Interim report for *Industrial organisation in China: Theory building and analysis of new dimensions*, IDE-JETRO, Fiscal year 2016

A study of technology platform-driven global value chains

Ding Ke and Shiro Hioki

Abstract

Technology platform vendors have played a crucial role in the development of global high-tech value chains. Compared with global buyers, platform vendors are more willing to share information on technology and markets with their customers, something that has enabled firms in developing countries to learn, upgrade, and innovate. Whether a technology platform can facilitate learning and innovation, however, depends on the technological capabilities of the platform's vendor and its user. China's mobile phone industry serves as a case study for this paper's analysis of the above characteristics of technology platform-driven global value chains.

Keywords: global value chain, technology platform, information flows, mobile phone, China

1 Introduction

Governance is an important perspective from which to study learning and innovation in global value chains (GVCs). The central topic of value chain governance concerns the ways in which lead firms and firms in developing countries exchange knowledge and information and the influence of this exchange on capability formation, industrial upgrading, and innovation (Gereffi, 1999; Gereffi et al., 2005; Morrison et al., 2008; Pietrobelli, 2011).

Existing studies have focused on the role of global buyers in facilitating learning and innovation in GVCs. However, a growing body of literature suggests that technology platform vendors, as lead firms, have played an increasingly important role in the development of global high-tech industries. As the success stories of Microsoft, Intel, and Google demonstrate, an increasing number of multinational companies began to

adopt platform strategies to acquire a dominant share in the global market (Gawer and Cusumano, 2002; Gawer 2009; Cusumano, 2011).

Gawer (2014, p.1245), through a thorough review of the literature on design engineering and economics, developed a comprehensive definition of a "technology platform."

> Technological platforms can be usefully seen as evolving organizations or meta-organizations that: (1) federate and coordinate constitutive agents who can innovate and compete; (2) create value by generating and harnessing economies of scope in supply or/and in demand; and (3) entail a technological architecture that is modular and composed of a core and a periphery.

From the perspective of GVCs, we can derive three important points. First, as technology platforms are continuously evolving, a dynamic analysis of platform-driven value chains is indispensable. Second, in the framework of a GVC, technology platform vendors are global suppliers rather than buyers. Technology platforms can facilitate innovation only when they are used in collaboration with other agents. Third, it is very important to take into account value chain modularity in the consideration of technology platform-driven value chains.

This paper discusses the impact of technology platforms on developing countries, which is missing in both GVC and platform literature. The first research question of this paper arises thus: How are information and knowledge exchanged between the platform vendor and the users, and how does this affect learning, upgrading, and innovation in developing countries? Using the terminology of GVC studies, we examine the unique governance pattern between global suppliers (as lead firms) and domestic producers.

It is useful to consider the experiences of China in this study. It has been widely recognized that technology platform sharing is common in China's manufacturing sector that produces goods such as automobiles, mobile phones, air conditioners, TV sets, motorcycles, and electronic two-wheelers (Ohara, 2006; Ding, 2013; Fujita, 2013; Watanabe, 2014; Humphrey et al., 2017). The interesting thing is that the roles of platforms in stimulating innovation differ greatly between different development stages.

In the 2000s, the role of platforms in innovation was very limited. Scholars argue that this stemmed from the platform's modular design architecture (Ge and Fujimoto, 2004; Steinfeld, 2004). The design architecture of platform-based finished products is usually modular (Baldwin and Woodard, 2009; Tatsumoto et al., 2009; Gawer, 2014). Modular design reduces interdependency and requires little explicit coordination between the platform and other components. Meanwhile, modularity makes it easier to outsource the R&D activities of technology platforms. These platforms have enabled Chinese firms to engage in the production of complex, high-tech products with little technological capability.

Conversely, modularity has undermined Chinese firms' opportunities for learning, upgrading, and innovation. First, modularity reduces not only interdependency but also knowledge and information flows between platforms and users, particularly tacit knowledge, which has made it difficult for Chinese firms to learn from platform vendors. Second, modularity causes intense competition and imitation, which have undermined profit margins, thus making it difficult to invest heavily in some key segments such as R&D. Third, the internal design architecture of each module, particularly for a technology platform, is generally integral. The high interdependency of this integral architecture has made it difficult to independently develop a new technology platform.

Since 2010, however, platforms have become a key driving force in innovation. For example, in the mobile phone industry, by collaborating with Qualcomm, the internationally leading platform vendor, a number of top-level Chinese firms have succeeded in developing highly differentiated products with high value-added and have gained dominant shares in the Chinese market (Humphrey et al., 2017). In the smart hardware sector, by making use of an open platform, a start-up, DJI, has rapidly gained a dominant share in the world's drone market.

It is paradoxical that in the literature on platforms, modularity is considered to be the key factor in stimulating innovation. Gawer (2014, pp.1242–1243) concluded that platforms and their related modularity can facilitate innovation in two respects. First, because of the modular architecture of platforms, platform users can specialize in autonomous innovation within each module. Second, platforms and users themselves

have their respective R&D resources. By opening interfaces to some extent, a platform and its users can share these resources and subsequently accomplish innovation.

If modularity has such advantages in facilitating innovation, then why did it play only a limited role in the early stages before becoming a key driver after 2010? Going back to the perspective of value chain governance, we need a theory to determine the factors that affect information flows between platforms and users and their consequences on innovation. This is the second research question of this paper.

This paper studies technology platforms by examining the case of China's mobile phone industry. The mobile phone industry has experienced significant structural changes since 2010. Prior to that, this industry was known as the low-end segment of the mobile phone industry, the so-called shanzhai sector. Shanzhai firms are generally small businesses with dozens of employees. The shanzhai value chain is highly disintegrated, with numerous independent firms that are specialized in narrow production processes. Value chain governance is typically an arm's length market that has the advantages of a market, i.e., rapid, flexible responses to demand changes, and the disadvantages of highly homogenous products and grave imitation. The value chain of shanzhai was driven by the Taiwanese platform vendor, Media Tek (MTK). MTK has succeeded in providing a turnkey solution to its underserved customers, which includes a platform (baseband IC) that conducts most system design and part of the software design and a reference design that makes most of the feature phone components easy to use. This turnkey solution has greatly reduced the technological barriers to entry into the feature phone sector. However, there were only marginal autonomous innovations on the platform (Wang and Lin, 2008; Zhu and Shi, 2010; Ding, 2014; Ding and Pan, 2014).

In recent years, however, instead of MTK, Qualcomm has become the driving force of the mobile phone industry. Significant innovation and upgrading have arisen. Both the value chain structure and the industrial organization have been greatly upgraded. As Humphrey et al. (2017) summarized, "the new generation of leading handset manufacturers were more vertically integrated, invested more in research and development, and engaged in intense interactions with platform providers and key suppliers." The mobile phone industry is, thus, an appropriate case through which to study the platform-driven value chain and the relationship between platforms and innovation.

Since 2009, we have regularly visited Shenzhen, the largest mobile phone cluster in the world, to conduct interviews with mobile phone makers. During the period between December 2014 and February 2015, we conducted a questionnaire survey in Shenzhen and its neighbouring areas, intensively investigating the information flows between platform vendors and mobile phone companies. The sample size is 56, including 22 design houses, 23 vertically integrated firms, and 11 system integrators.

In the remainder of this paper, Section 2 gives a brief introduction of the recent changes in China's mobile phone industry. Section 3 focuses on the characteristics of information flows in the mobile phone industry. Section 4 compares the strategies and influences of two typical technology platform vendors, Qualcomm and MTK, and Section 5 concludes.

2 Structural Changes in the Mobile Phone Industry in China

Table 1 Shipments of Major Smartphone Makers in the Global Market

	Vendors	2011	2012	2013	2014	2015	2016
1	Samsung	95	198	299	308	320	311
2	Apple	93	136	153	193	232	215
3	Huawei	17	31	52	75	108	139
4	OPPO	-	5	18	31	45	95
5	VIVO	-	3	12	30	44	82
6	Xiaomi	-	7	19	65	73	58
7	LG	19	26	48	59	60	-
8	ZTE	17	31	42	45	51	57
9	Lenovo	4	23	45	-	45	50
10	TCL-Alcatel	3	7	12	41	42	34

Source: Data of Samsung and Apple in 2016: IDC; other data: IHS iSuppli, a market research firm.

China's mobile phone industry experienced significant structural changes during the 2010s. In the global smartphone market, some newly emerged firms matured and rapidly replaced existing international brands (Table 1). In the domestic market, the emergence of smartphones had greatly raised the level of industry concentration. In 2012, the domestic shares of the top three and top five mobile phone companies, including both feature phones and smartphones, amounted to 29.6% and 43.2%,

respectively. On observing the smartphone industry, however, we find that subsequently shares of the top three and top five increased to 38.3% and 56.1%, respectively. Unfortunately, we cannot provide complete data regarding mobile phones (including smartphones and feature phones) in 2015. A look at the smartphone sector reveals that, from there, the top three and top five shares, respectively, only increased to 42.9% and 59.1%, a negligible, minor change from 2012.

Even though the concentration level of smartphones did not change significantly, it is interesting that, in line with the global market, newly emerged domestic firms have quickly replaced international brands and have become major players. From 2012 to 2015, the list of the top five smartphone makers in Chinese market has changed from Samsung, Lenovo, Apple, ZTE, and Huawei to Xiaomi, Huawei, Apple, OPPO, and VIVO. Among these, Xiaomi, OPPO, and VIVO were established in the 2010s.

Table 2 Market Share of Local Smartphone Brands in China

	2014 Q4			2015 Q3		
	Total	Share of local brands in each segment	Share of local top 3	Total	Share of local brands in each segment	Share of local top 3
High-end (>500$)	16%	-	4.2%	13.5%	-	9.4%
Mid-range (250-500$)	20.4%	76.5%	44.6%	24.8%	81.9%	58.8%
Low-end (<250$)	63.6%	100%	45.4%	61.7%	100%	48%

Source: Authors-calculated, based on GFK market research data.

In the 2000s, Chinese mobile phones firms primarily concentrated on the low-end segment of the domestic market (Ding and Pan 2014). As for the situation in the 2010s, we only obtained data for a short period from the fourth quarter of 2014 to the third quarter of 2015 (Table 2). We can see significant changes during this period. Even though these may be simply caused by temporary fluctuations, some basic situations still can be confirmed. First, Chinese firms maintained their absolute advantages in the low-end market. Second, they acquired certain shares in the mid-range market; it is

difficult to judge whether these shares will continue to increase from this table, though. Third, some Chinese firms began to enter the high-end segment.

In the 2000s, the value chain of feature phones was highly disintegrated. On the production side, a mobile phone company was usually separated into two processes: the design house and the system integrator. In the 2010s, however, an increasing number of vertically integrated firms, which had the functions of both the design house and the system integrator, emerged. The share of mobile phones developed by vertically integrated firms in Chinese firms' total shipments has increased from less than 30% to nearly 50% between 2010 and 2015[1]. The top four Chinese companies in 2015, Xiaomi, Huawei, OPPO, and VIVO, are all vertically integrated.

On the distribution side, most mobile phone companies relied on independent distributors in 2000s. In the 2010s, however, some leading mobile phone companies began to establish their own distribution channels. During the period between the first quarter of 2014 and the second quarter of 2015, the share of the top six "retail-focused OEMs" (which means that they have built their own sales network) in the Chinese market sharply increased from 26% to 47%[2]. VIVO, for example, established 250,000 outlets (some franchised) in China, which allows the company to reach out even to fourth-tier cities[3].

Humphrey et al. (2017) identified three factors to explain the above structural changes. The first factor is intense competition in the domestic market, which caused many small firms to exit the mobile phone sector while encouraging the remainder to strengthen their technological capabilities. The second factor is the upgraded domestic demand, which forced mobile phone firms to formulate brand strategies and develop differentiated products with more sophisticated functionality and better quality. The third factor is technological changes, which are the most important to the mobile phone

[1] IHS market research data provided by Jiutang Pan.

[2] These data are provided by Jiutang Pan.

[3] Xiaomi, as an exception, focused on its online sales instead of establishing any offline retail outlets. For this purpose, it integrated the user interface (MIUI) and various APPs and smart hardware in-house (through M&A) so that increase the number of online users as much as possible.

sector. These changes include the transition from feature phones to smartphones, evolution of telecommunication technologies from 2G to 3G and then to 4G, and speeding up of the time taken to develop a new technology platform from 24 months to 6 months. All three technological changes, combined with changes in the market, have greatly undermined the modularity of products and the value chain in the mobile phone industry.

3 Information Flows and Upgrading

With the above structural changes as the backdrop, this paper focuses on the mechanism of interaction with technology platform vendors through which mobile-phone firms learn, upgrade, and innovate. Section 3 first studies how knowledge and information are exchanged between these two parties and its consequences.

Table 3 determines the types of firms that take the initiative in product definition in a mobile phone value chain. It is clear that downstream users, whether design houses, vertically integrated firms, or system integrators, have shown the highest shares in initiating product definition. On the contrary, even though they are lead firms, the roles of technology platform vendors in product definition are limited. Only five design houses and three vertically integrated firms acknowledged technology platform vendors as having taken the initiative in product definition. This situation is very different from buyer-driven GVCs, in which lead firms have a fair amount of control over the chain and take the initiative in product definition.

The fact as to whether a lead firm defines a product has a profound influence on the upgrading opportunities for developing countries' firms. The literature has indicated that in buyer-driven GVCs, in which buyers define finished goods, "quasi-hierarchy" ("captive") governance is usually adopted. Under this type of governance, developing countries' firms are more likely to realize product and process upgrading, while functional upgrading by increasing the value-added in design and marketing are more difficult (Humphrey and Schmitz, 2000). This is because these two segments, as the key processes of product definition, are strictly controlled by global buyers. Even though they are willing to share knowledge and information on production and quality control with suppliers, these buyers will be more reluctant to share knowledge and information

on design and marketing so as to avoid making competitors of these suppliers (Schmitz and Knorringa, 2000; Bazan and Navas-Aleman, 2004; Morrisson et al., 2008).

Table 3 Who Takes the Initiative to Define a Product?

Design Houses (PCBA)							
	Design house	Integrator	Technology platform vendor	Design house and integrator	Design house and technology platform vendor	others	Total
	8	1	5	2	5	1	22
Vertically Integrated Firms (Mobile phone)							
	Vertically integrated firms	Technology platform vendor	Vertically integrated firm and technology platform vendor	Others			Total
	17	3	1	2			23
Integrator (Mobile phone)							
	Integrator	Design house	Integrator and Design house	Others			Total
	7	3	1	0			11

Source: Authors' questionnaire survey data.

In the platform-driven value chain, however, the situation is different. As Cusumano (2010, pp.24) indicated, an industry platform "has relatively little value to users without complementary products or service." Therefore, platform vendors have a strong incentive to share technological information that is necessary for designing a finished product (complement) and provide marketing information that helps platform users to explore new markets (Gawer and Cusumano, 2002, p.250). They are also capable of providing such information, as technology platform vendors not only specialize in the development of core technology, but also have sufficient system knowledge to determine the technological trend of the whole industry. The abovementioned structural changes in the market and in technology, which undermined product and value chain

modularity, have greatly strengthened the necessity of information sharing with platform users[4].

Table 4 Information Flows between Mobile Phone Companies and Technology Platform Vendor

	Often	Sometimes	Occasionally	Never	Total
When facing platform-based technological difficulties, do you often ask technical questions for solutions to the baseband IC maker?	38	2	5	0	45
Does the baseband IC maker take the initiative to provide technical information to you?	31	9	4	1	45
Does the baseband IC maker take the initiative to provide market information to you?	23	13	8	1	45
Do you take the initiative to provide feedback regarding market information to the baseband IC maker?	27	13	4	1	45

Source: Authors' questionnaire survey data.

Table 5 Frequency of Communication with Technology Platform Vendors

Total	Almost every day	Several times per week	Several times per month	Several times per year	No communication
45	15	18	9	2	1

Source: Authors' questionnaire survey data.

Table 4 clearly reveals this point. In more than two-third cases, platform vendors often provide technical information to mobile phone firms. They also frequently provide market-related information to more than half of the mobile phone firms. These happen

[4] It must be pointed out that active information sharing does not necessarily mean frequent interaction. By making use of a reference design, a firm can get basic technological information without interacting with the platform vendor. We discuss this point in Section 4.

to be the information that global buyers are unwilling to share with suppliers[5]. At the same time, mobile phone firms are very keen to learn from platform vendors. Most of these firms often ask technical questions for solutions to the baseband IC maker when facing platform-based technological difficulties. They also frequently feedback market information so that reflect consumer demands to the design of baseband IC. Table 5 suggests that the frequency of communication between these two parties is very high. One-third of the firms interact with platform vendors almost every day, and more than two-thirds of all firms interact with vendors at least several times a week. This suggests a clearly explicit coordination within this platform-driven chain[6].

The defining characteristic of information flows can be confirmed by the case of Qualcomm[7]. Before releasing a new platform, Qualcomm closely communicates with customers so as to reflect their requirements on the platform as much as possible. After a platform has been adopted, there are people who are particularly responsible for joint product development. Qualcomm provides regular and emergent support to its customers[8]. It also helps customers in conducting co-marketing, often jointly holding product release conferences or introducing overseas carriers to customers. In this way, Qualcomm has broadly exchanged technological and marketing information with customers.

It must be stressed that this situation on information flows was entirely different in the 2000s. Wang and Lin (2008, p.178) investigated 266 firms in the ICT industry in

[5] As system integrators do not transact directly with platform vendors, Table 4 and the following tables (except for Table 9) only include information on design houses and vertically integrated firms.

[6] In practice, it is difficult to ask firms to precisely distinguish between the communication frequency of technology and market-related information; therefore, we set up a question in Table 4 to measure the whole communication frequency.

[7] Author's interview with a product manager in Qualcomm (Shenzhen) in Dec. 2016.

[8] We also checked this point from the mobile phone company side. For example, the person in charge of the software development department of VIVO confirmed that "if we encountered emergencies, Qualcomm would mobilize its global resources to support us, including 30–40 engineers from Santiago and Hyderabad."

Shenzhen and Dongguan[9]. According to this study, "only 12 percent of enterprises considered that R&D cooperation was important and a mere 3 percent considered it very important while as many as 79 percent reported that they had never engaged in such cooperation with other local enterprises." In line with this statement, 80 percent of the firms did not exchange any R&D-related information or ideas with firms in the same region. This comparison implores us to consider an important question: If technology platform vendors are more willing to share information with their customers, then why was the situation in the 2000s so different? We try to provide answers in the following sections.

Table 6 Communication Frequency and Fields in Which a Firm Made the Most Significant Progress

	Hardware function	Software function	Body design	Cost control	Sales method	Brand image	After service	Total
Almost every day	2	5	5	1	0	2	0	15
Several times per week	2	6	5	0	1	2	1	17
Several times per month	3	0	0	4	0	0	0	7
Several times per year	0	0	0	2	0	0	0	2
No communications	0	1	0	0	0	0	0	1
Total	7	12	10	7	1	4	1	42
Pearson chi2(24) =34.9737 Pr = 0.069								
Fisher's exact = 0.013								

Source: Authors' questionnaire survey data.

Table 6 suggests that frequent communication with platform vendors is useful for mobile phone companies to improve software function, brand image, and body design,

[9] It is not clear how many mobile phone firms were included in this survey. However, the paper suggests that mobile phones is a major sector of ICT industry in Shenzhen and Donguan, and it selected 13 mobile phone firms to conduct in-depth interviews that suggest a poor situation with respect to research cooperation.

which can be regarded as product (software function) and functional upgrading (brand image and body design), respectively (Humphrey and Schmitz, 2000).

We have confirmed the causalities between intense communication and upgrading in practice. First, smartphone software is complex and requires continuous updating of both operating system software and application software. In this process, large numbers of problems are generated in the software and in the interaction between software and hardware. These problems require joint problem solving between the platform vendor and the mobile phone company using the platform in a finished product. Second, to establish a strong brand image, a mobile phone company has to have clarity regarding the key selling points for each new model, and this requires intensive communication with technology platform vendors so that there is an accurate understanding of the technology roadmap (Humphrey et al., 2017). Third, the ultra-thin body is a characteristic feature of branded smartphones that greatly increases electric current density and, therefore, raises the issue of radiation. To overcome these problems, mobile phone companies must create their own capabilities for hardware and reliability design. They also need to have deeper system knowledge, which is generally acquired from interaction with platform vendors.

Table 7 Communication Frequency of the Platform-related Technological Information When Sharing the Same Type of Technology Platform

	often	sometimes	Occasionally	Never	Total
Total	10	23	11	1	45

Source: Authors' questionnaire survey data.

Table 8 Would it be Difficult to Communicate with Peer Companies Without Sharing the Same Type of Technology Platform?

	Very difficult	Comparatively difficult	Ordinary	Comparatively less difficult	No problem	Total
Total	1	26	12	5	1	45

Source: Author's questionnaire survey data.

Another characteristic feature of the platform-driven value chain is that sharing the same type of platforms can stimulate horizontal information flows between the

platforms' users. As Table 7 suggests, about two-thirds of mobile phone companies exchange information with their peers even though it is not as frequent as it is with platform vendors. More than half of these firms acknowledged the difficulty or comparative difficulty of achieving this without sharing the same type of platform. This is because the technology platform, as the core part of a product system, provides a common knowledge foundation that enables mobile phone firms to share knowledge and information with each other. As the product circle of the baseband IC has been greatly shortened, an increasing number of software problems have arisen. These complex problems cannot be only resolved through collaboration with platform vendors; therefore, platform users have to jointly resolve these problems.

4 Platform Strategies and Innovation

Section 4 discusses the relationship between platforms and innovation from the perspective of firm capabilities and strategies. Even though platform vendors are more willing to share technology and market-related information with customers, the effects of learning and innovation differ greatly between platforms as the capabilities and related strategies of platform vendors are different. Section 4 focuses on a comparison between Qualcomm and MTK.

Qualcomm, as the developer of the world's first smartphone and the largest owner of 3G and 4G technology patents, entered the smartphone baseband IC market soon after Apple released the iPhone. In the 3G market in China, Qualcomm occupied a dominant position in 2012 but was soon overtaken by MTK in the course of one year. In the 4G market, from 2014, MTK spent two years and managed to catch up with Qualcomm in terms of shipment volume. However, Qualcomm's position remains unwavering in the middle- and high-end markets. Of the top ten smartphone makers in the Chinese market in 2015, eight are Chinese makers. Among these, five makers primarily adopt Qualcomm's platforms: Xiaomi (No.1, 70%), OPPO (No.4, 70%), VIVO (No.5, 60%), Coolpad (No.7, 60%), and ZTE (No. 10, 50%)[10].

Compared with Qualcomm, MTK is a technological follower in the baseband IC market. MTK was no longer able to obtain the dominant position when 4G was introduced. This

[10] These data are estimated by Shenzhen Huaqiang Electronics Industry Research Institute.

is because, being different from the mature technologies of 2G and3G, which had been developed for more than 15 years, 4G technology was comparatively new. MTK did not have sufficient time to absorb these technologies, and the shortened product life cycle of a new chipset accelerated this trend.

The technological capability gap between Qualcomm and MTK has greatly affected the platform strategies of these two companies. Qualcomm adopted a strategy enabling platform users to conduct product differentiation at a deep level, whereas MTK, with limited technological capabilities, had to continue its turnkey solutions, which was intended to lower technological barriers and enable more underserved mobile phone firms to enter the market. In concrete terms, Qualcomm opened about 80% of the source codes of its hardware drivers to mobile phone companies, whereas MTK merely opened 20% [11]. Moreover, Qualcomm allowed platform users to adjust some hardware specifications such as radio frequency specifications on the platform, whereas MTK users were not allowed to do likewise. Indeed, based on Qualcomm platforms, three of the top four Chinese smartphone makers, OPPO, VIVO, and Xiaomi, have succeeded in designing one or more of the world's first new functionalities in their new smartphone models (Humphrey et al., 2017).

Table 9 Problems of Technology Platforms: Making Product Differentiation Difficult

	Very important	Comparatively important	Ordinary	Comparatively less important	Total
MTK	5	15	21	1	42
Qualcomm	1	1	1	3	6
Total	6	16	22	4	48

Fisher's exact = 0.004

Source: Authors' questionnaire survey data.

Note: This table includes data from design houses, vertically integrated firms, and system integrators. Even though system integrators do not trade directly with platform vendors, the degree of differentiation of their products is greatly affected by platform strategy.

This difference is clearly reflected in Table 9. With regard to the question as to whether the platform made product differentiation difficult, which was a serious problem in the

[11] Author's interview with an engineer in a design house (Jan. 2017) who has been engaged in the design of mobile phones based on both the Qualcomm and MTK platforms.

2000s, the answers of MTK users (the share of the MTK platform in total is 50% or more, which is the same as shown below) and Qualcomm users are statistically different. The share of MTK users who think that the platform made product differentiation more difficult is significantly higher than the share of Qualcomm users who think so.

The second difference between the platform strategies of Qualcomm and MTK concerns their ways of interacting with their users. Qualcomm is more used to jointly resolving problems with customers, whereas MTK is more used to providing codified information through the reference design. MTK's reference design covers most mature technologies for software (such as the user interface) and hardware (such as the fast-charging function), integrating various solutions for possible problems into the reference design[12].

Table 10 Does the Baseband IC Maker Actively Provide Technical Information to Your Company?

	Often	Sometimes	Occasionally	Never	Total
MTK	19	8	4	1	32
Qualcomm	6	0	0	0	6

Fisher's exact = 0.401

Source: Authors' questionnaire survey data.

This difference can be confirmed by Table 10. All six Qualcomm users acknowledged that Qualcomm often actively provides technological information to them. On the contrary, among 32 MTK users, only 19 firms chose "often." This is because MTK can standardize most possible problems ex ante by providing the reference design. By making use of this reference design, mobile phone companies can develop a phone without intensively communicating with MTK; they could particularly do so in the 2000s. However, as Humphrey et al. (2017) stressed, due to technological changes in

[12] After entering Chinese market, through learning from MTK, Qualcomm soon began to provide turnkey solutions for their low-end platforms with a reference design known as "Qualcomm Reference Design" (QRD). However, as a technological leader, Qualcomm was more used to jointly solving problems with customers, QRD was not as easy to use as MTK's reference design.

the 2010s, hardware (i.e., radio frequency) and software (i.e., "bugs") became increasingly complex, thus making it increasingly difficult for MTK to provide a reference design. This is the reason why there are still 19 users who acknowledge that MTK "often" provides technological information to them.

Indeed, Qualcomm often sends a team to these customers to help them resolve problems. It also accepts the research teams of some Chinese companies to visit its headquarters for problem solving. In these situations, engineers in Chinese companies can conduct face-to-face communication with Qualcomm's core engineers and learn intensively from them (Humphrey et al., 2017)[13]. This is very important for the formation of technological capabilities. As Ernst and Kim (2002, p.1425) argued, "in most cases, the acquisition of explicit knowledge alone is not sufficient for the local suppliers to assimilate and use it in production, as the translation of explicit knowledge into actual operations requires a significant amount of tacit knowledge." Compared with Qualcomm users, most MTK users are only able to acquire codified knowledge, which, to a large extent, limits their learning opportunities[14].

As Morrison, Pietrobelli, and Rabellotti (2008, p.50) indicated, "although external sources of knowledge are essential, the creation and improvement of technological capabilities require some previous accumulation of skills in the firm, coupled with substantial firm-level efforts." Indeed, in addition to learning from platform vendors, Chinese mobile phone firms themselves have continuously invested in the formation of technological capabilities. They not only hire engineers from international mobile phone companies, particularly those from poorly performing companies (Motorola and Nokia), but have also begun to foster their own engineers. VIVO, for example, expanded the number of software development engineers from 37 to 700 during 2011–2015.

[13] It was confirmed by a manager in Qualcomm (Shenzhen) that Huawei and VIVO are particularly good at learning through collaboration (author's interview conducted in Dec. 2016).

[14] Yasumoto and Shiu (2007, p.66) pointed out this problem of the MTK platform in the feature phone era. Smartphones partly broke down value chain modularity of MTK platform, but the learning opportunities remain limited compared with Qualcomm as long as a turnkey solution is adopted.

Finally, it must be stressed that there are certain similarities between these two major platforms. First, from the perspective of design architecture, both the MTK and Qualcomm platforms are modular. The MTK platform has been fully modularized in order for the adoption of the reference design. At the same time, Qualcomm's platform is modular as well. On the basis of consumer needs and platform users' requirements, Qualcomm usually designs a new platform with various strong functionalities first. Subsequently, mobile phone companies ask Qualcomm to provide the source codes for them to create a high degree of product differentiation. Until now, however, no Chinese firm has been able to customize the Qualcomm platform and, thus, thoroughly break down the product's modularity.

Second, both Qualcomm and MTK regularly adjust the extent of their support in terms of the technological and marketing capabilities of customers. Qualcomm not only sells chipsets to customers but also collects license fees from them, which is determined by the retail price of a mobile phone[15]. To gain more fees, Qualcomm has a strong incentive to always choose the most competitive customers that create the highest value-added in the market. At the same time, as consumers increasingly tend to choose a mobile phone in terms of the brand name of the baseband IC, mobile phone companies flexibly change platform providers in terms of consumers' preference as well.

5 Discussion and Conclusion

As discussed in this paper, the feature of information flows and related institutional arrangements in the mobile phone industry driven by technology platforms are clearly different from traditional GVCs driven by global buyers. This new governance pattern shares several characteristic features with the existing pattern but is essentially different.

The product architecture of mobile phones is typically modular. Nevertheless, governance within this value chain is not modular. The modular governance feature can be summarized as customization with little explicit coordination (Gereffi et al., 2005, pp.83, 86). What we observed in the mobile phone industry, however, is, conversely, explicit coordination without customization. Up until now, no Chinese firm has been

[15] Qualcomm charges several percent of the retail price from customers. The information on Qualcomm's license fee was told by Professor Mariko Watanabe at Gakushuin University.

able to customize the baseband chipset, whereas rich flows of technological and marketing information occur, which implies explicit coordination between platform vendors and mobile phone firms.

In addition, it is not relational. As Gereffi et al. (2005, p.84) suggested, in relational networks, "we see complex interactions between buyers and sellers, which often creates mutual dependence and high levels of asset specificity." In the platform-driven chain that was discussed in this paper, interdependency is considerably high, which is in line with the definition of relational governance, even though we cannot observe asset specificity in transactions with technology platform vendors. This is because platform vendors wish to sell their products to customers as much as possible, unless a single firm has sufficient capabilities in design and marketing, and ensure that the quantity of their orders is large. In reality, only Apple maintains relational governance with the platform vendor.

The new governance appears to be market governance; however, it does not completely conform to market governance in the strict sense. As Gereffi et al. (2005) stated, "market linkages do not have to be completely transitory, as is typical of spot markets; they can persist over time, with repeat transactions. The essential point is that the costs of switching to new partners are low for both parties." The relations between technology platform vendors and their users are greatly in line with this definition. MTK fully modularized its platform with its adoption of the reference design. Qualcomm adjusts its support to customers in terms of retail prices; however, there remains a certain difference. Classical market exchange only generates flows of price information (Gereffi 2005, p.86). In the mobile phone industry, however, information on the technology and the market has been actively exchanged.

The term "supportive value chain" partially captures the important features of this new type of governance. As Marukawa (2014, p.58) suggested, "in such a chain, suppliers not only provide codified information but also a wide range of other information and engineering support, which differentiates it from modular value chains." This study further argues that "in the case of supportive value chains, due to the lack of technological capability at the core firm, there will be a lot of black boxes in its suppliers' processes, and the core firm will often fear that it will suffer from artificially high prices and low quality" (Marukawa, 2014, pp.66–67). However, Marukawa (2014)

did not show how Chinese firms can upgrade by overcoming this black box problem and, thus, underestimated the role of the platform in facilitating innovation and the potential for growth of each platforms user.

Compared with global buyers, one advantage of this new governance pattern is that the platform vendor, as the global supplier, is more willing to share information on technology and the market with its customers. This is because the technology platform alone does not create value. It becomes valuable only when the platform is broadly adopted by downstream users. For this purpose, platform vendors have strong incentives to share information and, thereby, help their users to conduct complementary innovation and explore new markets. The structural changes in markets and technology, which undermine product and value chain modularity, have greatly strengthened the necessity of information sharing.

Our questionnaire data and fieldwork information clearly corroborate this argument. There are rich information flows between platform vendors and users. Through frequent interaction with platforms, China's mobile phone firms have made significant progress in the key fields of mobile phone development, including software function, body design, and brand image. These facts suggest that, in a departure from global buyer-driven value chains, these firms are more likely to realize product and functional upgrading under the new governance structure.

With regard to the second research question, this paper suggested that the question as to whether a technology platform and its modular architecture could facilitate innovation depends on two factors: the platform's technological capabilities and the platform user's technological capabilities. By combining these two factors, we have observed two strategies in the mobile phone industry.

The first strategy is reflected in MTK's turnkey solution, which is adopted when both the platform's and users' capabilities are comparatively poor. As a technological follower, MTK is not able to provide a platform that supports innovation as powerfully as Qualcomm can. Moreover, a disadvantage for MTK is that it does not have many innovation resources that can be shared with platform users. MTK, thus, has not opened numerous hardware driver source codes to customers and has not allowed them to adjust hardware specifications until now. Instead, since the 2000s, it has continued to provide

turnkey solutions to underserved customers. In the feature phone era, MTK's turnkey solution was very easy to use, enabling mobile phone companies to develop products without close interaction with the platform vendor. In the case of smartphones, however, increasingly complex technologies have greatly undermined product and value chain modularity. Consequently, even MTK's customers have to interact more frequently with the platform vendor even though the frequency is comparatively lower than that in the case of Qualcomm.

The second strategy is adopted by Qualcomm. When a platform's technological capabilities are strong and platform users have accumulated technological capabilities to some extent, then the platform facilitates innovation. The background for the adoption of this strategy is the structural changes in the market and the technology situation in China. After 2010, the maturity of the Chinese consumers came to the fore, with the consumers requiring more differentiated products with better brand image. On the technology side, the technological complexities of smartphones and 4G have eliminated a large number of firms with limited technological capabilities. Qualcomm, as the leading company in 3G and 4G technologies, subsequently opened the source codes of a large part of its hardware drivers, enabling mobile phone companies to develop highly differentiated products. Consequently, several top companies have succeeded in developing never-before-seen functionalities in their smartphones by closely collaborating with Qualcomm.

The collaborations with Qualcomm have generated two paradoxical phenomena. First, innovations based on the Qualcomm platform have become increasingly systemic innovations, "the innovation involves changes that span stages of production or even industries" (Robertson and Langlois, 1995, p.553). In general, a vertically integrated firm is more suitable for conducting systemic innovation (Langlois and Robertson, 1992, pp.302, 311). What happens in the smartphone sector, however, is that systemic innovation is jointly conducted by two separate parties: the platform vendor and the mobile phone company.

Second, as Baldwin and von Hippel (2011, p.7) indicated, "modularity is important for collaboration in design because separate modules can be worked on independently and in parallel, without intense ongoing communication across modules." The innovation that is jointly conducted by mobile phone companies and Qualcomm is clearly open

collaborative innovation under a modular architecture. However, we have observed frequent, even face-to-face, communication between these two parties. In this sense, Qualcomm paradoxically facilitated innovation by increasing, rather than reducing, communication costs.

All the unique governance patterns and paradoxical phenomena in the innovation process must be explained from a dynamic perspective. Given their limited technological capabilities, these mobile phone companies cannot completely break down the platform's modularity, making it difficult to apply to any existing framework of governance, which is based on the assumption of a powerful buyer, to explain the platform-driven chain. Similarly, it is difficult to develop their own baseband IC in order to integrate the chain, which, thus, generates a paradox—systemic innovation without vertically integrated firms. Furthermore, compared with powerful buyers, underserved Chinese firms require more support and need to learn more from platform vendors, which increased communication cost associated with open collaborative innovation. From a dynamic perspective, however, we believe that the governance and the innovation process will return to normal as long as Chinese firms continue to accumulate capabilities and mature.

References

Bazan, L. and Navas-Aleman, L. 2004. The underground revolution in the Sinos Valley: a comparison of upgrading in global and national value chains, in: H. Schmitz

(ed.) *Local Enterprises in the Global Economy*, Cheltenham: Edward Elgar, pp. 110–139.

Baldwin, Carliss and C. Jason Woodard. 2009. The architecture of platforms: a unified view. in Gawer, Annabelle. ed. 2009, Cheltenham and Northampton: Edward Elgar Publishing, Limited and Inc., pp.19-44.

Baldwin, Carliss, and Eric Von Hippel. 2011. Modeling a paradigm shift: From producer innovation to user and open collaborative innovation. *Organization Science*. Vol.22, No.6, pp.1399-1417.

Cusmano, Michael A. 2010. *Staying Power: Six Enduring Principles For Managing Strategy & Innovation in an Uncertain World*. New York: Oxford University Press

Ding, Ke. 2013. Platforms and firm capabilities: a study of emerging global value chains IDE Discussion Paper, No.432

------ . 2014. The specialised market system: the market exploration of small businesses. In: Watanabe, Mariko. (ed.) *The Disintegration of Production: Firm Strategy and Industrial Development in China*. Cheltenham: Edward Elgar, pp. 149-178.

Ding, Ke and Jiutang Pan. 2014. The shanzhai mobile phone: platforms and small business dynamics in Watanabe, Mariko (ed.) 2014, pp.101-126.

Ernst, Dieter and Linsu Kim. 2002. Global production networks, knowledge diffusion, and local capability formation. *Research Policy*, Vol.31 No.8: pp.1417-1429.

Fujita, Mai. 2013. Exploring the sources of China's challenge to Japan: Models of industrial organisation in the motorcycle industry. IDE Discussion Paper, No.419.

Gawer, Annabelle ed. 2009. *Platforms, Markets and Innovation*. Cheltenham and Northampton: Edward Elgar Publishing, Limited and Inc.

Gawer, Annabelle. 2014. Bridging differing perspectives on technological platforms: Toward an integrative framework *Research Policy*, Vol.43, pp.1239-1249.

Gawer, Annabelle, and Michael, A. Cusumano. 2002. *Platform Leadership : How Intel, Microsoft, and Cisco Drive Industry Innovation*. Boston: Harvard Business School Publishing.

Ge, Dongsheng and Takahiro Fujimoto. 2004. Quasi-open product architecture and technological lock-in: an exploratory study on the Chinese motorcycle industry. *Annals of Business Administrative Science*, Vol.3, No.2: pp.15-24.

Gereffi, Gary. 1999. International trade and industrial upgrading in the apparel commodity chain. *Journal of International Economics*, Vol. 48, pp.37–70.

Gereffi, Gary, John Humphrey and Timothy Sturgeon. 2005. The governance of global value chains. *Review of International Political Economy*, Vol.12, pp.78-104.

Humphrey, John, Ke Ding, Mai Fujita, Shiro Hioki, and Koichiro Kimura. 2017. Platforms, innovation and the evolution of industry structures in China. Mimeo.

Humphrey, John and Hubert Schmitz. 2000. Governance and upgrading: Linking industrial cluster and global value chain research. IDS Working Paper 120.

Langlois, Richard N. and Paul L. Robertson. 1992. Networks and innovation in a modular system: Lessons from the microcomputer and stereo component industries. *Research Policy*, Vol. 21, No.4, pp.297-313.

Marukawa, Tomoo. 2014. The "make or buy" decision and supply-chain governance. In Watanabe, Mariko, (ed.) 2014, pp.51-73

Morrison, Andrea , Carlo Pietrobelli and Roberta Rabellotti .2008. Global value chains and technological capabilities: A framework to study learning and innovation in developing countries, *Oxford Development Studies*, Vol.36, No.1, pp.39-58

Ohara, Moriki. 2006. *Inter Firm Relations Under Late Industrialization in China - The Supplier System in the Motorcycle Industry*. Tokyo: IDE-JETRO.

Rabellotti, Roberta. 2011. Global value chains meet innovation systems: Are there learning opportunities for developing countries? *World Development*, Vol. 39, No. 7, pp. 1261–1269

Schmitz, Hubert and Peter Knorringa. 2000. Learning from global buyers, Journal of Development Studies, Vol.37, pp. 177–205.

Steinfeld, Edwards S. 2004. Chinas shallow integration: networked production and the new challenges for late industrialization. *World Development*, Vol. 32, No. 11, pp. 1971–1987, 2004

Robertson, Paul L., and Richard N. Langlois. 1995. Innovation, networks, and vertical integration. *Research Policy*, Vol.24, No.4, pp. 543-562.

Tatsumoto, Hirofumi, Koichi Ogawa and Takahiro Fujimoto. 2009. The effect of technological platforms on the international division of labor: A case study of Intel's platform business in the PC industry in Gawer, Annabelle. (ed.) 2009, pp.345-369.

Wang, Cassandra C., and George CS Lin. 2008. The growth and spatial distribution of China's ICT industry: new geography of clustering and innovation. *Issues & Studies*, Vol.44, No.2, pp.145-192.

Watanabe, Mariko, ed. 2014. *The Disintegration of Production*. Cheltenham and Northampton: Edward Elgar Publishing.

Yasumoto, Masanori and Shiu, Jingming. 2007. An investigation into collaborative novel technology adoption in vertical disintegration: interfirm development processes for system integration in the Japanese, Taiwanese and Chinese mobile phone handset industries. *Annals of Business Administrative Science*, Vol.6, pp.35-70.

Zhu, Sheng and Yongjiang Shi. 2010. Shanzhai manufacturing – An alternative innovation phenomenon in China. *Journal of Science and Technology Policy in China*, Vol.1, No.1, pp.29-49.

Acknowledgement: This work was supported by JSPS KAKENHI Grant Number 24330072.