Managing a Supply-chain based Two-sided Market

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Abstract:

This paper develops a theoretical model of positive monopolist who organizes a two-sided market in the IP license industry. This model indicates, as a platform owner, they faced a new phenomenon that developers' side acts as a supply chain of firms instead of single firm. They have to deal with network effect between developers and customers, but also within the supply chain. We have developed models by adopting license fee and royalty fee to facilitate such network effects among supply chain and customers in the platform ecosystem. This article specifically enriches the two-sided platform by introducing supply-chain based side. Some practical implications also provide for platform owners who want to set up their platform ecosystem by licensing their IPs. This result could also be able to explain why Intel adopted a close supply chain in the PC industry while ARM adopted an open platform model in the mobile industry as a positive monopolist.

Keywords:

Two-sided market, Network effects, Supply chain based platform, IP license model, Mobile Computing Industry, Positive Monopoly

1 Introduction

The platform based business has been popular during last few years along with the development of new technologies infrastructure, for example, the apps online store, the search engine market, the e-commerce market as well as many video games(Zhu and Iansiti 2012). All of these platform-based business are regarded as the two-sided market where the supplier and customers have positive or negative network effect to each other and then trigger the growth of platform business(Rochet and Tirole 2003, 2006).

The previous studies only addressed a very simple model, which has one side supplier and other side customer(Eisenmann et al. 2006, Rochet and Tirole 2006, Hagiu 2009, Cheng and Tang 2010). However, recently some case has experience a more complicated situation over that platform-based market. The partners in different sides are not fragmented, but works and connect as a supply chain. For example, ARM has deal with a supply-chain based two-sided market. This study explores the story of ARM, a semiconductor intellectual property (IP) supplier, whose success is due to its technological platform and business ecosystem. IP is a reusable unit of integrated circuit (IC or chip) design layout that performs some specific function and constitutes the fundamental architecture of chips used in digital products (Kaeslin, 2014). ARM's IPs are licensed to third-party IC design firms to accelerate the design and lower the cost. Because of this, ARM functions as a technological platform provider and positions itself in the upstream of the semiconductor supply chain. ARM started as a small company with only 12 engineers in Cambridge, U.K., in the early 1990s. Today, it is the world's leading semiconductor IP supplier. Its IP architecture firmly dominates the

mobile phone microchip market (Burt, 2014). Thanks to its excellent business ecosystem nurturing strategy (ARM, 2014), it currently has more than 1000 partners in its community.

In its platform, they not only dealt with the direct partners, but also support a supply-chain based group of partners. Those partners are all connected along the value chain and share the value proposition. As a result, this case cannot be easily simplified the supplier side just one unit, instead it is more a supply-chain based or more dynamic view as an ecosystem-based connected partners. This is so called a business ecosystem. The business ecosystem is an economic community, which composes of inter-dependent organizations, who co-evolve with each other and share the fate(Moore 1993, Adner and Kapoor 2010, Rong et al. 2015). This concept highlights the in-direct partners might contribute to the ecosystem platform and create the future business opportunities. So this concept expanded previous two-sided platform, into a more expanded scope namely as two-sided ecosystem.

Following this logic, we have deeply analyzed the ARM case: How ARM use this business model build up a two-sided ecosystem/market composing of supply network as well as other indirect ecosystem partners. ARM's unique business model is about its license business model. As a result, we try to explore how ARM build up the ecosystem by designing a well-balanced model of loyalty fee and license fee.

This case will challenge the existing model about the network effect between single group of suppliers and customers. Alternatively, the model is to study the network effects between the supply chain and customers or indirect partners within the platform ecosystem. This model will use the combination model of loyalty and license fee as the pricing strategy to achieve

the following objectives: stimulate the innovation rate by providing the well-accepted package of license model; acquire the enough profit from this model to meet the further expansion for the technology platform owner; profit maximization of this two-sided market and its business ecosystem.

In order to comprehensively under this new model, we also compare the different business model between ARM and Intel. Currently, Intel dominated the PC industry while ARM dominated the mobile industry. We also find that Intel has adopted a traditional monopoly strategy and conduct a close supply chain model while ARM adopted a supply-chain based open platform model and get the benefit from strong network effects.

The following parts of this paper are structured as follows: the second party is literature review which covers the two-sided market, supply-network based two-sided market and pricing strategy. The third part is about case study. The fourth party is to develop the theoretical model on the supply-chain based two-sided market. The fifth part will be discussion on how it contributes to the theory and practical implication. The final party will address the future research.

2 Literature review

2.1 Two-sided market

The concept of two-sided market has been introduced to describe the network effects in a platform based industry (Varian and Shapiro 1999, Rochet and Tirole 2003, 2006, Hagiu and Ha\laburda 2014). For example, the apple's online apps store, the more apps available, the more customers would like to subscribe on this platform. Then more customers on apps'

platform, then more developers would to develop apps. The network effects also take place in many other industries, such as e-business, game console industry, card payment (Rochet and Tirole 2006, Zhu and Iansiti 2012) and some emerging new industries such as Uber rideshare and Airbnb room booking industries.

There are roughly two ways of network effects. One is direct network effect, the other is indirect efforts. The direct effect takes place within the same group, for example, the customers on the apps platform would like to share with each other the use experience and they will each other generate the network effects (Hagiu 2009) or social bandwagon effects (Abrahamson and Rosenkopf 1993, Secchi 2009). The indirect network effects take place between different sides on that platform(Clements and Ohashi 2005, Stremersch et al. 2007), for example, the indirect network effects between apps developers and customers.

There are many studies over network effects and its determinants(Turrini et al. 2010). Some scholars mentioned the product quality and price are the key determinants of network effects (Basu et al. 2003). Then, other scholars found the network itself and its structure will determine strong network effects, especially strong social tie (Suarez 2005) and centralized network structure (Provan and Milward 1995, Turrini et al. 2010). Besides, other scholars also addressed some network resource such complementary assets (Tanriverdi and Lee 2008) , network context (Provan and Milward 2001) and conducting behavior such as timing of entry (Schilling 2002) will impact on network effects(Afuah 2013)

2.2 Supply-network based two-sided market

However the determinants to determine the degree of network effects are still on debate, even many scholars test it in the same industry, they did not get the consistent results (Ohashi 2003, Rysman 2004, Stremersch et al. 2007). Besides, they also argue on which side to nurture first so as to build up a two-sided market. Recently, they come to a preliminary conclusion that it was better to nurture the 'chicken/supply' side rather than the 'egg/customer' side (Stremersch et al. 2007).

In previous studies, the supply side is normally a strategy group composing of same type of firms. However, the studies did not explore a supply-chain based side. In that platform side, there are different types of firms connecting each other and formulate different supply chain system and transform incomplete goods to final ones. All of those types of firms have connected with the platform as well. In this situation, the platform owner will not only deal with the traditional direct and indirect networks but also needs to facilitate value creation and appropriation of whole supply chain.

2.3 Pricing strategy and IP license model

In two-sided market, the key thing is how to govern different sides by developing an accepted pricing model (Hagiu 2009, Rysman 2009). Taking newspaper as example, the customer/reader side is subsidized by the newspaper platform, while the newspaper platform will charge the advertisers side. Then, the advertisers are more willing to invest when the reader demand increase(Kaiser and Wright 2006). In summary, the pricing structure in this industry is charging supply/advertiser side but subsidized the reader/customer side.

Such pricing structure is also consistent with Google platform. Google provided all free service such as search engine, gmail, gtalk, google map and so on, but charged the advertiser on its search engine. However, there are also some opposite cases. Taking Apple platform as an example, Apple invested some online platform as iOS, however, they charge almost every side, such as customers for the devices, as well as the apps developers.

In some high-technology industry, IP license business model gains its popularity since it decrease the R&D cost and speed up the industry innovation rate (Garnsey et al. 2008). Taking ARM as an example, they produced IPs which are the fundamental architecture for mobile chips with the basic functions. ARM's IPs work as a technology based two-sided platform, based which, those IC design companies and OEM will develop their products. So far there are around 1000 partners on ARM's two-sided market. Thus those firms formulated the supply chain.

ARM will conduct several key strategies to promote its IP platform.

First strategy-Ecosystem strategy:

Since ARM was small at early stage of 1990s and positioned at the upstream of mobile supply chain. Thus, ARM hard to persuade direct partners such as Texas Instrument (TI) to adopt its IP. However, TI rejected ARM's offer in early 1990s since ARM was a small firm without credit about its IPs. This means, it was hard to run a platform-based business model if the company do not have the successful cases. Then, luckily enough, ARM persuaded Nokia through social network ties to help. Nokia, positioned at downstream of mobile supply chain, who was not the direct partners of ARM and persuaded TI to adopt ARM's IP since TI was

Nokia's supplier at that time. Nokia used its bargain power and forced TI. From this case, ARM significantly learned the power of ecosystem, in another word, indirect partners. Following this logic, ARM started to build up a platform based ecosystem, where direct partners or in-direct partners all get supports from ARM. ARM organized them to have a strong network effects, even though some of the network effects did not take place in ARM's platform.

Second strategy- subsidized leader partners:

It was well accepted to have a joint ownership to promote certain IPs (Hart and Moore 1990, Maskin and Tirole 1999). Because, many cases of the ex-post negotiation will stimulate the joint ownership of IPs (Maskin and Tirole 1999). However, in ARM's case, the story was very different. ARM subsidized the leader partners instead. ARM will not required its partners to have shares of its new IPs. Instead they developed their IPs one generation by generation and will find and subsidize some leader partners (chip designer such as TI, Qualcomm, Freescale) to co-design the IP. ARM gained feedback from leader partners and obtained licensee and royalty fee, while leader partners could speed up their chips design by firstly adopting the new technologies of chip IPs. In general, ARM subsidized leader partner significantly by involving four teams working with leader partners, such as marketing team, design team, architecture team and modeling team. All of those teams will facilitate leader partners to speed up the design and process to the market. There was no joint-ownership for such IPs. ARM only charged the IP license fee and royalty fee by numbers of final goods shipment.

Third strategy- a novel model of two-sided market

In 2014, the ARM occupied 98% of worldwide smartphone chip industry, acting as a monopolist. However, most of the IC design firms were willing to adopt its IPs and did not regarded ARM as a greedy monopolist. ARM acted as the virtual R&D center for those leading IC design firms and would charge only very few on license and royalty fee. ARM's revenue was only around 795.2 million GBP in 2014[1], which is rather a small amount of total industry revenue. ARM almost acted as a social enterprise and created a two-sided platform with strong network effects and enabled the final goods diversity. ARM did very well to keep balance of value creation and value appropriation. Besides, ARM also categorized those ecosystem community into three groups: the silicon partners, which have direct economic value linkage with ARM; the design support partners, who facilitate those silicon partners to better design ARM based chips; the software, training and consortia partners, who are far away from the ARM IPs, but help trigger the demand of ARM IPs (for example, training companies, consortia platform, research universities, who did not directly license from IP but they provide context book and train the engineers who understand ARM technology). In summary, ARM not only deal with those traditional sides on the two-sided markets, but also support those partners far away from the platform, who maybe based on other two-sided platforms. ARM conducted a more cross-platform network effects, which could be regarded as a two-sided ecosystem.

[1] http://markets.ft.com/research/Markets/Tearsheets/Forecasts?s=ARM:LSE

3 Case study

We have chosen the most successful cases in smartphone chip industry- ARM as Figure 1. ARM has dominated the smartphone chips by 98% (www.arm.com) so far, which is definitely a strong monopoly in this industry. However, this company is quite popular and vary rare to response to law suit. Seen from Figure1, ARM is positioning at the upstream of mobile industry which is far from the final goods. After an in-depth case study, we have known the way ARM built up its ecosystem and what was the license model to facilitate its growth. ARM has realized the importance of ecosystem around its IP platform. Hence, ARM not only provided the support to its direct partners but also its in-direct partners. As a result, around ARM's platform, there are around more than 1000 partners so far.

Insert figure 1 here

Then we summarized the framework as the following figure 2. The developers are the roles such as design firms or manufacturing firms or a supply chain of design, manufacturing and other firms, while the customers are the final goods customers. As a result, the platform owner not only deals with just one kind of developer, instead they deal with supply-chain based developers' groups. The platform owner needs to carefully consider their business model to facilitate more complicated network effects, within the supply-chain based developers as well as between developers and customers.

Insert figure 2 here

By learning from the Case of ARM, we have proposed a model that a firm owning an industrial platform with certain external demand. Based on this platform, there will be a supply chain of companies and the focal firm needs to support them. Such supporting activities will facilitate the network effects between the supply chain and customers. On the one side, there are more supplies of diversified chips which will result on more demand. On the other side, there are more various demands which generate more supply of diversified chips. This is because the mobile computing industry is hugely different from PC industry: firstly, the customers have heterogeneous demand for various products such as smartphone, tablet and netbook than that in PC industry; secondly, since the customers have huge demand of various products, those products with heterogeneity cannot substitute each other very much. On contrast, they each will stimulate more demand each other, for example, if you have iPhone, it will increase the possibility of your purchase for iPad. On contrast, in PC industry, each of us might only need one PC enough.

The reason we can use the platform concept to represent the relationship of supply chain partners is all of them in our case rely on the same common technology, despite their various positions along the supply chain. The owner of common technology could be regarded as a platform. In terms of ARM, they developed the common technology as IPs for chips. Those firms will rely on ARM's IP and then design and manufacture new generation of chips. From

ARM's perspective, ARM also relies on those partners' new technologies, products and production process along the supply chain partners to enlarge its platform scope. This matching relationship is also mentioned in technological innovation theories such as common technology and complementary technology. The platform theory has provided a great framework to analyze such phenomenon.

4 Theoretical model

We suppose the platform owner has some basic IPs, base on which new products might be developed by its partners. The platform owner charges the partners, by two means, an upfront license fee, denoted by L and a royalty fee denoted by r.

There are two types of firms: A and B firms. These two types of firms connecting each other and formulate the two parts of a supply chain. Firms of type A produce intermediate goods as inputs of firms of type B. Firms of type B produce final goods for consumers. We suppose there will be complete competition for firms of type A, so they have zero profit. Firms of type A must pay the license fee to the platform before it begins to produce and also have to pay a ratio r of the price for per unit goods. There could be many different types of intermediate goods to be developed based on the platforms IPs and we use u to denote a specific type of the intermediates and N to denote the total amount of these types.

The firms of type B gain the intermediates from firms A and then produce final goods. Denote the final goods as Y and the intermediates as $x(u)$ for the amount of variety u of the intermediates. The final goods production function is supposed to be

$$Y = \frac{1}{\alpha\beta}\left[\int_0^N x(u)^{\beta} du\right]^{a}, \tag{1}$$

where we have $\alpha\beta < 1$, $0 < \alpha < 1$, and $\beta \leq 1$. The first condition ensures that the production function has a decreasing return to the scale regarding the inputs, x's, with given N, while the second condition guarantees that the production function has a decreasing return to the scale regarding some single $x(u)$ and the third condition guarantees that N has a decreasing marginal return with given x's.

For this form of production function, the quantities of α and β can be used to measure the network effects. To achieve that, we assume that $x(u) = x$ for all u's, then

$$Y = \frac{1}{\alpha\beta} N^{\alpha} x^{\alpha\beta}.$$

When we fix total amount of the inputs, i.e. $Nx = \bar{X}$, so $Y = N^{\alpha-\alpha\beta}\bar{X}$. Therefore when $\beta < 1, Y$ increases with N as $\bar{X}$ is fixed, which means more types of inputs help the production of the final goods and which represents the network effects. Moreover, if the product, $\alpha\beta$, is equal to a constant, the greater is α, as the less is β and the bigger is the network effects. On the other hand, when $\beta = 1$, the amount of N has no effect on the production, which implies there is no network effect.

We firstly explore the problem of the production of the final goods to get the demand function for the intermediates. Firms of type B have to solve the following optimization problem to maximize its profits

$$\underset{x(u)}{Max} \quad \frac{1}{\alpha\beta}\left[\int_0^N x(u)^\beta du\right]^\alpha - \int_0^{N(t)} p^x(u)x(u)du\,, \tag{2}$$

where $p^x(u)$ is the price of intermediate of type u in the term of the final goods. By solving this problem we get the demand function for intermediates

$$x(u) = p^x(u)^{-1/(1-\beta)} X\,, \tag{3}$$

where $X = [\int_0^N x(u)^\beta du]^{\frac{1-\alpha}{\beta-1}}$.

Now consider the problem of intermediate producers. Assume each firm of type A can only produce one type of intermediates as a monopolist. For example, we can assume that the intermediates producer must develop some new patents, based on the platforms IPs to invent a new type of intermediates and they will produce the new type as a monopolist once it has been invented. So the problem for the producer of a new type of intermediates is

$$\begin{aligned} &Max \quad \pi(u) \equiv (1-r)p^x(u)x(u) - \psi x(u,t) \\ &s.t. x(u,t) = p^x(u)^{-1/(1-\beta)} X \end{aligned}$$

Here $\pi(u)$ is the monopolistic profit for the production of type u and ψ is the marginal production cost. So, from the above optimization problem, we have

$$p(u) = \frac{\psi}{(1-r)\beta} \tag{4}$$

and

$$\begin{aligned} x(u) &= [\frac{\psi}{(1-r)\beta}]^{-1/(1-\beta)} X \\ \pi(u) &= (1-r)^{1/(1-\beta)} (\frac{\psi}{\beta})^{-\beta/(1-\beta)} (1-\beta) X \end{aligned} \tag{5}$$

In the equilibrium, each type of intermediates is produced at the same amount, denoted by $\bar{x}$.

Therefore $X = N^{\frac{1-\alpha}{\beta-1}}\overline{x}^{\frac{\beta(1-\alpha)}{\beta-1}}$. Together with equations (5), we have

$$\overline{x} = x(u) = [\frac{\psi}{(1-r)\beta}]^{1/(\alpha\beta-1)} N^{\frac{1-\alpha}{\alpha\beta-1}}, \tag{6}$$

$$\pi = \pi(u) = (1-\beta)(\frac{\psi}{\beta})^{\frac{\alpha\beta}{\alpha\beta-1}}(1-r)^{\frac{-1}{\alpha\beta-1}} N^{\frac{1-\alpha}{\alpha\beta-1}} \tag{7}$$

Assume to invent the new type, the firm of type A must incur a lump-sum of costs, denoted by η, together with the license fee L. Because we assume any firm can become an intermediate producer after assuming the costs $L+\eta$, the free entry condition means that no incumbent firm could earn positive profit, i.e.

$$L + \eta = \pi = (1-\beta)(\frac{\psi}{\beta})^{\frac{\alpha\beta}{\alpha\beta-1}}(1-r)^{\frac{-1}{\alpha\beta-1}} N^{\frac{1-\alpha}{\alpha\beta-1}} \tag{8}$$

Now we turn to the problem of the platform whose income comes from two parts, the license fee and the loyalty. So, it maximizes

$$\begin{aligned} \Pi &= LN + rNp^{x}\overline{x} \\ s.t. L &\geq 0; r \geq 0 \end{aligned}. \tag{9}$$

From (4), (6) and (8),

$$rp\overline{x} = \frac{r}{(1-r)(1-\beta)}(L+\eta) \tag{10}$$

So from (8) and (10), the platform's objective function can represented as

$$\Pi = [L + \frac{r}{(1-r)(1-\beta)}(L+\eta)](1-\beta)^{\frac{1-\alpha\beta}{1-\alpha}}[\frac{\psi}{\beta}]^{\frac{-\alpha\beta}{1-\alpha}}(1-r)^{\frac{1}{1-\alpha}}(L+\eta)^{\frac{\alpha\beta-1}{1-\alpha}}$$

We assume the conditions $L \geq 0$ and $r \geq 0$ on the pricing behavior of the platform. So, the solution is reached at interiorly, we must have $\frac{\partial\Pi}{\partial L} = 0$ and $\frac{\partial\Pi}{\partial r} = 0$, otherwise it should be a

corner solution. After some tedious mathematics exercises, $\frac{\partial \Pi}{\partial L}=0$ and $\frac{\partial \Pi}{\partial r}=0$ means

$$L=\frac{-\eta(\alpha+r-1)}{\alpha(\beta r+1-\beta)}$$
$$r=1-\frac{\alpha(\eta+L)}{\eta+L\beta}$$

And then, we can prove the following statements.

Theorem 1. Under the conditions of $\alpha\beta<1$ and $\alpha<1$, when $\beta<1$, the model has a unique solution where $L=0$ and $r=1-\alpha$.

As stated before, when $\beta<1$, the production of intermediates will have network effect on the final goods. The variety and size of production of intermediates will have positive impact on those of final goods. The optimal pricing strategy could be determined as lowering price and encouraging partners enter the platform. Because the platform owner inclines to decrease the cost of innovation and production for those firms who produce the intermediate products. Hence, it will stimulate more production of intermediates based on the platform technologies. As a result, the industry will be scaled up through such network effects. As stated, when $\alpha\beta$ is fixed，if α increases, β will decrease. At this moment, the size and diversity degree of intermediates concerning the network effects matters more for the firms who produce final goods. Besides, learning from Theorem 1, when α increases, r decreased, indicating smaller royalty fee, which is regarded as the low pricing strategy. In the Theorem1, if $L=0$, it indicates L position as the corner solution, which indicates the platform owner is willing to conduct low pricing strategy as much as possible towards a lowest price. However, it will be a different story in real situation, on the one hand, concerning some other factors, the license fee should be at least higher than 0. For example, ARM charged a certain amount from its

licensers. On the other hand, the platform owner might subsidize partners and make L small than 0. For example, due to different types and big numbers of manufacturing firms based on ARM platform, ARM will subsidize those manufacturing firms to stimulate the network effects. As a result, we can summarize the phenomenon the following corollary.

Corollary 1. When the network effects are relatively significant, it is more possible that the platform will decrease the entry price and encourage more types of goods based on its patents. As the network effect increases, the royalty fee decreases.

Following this logic, we can also have the following theorem.

Theorem 2.

Under the conditions of $\alpha\beta < 1$ and $\alpha < 1$, when $\beta = 1$, there does not exist finite optimal solution, there always be $\partial\Pi/\partial L > 0$, which implies $N \to 0$.

When $\beta = 1$, the two parts in the supply chain will not have network effects with each other. The theorem states, the platform will set a higher license fee as much as possible in order to stop the intermediate producers to enter the platform based ecosystem. However, the number (N) of intermediate producers will not be 0, since the platform owners have to generate some revenue by encouraging some certain number of producers to produce and add value the platform. As a result, the optimal solution is to have only one intermediate producer, who can totally monopolize the platform technology. The equation (8) indicates that the profit coming from the monopoly system will be taken away by the platform owner. In this situation, the platform owner actually establishes a close industry system where the platform owner could monopolize the product design and manufacturing based on its technology. In PC processor

industry, Intel was the case we mentioned, who has hugely monopolized the process from design to manufacturing of PC chips. This is because, the variety of chip processors do not have network effect on PC manufacturing since the PC market is not dynamic. As a result, Intel inclines to adopt a close supply chain model. Then, we can summarize a new corollary:

Corollary 2. When the network effects are relatively weak, it is more possible that the platform will control the production, which is based on its patents, like a monopolist.

5 Discussion

5.1 Supply-chain based two-sided market

We have proposed a supply-chain based two-sided market model: in the two-sided market, each side is not only connecting with a focal platform, but also connecting each other among those sides. Those new connections will formulate supply chains. As a result, the scope of network effect was expanded by including the network effects within the supply chain upstream and downstream, in addition to the traditional direct and indirect network effects.

Our model suggests when the network effect is strong, the focal firm will adopt the platform based open supply chain model; when the network effect is weak, the focal firm will adopt a close supply chain model. These findings also explain why ARM adopted an open supply chain platform model while Intel adopted an integrated and close supply chain model.

Interestingly, these two focal firms both monopolize their own markets in PC and mobile industry respectively. However the way of monopoly is hugely different. The Intel is a traditional monopolist while the ARM is a monopolist in terms of an open two-sided industrial platform. Such new format of monopoly has significant implications for emerging

industry development:

Firstly, from the platform owners' perspective, they will be motivated to have a monopoly platform. Then they will strengthen the network effects in that supply chain by providing more promising policies to subsidize and attract new producers. This strategy will scale up emerging industries' output. Secondly, in terms of producers who work on that platform, they could dedicate themselves only into such platform and then make good use of the internal network effect to decrease the production cost. Since, the supply chain crossing different platforms has no or less network effects, the producers could more focus on this single platform; thirdly, in terms of whole industry, the competition based on such focal platform is a complete competing market, which stimulate various innovation and also relieve the effect that monopoly will slow down the innovation activities.

In addition, we also discuss about the possibility of platforms' substitution. If the platform is more open to its intermediate producers, when the numbers of those producers increase, the variety and size of goods will increase as well. In that way, the platform will maintain its competitive advantages with low possibility to be substituted by other entrant platform. Because if an entrant platform wants to replace an incumbent one, they have to not only provide the common technology but also create big variety and size of intermediate goods. This is a huge cost: we assume the production cost for the entrant and incumbent platform is similar. Following the model we developed, the cost to create a substitute platform will be the cost of producing the platform and the intermediate goods. The cost of creating such intermediate goods is equals to $N\eta$, which is positively associate the number of goods.

5.2 Positive monopoly debate

We still have the debate on the positive monopoly, whether is a general phenomenon or just a unique case. Monopoly will slow down the innovation rate, which is already demonstrated by many scholar works (Williamson 1968, Reinganum 1983, Iansiti and Richards 2006).However, the ARM case highly dominated the smartphone industry, but created a very innovate business ecosystem. This is really a very strong evidence to challenge the existing agreement on the monopoly.

Through our research, we have proposed some context factors to determine a positive monopoly:

Firstly, the platform owner should provide a fundamental and common platform for this industry. The platform owner only provides many basic functions where the other developers are reluctant to do the investment by themselves, because these common technologies are assumed without economics benefit. For example, some basic functions like audio coding and decoding in the smartphone chips.

Secondly, the license model should guarantee the profit maximization for whole platform ecosystem, not just for the platform owner. Because, taking ARM is an example, the revenue of ARM only had around 795.2 million GBP in 2014[2], which was a very tiny part of the revenue of the whole smartphone industry as 276.39 billion USD[3]. Though ARM dominating this market by 98% market share, its revenue is so tiny. In other words, ARM is more willing to do value co-creation with platform partners, but to do less value appropriation. Hence, as a

[2] http://markets.ft.com/research/Markets/Tearsheets/Forecasts?s=ARM:LSE

[3] http://www.statista.com/statistics/237505/global-revenue-from-smartphones-since-2008/

positive monopoly, they should be acting like a social enterprise to contribute more to value creation.

Thirdly, a positive monopoly should have a well-accepted vision for its platform ecosystem: for example, Apple's vision on smartphone against vision of Nokia. The well-accepted vision will drive the ecosystem stakeholders work together towards some directions, which will leave much space for stakeholders to create value, reduce the transaction cost and approach the mature of industry in a shorter period.

In summary, a positive monopoly should have a clear vision of industry future, provide a fundamental platform to other ecosystem stakeholders as well as create more space for value creation and appropriate less value as a social enterprise.

5.3 From two-sided market towards two-sided ecosystem

There will be three levels of two-sided market: product, platform and ecosystem. In the first level of product, like Intel, it is more like a close supply chain model, which acted as an internal platform to trigger the internal innovation activities. In the second level, like the key business in ARM's platform, it is a supply-chain based two-sided market. The direct partners or supply chain partners will trigger the strong network effects for each other. In the third level, like the in-direct partners of ARM, for example, training companies, consortia platform, universities, they did not license IPs from ARM but they provided the goods like context books and trained the engineers who understood ARM technologies. All of those in-direct partners will facilitated the ARM's platform network effects. We named this as the ecosystem partners around the two-sided market. All of those three levels of partners compose of a

two-sided ecosystem.

By learning from those three levels, the next step is to know how to build up such ecosystem. The key to build up a platform based ecosystem is to attract more suppliers and customers to contribute to this platform. Hence, the degree of stickiness and size of those stakeholders are the performance benchmarking for a platform's success. As a result, how to nurture such a platform will be the key question to answer. Our article has addressed on that question especially on a supply-chain based two-sided market.

There are three steps to nurture such supply-chain based two-sided platform. Firstly, it is really important for focal firms to attract not only the direct suppliers but also indirect suppliers, which might have indirect network effect to the key customers. Secondly, it is necessary to identify some key partners in the developers' sides to nurture them as a loyalty member to continuously trigger the innovation of whole platform. Thirdly, it is better to diversify the platform offering by involving more stakeholders' contribution.

6 Conclusion

This article has proposed a conceptual model to organize a supply-chain based two-sided market as well as demonstrates how the IP license model could better organize this platform ecosystem and trigger even stronger network effects.

Specifically in chips industry, this article is able to explain why Intel and ARM adopted different business models. Intel conducted a quite close supply chain model by integrating R&D and manufacturing, while ARM established an open platform ecosystem to attract thousands of partners to design and manufacture chips on the platform by charging only a

small amount of license fee and royalty fee. By learning from the unique case, we have proposed a theoretical model of supply-chain based two-sided platform model, where the supply chain has strong network effect inside. This model not only explains the difference between ARM and Intel's business model and their success or failure, but also has its general implication for other two-sided market theories.

Our research demonstrates that, when the parts of supply chain have strong network effect to each other, the platform owner is more willing to adopt platform based business model; when such network effects is weak, the platform owner might adopt a close supply chain model. Furthermore, due to the strong network effect, the cost of entering the platform is quite low for those partners which also results a more open supply chain. This result indicates the difference business model adopted by Intel and ARM is because of weak network effect in PC and strong network effect in mobile industry respectively.

There are both monopolists existing in both close supply chain model and open supply chain based platform model. The former is the monopoly in terms of the supply chain level and the latter is the monopoly in terms of the platform level. The platform monopoly we regarded as a positive monopoly which is different from the traditional monopoly theories. Because this platform will accelerate the innovation rate and lower products cost and finally formulate a business ecosystem to support this platform based business so as to scale up the industry scope. As a result, we called this is a 'Positive Monopoly'.

The supply-chain based platform also enriches the business ecosystem theories. This has following implications in terms of nurturing business ecosystems: it is necessary to

distinguish the roles of the platform owners and other relevant stakeholders; it is necessary to further distinguish roles by their nature whether they have strong capability to trigger network effects or not. In that way, they could better generate whole ecosystem's network effects; finally, this research also provides the implication to the situation when the supply chain itself within the platform ecosystem has the network effect as well as when focal firms cope with the external demand outside the platform ecosystem, which generate further network effects.

7 Future research

There are several ways to conduct the future research: firstly, we need to test those theorems and corollaries, by collecting supply-chain based platform data. This is rather a difficulty task. Because, the previous studies have only touched the single group of developers, and focused on the single industry. In our framework, we needs to have cross-industry data, which is more reflecting the real situation of industry development; secondly, we needs to do more case studies to obtain more evidence to demonstrate the existence of positive monopoly in order to generalize the attributes of positive monopoly; thirdly, in terms of three levels of two-sided market from product, platform and ecosystem, we did not touch the ecosystem level. We might further develop the theoretical framework of a positive monopoly, especially how they organized an ecosystem level's two-sided platform.

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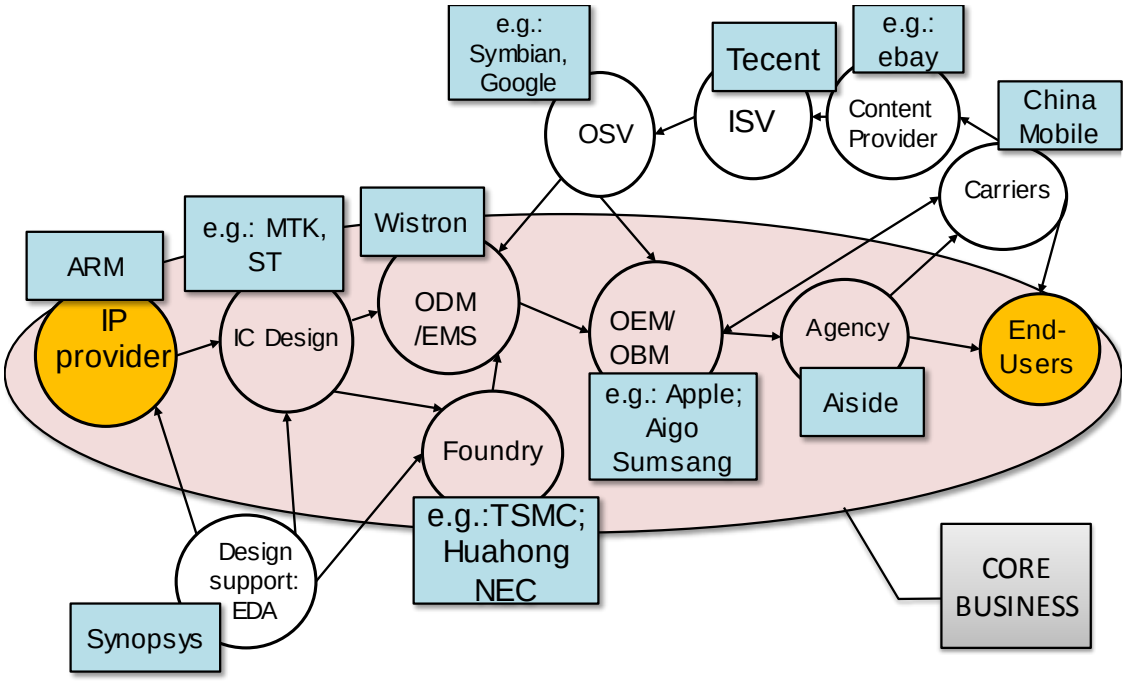
Appendix

Figure



IP- intellectual property, IC- integrated circuit, OEM- original equipment manufacturer, OSV- operating system vendor, EDA- electronic design assistant ISV- independent system vendor, EMS: electronics manufacturing service; ODM- original design manufacturer ;

Figure 1 ARM's business ecosystem (Source: Rong and Shi 2014)

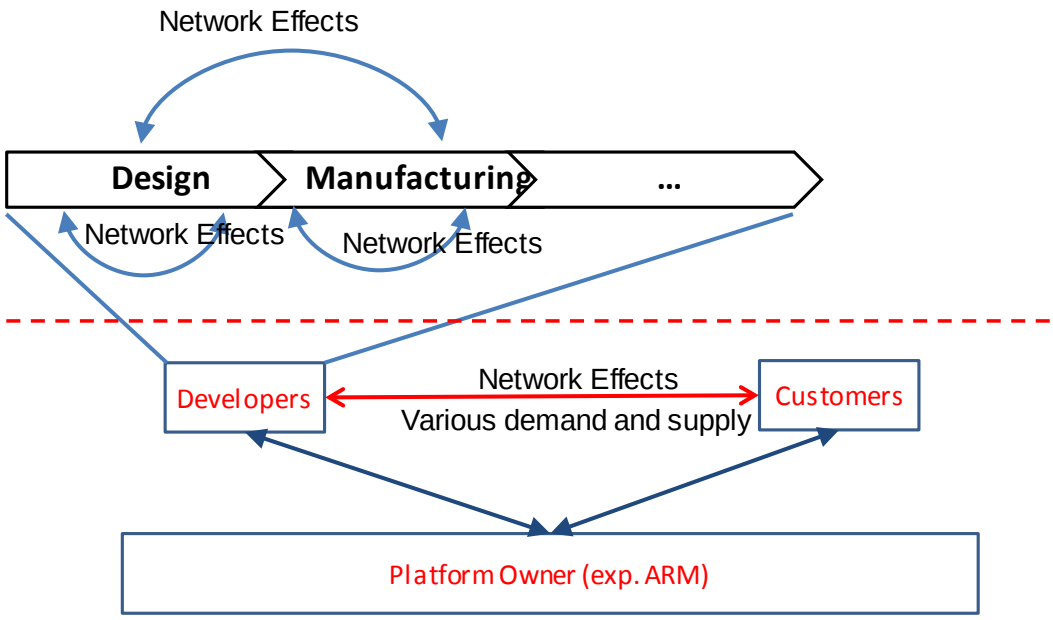


Figure 2 Research framework