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Open Innovation in Platform Competition

Abstract

We examine the competition between a proprietary platform and an open platform, where each platform holds a two-sided market consisted of app developers and users. The open platform cultivates an innovative environment by inviting public efforts to develop the platform itself and permitting distribution of apps outside of its own app market; the proprietary platform restricts apps sales solely within its app market. We use a game theoretic model to capture this competitive phenomenon and analyze the impact of growth of the open source community on the platform competition. We found that growth of the open community mitigates the platform rivalry, and balances the developer network sizes on the two platforms. The platforms' relative dominance is found to be a key determining factor in the effect of open community growth in equilibrium. Furthermore, total surplus on the open platform and total welfare of the two platforms both increase as the open community grows.

Keywords: Game theory, open innovation, platform economy, network effect.

1 Introduction

Platform businesses have expanded its boundaries. Besides online advertising, digital music stores, and e-book readers, the mobile services opened up a marketplace for application developers and mobile users. Driven by state-of-the-art technologies, smartphones such as the iPhone and G1 have gained considerable market popularity and attracted numerous app developers. While the innovative features provided by the smartphones are highly valued by the consumers, the variety of applications is generating notable buzz and, more importantly, dollars for both app developers and the platforms.

Many mobile platforms provide tools kits and support for their developers, and open a market place for developers to distribute their apps. Currently, in order to distribute apps for iPhone or iTouch, app developers pay \$99 for the standard developer program [7]; Google also charges the membership fee of \$25 for publishing in the G1 app marketplace [1]. The app developers can set download prices for their apps, but a transaction fee will be applied by the platform. Both Apple and Google charge developers 30% of the app's price for the transaction fee.

A key difference between Apple and Google's business models is the *open* innovation, which is a new element that distinguishes this platform competition from others in the past studies. While Apple keeps its iPhone platform proprietary, Google is taking an active role in

aligning with the open source community by using an open platform, Android¹. Android is built on the Linux kernel, which is developed and maintained by the open source community. The open platform does not only offer a more creative development experience by allowing developers to contribute to the design and development of the platform itself, it also allows for considerable freedom and flexibility in app distribution. We are interested in investigating how platform competition and welfare respond to the growing open source community.

Our work contributes to the following three research literature themes: (1) the economics of two-sided markets; (2) the economics of open source software; and (3) the economics of open innovation.

A line of interesting works have looked at the pricing problem of two-sided markets. Rochet and Tirole examine the factors that determine how platforms tilt and allocate the charges to the two sides of the market [11]. They find that characteristics of buyers, such as degree of multihoming that generates a high surplus, indeed lead to more a favorable pricing structure for the sellers' or buyers' side [11]. Armstrong presents three models of different types of competition between platforms based on whether agents join one or several platforms [2]. The fee structures of two-sided markets are studied by Caillaud and Jullien in [4], where the one-time registration fee and transaction prices could be introduced. They derive results in the impact different fee structures have on platform competition and equilibrium prices [4]. Most of these studies are based on the model where both sides benefit directly and only from the participation of the other side of the market, which is exactly evident in traditional two-sided market examples. However, the platform economy has evolved in the IT age. Much value is created by the platform itself; Hence, often both sides of the market benefit considerably from the platform. Bakos and Katsamakas look at the design issue of the competing platform and endogenized the network externality by formulating it as the technology investment by the platform [3]. Under various ownership structures, they find platforms' design strategies in technology investment to be highly asymmetric to extract surplus from a particular side of the market [3]. In our work, we analyze growth of the open source community, when a platform undertakes an innovative business model that uses an open-source platform system and allows for open participation.

The literature on open source focuses mainly on the individual incentives to participate in open source projects, the incentives of firms to adopt open source initiatives, the business models of firms operating within the open source landscape, and the competitive implications of open source software [10]. Lerner and Tirole [8] [9] argue that individual programmers are motivated by "peer recognition" and delayed career benefits such as being hired by a software firm, or getting access to funding for future software ventures. Firms participate in open source projects because of the money made from complementary applications or services, the access to development talent that they may hire in the future, and open-source technologies that they may use in the future. Mustonen [?] proposes a model in which the participation of programmers in open-source projects is endogenous and shows that a low implementation cost of an open-source application is crucial for its survival when it competes with a proprietary application. Economides and Katsamakas [5] compare industry structures based on a proprietary platform with those based on an open-source platform and analyze the structure of competition and industry implications in terms of pricing, sales, profitability,

¹<http://www.android.com>

and social welfare. Hagiu [6] identifies a fundamental economic welfare trade off between two-sided open platforms and proprietary platforms, and shows that sometimes proprietary platforms can be more socially desirable than open platforms. Most of these studies regard the open platform as a non-profit agent that is not concerned with any pricing strategy. In the context of smartphone platforms, the open platform serves as part of the firm’s business model. Thus, the competing firms, each with an open or a proprietary platform, set prices strategically to attract developers and users on two sides of the market. The overall growth of the open community has positive implications for both firms’ profits and total welfare.

Von Hippel and von Krogh [12] propose that open source software development is a compound private-collective model of innovation that contains elements of both the private and the collective innovation models. West and Gallagher [13] identify three fundamental challenges for firms in applying the concept of open innovation as well as four strategies firms employ: pooled R&D/product development, spinouts, selling complements and attracting donated complements, and discuss how they address the three key challenges of open innovation. Our paper considers the pricing strategies competing platforms employ, when one of them invites open innovation.

Our main findings demonstrate that as the open community continues to mature and grow, both platforms may benefit depending on the relative platform dominance. In fact, growth of open community balances the developer networks of competing platforms by shifting developers away from the more dominant platform in terms of its app revenues. While the propriety platform’s equilibrium revenues may decrease in the open community growth depend on such balancing effect, the open platform’s equilibrium revenues are higher as the open community matures. When platforms’ user bases are also driven by the open innovation, above results still hold. Moreover, the total welfare of the two platforms is increasing with the growing open community.

In Section 2, we introduce the benchmark model, analyze the equilibrium, and discuss the findings. In Section 3, we analyze the impact of the option of open app distribution on the open platform. Section 4 presents results under two model setting, exogenous user demand and feature-driven user demand, and examine the impact of open community growth on platform rivalry. In Section 5, we discuss the welfare results. And then we conclude.

2 Model

We consider two competing platforms, M and G. M indicates the proprietary platform, which develops the platform in-house and does not distribute the source code. Platform G, on the other hand, uses an open-source platform that invites contribution from the public, and releases its source code. The developers on platform G then have the opportunity to engage in the open source community development activities. Moreover, platform G imposes less restriction on the applications created for its platform. All developers on platform M must sell their apps in the platform M marketplace, whereas platform G developers have the option of distributing their apps elsewhere as third-party applications². Let λ exogenously denote

²This is made possible by the open-source property of the open platform. For example, the Android SDK is free for download; thus, Android poses no restricting ties between app development and app sales. However, iPhone’s SDK is only accessible to those who have enrolled in the “iPhone Developer Program,”

the possibility that a platform G developer lists his/her app in the platform G app market. Equivalently, λ can be viewed as the proportion of platform G developers who enroll in the Android market; thus $1 - \lambda$ of the developers choose to distribute third-party apps.

In the base model, user demand on a platform is the existing user base, which is given exogenously and denoted by n_M or n_G on platforms M or G, respectively. Developers observe the fixed membership fees set by the platforms and then choose between platforms M and G. When developers enroll in the platforms' app marketplaces, the revenue of each transaction/download is split between the platform and the developer.

App Developers

Let the app developers be heterogeneous in their experience in open-source development, denoted by s , uniformly distributed between 0 and 1. s then implies the probability a developer contributes to the platform project, if he/she chooses platform G. We let α characterize the maturity the open-source community - growth of the community is reflected by increased α . The utility functions for developing on platforms M and G then follow:

$$u_D^M = (1 - \beta_M)p_M n_M - F_M \quad (1)$$

$$u_D^G = \lambda[(1 - \beta_G)p_G n_G - F_G] + (1 - \lambda)\alpha n_G + \alpha s \quad (2)$$

For both platforms, if the developer enrolls in the app marketplace, he/she receives the profit share of the transactions proportional to the user base and incur the cost of membership fee. Developers on platform G have $1 - \lambda$ probability to resort to a third-party option, thus the size of platform G's user base determines the level of utility for this channel weighted by α . As the open community grows, developers derive higher utility from distributing their apps outside of the platform app market, since the expected recognition from and interaction with the open community becomes more appealing. In addition, platform G offers the higher utility depending on each developer's likelihood of participating in platform projects and the open community maturity.

The expressions for the developer demand on the two platforms are:

$$x_D^M = \frac{1}{\alpha} [(1 - \beta_M)p_M n_M - F_M - \lambda(1 - \beta_G)p_G n_G + \lambda F_G - (1 - \lambda)\alpha n_G] \quad (3)$$

$$x_D^G = 1 - \frac{1}{\alpha} [(1 - \beta_M)p_M n_M - F_M - \lambda(1 - \beta_G)p_G n_G + \lambda F_G - (1 - \lambda)\alpha n_G] \quad (4)$$

Platforms

Platforms' profit functions are as follows:

and agree to distribute their apps in the Apple App Store.

$$\pi_M(F_M) = \beta_M p_M n_M x_D^M + F_M x_D^M \quad (5)$$

$$\pi_G(F_G) = \beta_G p_G n_G (1 - x_D^M) \lambda + F_G (1 - x_D^M) \lambda \quad (6)$$

Each platform's revenues come from two components: 1) The profit shares from app sales and 2) the membership fees paid by the developers. Let β_M and β_G exogenously denote the profit proportions received by the platforms. x_D^M and x_D^G , the size of developer bases on Platform M and G, can be derived in the analysis later. The marginal cost of platforms is assumed to be zero, consistent with the literature of information goods.

2.1 Model Analysis

Lemma 1. *The equilibrium results are as follows,*

$$F_M^* = \frac{1}{3} [p_M n_M - \lambda p_G n_G - (1 - \lambda) \alpha n_G + \alpha] - \beta_M p_M n_M \quad (7)$$

$$F_G^* = \frac{1}{3\lambda} [\lambda p_G n_G - p_M n_M + (1 - \lambda) \alpha n_G + 2\alpha] - \beta_G p_G n_G \quad (8)$$

$$x_D^{M*} = \frac{1}{3\alpha} [p_M n_M - \lambda p_G n_G - (1 - \lambda) \alpha n_G + \alpha] \quad (9)$$

$$x_D^{G*} = \frac{1}{3\alpha} [\lambda p_G n_G - p_M n_M + (1 - \lambda) \alpha n_G + 2\alpha] \quad (10)$$

$$\pi_M^* = \frac{1}{9\alpha} [p_M n_M - \lambda p_G n_G - (1 - \lambda) \alpha n_G + \alpha]^2 \quad (11)$$

$$\pi_G^* = \frac{1}{9\alpha} [\lambda p_G n_G - p_M n_M + (1 - \lambda) \alpha n_G + 2\alpha]^2 \quad (12)$$

Positive demands imply the condition that

$$2\alpha > p_M n_M - \lambda p_G n_G - (1 - \lambda) \alpha n_G > -\alpha \quad (13)$$

Proposition 1. *The dominant platform's equilibrium membership fee is increasing in the difference of two platforms' average app revenues; the dominated platform's equilibrium membership fee is decreasing in the difference of two platforms' average app revenues.*

The more dominant platform offers a more lucrative marketplace to the app developers than the dominated platform; intuitively, it is able to raise its membership fee based on such an advantage. For platform G, such effect is more salient by the factor of $\frac{1}{\lambda}$ because the fee is born by λ fraction of developers who enroll in platform G's app market.

Proposition 2. *Platform M's equilibrium membership fee is decreasing in $(1 - \lambda) \alpha n_G$; platform G's equilibrium membership fee is increasing in this quantity.*

In its membership fee, platform G receives a premium proportional to the magnitude of developers' utility for distributing their app through channels other than the platform's app market. The competition creates the opposite effect for the rival - the higher the utility for third-party distribution, the more platform M would cut its membership fee in equilibrium.

Proposition 3. *For both platform, when $\beta < \frac{1}{3}$, the equilibrium membership fee is increasing in the platform's AMI; and the reverse holds.*

Whether higher average app revenues on either platform lead to a higher membership fee is linked to the revenue share percentage. Both platform can charge a higher membership fee as this value increases, when the revenue share is limited within a threshold. Otherwise, with higher average app revenues, platforms would actually need to lower their membership fees to maintain a developer network size for optimal revenues.

The competitive force here drives the platforms to cut their own shares in order to attract developers, since platforms' transaction revenues are directly dependent on the developer network size. Therefore, in equilibrium, the membership fees only increase in the platform's average app revenues, if the revenue share obtained by the platform is less than $\frac{1}{3}$ of the total transaction. This result, in turn, indicates that the equilibrium solution is jointly characterized by β and F . In other words, the equilibrium membership fees are sufficient in describing the pricing problem.

3 Impact of Multi-Channel Distribution

The open platform G invites developers to contribute to building the platform itself; additionally, the flexibility allows for app distribution through channels aside from the app market run by the platform. Such freedom enables a fraction of developers on platform G to deviate away from the platform app market by presenting their products to the platform users in other ways. In this section, we discuss the relevant factors that contribute to the changes in platform competition due to the option of multi-channel distribution provided by platform G.

Proposition 4. *Both $\frac{\partial F_M^*}{\partial \lambda}$ and $\frac{\partial F_G^*}{\partial \lambda}$ depend on the relative platform dominance, and the value of α :*

$$\frac{\partial F_M^*}{\partial \lambda} = \frac{1}{3}[\alpha n_G - p_G n_G] \quad (14)$$

$$\frac{\partial F_G^*}{\partial \lambda} = \frac{1}{3\lambda^2}[p_M n_M - \alpha n_G - 2\alpha] \quad (15)$$

When $\alpha n_G > p_G n_G$, $\frac{\partial F_M^}{\partial \lambda} > 0$; otherwise, $\frac{\partial F_M^*}{\partial \lambda} < 0$. When $\alpha n_G > p_M n_M$, $\frac{\partial F_G^*}{\partial \lambda} < 0$; however, when $\alpha n_G < p_M n_M$, $\frac{\partial F_G^*}{\partial \lambda} > 0$ only when α is sufficiently low.*

The impact of λ on platform M's equilibrium membership fee depends on the relative utilities of the distribution channels on platform G. When third-party app distribution yields higher payoff than the platform G app revenues, higher λ reduces the competitive pressure

on platform M; thus, its membership fee increases. The opposite case holds, as platform M lowers its membership fee when the competitive pressure increases.

Constraining more developers to its own app market will actually result in lower membership fee on platform G, when its third-party channel yields higher payoff than the competitor’s app market. Unlike on platform M, platform G’s membership fee is only imposed on the proportion of developers who does not resort to outside channels. So platform G’s app-market developers’ shared cost is reduced as λ increases. On the other hand, when the third-party channels do not generate as much payoff compared to the competitor’s app market, platform G’s developers get a “discount” on their membership fees based on this difference, increased λ may lead to higher membership fees as this “discount” is shared among more members; however, this is also conditional on whether this increase is offset by the reduction of other parts of the fee as the proportion grows.

Proposition 5. *The impact of λ on the equilibrium profits of the two platforms also depends on the relative impact of the two options on platform G.*

$$\frac{\partial \pi_M^*}{\partial \lambda} = \frac{2}{3} x_D^{M*} [\alpha n_G - p_G n_G] \quad (16)$$

$$\frac{\partial \pi_G^*}{\partial \lambda} = \frac{2}{3} x_D^{G*} [p_G n_G - \alpha n_G] \quad (17)$$

If the third-party distribution of apps dominates the impact of platform G’s app market, platform G suffers profit losses as more developers publish apps in its app market. This is due to the reduced demand, as well as the lower membership fee. In the meantime, platform M reaps additional revenue from the demand surge and the higher membership fee. If platform G’s app market dominates the third-party option, platform G benefits from the competition intensity, while platform M has reduced profit in equilibrium.

4 Impact of Open Community Growth

4.1 Exogenous User Network Size

Proposition 6. *Both equilibrium membership fees are increasing in α . F_G^* increases in α at more than twice the rate as F_M^* .*

$$\frac{\partial F_M^*}{\partial \alpha} = \frac{1}{3} [1 - (1 - \lambda) n_G] \quad (18)$$

$$\frac{\partial F_G^*}{\partial \alpha} = \frac{1}{3\lambda} [2 + (1 - \lambda) n_G] \quad (19)$$

Growth of the open-source community sharpens the appeal of the open platform. The result is mitigated price competition among the platforms. Both platforms increase the membership fees, with platform G reaping more than doubled the reward.

Proposition 7. *The impact of α on the developer demand depends on the relative platform*

dominance. Increasing α has a balancing effect for the distribution of developers.

$$\frac{\partial x_D^{M*}}{\partial \alpha} = \frac{1}{3\alpha^2}[\lambda p_G n_G - p_M n_M] \quad (20)$$

$$\frac{\partial x_D^{G*}}{\partial \alpha} = \frac{1}{3\alpha^2}[p_M n_M - \lambda p_G n_G] \quad (21)$$

The shift of developer demand when α changes is again connected to the relative platform dominance. The increased α actually balances out the demand by shifting developers away from the more dominant platform. To see the intuition for this, let's first look at the equilibrium payoffs of the developers on both platforms:

$$u_D^{M*} = \frac{2}{3}p_M n_M + \frac{1}{3}\lambda p_G n_G - \frac{1}{3}\alpha(1 - (1 - \lambda)n_G) \quad (22)$$

$$u_D^{G*} = \frac{2}{3}\lambda p_G n_G + \frac{1}{3}p_M n_M - \frac{2}{3}\alpha(1 - (1 - \lambda)n_G) + \alpha s \quad (23)$$

The indifference developer s satisfies

$$\frac{1}{3}(\lambda p_G n_G - p_M n_M) + \alpha \left[s - \frac{1}{3}(1 - (1 - \lambda)n_G) \right] = 0 \quad (24)$$

As a result of mitigated competition, developers pay a premium for enrolling on platform G, and this amount increases in α . Such utility is amplified with higher type developers. Therefore, the more dominant platform G is (i.e., $\lambda p_G n_G > p_M n_M$), more lower types of developers would reside on platform G at the incentives of higher app sales revenues. However, as α increases, higher premium for third-party development is only justified by users of higher types. For the lower types of developers, the increase in the utility from participating in open contribution is not enough to offset the increased premium, so they would choose platform M. In brief, α brings up the premium platform G developers have to pay for openness, hence such increase in cost is only justified by higher type developers due to their affinity towards open-source development on platform G.

In the other case, the dominance of platform M attracts higher type developers. As α increases, the appeal for open development on platform G exceeds the profitability platform M offers over platform G for higher types developers, thus there is demand shift from platform M to G. In both cases, growth of open community balances out the demand on the two platforms by amplifying the cost and utility of open development and third-party distribution.

Proposition 8. *In equilibrium, platform G's profit is increasing in α , while the impact of α on platform M's profit is dependent on the relative platform dominance.*

$$\frac{\partial \pi_M^*}{\partial \alpha} = \frac{1}{3\alpha} x_D^{M*} [-p_M n_M + \lambda p_G n_G - (1 - \lambda)\alpha n_G + \alpha] \quad (25)$$

$$\frac{\partial \pi_G^*}{\partial \alpha} = \frac{1}{3\alpha} x_D^{G*} [p_M n_M - \lambda p_G n_G + (1 - \lambda)\alpha n_G + 2\alpha] > 0 \quad (26)$$

If $\lambda p_G n_G > p_M n_M$, $\frac{\partial \pi_M^*}{\partial \alpha} > 0$; otherwise, $\frac{\partial \pi_M^*}{\partial \alpha} > 0$, iff $\alpha [1 - (1 - \lambda)n_G] > p_M n_M - \lambda p_G n_G$.

The implication of open community growth on platform M's profit is directly related to the demand balancing effect. A higher degree of dominance of platform M over platform G leads to more profit loss on platform M, as a larger number of platform M developers finds the potential to participate in open source projects and developing third-party applications attractive. On the other hand, if platform G is dominant, both platforms gain from open community growth. In this scenario, platform M benefits from mitigated price competition and balanced demand, while platform G receives profit rewards from a higher membership fee.

Surprisingly, platform G's permitting third-party distribution and inviting open contribution to its platform may have a positive effect for both platforms. The reduced competition intensity gives a boost to the equilibrium membership fees, while the allocation of developers among the two platforms is balanced by increased open interaction. The current industry phenomenon resembles more of the case when platform M is dominant. Thus, as open-source community becomes more active, more developers are willing to reside on platform G as a result of the balancing effect. Furthermore, as platform G experiences a revenue gain, platform M may benefit as well, depending on the relative platform dominance.

4.2 Feature-Driven User Network Size

The traditional two-sided models have focused on the cross-side network externality, in that the network size of one side of the market increases as the other size becomes larger. However, in many platform markets, users put a significant emphasis on the features provided by the platform itself while making their purchase decision. Especially in the smartphone market, the brand name, functionality, vendor applications, and other characteristics of the phone strongly influence user preferences. In fact, some of these fundamental characteristics have the impact of undermining or underscoring the effect of pure network externality. For example, the restrictions imposed on the customizability of proprietary platforms effectively eliminates certain apps that would otherwise offer users high utility, such as Google Voice. Moreover, the level of open innovation amplifies the attraction of the open platform, as users envision a fast growing app market given the potential of global innovation.

Aside from the existing users, there is a third group of users $1 - n_M - n_G$ whose choice of platform is affected by α . These users value the attribute of open-source of the platform based on maturity of the open community. Let V represent the base utility a platform provides.³ Users on platform G receive an added utility from the open innovation. Platforms are horizontally differentiated in a Hotelling sense, such that platform M locates at 0 and platform G locates at 1; this third group of users are uniformly distributed between the two points and incur a unit transportation cost of t_u . Their utility functions on the two platforms are characterized by,

$$u_M = V - t_u y \tag{27}$$

$$u_G = (1 + \alpha)V - t_u(1 - y) \tag{28}$$

³Here we implicitly assume that the two platforms provide the same base utility.

Assuming the market is covered, the user demand on platforms M and G are respectively N_M and N_G :

$$N_M = n_M + (1 - n_M - n_G)\hat{y} \quad (29)$$

$$N_G = n_G + (1 - n_M - n_G)(1 - \hat{y}) \quad (30)$$

where

$$\hat{y} = \frac{1}{2} - \frac{\alpha V}{2t_u} \quad (31)$$

$$1 - \hat{y} = \frac{1}{2} + \frac{\alpha V}{2t_u} \quad (32)$$

The equilibrium results then take the following forms:

$$F_M^* = \frac{1}{3} [p_M N_M - \lambda p_G N_G - (1 - \lambda)\alpha N_G + \alpha] - \beta_M p_M N_M \quad (33)$$

$$F_G^* = \frac{1}{3\lambda} [\lambda p_G N_G - p_M N_M + (1 - \lambda)\alpha N_G + 2\alpha] - \beta_G p_G N_G \quad (34)$$

$$x_D^{M*} = \frac{1}{3\alpha} [p_M N_M - \lambda p_G N_G - (1 - \lambda)\alpha N_G + \alpha] \quad (35)$$

$$x_D^{G*} = \frac{1}{3\alpha} [\lambda p_G N_G - p_M N_M + (1 - \lambda)\alpha N_G + 2\alpha] \quad (36)$$

Proposition 9. *The balancing effect of α on the developer demand persists; The third-party distribution option creates a user network effect in favor of platform G.*

$$\frac{\partial x_D^{M*}}{\partial \alpha} = \frac{1}{3\alpha^2} \left[\lambda p_G n_G - p_M n_M + \frac{1}{2}(1 - n_M - n_G)(\lambda p_G - p_M) - (1 - \lambda)(1 - n_M - n_G) \frac{\alpha^2 V}{2t_u} \right] \quad (37)$$

$$\frac{\partial x_D^{G*}}{\partial \alpha} = \frac{1}{3\alpha^2} \left[p_M n_M - \lambda p_G n_G + \frac{1}{2}(1 - n_M - n_G)(p_M - \lambda p_G) + (1 - \lambda)(1 - n_M - n_G) \frac{\alpha^2 V}{2t_u} \right] \quad (38)$$

The balancing effect found in the exogenous user network setup still holds in this setting, in fact, on both aggregate level and per-transaction level for each platform. Moreover, when users are also driven by open innovation, the feature of allowing third-party app distribution on platform G provides an additional leverage dependent on the size of user base that values open source development.

5 Welfare Analysis

The total surplus on each platform is characterized by the total revenues, which are split between the developers and the platform, on the platform.

The equilibrium total surplus on platform M is then

$$TS_M = x_D^{M*} p_M n_M \quad (39)$$

And the equilibrium total surplus on platform G is the total revenues plus the developers' expected utility from participating in open platform development.

$$TS_G = x_D^{G*} (\lambda p_G n_G + (1 - \lambda) \alpha n_G) + \frac{1}{2} \alpha x_D^{G*} (2 - x_D^{G*}) \quad (40)$$

$$= x_D^{G*} \left(\frac{5}{6} \lambda p_G n_G + \frac{1}{6} p_M n_M + \frac{5}{6} (1 - \lambda) \alpha n_G + \frac{2}{3} \alpha \right) \quad (41)$$

Proposition 10. *The total surplus on platform M increases/decreases in α in the same direction as x_D^{M*} ;*

$$\frac{\partial TS_M}{\partial \alpha} = p_M n_M \frac{\partial x_D^{M*}}{\partial \alpha} \quad (42)$$

The welfare on platform M depends on the developer network size. Thus, the balancing effect directly impacts the total surplus. Growth of the open source community could benefit or lower the total revenues on platform M.

Proposition 11. *The total surplus on platform G increases in α ;*

$$\frac{\partial TS_G}{\partial \alpha} = \frac{5}{6} (1 - \lambda) n_G \left[x_D^{G*} + \frac{\partial x_D^{G*}}{\partial \alpha} \alpha \right] \quad (43)$$

Open community growth has a positive impact on the welfare on platform G. The potential reduction in developer network size due to the balancing effect can be offset by the increase in the remaining platform G developers' utility from open innovation participation.

Lemma 2. *The total welfare among the two platforms is,*

$$TW = p_M n_M + \frac{5}{6} x_D^{G*} (\lambda p_G n_G - p_M n_M + (1 - \lambda) \alpha n_G + \frac{4}{5} \alpha) \quad (44)$$

Proposition 12. *The total welfare increases in α ;*

$$\frac{\partial TW}{\partial \alpha} = \frac{5}{6} \left[(1 - \lambda) n_G + \frac{4}{5} \right] \left[x_D^{G*} + \frac{\partial x_D^{G*}}{\partial \alpha} \alpha \right] \quad (45)$$

Through balancing developer networks on the competing platforms, and locating developers to the platform that best serves their interests (pure revenue incentives or open-innovation incentives), growing open community improves overall welfare of the platforms and the developers. The implication on the platform users who purchase apps on the platforms is not conditional on the open community growth at this stage of the study.

6 Research Plan and Conclusion

We have introduced a game theoretic model to capture the competition between two platforms, both of which open a marketplace for app developers and users; however, one of the platforms uses an open-source platform operating system, thus attracts highly innovative app developers. We examined the role of growth of the open community in this competition - whether the open platform necessarily benefits from increasingly mature open community, and how this force impacts the competing proprietary platform. The key finding is that the open community growth mitigates the competition and increases the equilibrium membership fees up for both platforms. Moreover, it balances the developer network sizes on two platforms by shifting developers away from the more dominant platform. Total welfare is improved with growth of the open community.

To proceed further in this study, we will extend the model by relaxing a few assumptions. First, we will analyze the impact of the open community growth when user demand is also driven by developer network size. We will also consider a multi-homing setup, where the developers may create apps for both platforms.

References

- [1] Android Market. [http : //market.android.com/support/bin/topic.py?hl = en&topic = 15866](http://market.android.com/support/bin/topic.py?hl=en&topic=15866).
- [2] Armstrong, M. (2006). "Competition in Two-Sided Markets." *RAND Journal of Economics*, 37(3), pp. 668-691.
- [3] Bakos, Y. and E. Katsamakas (2008). "Design and Ownership of Two-Sided Networks: Implications for Internet Platforms." *Journal of Management Information Systems*, 25(2), pp. 171-202.
- [4] Caillaud, B. and B. Jullien (2003). "Chicken and Egg: Competing Matchmakers." *RAND Journal of Economics*, 34(2), pp. 309-328.
- [5] Economides, N. and E. Katsamakas (2006). "Two-sided competition of proprietary vs. open source technology platforms and implications for the software industry." *Management Science*, 52(7), pp. 1057-1071.
- [6] Hagiou, A. (2006), "Proprietary vs. Open Two-Sided Platforms and Social Efficiency", *AEI-Brookings Joint Center Working Paper*. No. 06-12.
- [7] iPhone Developer Program. [http : //developer.apple.com/iphone/program/](http://developer.apple.com/iphone/program/).
- [8] Lerner, J. and J. Tirole (2001), "The open source movement: Key research questions." *European Economic Review*, 45(4-6), pp. 819-826.
- [9] Lerner, J. and J. Tirole (2002), "Some simple economics of open source." *Journal of Industrial Economics*, 50(2), pp. 197-234.

- [10] Lerner, J. and J. Tirole (2005), “The economics of technology sharing: open source and beyond.” *Journal of Economic Perspectives*, 19(2), pp. 99-120.
- [11] Rochet, J. and J. Tirole (2003). “Platform Competition in Two-Sided Markets.” *Journal of the European Economic Association*, 1(4), pp. 990-1029.
- [12] Von Hippel, E. and G. von Krogh (2003), “Open source software and the private-collective innovation model.” *Organization Science*, 14(2), pp. 209-223.
- [13] West, J. and S. Gallagher (2006), “Challenges of open innovation: the paradox of firm investment in open-source software.” *R & D Management*, 36(3), pp. 319-331.