When to Use the Open Business Model for Software Products under Network Effects?

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1 Introduction

Open business models, whereby incumbent software firms share their intellectual property (IP) with third parties, have been increasingly used in business practices (Parker and Alstyne 2013). For example, BitPay, the largest payment processor for bitcoin (a cryptocurrency), shares its IP (source code) so that other startups can develop similar bitcoin payment software apps to accelerate the adoption of bitcoin. Additional examples of companies using open business models in the software space include SAP (Ceccagnoli et al. 2012) and Salesforce. More industry examples using open business models in both the markets for information goods such as software and markets for physical goods such as t-shirts have been documented by Parker and Alstyne (2013) and in Lessig (2002). However, there are few formal studies on open business models (Parker and Alstyne 2013) that offer actionable guidance on when a firm should embrace an open business model compared with traditional closed (do-not-open) business models. In this paper, we address the following research question: **Under network effects and competition, when should an incumbent software firm share its IP and its market with a potential third-party entrant?**

Using a game-theoretic model, we identify conditions under which the software maker should embrace the open business model and when it should not. One novel finding we uncover is an interesting back-and-forth switch pattern among optimal business models (open vs. closed) as the strength of network effects increases: when the quality of the software product of the third party competitor is below a threshold, as the strength of the network effects increases from low to medium, the incumbent software firm switches to an open business model. Surprisingly, as the strength of the network effects continues to increase, after a higher threshold, the incumbent software firm switches back to the closed business model. We discuss managerial implications and our program of work in the conclusion section.

2 Model

We consider an incumbent firm (firm 1) selling its software product with quality \( q_1 \). There is a potential entrant (firm 2) that is exploring options to enter the market in which firm 1 operates. Prior to firm 2’s making a decision about market entrance, the incumbent has the option to open its proprietary platform and share (or give away for free) its existing technology and IP with the entrant to facilitate the market entry of the latter by effectively reducing firm 2’s entry costs to \( c_l \). If firm 1 keeps the platform closed, then firm 2 would have to incur \( c_h > c_l \) to develop its product from scratch all on its own. For now, we focus
on the case when \( c_h \) is high enough (\( c_h >> c_l \)) so that entry is not profitable for firm 2 if the incumbent does not open its intellectual property. We will relax this assumption as an extension.

After incurring the investment cost \( c_l \), the entrant is capable of developing a competing software product with quality \( q_2 \). With experience and reputation accumulated over time, the incumbent’s product is superior to the new entrant’s, i.e. \( q_1 > q_2 \). Without loss of generality, we let \( q_1 = 1 \) and \( q_2 = q \in (0, 1) \). The development costs to the incumbent are sunk and, given that software is a digital good, we assume negligible replication (marginal) costs for both firms.

There is a continuum of consumers with total mass 1 in the market, and each individual consumer needs at most one of the software products. Consumers exhibit heterogeneity in their product valuation \( \theta \), where \( \theta \) is uniformly distributed in the interval \([0, 1]\). We assume the software products to exhibit network effects - they are more valuable to each user if the installed base is larger. Such network effects could be due to the ability of users to use the software to collaborate or exchange information. If the incumbent opens its IP, and the entrant develops the product on top of the incumbent’s IP, the two firms’ products are compatible, and the network effects are proportional to the sum of the network sizes of the two product. Specifically, the utility a consumer with valuation \( \theta \) from making a selection \( s \) (where \( s \in \{1, 2\} \) represents a choice of one of the two products and \( s = 0 \) indicates that the consumer does not buy any of the products) is as follows:

\[
\begin{align*}
    u(s = 0|\theta) &= 0, \\
    u(s = 1|\theta) &= (\theta + \gamma N) - p_1, \\
    u(s = 2|\theta) &= (\theta + \gamma N)q - p_2,
\end{align*}
\]

where \( \gamma > 0 \) indicates the strength of the network effects, and \( N = N_1 + N_2 \) is the sum of both firms’ installed bases. Prices \( p_1 \) and \( p_2 \) are strategically determined by each firm.

We consider the following timeline corresponding to a sequential Stackelberg game. First, the incumbent (firm 1) decides whether to open its IP or not. Next, contingent on the incumbent’s IP being open, firm 2 enters the market and sets its price \( p_2 \). Third, the incumbent responds with price \( p_1 \). Finally, consumers make their purchase decisions after observing the prices.

### 3 Analysis and Preliminary Results

We start the analysis with the case when the incumbent chooses not to open its IP to the potential entrant. As the entry cost is prohibitive, firm 2 stays out of the market, and the incumbent acts as a monopolist. In this scenario, we can derive the incumbent’s equilibrium price, demand, and profit as follows.

**Proposition 1.** In the case of monopoly under firm 1, the equilibrium can be summarized as follows:

(i) Under weak network effects (i.e., \( \gamma < \frac{1}{2} \)), we have \( \{p_1^*, N_1^*, \pi_1^*\} = \left\{ \frac{1}{2}, \frac{1}{2(1-\gamma)}, \frac{1}{4(1-\gamma)} \right\} \);
(ii) Under strong network effects (i.e., $\gamma \geq \frac{1}{2}$), we have $\{p_1^*, N_1^*, \pi_1^*\} = \{\gamma, 1, \gamma\}$.

Note that the equilibrium concept we use here is the *fulfilled-expectations equilibrium (FEE)*, in which firms decide their optimal prices given the consumers’ expectations about the network sizes, and these expectations are rational and fulfilled in equilibrium (Katz and Shapiro 1985).

Next, we consider the case in which the incumbent chooses to open its IP to the entrant, who subsequently enters the market. To derive the equilibrium outcome, we start with the incumbent’s best response (in terms of pricing strategy) to the entrant’s price. The incumbent sets $p_1^*(p_2)$ to maximize its profit such that

$$p_1^*(p_2) = \arg \max_{p_1} p_1 D_1 (p_1, p_2, N(p_1, p_2)),$$

where $D_1$ is the demand of firm 1’s product. Note that the demand depends not only on the prices but also on consumers’ expectations about the total network size $N$. By FEE, $N = D_1 + D_2$ which, in turn, also depends on the prices. In other words, consumers’ expectations about the total network size must be endogenously determined when deriving the equilibrium demand.

It is also worth noting that some consumers may choose not to purchase from either firm if the prices are too high. Therefore, in deriving the demand functions, we analyze the boundary consumers who are indifferent between firm 1’s and firm 2’s products as well as those indifferent between purchasing firm 2’s product and not purchasing any product at all. As a result, in addition to the case of fully covered market, we also consider the scenario when the market is not fully covered.

After deriving the incumbent’s best response to the entrant’s price, $p_1^*(p_2)$, the entrant’s optimal price $p_2^*$ can be determined by solving the following optimization:

$$p_2^* = \arg \max_{p_2} p_2 D_2 (p_2, p_1^*(p_2), N(p_1^*(p_2), p_2)).$$

The equilibrium prices, demands, and profits for both players are summarized in the following result.

**Proposition 2.** When the incumbent opens its IP to the entrant and the latter enters the market, the equilibrium outcomes can be summarized as follows:

(i) If $0 < \gamma < \frac{2-\sqrt{2}}{2}$ and $0 < q < \frac{2\gamma^2 - 4\gamma + 1}{1 - 2\gamma}$, the equilibrium prices are

$$\begin{cases}
  p_1^* = \frac{(1-q)(4-q-3\gamma)}{4(1-\gamma)(2-q-\gamma)}, \\
  p_2^* = \frac{q(1-q)}{2(2-q-\gamma)}
\end{cases}$$

and the equilibrium demands and profits are

$$\begin{cases}
  N_1^* = \frac{4-q-3\gamma}{4(1-\gamma)(2-q-\gamma)}, \\
  N_2^* = \frac{1}{4(1-\gamma)}, \\
  N^* = \frac{3-q-2\gamma}{2(1-\gamma)(2-q-\gamma)} < 1 \\
  \pi_1^* = \frac{(1-q)(4-q-3\gamma)^2}{16(1-\gamma)^2(2-q-\gamma)} \\
  \pi_2^* = \frac{q(1-q)}{8(1-\gamma)(2-q-\gamma)}
\end{cases}$$
If \( 0 < \gamma < \frac{2 - \sqrt{2}}{2} \) and \( \frac{2\gamma^2 - 4\gamma + 1}{1 - 2\gamma} < q < \frac{1 - \gamma}{1 + \gamma} \), or \( \frac{2 - \sqrt{2}}{2} < \gamma < 1 \) and \( 0 < q < \frac{1 - \gamma}{1 + \gamma} \), the equilibrium prices are

\[
\begin{align*}
p_1^* &= \frac{1 + \gamma - q}{2} \\
p_2^* &= q\gamma
\end{align*}
\]

and the equilibrium demands and profits are

\[
\begin{align*}
N_1^* &= \frac{1 + \gamma - q}{2(1-q)} \\
N_2^* &= \frac{1 - \gamma - q}{2(1-q)} \\
\pi_1^* &= \frac{(1+\gamma-q)^2}{4(1-q)} \\
\pi_2^* &= \frac{(1-\gamma-q)\gamma}{2(1-q)}
\end{align*}
\]

(iii) If \( \frac{1 - \gamma}{1 + \gamma} < q < 1 \), the equilibrium prices are

\[
\begin{align*}
p_1^* &= \frac{1}{4} (1 - q)(3 + \gamma) \\
p_2^* &= \frac{1}{2} (1 - q)(1 - \gamma)
\end{align*}
\]

and the equilibrium demands and profits are

\[
\begin{align*}
N_1^* &= \frac{3 + \gamma}{4}, \\
N_2^* &= \frac{1 - \gamma}{4}, \\
\pi_1^* &= \frac{1}{16} (1 - q)(3 + \gamma)^2 \\
\pi_2^* &= \frac{1}{8} (1 - q)(1 - \gamma)^2
\end{align*}
\]

Figure 1 illustrates the equilibrium outcomes in Proposition 2.

Figure 1: Equilibrium Outcomes When the Incumbent Opens its Platform

Comparing the equilibrium profits of the incumbent in Proposition 1 and Proposition 2 over different parameter regions, we can derive the incumbent’s optimal strategy contingent on the strength of network effects and the quality of the entrant’s product, as illustrated in the next result.
Proposition 3. The incumbent prefers opening its IP to the entrant in the following parameter regions: (a) $0 < \gamma \leq \sqrt{2} - 1$, and $0 < q < \gamma$; (b) $\sqrt{2} - 1 < \gamma \leq \frac{1}{2}$, and $0 < q < 1 - \frac{4}{(1-\gamma)(3+\gamma)}$; (c) $\frac{1}{2} < \gamma < 1$, and $q < 1 - \frac{16\gamma}{(3+\gamma)^2}$, as highlighted in the gray area in Figure 2.

Figure 2: Equilibrium Outcomes When the Incumbent Opens its Platform

When $q > \sqrt{2} - 1$, the incumbent prefers monopoly to opening its IP to competition regardless of the strength of network effects. This is somewhat intuitive. As products become less differentiated, the price competition intensifies, hurting the profits of the incumbent. This adverse effect is too strong and it dominates any benefit from the increase in the willingness to pay of the consumers due to network effects (especially since both incumbent and entrant benefit from these effects). Thus, the incumbent prefers to keep its IP closed and enjoy a monopolistic position.

On the other hand, things get interesting and nontrivial when products are differentiated enough ($q < \sqrt{2} - 1$) as summarized by the following corollary to Proposition 3.

Corollary 1. For every entrant product quality level $q \in (0, \sqrt{2} - 1)$, there exist thresholds $0 < \gamma_1^*(q) < \gamma_2^*(q) < 1$ such that:

(i) when network effects are of intermediate strength (i.e., $\gamma_1^*(q) < \gamma < \gamma_2^*(q)$), then the incumbent prefers to open its IP to the entrant;

(ii) when network effects are either very weak (i.e., $0 < \gamma < \gamma_1^*(q)$) or very strong (i.e., $\gamma > \gamma_2^*(q)$) then the incumbent closes its IP and prevents the competitor from entering the market.

Corollary 1 has interesting implications. First, it is intuitive that when the strength of network effects is weak, the incumbent software firm prefers the closed business model, given the limited value generated by the third party entrant through the incremental installed base. Second, it is somewhat surprising to find that the incumbent software firm also prefers the closed business model when the strength of network effects is strong. This is because the
market size is finite and once again, the value generated by the third party entrant through
the incremental installed base is limited. We point out that this latter result contrasts with
the result in Conner (1995). In a different context, Conner shows that, when the strength
of network effects is strong enough, the incumbent would always prefer inviting imitators
under the assumption of unlimited or infinite market size.

4 Conclusions

In this study, we provide a theoretical framework to help incumbent software firms choose
between open vs. closed business models. We find that there is a region when open is
preferred over closed: the software firm would like to share its IP and its market with a
third party competitor, and forgo the monopolist power it has. On the other hand, we
also show that there are regions where traditional closed business models are still favored
over open business models. Furthermore, when the quality of the software product of the
third party competitor is below a certain threshold, we uncover an interesting back-and-
forth switching pattern between optimal strategies (closed, open and then closed again) as
the strength of network effects increases. We also contribute to the literature on markets for
technology buyouts (Kremer 1998, Bessen and Maskin 2009) by identifying conditions when
such markets are desirable and when they are not needed.

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