Intellectual Property modularity: a strategic tool to align digital platform owners and their complementors

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Résumé:

Cet article traite du rôle de la modularité des droits de propriété intellectuelle (DPI) dans l'élaboration d'une stratégie de plateforme. Pour ce faire, nous mobilisons l'approche de Baldwin et Henkel (2015) en considérant les questions techniques et stratégiques soulevées par la modularité. Nous contribuons à la littérature récente qui aborde les questions stratégiques de la modularisation sous l'angle des DPI en répondant à la question de recherche suivante : « Comment et pourquoi la modularité de la propriété intellectuelle peut-elle être utilisée dans la conception technique et stratégique d'une plateforme numérique ? ». Nous étudions le cas de l'adoption d'une stratégie de plateforme numérique par l'un des principaux constructeurs automobiles mondiaux, dans le domaine des services automobiles connectés. Grâce à notre étude de cas approfondie, nous caractérisons trois modèles génériques de modularité des DPI qui soulignent le rôle clé de la modularité dans l'alignement d'acteurs complémentaires lors de la conception d'une plateforme. En d'autres termes, nous montrons comment la modularité des DPI peut être mobilisé comme un outil stratégique qui permet d'aligner les statuts de propriété intellectuelle et les technologies détenues par un propriétaire de plateforme et ses complémenteurs.

Keywords : Platform strategy, Modularization, Intellectual Property Modularity, Digital Convergence, Alignment.

INTRODUCTION

Digital convergence poses significant challenges for incumbent firms (Teece, 2018), as it leads to the emergence of new complementarities between their products and external digital systems (Baldwin, 2014). It can thus lead incumbent firms to collaborate closely through co-innovation projects with digital firms to adapt their respective technical systems to each other (Baldwin, 2014; Kapoor, 2018). Such co-innovation projects can also aim at developing a digital platform, to support the generative potential of digital technologies (Pushpananthan & Elmquis, 2022). Digital platforms are an architectural product that embodied digital technologies and connectivity to exploit and control digitized resources of external firms, creating value by facilitating connections across a set of complementary actors (Gawer, 2021). Nevertheless, these complementary firms often show diverging strategic interests that can lead to conflicting relationships. Indeed, in platform-based ecosystem, competition occurs not only between the platform and another platform. There are also two other levels of competition: (i) between the platform owners and its complementors and, (ii) among complementors (Teece, 2018).

Strategizing the product technology design of the platform to balance between competition and collaboration is one among four key levers to core a platform (Gawer and Cusumano, 2002, 2008). A platform owner has several strategic alternatives to influence the direction of innovation in complementary products by third parties that are both competitors and collaborators. Platform owners gain an architectural advantage from this relatively central position (Gawer and Cusumano, 2014). As they are the one who choose what functionality or features to include in the platform and whether the platform should be modular.

Modularity is a second lever to core a platform strategy (Gawer and Cusumano, 2002, 2008). It is defined, in platform literature, as the technical design of a platform that materialize the degree of openness of the platform to outside complementors. Authors were interested in strategic issues related to platform, adopted a platform-centric view. Competitive interactions in the process of platform design are thus neglected (Zhao et al. 2020). And, if more recent works shift the focus towards the complementor strategies (Wang & Miller, 2019; Wen & Zhu, 2019; Cenamor, 2021), ittle, if no, attention (with the exception of Attour and Della Peruta, 2016) to the case of co-designed platform strategy by the platform owner and its partners.

Furthermore, in platform literature, modularity has been studied from its technical side. The technical design of modularity materializes strategic decisions. By choosing the appropriate degree of modularity, a platform owner decides of the openess or close of product interfaces and, choices information disclosed to complementors. Indeed, prior platform research focus mainly on how a company exercises a leadership position, creates attractive features and add-ons for complementary innovation (Gawer and Cusumano, 2008, 2014) and, how the degree of openness materialized by interfaces of the platform's modular architecture impact innovation (Parker et al. 2016, Parker and Van Alstyne, 2017, 2018). It states that the platform enhance alignment with complementors and among complementors. But this role is mainly studied through the degree of modularity, the trade-offs between openness and close of the platform's interfaces and the level of information disclosed to complementors.

In the modularity literature, modularity partitions knowledge between innovators and ensures compatibility to design strategy (Baldwin & Clark 2000; Baldwin 2015). It defines how firms can combine their resources and benefit from their own innovations while sharing knowledge. From that point of view, this body of research has paid a specific attention to intellectual property (IP) modularity (Henkel and Baldwin, 2013, 2015). It suggests that the modularization of IP has become a key strategic issue, not only for value creation but also for value capture. However, if the technological and organizational aspects of modularity have received a great deal of scholarly attention, in both platform and modularity literature, strategic issues have been under-studied (Badwin & Henkel, 2015).

We address these gaps by focusing on the strategic dimension of modularity, i.e. IP modularity, by studying the following research question : "how and why IP modularity can be used in the technical and strategical design of a digital platform ? To answer this question, we investigate the case of digital platform strategy adoption by leading global car manufacturers, in the domain of automotive connected services. Adopting a digital platform strategy appears indeed as a strategy to face digital convergence challenges (Teece, 2018). the best way to face who aim to face through this strategy challenges of digital convergences. We focus on the analysis of the platform design of a leading global car manufacturer. Its "Connected Car Platform" (CCP) is a software platform that the company co-designed with two partners to develop, integrate, and deliver its own connected services to its customers. Studying CCP at its technical and strategic phase of design enables the analysis of technical and IP modules outlining its modular design.

Thanks to this case study, we contribute to a better understanding of the role of modularity in platform strategy. We identify that IP modularity is a strategic tool for aligning platform owners and (its) complementors. We characterize three generic IP models which outline the key role of modularity in enabling the alignment of the various IP status and technologies. In other words, IP modularity is considered as a strategic tool that enable the alignment of IP status and technologies owned by a platform owner and his complementors. This alignment enables in turn technological and IP complementarities between a focal firm and its partners.

1. THEORETICAL BACKGROUND

Platforms are technological product architectures formed by a core and periphery (Gawer, 2014 ; Jacobides et al. 2018). Platform technology represents the core, and innovation complements (assets from external actors) form the periphery. Modular interfaces achieve connection between the two. Both, platform architecture and interfaces determine the incentives for complementors to support a technology. It therefore materializes platform owners strategic and governance decisions (1.1). More generally modularity stands as a design strategy whose goal is to manage complexity by partitioning knowledge between innovators, while ensuring their innovations to be compatible, as long as they comply with the module's standardized interfaces (Sanchez et Mahonney, 1990; Baldwin & Clark, 2000) (1.2).

1.1. PLATFORM STRATEGY: ALIGNEMENT ACHIEVED THROUGH TECHNICAL MODULARIZATION

In a platform-based ecosystems, the platform achieves alignment between actors to maintain or increase competition among complementors. As Jacobides et al. (2018, p.2276) underline, alignment defines "how all members benefit from the success of the collective enterprise". In a platform-based ecosystems, aligning actors is achieved through the control gained over the platform, intellectual property licensing and, by attracting external partner investments through a mechanism that facilitate complementary innovation that is modularization (Gawer and Cusumano, 2014). Modularization is the subdivision of a system into a set of relatively independent and interconnected components called modules (Simon, 1962).

Applied to product architectures like platforms, modularity lies on two key principles: 1) gathering within modules the components of the product which are highly interdependent on each other; and 2) the standardization of the interfaces between these modules (Ulrich, 1995). When conscientiously applied, these principles allow the product's modules to be designed, produced and combined with the least coordination possible (Baldwin & Clark, 2000; Hao et al., 2017). In such case, they create favorable conditions for coring a platform (Gawer and Cusumano, 2002) and enabling loosely coupled firms to innovate within specific modules without caring about what happens in the others (Orton & Weick, 1990; Langlois, 2002; Moore, 2006; Jacobides et al., 2006, 2018).

Each module has indeed an interface which indicates how the component interacts with the larger system (Baldwin and Clark, 2000, p.64). As summarized by Gawer (2014, p.1242), modular system achieves economies of scope in production and design which in turn allows economies of scope in innovation. It however increases competition and imitation risks between platform owners and complementers within industry ecosystems (ibid). Those risks are managed by the degree of the platforms' interfaces according to two different approaches: granting outsiders access to the platform (opening up markets for complementary innovation around the platform) or control access over the platform itself (Boudreau, 2010 ; Parker et al. 2016, Parker and Van Alstyne, 2017, 2018). Alignment is thus achieved through the control gained over the platform, intellectual property licensing and, by attracting external partner investments through a mechanism (modularity) that technically facilitate complementary innovation and manage complexity.

Interfaces' degree of openess is in some way a technical tool materializing a platform owner's strategic decisions related to how to attract and align complementary innovation from external actors. This degree of openess has an influence on the nature of the innovation (Boudreau, 2010) and on the extent to which innovation is facilitated (Gawer, 2014). It follows that, to gain an architectural advantage, when designing a platform, a firm needs to decide both business and technology aspects related to two strategic choices : (i) coring (creating a new platform) and (ii) tipping a market (toward its platform) (Gawer & Cusumano, 2015).

To core a platform, a firm needs to achieve four levers (Gawer and Cusumano, 2002): (i) the scope of the firm (create product complements internally or not), (ii) strategize the product technology design, (iii) shape relationships with external complementors (how to balance competition and collaboration) and, (iv) optimization of internal organizational structures (how the platform owner will effectively manage internal and external conflicts of interest). If the role of modularity in achieving the second lever is well recognized, it is less clear for levers three and four. As it has been mostly studied through the lenses of trade-offs between openness or close of the platform interfaces, in reference to Boudreau (2010), Parker and Van Alstyne (2017, 2018). To better identify how modularity can materialize strategic decisions, next section reviews strategic principles of modularity.

1.2. Strategic principles of modularity and the need for a better understanding of IP-oriented modularity

Baldwin and Henkel (2015) outline that the modular structure of a technical system is a choice that system architects make. Such design decisions are crucial, as the technical systems can be designed to be more or less modular. For designers, the key issue is the access specified by the design rules of the interfaces connecting the modules[1]. Making such a design strategy viable requires overlying the modular technical architecture with a suitable contract structure, defining firms' boundaries, transactions and Intellectual Property rights to ensure (Baldwin & Clark 2000, Baldwin 2015). This challenging issue is at the cornerstone of IP modularity and claim for further research on its strategic dimension.

In the same line of technical modular systems, modularity of IP has been applied to the various IP status and their potential combination. Following Baldwin and Henkel (2009, 2) "*A product or process design that is modular with respect to intellectual property (IP) allows firms to better capture value in situations where knowledge and value creation are distributed across many actors*". As mentioned by the authors, IP modularity has mostly been investigated in relation to value creation between various actors, whereas appropriation has been under-investigated and

[1] Indeed, as indicated, Module A's designers do not need to have specific knowledge about Module B's internal structure as far as they can access the interfaces (Baldwin and Henkel, 2015).

even recognized as being problematic. Baldwin and Henkel (2009, 2015), fill this gap by outlining the key role of IP modularity in value appropriation. They show that modular systems "*can be used to protect IP by enabling companies to disperse and hide information that might otherwise be difficult through the legal system*" (2015, 1638). From that point of view technical modularity is clearly an effective mean of IP protection. The main idea is that the division of knowledge prevents from the threat of expropriation. In case of ineffective legal IP protection, the innovator has two main choices to avoid misappropriation of his knowledge by agents: either use the protection which stemmed from the surrounding society (common values such as in clans and social norms) or refer to modularity in order to split the knowledge[2]. This research is very relevant to understand how a specific firm (here named as the principal or innovator) can avoid expropriation by agents and from that respect enrich Teece's Profiting from Innovation approach[3]. Indeed, in this seminal research the appropriation issue is the key issue partly influenced by appropriability regimes. This main contribution combines IP, technological and strategic issues in showing how the innovator (or the imitator) will get the lion's share of the rents, depending on the appropriability regime, market timing, and the ownership of complementary assets.

"IP modularity" or "IP-oriented modularity" is a key strategic issue to solve intrinsic conflicts between value co-creation and value capture (Baldwin and Henkel, 2009). It relies in the articulation between different IP treatments (or IP status) for the different parts of a complex system. Baldwin and Henkel even state that "*IP modularity may even form the basis of a firm's business model*" (ibid, 7). In line with Jacobides et al. (2006), the modular architecture which stemmed from the contractual relations that the innovators and its partners (complementors and / or suppliers) enables to build an "architectural advantage". More precisely, "*a particular*

[2] These choices are not opposite as clans and modularity complement each other.
[3] However, in this paper, Baldwin and Henkel do not explicitly refer to "IP modularity" (modularity remaining that of the technical system) which is has been previously the focus of their attention (Baldwin and Henkel, 2009).

module of a larger system is "IP-modular" if all of its elements have the same or compatible IP status" (Baldwin and Henkel, 2009, 17). IP status refers to the IP which covers a particular module (or any element of the system)[4]. In other terms, IP status refers to the legal rights and de facto accessibility of knowledge about the module. This defines an "IP module." If all the modules of a system are IP modules, the system as a whole is said to be "IP-modular" (Baldwin and Henkel, 2009). What is very important to notice is that "*a system may use different, incompatible forms of IP and still be IP modular as long as the incompatible "chunks" of IP are associated with different modules of the overall system"* (ibid, 18)[5]. This is exactly when the situation becomes interesting: as the different elements of the system have different IP status, then IP modularity becomes crucial for designers and strategic managers. This what the author called a "mixed-IP strategy". From that perspective we can say that the key strategic issue is whether to leave technological knowledge and IP unseparated or, on the contrary to segregate between knowledge and the related IP status. We propose the figure 1 as a synthesis of the complementarity of technical and IP modularity.

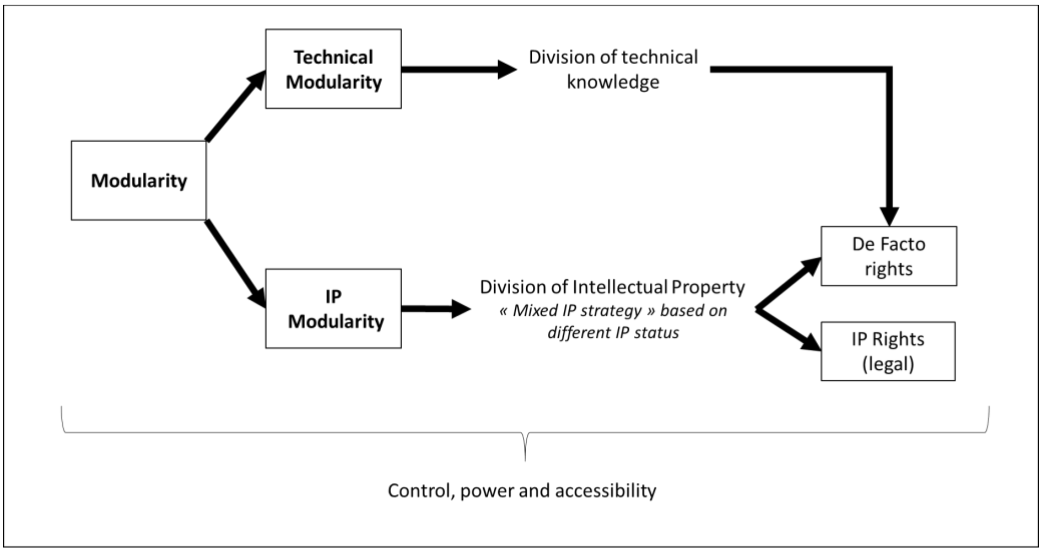

Figure 1 – *Links between technical modularity and IP modularity*

[4] This is what Baldwin and Henkel (2009) call the module's "IP status."
[5] Very relevant also is that quote "*Fundamentally, IP modularity eliminates incompatibilities between IP rights in a given module, while permitting incompatibilities within the overall system*" (Baldwin and Henkel, 2009, 36).

Our purpose is to get a better understanding of this mixed-IP strategy by outlining what we call a "strategic IP modularity". Our aim is to understand "how and why IP modularity can be used in the technical and strategical design of a digital platform?".

2. METHODOLOGY

For the purpose of our research question, we conduct a qualitative case study of the strategy of one of the leading global car manufacturers, in the domain of automotive connected services (2.1). An in-depth qualitative case study is appropriate for exploring the *how* and the *why* characterizing the observed phenomena (Yin, 2008). Data collection and analysis are detailed in 2.2. and 2.3. of this section.

2.1. CASE PRESENTATION: THE "CONNECTED CAR PLATFORM" (CCP) PLATFORM

The automotive industry is a key sector to study modularity (Jacobides et al. 2016) and the rapid advent of connected cars which dramatically shifts the automotive industry strategic landscape makes it even more relevant. Concretely this trend unfolds through the rapid multiplication of connected services that largely rely on digital technologies. For a few years, this new imperative has become a central preoccupation for most automakers and implied them to renew their strategy both from a technical and organizational viewpoint.

More precisely we focused on the analysis of its "Connected Car Platform" (CCP), a software platform that the car manufacturer co-designed with two partners to develop, integrate and deliver its own connected services to its customers. The development of CCP lasted three years, from 2017 to the end of 2020. It took the form of a co-innovation project between the automaker (the OEM), one of its historical suppliers (the Tiers 1) and one of the leading mobile services providers, that entered the automotive industry a few years ago, focusing on automotive connected services (the complementor). During this project, each of the partners either brought some existing software modules and/or developed new ones specifically dedicated to this project. More precisely the contributions of each partner can be summarized as follows:

- The contribution of the complementor is twofold. First, the overall platform is built around an open-source operating system developed and maintained by this partner. This operating system defines both some elementary modules and logical rules and protocols that served as a basis to design the platform. Second, this partner also brought in the platform a consistent bundle of applications running on top of this operating system. These two contributions constitute two distinct commercial offers.
- The contributions of the Tiers 1 mainly consist in the customization of the operating system developed by the complementor according to specific requirements formulated by the OEM. Concretely, its role was to develop custom software modules, using the logical rules and protocol defined by the operating system. Also, the Tiers 1 was responsible for the integration of the software platform on the hardware parts embedded in the vehicles.
- The contribution of the OEM to the project was twofold. First it designed the CCP's architecture and its custom requirements. Second it kept the development of some specific software modules in-house.

Our analysis covered two dimensions of this platform: its software technical architecture and the structure of the Intellectual Property Rights designed around its modules.

2.2. Data collection

Data collection was carried out following a participatory observation approach, made possible by the integration of one of the researchers within the OEM's subsidiary in charge of the development of its Connected Car Platform (CCP). This approach allowed us to collect data within the company.

First, we got access to the contracts and license agreements governing the collaboration of the three partners around the project. These documents constitute a contract structure composed of three generic contracts signed between the OEM and the complementor (contract 2, 3 and 4), two generic license agreements (license agreements 1 and 2) signed between the complementor, and the Tiers 1 and one ad hoc contract signed between the OEM and the Tiers 1 (Contract n°1). Also, we got access to many technical and project management documents backing this contract structure. The figure 2 represent this contract structure.

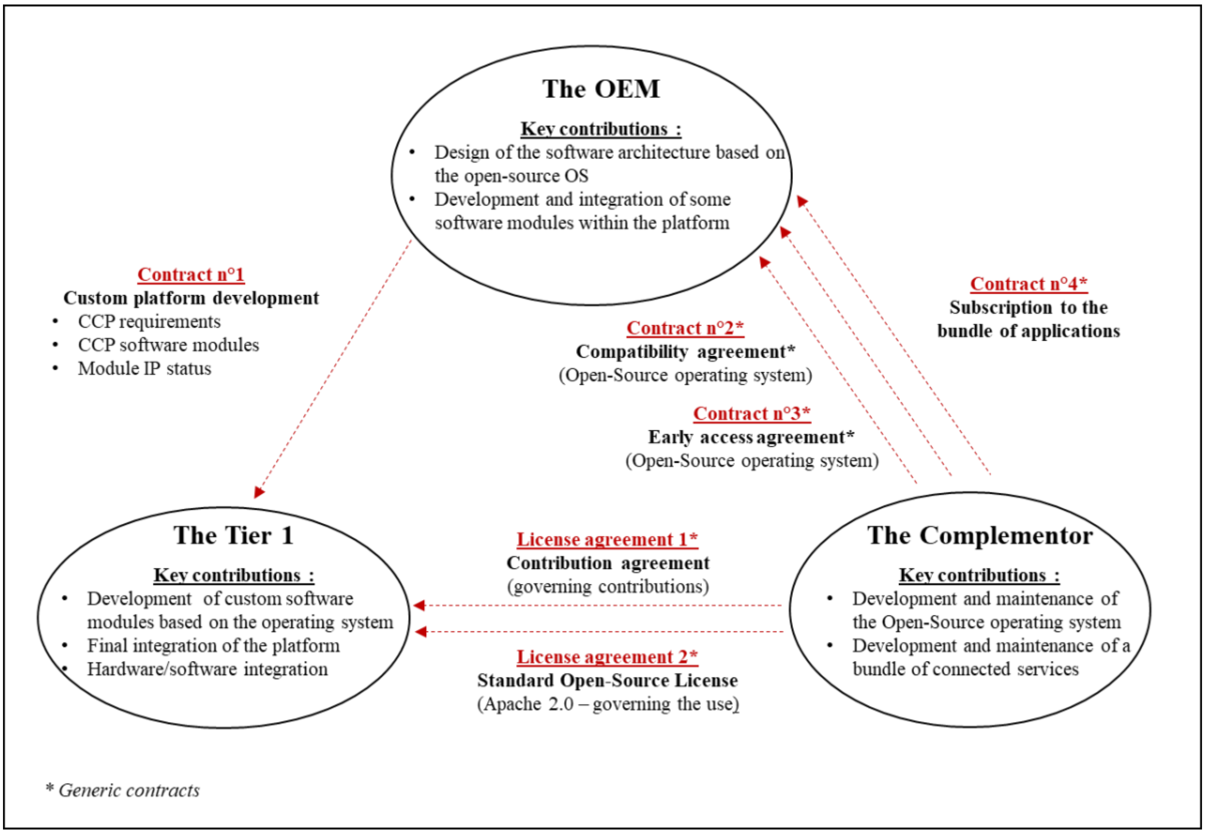

Figure 2 - *The contractual structure underlying the development of the OEM's Connected Car Platform*

Second, we used primary data collected within the company to understand the strategic rationales that guided the design of this contract structure and the definition of each module's IP status. This primary data collection unfolded in two ways. Foremost, field observations were collected over a two-year period from March 2019 to January 2021 thanks to the presence on-field of one of the researchers. Integrated within the "Strategy team" of the OEM's subsidiary, he participated to many weekly or *ad hoc* meetings dealing with strategic issues regarding connected cars' software. These meetings represent a total of at least 145 hours of field observations. Finally, these field observations were also completed by interviews with engineers and/or managers implied in the development of the platform or connected services. The tables 1 and 2 synthesis the data collected.

Type of Document	***Purpose***	***Generic or ad hoc***	***Redactor***	***Signatory***	***Compensation***
		The contract structure			
Contract 1	Custom platform development	Ad hoc	OEM	Tiers 1	Yes
Contract 2	Compatibility agreement	Generic	Complementor	OEM	No
Contract 3	Early access agreement	Generic	Complementor	OEM	Yes
Contract 4	Subscription to the bundle of applications	Generic	Complementor	OEM	Yes
License agreement 1	Contribution agreement	Generic	Complementor	Tiers 1	No
License agreement 2	Open-source license	Generic	Complementor	Tiers 1	No
		Project management documents			
Internal	CCP technical requirements	Ad hoc	The OEM	N/A	N/A
Internal	CCP technical architecture	Ad hoc	The OEM	N/A	N/A
Internal	"Bill of material"	Ad hoc	The OEM	N/A	N/A
Internal	Technical roadmap	Ad hoc	The OEM	N/A	N/A
Internal	Request for information (to select the Tiers 1)	Ad hoc	The OEM	N/A	N/A
Internal	The strategic interest of the CCP	Ad hoc	The OEM	N/A	N/A

Table 1. *An overview on the secondary data collected.*

Purpose of the meeting	***Frequency***	***Average time***	***Number of occurrences***	***Total time***
		Field observations		
Technology roadmap definition and follow-up	Bi-Weekly	1h	20	20h
Strategy team weekly meeting (pass down regarding strategic projects progress)	Weekly	1h30	40	60h
Strategic axis definition	Weekly	2h	16	32h
Working sessions on issues related to connected cars	Ad hoc	2h	13	26h
Presentation of the connected car strategy by corporate executives	Ad hoc	1h	7	7h
		Semi-Directed interviews		
Interview with the project manager responsible for the relationship with the Tiers 1	Ad hoc	1h30	1	1h30
Interview with a business developer responsible for connected services	Ad hoc	1h	9	9h
Interview with the project manager responsible for in-vehicle connected services	Ad hoc	1h30	1	1h30
Interview with the manager of the team responsible for vehicles software architecture	Ad hoc	1h30	1	1h30
Interview with the manager of the strategy team	Ad hoc	1h30	6	9h
			Total time – field observations	**145 h**
			Total time – semi-directed interviews	**22 h 30**

Table 2. *An overview on the primary data collected.*

2.3. DATA ANALYSIS

Our analysis was mainly based on the contract structure governing the project and the complementary documents collected. This structure outlines the links and types of agreements between the OEM, its historical supplier, and the new mobile services provider. The analysis was conducted in two key steps.

The goal of the first step was to characterize the IP modular structure of the platform. Based on the contract structure and the complementary documents we were able to distinguish the various technical modules of the platform and their respective IP treatment. First, the analysis of the contracts and license agreements led us to identify 7 license types associated with the different modules of the platform. These documents allowed us to compare these license types on the following criteria: delivery responsibility, compensation practice, delivery format of the module, the rights given to licensee and the conditions under which the module can be sub-licensed (see table 3 for more details). These criteria led us to distinguish two key dimensions that allowed us to understand the strategic implications of these license types: the degree of encapsulation, that mainly relies on the rights granted to licensee (see 3.3.1) and the degree of isolation that mainly relies on the delivery format of the module (see 3.3.2). Each of the license type positions differently on these two dimensions (see 4.1). Second, based on project management and technical documentations we were able to identify the different modules integrated within the platform and to classify them into 4 main categories: applicative modules, runtime & services, hardware interface and testing modules. Also, we were able to associate each of these modules with the license type that defines its IP status.

The goal of the second step was to understand the strategic rationales governing the use of the different IP status. The joint analysis of the technical role and the IP status of the modules led us to identify different groups of modules that belong to the same technical category and share the same IP status (see table 4). For each of these groups, we relied on both our secondary and primary data to understand the strategic rationales governing the definition of their IP status. It led us to identify three generic IP modular models that serve different strategic rationales. The figure 3 synthesize the different steps of our analysis.

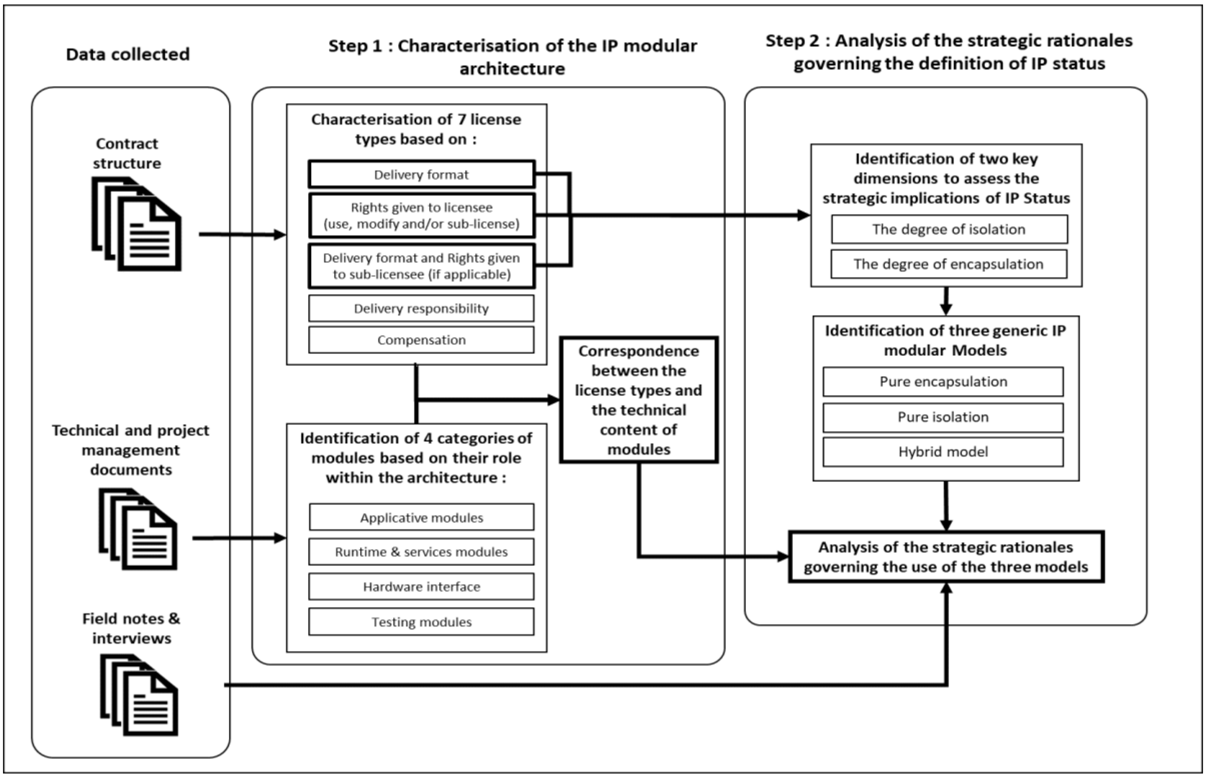

Figure 3. The different steps of our data analysis

3. RESULTS

Our results outline the IP modular nature of the platform. We present its technical architecture and the different license types protecting the modules. We show that the platform relies on a design strategy clearly defined by the leading firm. In this design strategy, we outline the articulation of the different IP treatments (or IP status) of the various modules.

3.1. THE TECHNICAL ARCHITECTURE OF THE PLATFORM

The CCP architecture gathers 386 software modules[6] developed and/or integrated during the project by the R&D partners. Based on technical documentation we were able to identify 4 main types of technical modules according to their role within the CCP architecture: applicative modules, runtime & services modules, hardware interface modules and testing modules.

First, "applicative modules" represent the concrete implementation of the connected services. They constitute the user visible part of vehicles' connected software since their role is to implement specific behavior from the vehicle in response to any defined context or trigger. These modules represent 23% of the modules developed during the project (90 modules). Nevertheless, as already noticed, one of the key goals of the CCP platform is to allow the OEM to develop by its own new applicative modules and to integrate them within the platform all along its lifecycle.

Second, the modules we labeled as "runtime and services modules", constitute the very heart of the CCP and represent 41% of the modules developed in this project (157 modules). These software modules organize the allocation of physical resources (memory, computing power, etc.) as well as the way the other modules must interact and behave, through defining standard interaction protocols and logical rules. Altogether they constitute the technical environment that allows the applications to run in a consistent, secure, and efficient way. They thus govern the inner functioning of the platform and constitute a stable set of standardized resources allowing to decouple applicative innovation from hardware innovation.

Third, the "hardware interface modules" (also called "Hardware Abstraction Layer") are software modules whose role is to manage the interactions between the software platform and the hardware parts. These modules cannot be standardized at the platform level since they are strongly dependent on the hardware parts used. Thus, changes in these modules can be

[6] « Modules » here is the term employed in the company.

necessary to integrate the software platform on different hardware parts. These modules represent 26% of the modules we identified (100 modules).

Fourth and last, "testing modules" are the software modules used to test the functioning of the platform during its integration. These modules are not directly integrated within the platform but are necessary to ensure and validate its proper functioning during the development project but also all along the CCP lifecycle. Testing modules represent 10% of the modules we identified (39 modules).

3.2. THE IP ARCHITECTURE OF THE PLATFORM

We identified seven different IP status, corresponding to different license types. These license types define the extent to which the R&D partners can use, modify and sub-license the technology of the dedicated modules. Five of these license types are defined by the contract signed between the OEM and the Tiers 1 (contract N°1). The two other license types are used by the complementor for the use of its own products (license agreement 2 and contract 4). The other contracts (2 and 3) use the same types of licenses.

First, regarding the license types defined by the contract n°1, overall, it is indicated that:

> *"[The OEM] shall have the right to reproduce in whole or in part, in any way, manner, form or support, translate, adapt, arrange, modify, change, use, distribute, exploit, or create derivative works from the [CCP]; [The OEM] shall be entitled to make the [CCP] available to or sub-license the same rights as those defined above to have tasks performed by Suppliers of choice for [the OEM] without need of a specific authorization [from the Tiers 1] but subject to limitations regarding licensing categories [associated with each modules]. It is expressly agreed that in case [the OEM] will sub-license to another supplier of choice, the scope of the license shall be limited to [OEM] products."*

In other words, this contract allows the OEM to use, modify and sub-license the platform as a whole, as long as it respects the individual constraints defined for each module by their IP status. More specifically, the contract differentiates five license types according to : 1) who is responsible for the delivery of the module; 2) the format in which the module is delivered and the extent to which it can be used and modified; and 3) the extent to which it can be sub-licensed, including the delivery format, the right to use, modify and to sub-sub-license.

The first three types of licenses defined in this contract, referred as "Type A", "Type B-A" and "Type B-B" refers to modules that must be delivered by the Tiers 1 to the OEM. First, Type A license states that the module must be delivered in binary format to the OEM and that the OEM can only deliver the module in binary format in case of sub-license. Since binary format is a non-human-readable format, this license type prevents the OEM and its potential sub-licensee to modify the module and even to know its internal functioning and structure. Second, Type B licenses states that the module must be delivered to the OEM in source code format, which is human-readable format that allows the OEM to know the functioning and internal structure of the module, but also to modify the module. In Type B licenses, two subtypes are distinguished depending on the extent to which the OEM can sublicense the module. In Type B-A license, the OEM can only sublicense the module in binary format, which means that the sub-licensee cannot know the functioning and internal structure of the module and thereby cannot modify it. In Type B-B license, the OEM can sub-license the module in source code format, which means that the sub-licensee can know the internal structure and functioning of the module, but also modify it.

The fourth license type in this contract, referred as "Type C" license, concerns module that must be delivered by third parties, including proprietary and/or open-source software modules depending on cases. The contract states that the Tiers 1 must assist the OEM in procuring these modules in sub-licensable source code format.

Finally, the fifth license type, referred as "Type D" license concerns modules that must be delivered by the OEM. The OEM reserves the possibility to deliver the module in source code or in binary format depending on cases but clearly excludes the rights to modify, to sub-license or to create derivative products from these modules.

Alongside with these license types defined by the contract 1, two added IP status govern the modules delivered by the complementor. First, the core of its contributions lies in its generic operating system consisting in software modules based on a generic Open-Source license (APACHE V2.0). This license type allows the partners to use, modify, share and sub-license these modules. Finally, the bundle of applications provided by the complementor consists in modules delivered in binary format and with no possibility to modify, share or sub-license the modules (proprietary).

The following table syntheses the seven license types and their key characteristics as described below.

Licence types		Type A	Type B-A	Type B-B	Type C	Type D	Apache V2.0	Proprietary
Defining document		Contract n°1					License agreement n°2	Contract n°4
Scope of the document		Custom Platform development					Open source operating system	Bundle of application
Delivery responsibility		Tiers 1	Tiers 1	Tiers 1	Third party	OEM	Complementor	Complementor
Compensation		yes	yes	yes	Depends	N/A	no	yes
Platform specific		no	yes	yes	no	yes	no	no
Licencing *(as a module)*	**Delivery forma**	***Binary***	Source code	Source code	Source code	Depends	Source code	***Binary***
	Right to use	yes	yes	yes	yes	yes	yes	yes
	Right to modify	***no***	yes	yes	yes	***no***	yes	***no***
	Right to sublice	yes	yes	yes	yes	***no***	yes	***no***
Sub-licensing *(as part of the CPP)*	**Delivery forma**	***Binary***	***Binary***	Source code	Source code	***N/A***	Source code	***N/A***
	Right to use	yes	yes	yes	yes	***N/A***	oui	***N/A***
	Right to modify	***no***	***no***	yes	yes	***N/A***	oui	***N/A***
	Right to sublice	***no***	***no***	***no***	yes	***N/A***	oui	***N/A***

Table 3. *The seven license types.*

We found that each technical module is associated with a specific IP status defined during the design of the CCP. So far, the technical design is consistent with the IP design. The table 4 synthesis the correspondence between the different license types and the technical content of the modules that constitute the platform.

	Type B-B	Type C	Apache V2.0	Type D	Type B-A	Type A	Proprietary *(bundle of apps)*	Total
Applicative	-	-	-	12 (3%)	-	-	78 (20%)	**90 (23%)**
Hardware interface	11 (3%)	15 (4%)	58 (15%)	3 (1%)	13 (3%)	-	-	**100 (26%)**
Runtime & services	95 (25%)	12 (3%)	40 (10%)	10 (3%)	-	-	-	**157 (41%)**
Testing modules	27 (7%)	-	-	-	-	12 (3%)	-	**39 (10%)**
Total	**133 (34%)**	**27 (7%)**	**98 (25%)**	**25 (6%)**	**13 (3%)**	**12 (3%)**	**78 (20%)**	**386 (100%)**

Table 4. *Correspondence between the license types and the technical content of the modules.*

3.3. A STRATEGIC DESIGN OF THE CCP BASED ON MODULARITY

The modular structure of the technical system and IP status outlines a strategic design of the platform from the OEM in the context of its strategic orientation to connected services. The joint analysis of the license types and the modules led us to distinguish two dimensions we named "encapsulation" and "isolation". These dimensions enable to understand the different strategic implications of the technical and IP modularity.

3.3.1. Encapsulation

From a technical viewpoint, modularity requires the modules to be customizable or at least, to support extensions to serve as a base for the design of larger modules. While customization supposes a flexible inner architecture for the module, extension supposes some degree of interface standardization and openness. In both cases, some technical arrangements are needed to support improvements of the technical knowledge by the various actors. As presented above (3.1.), the four technical modules are defined to allow these interactions between the leading firm (OEM) and the complementors. This technical design is based on the division of software modules in core functions for the platform (with the "runtime and services modules" being the very heart of them). At the same times it requires technical integration among the main four modules and the various constitutive ones.

In the same vein, from an IP viewpoint, modularity enables both to provide readable versions of the software module, but also through the licenses to use, modify and create derivative modules. Even if the modules technical characteristics support potential integration and improvements, this IP modularity is legally essential to such improvements. Conversely, even if the IP arrangements allowed to read, use, modify and create derivative products from a module, effective integration could not be feasible if suitable technical arrangements are missing. This alignment of technical and IP modularity is at the cornerstone of the design of the CCP by the leading firm. Such alignment illustrates therefore that coring a platform goes beyond the alignment of complementors through the traditional strategic choice between openness and close of the interfaces of the platforms (Gawer and Cusumano, 2002; Boudreau, 2010).

More precisely, as far as IP modularity is concerned, the seven license types illustrate different degree of potential improvements and diffusion. Typically, the bundle of applications brought by the complementor shows very low level of improvements since the code is only delivered in binary format and no rights to modify nor to sub-license are granted to the OEM. Thereby, these applications can neither be customized nor extended by the partners. Similarly, Type A licenses also support low level of improvements although it is a little higher since the right to sublicense is granted to the OEM, in binary, non-modifiable format. Contrarily, the Type C license and the open-source license grant unlimited license to use, modify and sublicense the modules, allowing to create derivative products without limitations. Between these extremes can be positioned the Type B-A, Type B-B and Type D licenses which all grant the right to use and modify the modules only in the context of the OEM's product. Moreover, while Type B-B license grants the rights to use and modify to the OEM and potential sublicensees, these rights are only granted to direct licensee with type B-A and D licenses.

The results lead us to frame this potential improvements / diffusion based on the technical and IP modularity as what we named "the degree of encapsulation". We define the degree of encapsulation as the extent to which an IP module embeds smaller IP modules and/or can be embedded in larger IP modules (assuming that these two aspects are not necessarily mutually including). Of course, it makes sense only if the smaller and larger modules come from different partners.

3.3.2. Isolation

Technical and IP modularity can also be used to prevent the partners to gain access or use the technical knowledge.

As far as technical arrangements are concerned, they can reinforce the degree of protection of a module. For example, the bundle of applications brought by the complementor shows both high degree of IP protection, since the modules are only delivered in binary format according to a restrictive contractual agreement (contract n°4) and also high degree of technical protection due to the position of the modules within the architecture and to the degree of standardization of their interfaces. Indeed, these modules are not directly integrated within the platform during the project but connect to the CCP thanks to a highly standardized interface. Thus, the development of these modules is not a part of the CCP development project and the bundle's highly standardized interfaces create the condition for keeping hidden the knowledge it embeds. Moreover, the complementor both provides the OEM with a very detailed documentation specifying the technical requirements to comply with, and a series of technical tests to complete to ensure the compatibility between the platform and its bundle of applications. These modules are therefore highly isolated from the rest of the CCP's modules, both contractually and technically. The same phenomenon is true for the modules protected under Type A licenses which state that the modules are delivered in binary format. Indeed, they correspond to software modules used to test the platform during its development and integration. Consequently, they are technically separated since they are not parts of the platform and rather position as complementary external software.

More precisely, regarding IP status, this separation phenomenon is noticeable. As mentioned, the contract 4, based on a proprietary license, prevents the complementors to reuse the related knowledge. On the contrary, the modules protected under Type B-B, Type C and Apache V 2.0 licenses must be delivered in source code, which implies disclosure regarding partners' knowledge of the modules. In our case, the fact that some license types specify that the modules must be delivered in binary format constitute the main instance of non-disclosure mechanisms. Nevertheless, our seven license types show that these mechanisms are again a matter of degree as they appear to be partially applied to some modules. Typically, the Type B-A license implies the Tiers 1 to disclose its knowledge to the OEM (by delivering the module in source code format) but prevent the OEM to disclose this knowledge, (by allowing the delivery of the module to potential sublicensees in binary format only). Similarly, through Type D license, the OEM reserves the rights to disclose its own knowledge, but strictly prohibits its licensee to disclose this knowledge to other partners through sub-licensing.

Overall, we framed this protective or separated design mechanisms as "isolation". Based on the above results, we define isolation as the extent to which the knowledge contained in an IP module is kept hidden for the partners.

4. STRATEGIC IMPLICATIONS OF THE TECHNICAL AND IP MODULARITY

Our results outline how the correspondence of the technical and IP modularity is essential for the strategic development of the CCP. By outlining the strategic dimension of modular systems, these results contribute both to the IP modularity and the IP strategy literature. In line with Somaya (2012), we characterize three generic models for IP modular systems. To the best of our knowledge, this paper is a first attempt in such a modular IP model. In contrast with technological and organizational approaches of modularity which have received a great deal of scholarly attention, the strategic one has been under-studied (Badwin & Henkel, 2015). Our research fills this gap by outlining how IP modularity can be used as a tool to align platform owner and complementors during the design of a platform strategy.

4.1. THREE GENERIC MODULAR IP MODELS

The different levels of encapsulation and isolation we observed led us to identify three generic IP modular models (Figure 4): pure encapsulation, pure isolation, and hybrid ones.

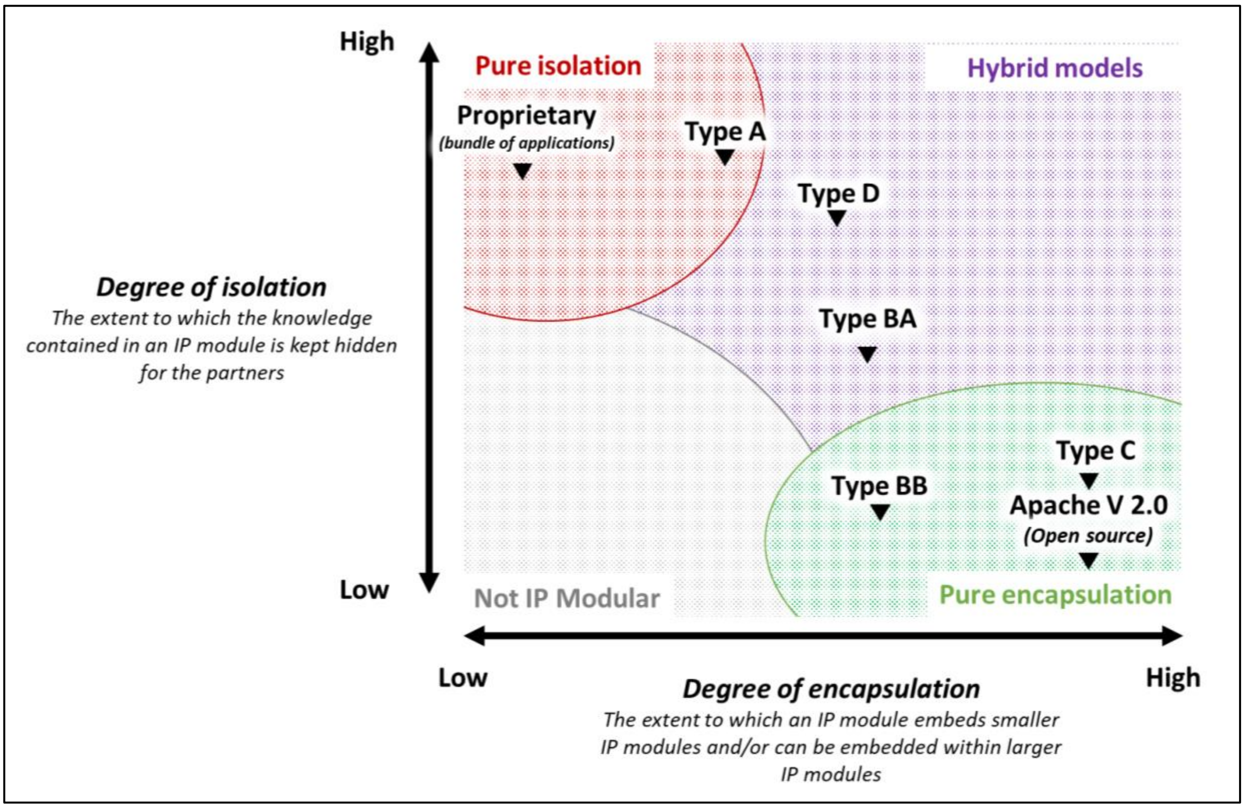

Figure 4. *Generic models for mixed IP modular systems.*

4.1.1. The strategic rationales for Pure Encapsulation

Pure Encapsulation corresponds to modules whose degree of encapsulation is high while degree of isolation is low (modules brought by the Tiers 1 and the complementor). These modules constitute the very technical heart of the CCP and correspond either to open-source modules

(Type C and Apache V2.0) or to custom extensions to these modules developed by the Tiers 1 according to the OEM requirements (License B-B).

The open-source modules brought by the complementor represent the technical base of the platform: 40 of these modules correspond to runtime and services modules and 58 to hardware interfaces. They define the fundamental mechanisms governing the functioning of the platform and ensure the functioning of the software platform.

Alongside, the modules developed by the Tiers 1 under type B-B license correspond to software modules built on the base of the complementor's generic open-source platform to adapt them to the specificities of the OEM vehicles. The collaborative R&D challenges are high for the development of these modules since the Tiers 1 is subject to a double constraint: it must deal with the technical constraints of the generic platform and the specific requirements of the OEM. Knowledge exchanges are necessary to manage these high collaborative challenges. They justify the low degree isolation and support the implementation of a pure encapsulation strategy.

Last, but foremost, the encapsulation logic of the CCP architecture results from a design choice clearly operated by the OEM. Overall, this choice is supported by two key strategic rationales. In the one hand the rapid advent of connected services strains the OEM to move fast and qualitatively in this domain. On the other hand, the implication of the OEM on the development of its vehicles' software is very recent and its resources and competencies in these activities remain quite limited at the moment. Jointly, these two elements, that characterize most of automakers nowadays, led the OEM to design its platform to be able to leverage cutting-edge external capabilities while learning from its partners and ensuring to get control over its platform. This encapsulation logic thus lies at the heart of the collaborative effort deployed by the partners during the project.

4.1.2. The strategic rationales for Pure Isolation

Second, we investigated the strategic rationales underlying the use of pure isolation strategies which are employed for about 23% of the CCP modules and mainly correspond to modules brought by the complementor through its bundle of applications and to some testing modules brought by the Tiers 1.

The applications brought by the complementor correspond to the large majority of applications supported by this initial instantiation of the CCP platform. As already noticed, the complementor is a leading actor in the mobile industry and is currently diversifying by adapting its offers to the automotive industry. Its bundle of application consists in an adaptation of its usual mobile connected applications to the specific technical context of the automotive, merely approached as another type of electronic device. These applications are central in its mobile-centered business model, since they embed some of its usual revenue generation mechanisms. Porting them to automotive devices represent a great strategic opportunity for this actor, both to grow and create new kind of services dedicated to the automotive industry, but also to further assert its status of leader in the connected services domain by organizing the continuity of its applications on a wider diversity of devices. These applications thus stand as first-rate strategic assets for the complementor, that it must protect, justifying its pure isolation strategy. Moreover, an interesting point to underline regarding the positioning of the complementor vis-à-vis this platform and more broadly vis-à-vis the automotive industry, is the duality between its offers. Indeed, it both provides the CCP development project with generic, free, open source modules constituting the heart of the CCP and with a highly protected paying bundle of applications. These two contributions are the two side of a unique consistent strategy elaborated by the complementor, that consist in helping the automotive OEMs to build their own connected services platform by providing them with a free, generic operating system while ensuring their platform to be compatible with its own value-generating applications. This way automotive

OEMs can accelerate their shift toward connected vehicles and the complementor position as a privileged partner for vehicle application provision.

Alongside, the testing modules brought by the Tiers 1 using pure isolation strategy correspond to a generic test and integration platform developed and owned by the Tiers 1 independently from this specific project. In the automotive electronics domain, module integration and test are parts of the core business of Tiers 1 suppliers. Such testing platform thus constitute key differentiating assets for them, which justifies for the Tiers 1 to keep these modules highly isolated.

4.1.3. The strategic rationales for Hybrid models

Third, Hybrid models correspond to modules whose both degree of encapsulation and isolation vary from medium to high. Such approaches are employed either by the OEM or by the Tiers 1.

The OEM used a hybrid model for each module developed on his own for the platform. Indeed, the contract n°1 clearly states that every module licensed under a Type D license is differentiating for the OEM. Three different types of modules corresponding to three different rationales claim for this hybrid logic. First, The OEM decided to internalize the software modules involved in the implementation of Advanced Driving Assistance Systems (ADAS). ADAS are of critical importance for the OEM and stand as key differentiators among automotive brands. But they also constitute a critical factor of risks since any bug or dysfunction in ADAS applications can lead to dramatic consequences such as fatal road accidents. Keeping tight control over the quality and safety of these applications is of prime importance for the OEM. Both their differentiating aspect and their associated risks thus constitute strong rationales for the OEM to internalize their development and keep some control over the knowledge embedded in these modules. Nevertheless, through its hybrid strategy the OEM reserves the possibility to share and improve source code by leveraging its partners' skills, under the essential condition that they keep its knowledge secret. Second, the OEM decided to internalize modules that are linked to its vehicles' audio systems. Just like ADAS, the vehicles' audio systems are considered as differentiating since they play a decisive role in the quality of the vehicles' on-board user experience. Moreover, from one range of vehicles to another the OEM generally uses different audio equipment, which may require adaptations regarding these software modules. In this context, keeping control over these modules allows the OEM to adapt them with more flexibility. Third, the OEM decided to internalize modules that constitute the interface between the CCP (the on-board connected services platform) and its off-board connected services platform. These modules seem quite strategic for the OEM since they ensure the continuity between the two platforms and manage data upload from the vehicles to the OEM's off board infrastructure.

In regard to the Tiers 1, we found that the modules benefiting from a hybrid model (Type B-A licenses) all correspond to hardware interfaces for highly standardized technologies, such as Wifi or Bluetooth to name a few. The high degree of standardization of these technologies leads these modules to embed components that can be reused by the Tiers 1 across automotive software development projects, whatever the project, the vehicles and the OEM. However, these modules themselves are not standardized ones and their development depends on Tiers 1 capabilities. Thus, they stand as differentiating modules between automotive Tiers 1, which justify that the Tiers 1 prevents the OEM to disclose the source code to other Tiers 1 in case of sublicense. Thus, the strategic rationales underlying the use of a hybrid model by the Tiers 1 is lies in its competitive relationships with other Tiers 1.

4.2. Generic IP modular models: a new avenue for value creation and value capture through platform strategy?

Overall, this research outlines how the OEM enabled new value creation and value capture dedicated to its new activities for connected services. These connected services illustrate the new imperative for car manufactures to move from pure industrial activities to services ones through the adoption of a platform strategy. The CCP has been designed to be able to leverage cutting-edge external capabilities while learning from its partners and ensuring to get control over its platform. By splitting the technical competences in numerous modules (which we gathered in four categories) and allowing specific IP status (which we gathered in seven categories), the OEM has designed a modular architecture which enables both collective technical improvements related to value creation and private appropriation which enable value capture. In other words, our results shed light that modularity within a platform strategy is technically and strategically designed to align actors through value creation and capture mechanisms. Alignment enhanced by the platform is not limited at a role of enablers of innovation, as identified by the platform literature. Alignment occurs through value creation and capture mechanisms materialized through IP modularity.

This modular architecture enables us to outline three generic modular IP models we named as "pure encapsulation", "pure isolation" and "hybrid". These three configurations depend on the interest of each module in terms of value creation and value capture. Finally, the choice of these models can be analyzed in terms of value creation and value capture challenges (Figure 5).

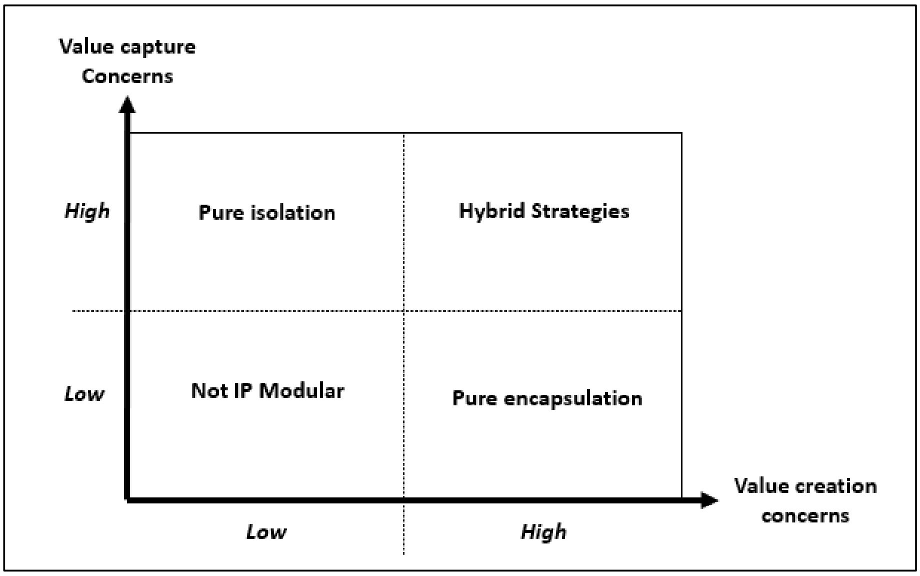

Figure 5. *Consistency of the IP-modular models depending on the strength of value creation and value capture concerns*

This added reflection in terms of value creation and capture reinforces the strategic dimension of IP modularity making the various potential configurations even clearer in terms of strategic orientations.

5. DISCUSSION AND CONCLUSION

Based on an in depth case study of one of the world leading car manufactures we outline how this major company uses IP modularity in designing and implementing a digital platform strategy with new partners from the software sector. IP modularity appears as a key strategic tool for aligning complementors through three generic modular IP models related to value creation and value capture. Thanks to the characterization of these three models, the theoretical contribution of this research is twofold.

First and foremost, this research contributes to the IP modularity literature by outlining the strategic dimension of modularity which has been the less investigated by previous research (Baldwin & Henkel, 2015). More precisely, by characterizing three generic modular IP modes we go further than previous research which define and insist on the importance of IP modularity but claim for a better understanding of its strategic deployment. To the best of our knowledge, this research offers the first attempt to distinguish various models or configurations related to IP modularity. Moreover, we aim at relating these generic modes with distributed value creation and capture. From that perspective, we intend to contribute to the still emerging literature which relates modularity to business model, stating that IP modularity may be the basis for a firm's business model (Baldwin and Henkel, 2009). We do think that this research is a first step in this direction. This step is consistent with Teece (2018) recent approach on « Profiting from Innovation" which clearly moves from the value chain approach of its seminal research to a coordination perspective based on IP *« … complementarities place a burden on the innovator to coordinate with all owners of relevant intellectual property and with downstream implementers »* (ibid, 1375).

Second, this research adds to the platform literature a deeper understanding of the role of modularization. The degree of modularity designed and implemented in the product architecture of platform allows certainly economies of scope in innovation by achieving economies of scope in production (Gawer, 2014, p.1242), through the openness degree of the platform's interfaces. However, modularization achieve one other type of alignment than the one of materializing coordination mechanism of innovation. Alignment occurs among the technical and the strategical (IP) side of modularization, and within modules. Such alignment materializes the value creation and capture mechanisms co-designed by the platform owner and its complementor. In other words, if in platform literature modularization has been highlighted has a tool for a platform owner to gain an architectural advantage to enhance alignment with and among complementors; our research shed light that, when co-designed with (some of) the platform's partners, modularization is a strategic tool to align complementors that build during competitive advantages they build within and outside the platform. Those competitive advantages are secured through IP modularity. Following Zhao et al. (2020), we contribute to the platform literature by considering complementors' competitive interactions in the process of platform design.

Finally, this research has also strong managerial implications. It shows the key role of modularity as a design strategy. For designers, the design rules which specify the interfaces between the modules not only deal with technical and IP issues. They inherently encompass huge strategic implications, which in the company are part of its strategic renewal. Indeed, the rapid advent of connected cars is dramatically shifting the automotive industry. The increase of connected services that largely rely on digital technologies force most automakers to move from pure car producers to services ones. This implies them to work with totally new partners from the software sector and more fundamentally to renew their strategy. Strategic renewal stands as an increasingly critical issue for leading firms, especially when it comes to address digitization challenges which affect all industries.

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