the openness of innovation in automotive industry cannot be too low due to its long industry chain. According to Oliver Gassmann, Ellen Enkel as well as Henry Chesbrough [7], automotive original equipment manufacturers (OEMs) need to look outside its own boundaries, also for the purpose of achieving better R&D productivity. How to successfully implement open innovation is a topic that been discussed for long time. Some scholars, represented by Letizia Mortara, Gerhard Huber and Serhan Ili [8-10], discussed from company culture’s perspectives and emphasized the importance of company’s internal or external cultures. And some other researchers indicated the necessity of organizational and HR (human resource) arrangement [11], as well as knowledge capacities and knowledge integration. We think that such criteria may be most possibly influenced by the business architecture, because no matter culture or organizational arrangement everything serves a common goal of enhancing business capabilities.

It is too hard to detect a rigid business model or business structure for all innovation activities that are being processed in an open way. So in this research we will stand on modularization’s viewpoint and try to find out the possible business structure based on cross industry open innovation.

Ellen Enkel [5] pointed out that solutions from outside, especially from other industries, can also be patents, specific knowledge, capabilities, business processes, general principles or even whole business models. In our opinion, what kind of resources will be required does not depend on industry characters but no how businesses are arranged in the whole industry.

Hence in this paper we will choose a typical type of open innovation, cross-industry innovation, to be research object. Considering also customers' influence on innovation, we will choose service-oriented product as research object in order to guarantee that both industrial horizontal collaboration and vertical integration can be enrolled. In other words, customers as well as partners and complementary or other third parties are included simultaneously [12]. The research object for this paper is named here as CICI open innovation (customer integrated cross industry open innovation). And we will use previous case studies and telematics services as evidences to illustrate our theoretical framework.

II. LITERATURE REVIEW

A. Open Innovation VS Closed innovation

The concept of open innovation is defined together with closed innovation by Henry Chesbrough [1]. Quoted from this book, Fig-1 shows the process of closed innovation. Similarly Fig-2 provides a general understanding to the process of open innovation. The major difference is that whether a project/idea can be performed/transferred across the firm's boundary. Of course such projects are not limited to engineering hi-tech projects [5].

Unlike closed innovation, open innovation combines both internal and external knowledge and ideas into architectures and systems [1]. In order to discuss open innovation for both academic people or industrial companies, many perspectives should be paid attention to such as process and structure [13]. Since open innovation process allows a company to integrate internal and external ideas into architectures and systems [14], it calls for an end to knowledge monopolies in order to inbound absorb and outbound share when necessary [1, 8, 15]. Knowledge is required to be shared within a proper period of time, especially for new products or services. Knowledge sharing includes making best use of internal and external knowledge efficiently and combining knowledge creatively. Open innovation helps guarantee the effectiveness of the commercial relationship between the company and its customers, which may be even more important than product's competitiveness itself [16] because open innovation offers an effective way to shorten R&D duration and knowledge transferring [1].

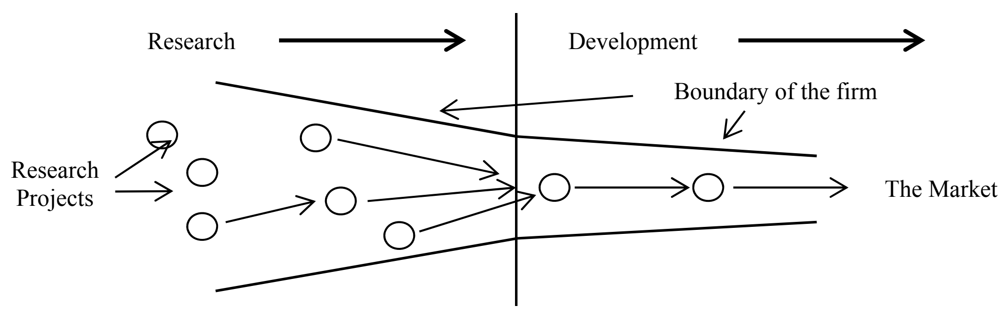

Fig-1: Process of Closed Innovation
(Closed Paradigm for Managing Industrial R&D, 'Open Innovation', Henry Chesbrough)

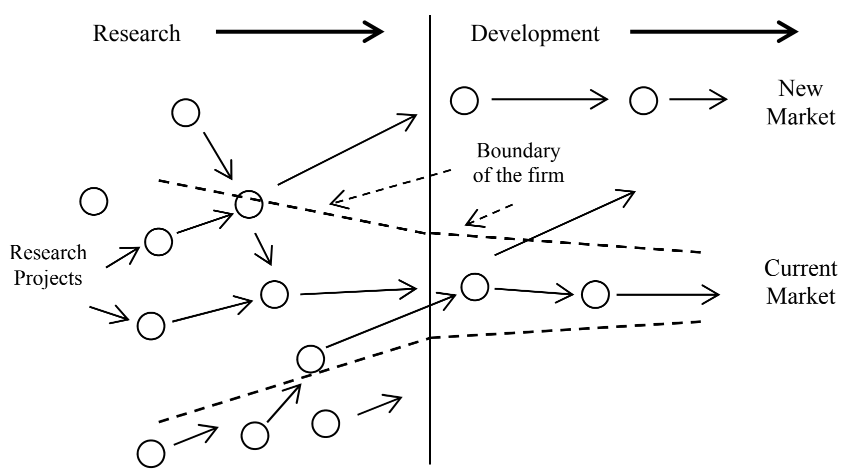

Fig-2: Process of Open Innovation
(Open Paradigm for Managing Industrial R&D, 'Open Innovation', Henry Chesbrough)

B. Scope of Open Innovation

Further investigations on open innovation showed that open innovation process lasts not only within R&D (research and development) stages, but in commercialization stage as well, as indicated by Michael Docherty and Henry Chesbrough himself [1, 17]. In R&D stage, resources like knowledge in terms of IPs can be licensed either inbound or outbound [14, 15, 18]. For commercialization, open innovation can be implemented in terms of product in-source (e.g. co-branding) or technology spinouts.

If jumping out from business flow and viewing open innovation from companies' business scope, Researchers represented by Robert Kirschbaum also hold the opinion that open innovation is consist of three stages which are potential opportunity stage, primary business plan stage and mature business plan stage [19]. In order to make a potential opportunity to become mature, external resources are required to overcome internal knowledge gap between current business scope and potential opportunities. But the magnitude of such gap is not fixed. For cross-industry open innovation, the gap between two companies is comparatively wider. The concept of boundary innovation can best describe such situation [20]. Mitsuru Kodama built a vertical value chain model in his research on boundaries innovation and knowledge integration. This model reveals that knowledge integration keeps happening all the time everywhere in the value chain either within or outside the innovator. Such knowledge integration here is also considered as a combination of R&D and commercialization.

Open innovation makes technology implementation becoming more flexible for a company. Especially for the inbound process, companies' innovation capabilities and knowledge database can be enriched through the integration of any external sources. Consequently, business opportunities increase at the same time [21-23]. Laursen Keld and Salter Ammon [21] drew the conclusion that a company would gain more opportunities by looking for a new innovation pattern, based on their study on manufacturing industry in UK. So it is obvious that managing resources for innovation are as important as absorbing external knowledge.

C. Source of Open Innovation

From knowledge flow viewpoint, the effects of open innovation are closely related with stakeholders such as users, suppliers or even competitors [24].

Generally combining the previous achievements, all the sources of knowledge in open innovation can be classified into four categories, which are vertical source, horizontal source, professional source and maybe also neutral sources. Vertical sources include suppliers and users. Horizontal sources include competitors and some indirectly related companies for instance companies from other markets or industries. Professional sources consist of university, research institute, technology intermediaries and IP organizations. Neutral sources are represented by venture capital and government, which has no bias on any single company.

Different sources may have different significance in inbound process [24]. Most common knowledge sources were clients who occupy 78% of the overall knowledge transferring, suppliers (61%) and competitors (49%). Comparatively, the percentage of public and commercial research institutions was only 21%. Consultancies were used even to a lesser degree [25]. So for open innovation, directly obtaining knowledge from relational parties is more efficient than requiring third party's assistance. Ellen and Oliver's research also revealed that a surprisingly large body of other sources was used, at the percentage of 65, namely non-customers, non-suppliers, and partners from other industries. Conclusively, cross-industry innovation is almost equally important as clients who are in the industry chain with the innovator. Inversely for outbound process, being the sources of innovation can also allow a company to externalize internal knowledge and innovation to the market with higher efficiency [24]. But the companies were discovered to be more likely to launch inbound policies than outbound policies.

D. Capability for Open Innovation

In order to implement open innovation, a company should get well prepared in lots of fields. Since not all the companies are operating in the same country, each company should build a clear vision on its globalization strategy, i.e. spatial perspective [7]. Meanwhile, organizational structure and process, user and supplier, tool and culture are also the elements that cannot be neglected. The researches that had been done before have covered nearly the entire range of these elements. But various companies in various industries may require totally different criteria. The previous achievements revealed that building capabilities/capacities and cultivating cultures are the most basic fundamentals.

Based on the classic evolutionary model of variation–selection–retention [26], a capability based view of open innovation processes was made by Lichtenthaler [27], and this model involved multiple interactions with a firm's environment [1]. A company's capacities were divided into internal and external parts. The process of knowledge transferring in each part followed the route of "exploration – retention – exploitation". Correspondingly, three external capabilities were defined as absorptive capacity, connective capacity and desorptive capacity. There is one thing we need to notice that the capacities mentioned above is more adaptable for independent innovation. In other words, though the knowledge comes from outside but the innovation activities are generally performed along. Such circumstances maybe common for inner industry innovations but not for cross industry innovations which requires interactivities. But Lichtenthaler also emphasized dynamic capabilities for managing knowledge is necessary as a complement to absorptive capacities [27]. In line with our understanding, open innovation should be long lasting in order to absorbing external knowledge.

Absorptive capacity has been regarded one of the most important factors toward successful open innovation. It refers to a set of organizational routines and processes, by which firms acquire, assimilate, transform and exploit knowledge to produce a dynamic organizational capability [15, 28, 29].

Some other authors reviewed such absorptive capacity in two dimensions, which are the extent of external technology acquisition and the extent of external technology exploitation [6]. Lichtenthaler defined open innovators as the company that has high extent on both external technology acquisition and exploitation. Generally, we agreed with his viewpoint that open innovators should have high extent in both exploitation and acquisition in order to cultivate competitive advantages. But when viewing from cross-industry innovation perspective, not all companies are required to totally absorb knowledge or technologies from partners from other industries. For example in telematics services, digital circuit design that aims to coordinate different functional modules may require the partners to cooperate closely. Especially for automotive companies, they are even required to absorb external technologies for further exploitation in order to guarantee product performance. But between automotive company and telecom service provider, it is unnecessary for either of them to totally understand the core technologies from each other.

The ability to absorb the technology acquired was only one dimension of absorptive capacities, and the other dimension was named the ability to identify the market for technology [30]. The R&D-related activities had been proved to be more important than the R&D activities themselves, especially for collective research centers at the inter-organizational level [15]. Even though R&D activities can be performed independently within one company, the R&D-related activities still require collaborations.

The reason for such fact may be the recognition gaps among different companies or industries. But the openness of the innovation process was proved not to be mainly determined by industry characteristics [6]. It can be referred that all companies are capable of launching open innovation at all possible openness level. The only question is the mechanism of their cooperation, and this may only be determined by the characteristics of their business model. For example customer oriented innovation may differ from industry oriented innovation, and product innovation may also be different from process innovation [31]. So innovation on engineering R&D may also be different from innovation on business pattern. So in this paper, we will specifically focus on only one type of open innovation, which is customer-integrated cross industry open innovation. We will try to use public patent data to discover the mechanism or potential business pattern for CI-CI open innovation.

E. Culture for Open Innovation

Besides capabilities, culture is also an extreme important condition for successfully implementing open innovation [7], absolutely for automotive industry as well [10]. Some researchers even demonstrated that open innovation is a culture rather than a process [19]. Cultures can be both internal and external. Each one is composed by lots of ingredients as well. Internal cultural heritage might facilitate the adoption of open innovation [8], and successful innovation activities require foundations from team spirit and company culture [19], for example managers' involvement [20] and attitude towards change [31]. Among all these spirits or cultures, the culture of trust was treated to be more important than organizational controls [9].

In cross industry innovation, all players involved can be reasonably presumed to have a steady internal innovation culture because of the trust they need to build upon each other. But due to the focus of research topic's consideration, we may not be able to discuss company culture into details, but we will explain the possible influences that external culture may allocate, for instance social and policy environment.

F. Models of Open Innovation

Lots of studies had focused mainly on the capacities that required in launch open innovation. And there are also some researchers have named some models for open innovation from different standpoints. From capability's perspective, there was a conceptual model of absorptive capacity and its influence on innovation output [31]. From knowledge management and customers' involvement's perspective, there is already a customer knowledge management (CKM) model [32]. But the models that drew our attention most are following three.

First, the model created according to open innovation partnership's stability and product type [13]. According to Almirall's model, partnership can be either fixed or flexible. And the way in which open innovation projects are performed also variously case by case based on whether the company are providing complete products or supplying OEMs. For companies who aim to provide product as well as services, their innovation strategies may differ from the previous cases that presented by other researchers.

Second, taking culture and structure into consideration, Kodama presented a multi-layer model [20], in which the importance and necessity of managers' enrollment as well as horizontal communications are clearly revealed, especially for large-scale NPD (new product development) and a company's major project such as NTT DoCoMo's i-mode project. The enrollment of managers or even "heavy weigh" managers is more necessary for open innovation [18], for the purpose of defining interface [11]. Consequently, open innovation require both process and culture changes and even reformation for the reason that not only horizontal communications are required, but vertical integrated as well [20].

Thirdly, Ron Sanchez emphasized the importance of modularity in product strategies, organization structures and business process in his modularity maturity model [11]. He pointed out eight levels of understandings and each one serve special purpose. Modular product strategy can offer companies with greater product variety, more rapid upgrading of product performance and cost reduction. Business process should cover all design, development, production and after service stages [11, 20]. In addition, not only solutions in terms of technologies can be inbounded from other industry, business models and experiences can also be introduced across industry boundaries [5], especially when the potential market locates in the intersection of two industries. For example, telematics service was at first announced by automotive companies but it is now more appropriately to be operated according to the business model in telecom/internet industry.

G. Modular Architecture

In this paper, we hold the opinion that modular architecture is more appropriate for open innovation than integrated architecture. Modularizing products helps companies maintaining effective relationships with suppliers [33]. But when some companies have not absorbed or accumulated enough knowledge and know-how to continue modularizing, integral architecture need to be adopted for a second time [34]. For automotive companies who are planning to launch telematics services, they need to improve internal technologies as well as absorbing external knowledge. Telematics is the service-oriented product born between two industries, which can enlarge values for both customers and companies. Module dynamics, which refers to the process of product innovation that occur in highest-order modules of modular products [34], is an efficient way of enlarging customer value with lower risks. Module dynamics is achieved through a two-stage process, which are partitioning and integrating modules. Parallel development is also a way to reduce uncertainty in technology transition between two companies [35]. Since in cross industry innovation, projects are launched simultaneously on both sides, horizontal connection or interdepartmental relationship must be contingent on the parallel development strategy [35]. If we consider the complementary services also as modules, modular architecture and module dynamics may help us understand the mechanism and strategies for cross industry open innovation.

III. METHODOLOGY AND RESEARCH OBJECT

The main methodology of this paper is literature review. This paper presents only theoretical analysis on open innovation based on the previous theoretical literatures and empirical study implemented by scholars. Based on literature reviews on open innovation and modularization theories, the models that will be pointed out in this paper is only on hypothesis/conceptual level without complete quantitative evidence support.

As discussed above, there might be no mechanism that can be universally adaptable for all open innovation projects. In order to more clearly identify a specific kind of open innovation for further discussion, we will firstly complement the theory system of open innovation.

According to the models been reviewed, we need to emphasize three characteristics that they share in common. Firstly, open innovation's feature of dynamic. No single business model is universally adaptable for all kinds of open innovation. Open innovation can be either strategic alliance or joint venture. It can also be either engineering collaboration or marketing cooperation. Even for the same kind of open innovation, the corresponding business model may still differ from time to time according to specific situations. Second, horizontal communication is necessary in the innovation system no matter intra- or inter-company, even cross industry. Necessities cover process necessity and culture necessity. Third, vertical integration is required to guarantee the smoothness of innovation process as well as complimentary follow-up. But different open innovation project may require various level of vertical integration.

So in order to better discuss the mechanism of open innovation, a special kind of open innovation must be specified. Though there are already different kinds of open innovation models that have been pointed out based on various standards, for example partnership [13], the existing classification methods do not follow the same standards or rules. The current theory system has not been consummately implemented yet. So here by now, we want to try a new way of categorizing open innovations from industrial perspective. Then we will pick up one specific type as our research target.

Open innovation partners can come from either the same industry or different one. They can be upstream suppliers or downstream purchasers. Also, a company's business scope (i.e. manufacturer or service provider) meanwhile affects its innovation strategy. Besides, organizations like research institutions or universities may also be enrolled in a company's open innovation activities.

Based on the achievements presented by other researchers and according to the functions of different stakeholders in the industry chain, we would firstly summarize a conceptual model for open innovation from industry chain's perspective, as shown in Fig-3. Different from the model used for analyzing P&G [1], we integrate some elements together to make the model more understandable and structuralized. And of course demand-pull and science-push factors are also included [31].

In this industrial model, we start to view open innovation from industrial chain. Any company or organization related to the industrial chain can be enrolled in open innovation activities by sharing their knowledge in terms of experience, technologies or IP. Sharing can be implemented through licensing or acquisitions, which are indicated by double arrowed lines. Such knowledge can come from the organizations from either the same industry or another totally different industry. The culture of trust is required in this model in order to guarantee the effectiveness and efficiency [9, 36], especially for cross industry innovation.

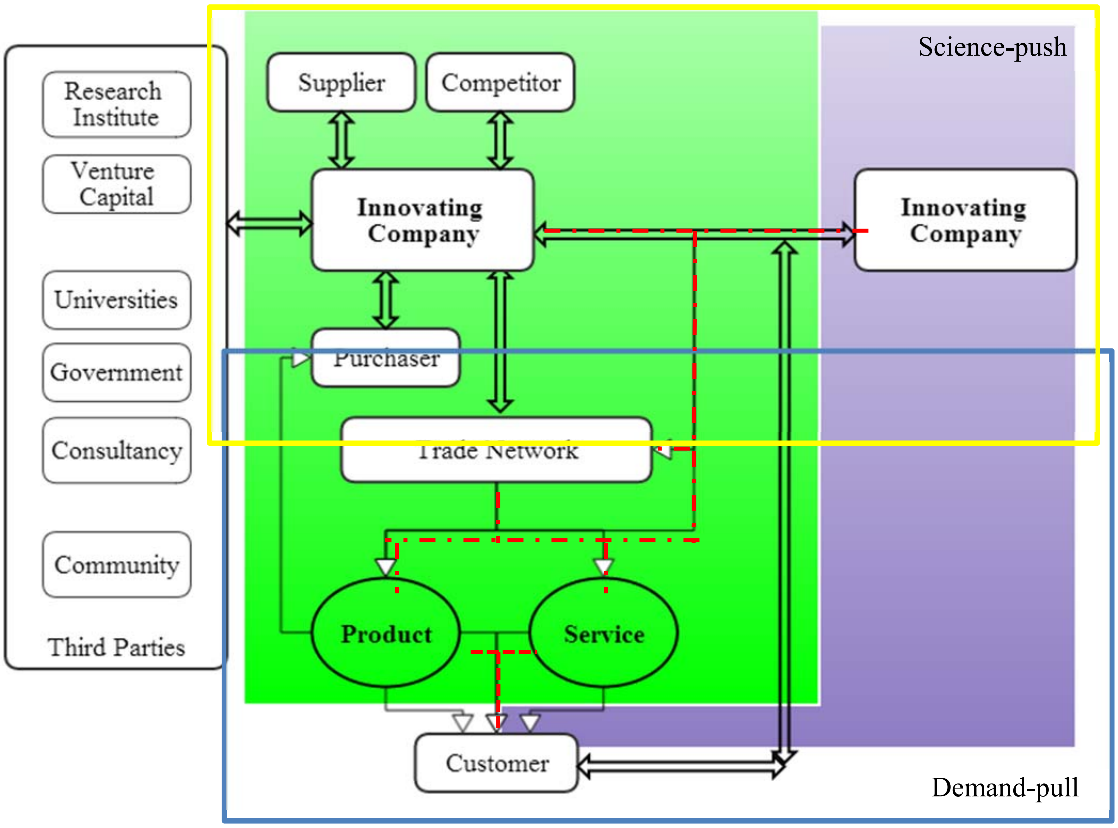

Fig-3 Open Innovation Coordinate

Generally speaking, the outcomes of open innovation, which are indicated by single arrowed narrow lines, can be either products or services. In fact, product sometimes cannot be completely separated from services. The delicate difference is that in which way they are interconnected. For example computer manufacturers provide technology support in fixing, and automotive companies provide maintenance and financial service via dealer networks. Both two kinds of companies are manufacturers; their business scope still varies from each other. In order to more clearly specify our research target, we prefer to only look into service oriented product field, which is also called product/service-system (PSS) [37].

Service oriented product is considered as ideal research object because its development requires vertical integration within the organization [38]. When the situation comes to cross industry innovation, the vertical integration and horizontal interactivity will be even more indispensable. As a typical example of service oriented cross industry innovation, we will choose telematics as our main research object.

IV. INDUSTRIAL BUSINESS MODEL FOR CICI

A. Telematics: Full of Open Innovation

Taking telematics as an example, automotive OEMs, telecommunications companies and electronic device manufacturers are in need of one other. Automotive OEMs are not the only players who recognize the trend and necessity of providing telematics service. Electric and electronics producers had also identified such increasing market demand for mobility, safety, comfort, seamless connectivity and ease of use in cars [39]. Nowadays, entire global automotive industry is on telematics rivalry track. Companies represented by Daimler and BMW from Germany, Toyota and Honda from Japan, GM and Ford from US have already treated telematics as an extreme important part of their strategies.

According to Midler, telematics can be customarily grouped into four areas, which are emergency breakdown service, navigational aid, communication service and entertainment or so-call “infotainment” [16], and each of them can be better treated as a secondary module for the whole telematics module in a vehicle. New devices are required to be imbedded into the digital control system for functional consideration. The introduction of new electronic device may cause interferences to the original digital control system. So we would treat safety and security function as the fifth module. Because telematics demands in commercial vehicles market may probably differ from that in passenger vehicles market, we will only take passenger vehicle as research object here, which is normally called cars.

Developing and managing the whole set of telematics business require lots of players to be involved in a complex cooperating process [16]. In this section, we will only try to briefly discuss what kind of companies from different industries may collaborate with one another, in order to further discovering the business architecture for telematics market.

First of all for safety and security modules, automotive companies may be more likely to choose M&A or licensing strategies for the purpose of acquiring external knowledge or technology. The technologies imported into iDrive system, which resolved BMW's controlling problem for over 500 functions on 7-series sedan, was transferred from game industry through a third-party intermediary [5, 36]. Though this was no doubt cross industry innovation, customers were not required to be integrated into the innovation process. Besides, considering the stability of the safety and security system as well as technology protection issue, keeping the implementation of the system internally within the company seemed to be better then opening up. We think these were probably the reason for the short-term open innovation this time, because the two industries will probably not have an intersection again in that particular area. Even if they really have, it is unnecessary and unreasonable for BMW to open up the nervous system, which closely relate with core businesses and competitive advantages. In this special case, lower the level of openness by performing R&D internally and independently after absorbing knowledge externally is necessary.

Core competencies are formed through long-term evolution of core businesses. But being open in innovation mostly means both companies are in particular need of each other. Such circumstances always happen when the open innovation project locates in the business scope intersections of companies or industries, i.e. boundary innovation [20], as shown in Fig-6. BMWs iDrive system is a good example for simplex but not duplex open innovation.

On the other hand, for emergency, navigation, communication and infotainment modules, they greatly differ from safety and security module. None of these were core business for traditional automotive companies. That is to say the risks of opening up and sharing are comparatively low. There is no threat to safety and automotive company can never do better without the help from external resources. Companies from ICT industries are either incapable of providing telematics services of high satisfaction without automotive companies' help.

Focusing only on R&D and manufacturing of modules, automotive companies can establish joint venture companies with electronic manufacturers, for example Fujitsu-Ten between Toyota and Fujitsu. Expending our viewpoints to the complimentary services for telematics modules, collaboration is also required. For example, automotive companies can improve their navigation services by collaborating with professional navigation service provider, and establish long-term strategic cooperation with telecom operator in order to upgrade in Internet related services. In order to comprehensively improve services for all modules, it is necessary for automotive companies to create strategic partnerships with telecom operators, for example KDDI's support on Toyota's G-book system. Because traditional automotive market has hardly any intersection with information and entertainment markets, the business model in telecom/internet industry can even be directly transplanted across industrial boundaries onto telematics market by viewing cars as simply new kind of mobile terminals [5]. How companies work with customers is very important for service innovation [40], absolutely for customer integrated innovation as well. Compared with automotive industry, telecom industry has higher network externality. After merging with Internet and cable TV industries, telecom operator has accumulated already tremendous experiences and resources towards mobile and Internet services because SP (service provider) and CP (content provider) and it being integrated into telecom industry chain. Not only service provider, other companies from ICT industry can also contribute to the enrichment of telematics services. VW officially cooperated with Apple to make iPod compatible with its Lavida cars in order to enhance customer experience and to make a car more closely linked with our daily lives. This demonstrates that increasing customer experience is an effective way of incorporating services in open innovation [12].

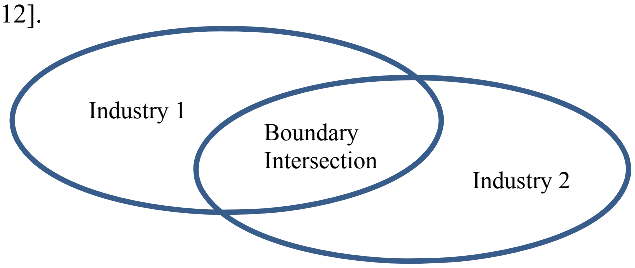

Fig-4 Boundaries Innovation with High Level of Openness

B. Industry Boundaries

Measuring the distances between different industries has been a popular research topic for a long time. In fact, it is still hard to differentiate two industries on quantitative level. In order to better clarify what is the boundary between two industries in this paper, we would at first like to refer to Porters' definition of industry to help explain what is one industry. According to Michael Porter in 1979, an industry was explained as a group of competitors producing substitutes that are close enough that the behavior of any firm affects each of the others either directly or indirectly. As industry structure getting more complex, the definition was changed to 'a group of companies offering products or services which are close substitutes for each other, that is, products or services that satisfy the same basic customers needs.' Related suppliers and purchasers form a complete industry chain. So in this paper, we only briefly differentiate two industries according to their main products, for instance automotive and telecommunications industries, which are car centralized and telecom service oriented respectively.

In fact, one industry may differ either slightly or greatly from another industry. The distance between two industries will definitely have certain impacts on the cross industry innovation activity among them, for example the impacts on organization of innovation activities or the outcome of the collaboration. The cross industry examples in this paper may be only representative for similar open innovation activities between two companies that come from two industries and have their own product service systems.

C. Discovering Industrial Business Model

Before discussing the industrial model for CICI open innovation, we would like to use telematics service as an example in order demonstrate how modularized structure is utilized in reality. Fig-5 includes two charts. The one above is the vision on modularization from industrial evolution perspective, and the one below is based on functionalities and product structures.

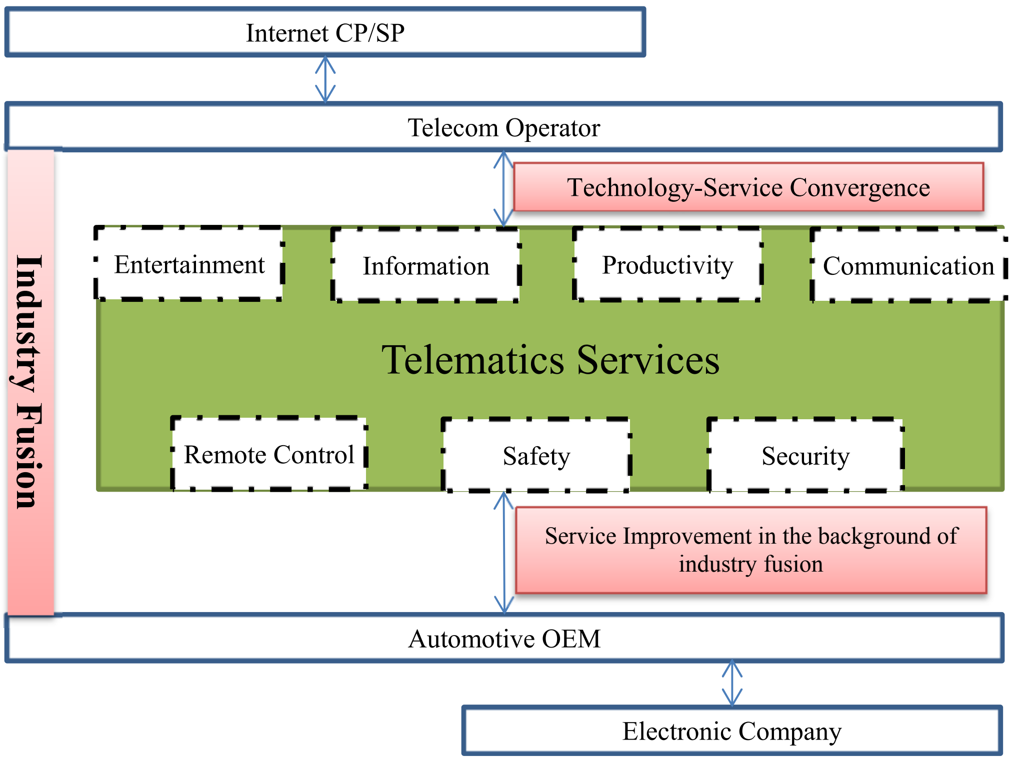

Fig-5 (1) Industrial Structure for Telematics

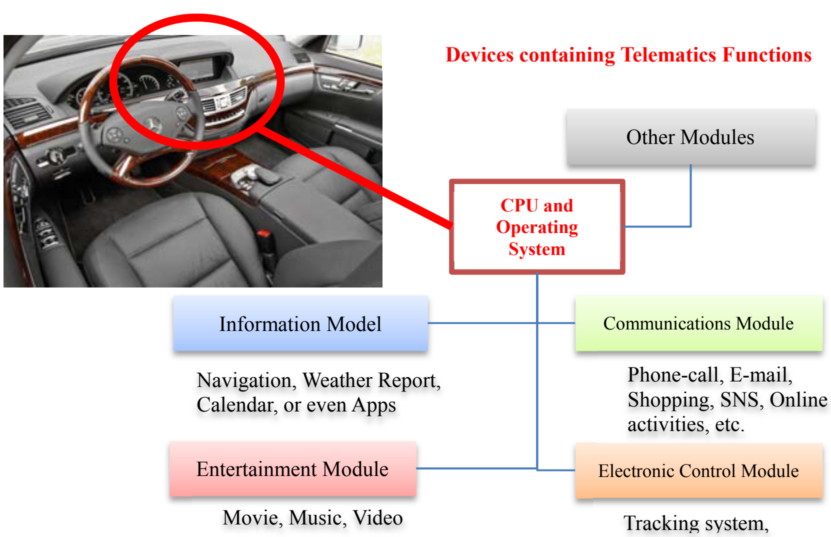

Fig-5 (2) Product Architecture for Telematics

The industry structure of telematics services is reviewed in the picture above, which is supported by both electronic device manufacturers and telecom/internet companies. According to the relationships among all functions, telematics services can be grouped into seven modules, as shown in Fig-5 (1), which are entertainment, information, productivity, communication, remote control, safety and security modules. In the industry chain, Internet companies are responsible for providing contents, such as CP/SP (content provider and service provider). Telecom operators are responsible for providing telecommunications connections to cars. These two kinds of companies are mainly supporting the previous four functional modules. On the other hand, remote control, security and safety modules are required to be further integrated in automotive OEMs' business scope due to safety/stability considerations.

Fig-5 (2) provides draft understanding towards telematics system in terms of modular architecture. In the chart, only main infotainment functionalities have been categorized into four modules. Since we are only trying to provide a general understanding on the telematics' product architecture in order to help explaining the two models bellow, not all functionalities were listed here.

1) Modularization Model

According to our studies on the business arrangement for telematics market, we can generally conclude two types of business architectures. One is in full modularization and the other is treated as quasi modularization. The first type, shown in Fig-6, was probably considered by most people to be standard modular architecture for telematics services. This modular architecture generally follows the route marked by red line in Fig-3. But an interesting phenomenon is discovered that modular architecture may be shift downward along industry chain. In the second mode of modular architecture, all modules are only organized together after being delivered to end customers, as shown in Fig-7. In this paper, we would like to call it quasi-modular architecture.

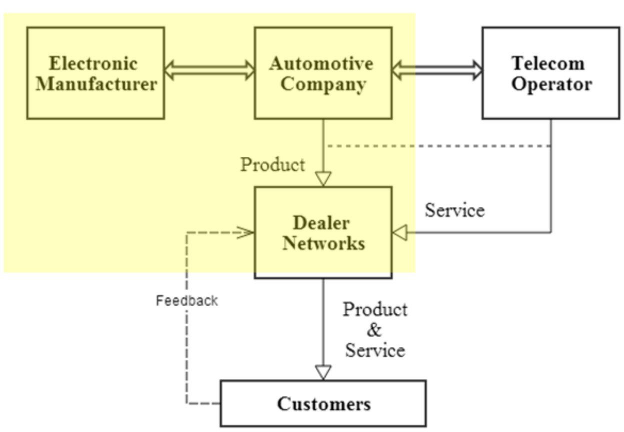

Fig-6 Modular Architecture for Telematics

Same as Fig-3, double arrowed lines represent knowledge sharing or technology transferring among companies. These processes can be in different forms and the tightness of their connectivity also varies. The relationships between electronic and automotive companies are expected to be closer than that between automotive and telecom companies. For example, Toyota established a joint venture company with Fujitsu called Fujitsu-ten who is responsible for the R&D on telematics. But telecom operators like KDDI only have to be able to support telecommunications functions to Toyota's G-Book system as a strategic partner, and NTT Docomo only needed to enhance the compatibility between their mobile devices with the system. All functions required in telematics services are grouped into several modules, which are combined together as a single telematics device using modular architecture. Devices that imbedded into a car as a module must be well designed and tested to guarantee their function stability. But they are lying comparatively farther from final customer in the upstream. So, on the other hand automotive companies have stronger power in making decisions on telematics than electronic companies. Joint venture companies are consequently easier and necessary to be created due to the stable situation in module production and the wiliness from both companies. Even there is any unexpected rapid change in market, joint venture companies can rapidly react using module dynamics [34].

For automotive companies and telecom operators, the situation is quite different. Firstly, telecom operators do not need to interference any internal activities in automotive companies and vice versa. Second, their cooperation is based entirely on customer demand, i.e. demand-pull. Telematics lie in the downstream in the chain and the market has not been naturally developed. Their relationships are better to remain strategic partners, which can allow deep cooperation on high management level and meanwhile allow their alliance to be more flexible in adapting to market changes. Third, automotive companies deal with customer through their dealer networks but telecom operator provides services directly to each end terminal, for example cellphone, tablet PC. Viewing from telecom operators, their module is not more likely to be service based, and their experience in telecom/internet industries can be expanded into telematics market. The cooperation between telecom operators and automotive companies are focused on strategic level. They consult each other to adapt to and develop market.

The entities, which directly cooperate with telecom operators on functional level, are the dealers. They are in responsible for delivering products to customers and dealing with customer feedback. The closer a company lies to the market, the more efficient they can response to market feedback. So telecom operators in this module may get access to market demand through automotive dealer networks or other after service departments belong to automotive companies

Single arrowed lines indicate products and service delivery. It is obvious that how such service oriented products are delivered via industry chain. Connecting with dealer networks may also be an effective way in gaining access to external result, especially when customer integration is required. For compatibilities concern, telecom operators are still necessary to be involved in the early stage in modularization process, which is indicated by dashed line.

2) Quasi-Modularization Model

Telematics services can be treated as value-added services for automotive companies. The purpose of providing such services is to increase customers' convenience and experience in car life. The whole set of hardware and software facilities will increase to the cost of a car as a whole. Today's lower prices may still be too much, says Sandeep Kar, a global director from Frost & Sullivan. For high end cars, for example luxury vehicles like Mercedes-Benz S-class or BMW 7-series, telematics will be no doubt imbedded, but how about non high end customers? People driving VW Passat may want only parts of telematics services and a young person who just bought his first car may not need any services which will continuously charge him but he hardly use them at all. Such demand diversity can be handled to a certain degree by modular strategy but modularization's capabilities are still limited.

According to our background study, lots of independent small companies are providing separated devices such as navigator or even refrigerator. In information age, everyone has already got at least one smart mobile devices with 24-hour Internet connection. Maybe someday we would rather give up the embedded devices in the car if it cannot 100% compatible with our smart devices at hands.

This concern may be a little bit radical when viewing from traditional automotive industry's perspective. But telematics services are also supported by telecom industry or even Internet industry if infotainment services are used. Being a new kind of mobile terminal, telematics devices will merge or be merged with other mobile devices sooner or later, just like now we can hardly tell the different between a cellphone and a PDA which are combined as smartphone. This kind of industry fusion had happened in television, telecommunications and internet industries. Market trends, which weighted over 70% among external knowledge [24], will make it happen again, by the means of open innovation.

Fig-7 shows the business model we discovered in non-high end market. Cars are delivered to customers equipped with only the basic telematics services or the ones been chosen by customers. All other complementary devices will be supplied/provided separately by other manufacturers, for example electronic or other device manufacturers. Dashed line means there might be some interactivities between two companies for safety's consideration, for instance the voltage or power for a portable refrigerator.

Telecom operators provide their services directly to the customers. All the service modules and product modules will be assembled totally according to customers' willingness, as presented by the yellow area. There are already some non-automotive companies expanding their business into telematics markets.

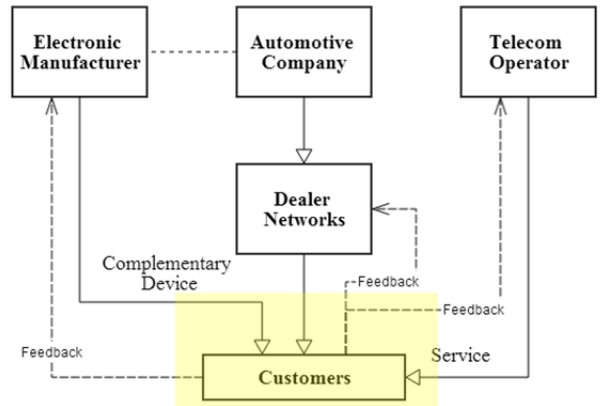

Fig-7 Quasi-modular Architecture for Telematics

But in fact, increasing customer diversity may introduce unexpected potential risks to the overall safety performance. So even in quasi-modular model, not all modules can be separately provided. Anyway, some functions such as entertainment may be designed independently from electronic controlling system for safety's consideration. Besides, customers can use personal tablets via personal mobile network in the car in order to increase ease of use. Meanwhile, total cost of purchasing cars, devices and services can be reduced, which is attractive enough for normal customers. For example, telematics market/product in Japan is more likely to be of modular architecture, while quasi-modular architecture is also developing fast in Chinese automotive market. Such difference may be introduced by demand-pull factors, science push factors or even market matureness factors, which need to be further investigated in the future.

V. CONCLUSIONS

In this paper, we concluded a theoretical structure for open innovation based on the foundation formed by previous researches. The perspective of, for example, partnership's stability is really a good way in identifying open innovation [13], we prefer to hold the opinion that it is determined by the needs/characters of business instead of the willingness of innovators. In other words, some parameters that been used previously are rather dependent variable than independent variable. So, without a systematical structure, achievements on open innovation cannot form a complementary theoretical system, though the theoretical structure in Fig-3 may not be perfect for all perspectives.

We picked out one specific type so called customer integrated cross industry (CICI) open innovation as our research object, because this type has high level of openness and can reveal lots of key features of open innovation. Features include horizontal communications [20, 35], vertical integration [12, 20], long lasting [27, 34], etc.. These features in open innovation are necessary and important in both fostering market and cultivating internal capabilities through knowledge absorption.

Combining modular architecture theories and telematics market, we found two typical industrial business models, which have been defined as modularization and quasi-modularization. Modularization model is within expectation but quasi-modularization surprised us a little bit. Such model is not common in normal manufacturing industries. Similar as telecom market, customer preference plays a more significant role in telematics market than traditional automotive market. This may lead to a trend of functional fusion between cars' control panel and mobile terminals. Even though such model serves mainly middle and low-end customers in passenger vehicle markets at present, this model may become the most common model in the future when taking the entire industry including commercial vehicles into consideration. The further discussion between these two models forms another research opportunity for further study.

After industrial business model, we discussed the process and mechanism in implementing open innovation. Though the process model was concluded according to our understanding on telematics services as an example of CICI open innovation, we have reason to believe that only if nature of business is not core competency related, this process model could be adaptable for all kind of open innovation that drew from our theoretical structure in Fig-3.

The most obvious limitation of this research is that we do not have too many companies' insights to make our model universally adaptable. As pointed out in the beginning, open innovation can be in multiple forms. It is not easy to make a common conclusion. Further studies can also start from here to expand the feasibilities of our theoretical achievements in this research.

Though there exists certain limitations due to this special innovation pattern we study, this CICI type might be the most complex type. So we think the theoretical framework can be expanded for the discussion of other kind of open innovation.

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