Management of Successive Generations of a Software Product

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1. Introduction

Typically the provider of a software product introduces one generation after another in the market. This cycle is looked upon both with suspicion and elation by the users. On one hand, existing users believe that the provider has an incentive to force them to buy the newer generation when they do not actually need it. On the other hand, the added functionality provided by the new generation is appreciated by the market. An example of this mixed market reaction can be observed each time a new generation of the windows operating system is introduced, see report in New York Times (July 6,2000).

While the provider stands to gain by selling the new generation to the existing user, the new product may also provide better utility to these users. Add to this the fact that when the provider can price discriminate, usually an upgrade price lower than the market price of the new generation is provided to existing users. Thus, they may not have the raw end of the deal after all.

The above discussion lays out the framework for this paper. There are many interesting questions to answer in this context: what is the optimal time frame for introduction of the next generation; how good is this time frame from the standpoint of social welfare; can a new generation with added features but lower quality be introduced; when should upgrade pricing be provided etc. The presence of new users (those who are buying the product for the first time) adds an interesting dimension to the market behavior. Their presence ensures the provider a minimum market for the new product. In effect, this imposes a negative externality on existing users because the provider may be able to force them to switch to a new generation by leveraging the forward incompatibility among the generations and the new user base. The type of existing user base

also has an important role to play in the market. If it comprises of some people who use the product merely for its stand alone value and do not need to communicate with others or make use of the externality in any way, then this may also affect market behavior.

The next section incorporates a brief literature survey followed by ideas on how to model the situation.

2. Literature Survey

The market for a software monopolist has been previously studied by Bhargava and Choudhry (2001) and Jing (2002) in the framework of static optimization models. However, the approach has been to look at the pricing problem and to resolve the issue of the number of versions to be introduced at one time in a vertically differentiated market. Hence the dynamic aspect of successive introductions is missing.

Some related questions have been explored in the economics literature too. Choi (1994) has dealt with compatibility choice and planned obsolescence in a two period model with network externality. In his model, the reason for obsolescence is incompatibility of the new product with the old one. Our model adds to his model as we consider the fact that utility provided by an older generation is reduced as the needs of users evolve over time. This is an additional factor influencing obsolescence, and as it turns out, this generates interesting implications in terms of product introductions and pricing policies.

Ellison and Fudenberg (2000) explain reasons for more upgrades than is socially optimal by a monopoly supplier. One reason is a version of the commitment problem, also explained by Waldman (1993). The monopolist has an ex-post incentive to sell the new generation to old customers, who have to either incur costs of learning of the new generation or suffer lack of compatibility with new customers. Thus forward looking customers will be willing to pay less for the older generation in first period. This effect may reduce the profits and welfare. The second reason arises from customer heterogeneity and an oversupply results due to difference in externality that upgrades introduce on the marginal and average customers. Another relevant paper is by Fudenberg and Tirole (1998) where they deal with issue of pricing overlapping generation of a durable good. They also consider situations where price discrimination of different degrees is applicable.

3. A Dynamic Model

The market of software users is vertically differentiated consisting of buyers uniformly distributed in $[-\infty, 1]$ in their willingness to pay attribute θ. The monopolist introduces successive generations of the software product in this market. Each generation is characterized by the functionality it encompasses and its quality

w (e.g. how effectively can each functionality be used). The customers' needs for functionality vary with time because of constantly evolving needs. The utility provided by the product is due to its quality and how close a fit it is in terms of the functionality requirement of the customers. Thus while a newly introduced product provides full value of quality to the customer, its utility erodes with time at a rate α. Following Jing (2002), we take the utility provided at an instant to be $(w - \alpha t)(\theta + (1 - \theta_m)\gamma)$, where θ_m represents the marginal customer, γ represents the externality associated with the product and t represents the length of time the product has been in the market. When the next generation is introduced, the remaining value of the old generation is damaged by the monopolist by limiting the support provided and new and complementary software development by third parties being based on the new generation rather than the old one. Thus, on a new product introduction, the monopolist has a market which is identical to the previous period market.This is presumably a simplifying assumption but allows us to focus on the issue of endogenizing the timing of introductions. In general, the damage to the older generation product is not complete and it still has some residual value. We intend to incorporate this effect in subsequent refinements of the model. If a particular generation remains in market for time T, the forward looking marginal customer is given by:

$$\int_0^T (w - \alpha t)(\theta_m + (1 - \theta_m)\gamma)dt - p = 0, \tag{1}$$

where p represents the price of the product. Then the profit function is $\pi = (1 - \theta_m)p$, where the value of θ_m as a function of p is obtained from (1). The first order condition on the profit function gives us a value for price, which is $p = \frac{1}{4}T(2w - T\alpha)$. We assume $\gamma < 1$ and $T < \frac{w}{\alpha}$ as the product looses all its value by the time $\frac{w}{\alpha}$ and the monopolist will replace it with a new generation not later than this time. These conditions ensure concavity of the profit function.

In the next step, we endogenize the time T. Assuming an interest rate of δ, the profit of the monopolist summed over all future generations is given by $\frac{1+\delta T}{\delta T}\pi$. The first order condition on this overall profit function provides us with a value for $T = \frac{2w\delta - \alpha}{2\alpha\delta}$. This overall profit function is concave in T for $\gamma < 1$, which we already assumed. The marginal customer is then given by $\theta_m = \frac{1-2\gamma}{2-2\gamma}$. The Social Welfare in this situation is given by:

$$\int_0^T \int_{\theta_m}^1 (w - \alpha t)(\theta + (1 - \theta_m)\gamma)d\theta dt$$

The value of T that maximizes social welfare is $\frac{w}{\alpha}$. Therefore, we conclude that monopolist introduces the next generation $\frac{1}{2\delta}$ earlier to the social welfare maximizing solution. Thus a high interest rate regime is good in terms of monopolist behavior being more aligned to the socially optimal behavior.

We propose to investigate the timing issue when two products are introduced in each generation: one of high quality and the other of low quality. In a static model such as Jing (2002), this improves the profits due to the externality effect of the the lower quality model being dominant over the cannibalizing effect on sales of higher quality product. Our analysis should clarify this two product policy even further. We also want to consider how the threat of entry alters the incentives of the monopolist in terms of product introduction timings.

4. A Model With New Users

We use a one period model to focus on some of the other issues we raised. Let N_1 customers already have the use of the old generation at time 0, whose adjusted quality at this time, is given by q. The quality of the new generation introduced at this time is Q and there are N_2 new customers in the market. Each old customer enjoys an instantaneous value of $(q-\alpha t)(1+N_1\gamma)$ from the older generation at time t from time 0. Similarly, any customer who buys the new generation enjoys an instantaneous value of $(Q-\alpha t)(1+N_1\gamma+N_2\gamma)$ because the generations are assumed to be backward compatible but not forward compatible. The customers expect to use the product for a length of time z. The question we focus on here is whether the monopolist should provide an upgrade price to existing customers at time 0 or wait for time $\frac{q}{\alpha}$ so that the value of the older generation is damaged to 0 and then sell the product at a price which extracts the remaining surplus of the new generation. We first look at the case when monopolist can price discriminate between new and old customers. There are two subcases to investigate.

SUBCASE 1:$Q(1+N_1\gamma+N_2\gamma) > q(1+N_1\gamma)$: First consider the wait strategy. The price charged to the older customer is $p_w = \int_{\frac{q}{\alpha}}^{z}(Q-\alpha t)(1+N_1\gamma+N_2\gamma)dt$ and price charged to new customers is $p_1 = \int_0^z (Q-\alpha t)(1+N_1\gamma+N_2\gamma)dt$. The total profit by this approach is $\pi_w = p_1N_2+p_wN_1$. Now consider the upgrade policy. The price charged to new customer remains same while the price of older customer is $p_u = p_1 - \int_0^{\frac{q}{\alpha}}(q-\alpha t)(1+N_1\gamma)dt$.The profit by this approach is $\pi_u = p_1N_2 + p_uN_1$. Comparing these two profit values we find that upgrade policy always dominates.

SUBCASE 2:$Q(1+N_1\gamma+N_2\gamma) < q(1+N_1\gamma)$:For this case, we assume that the rate of damage to the new generation is smaller than rate of damage to old generation. This is plausible because new third party products will be more consistent with the newer generation and the monopolist can also create an influence by limiting further support. Now by a similar analysis as in subcase 1, we find that the wait policy will dominate the upgrade policy under certain conditions on damage rates, customer population and qualities of the new and old generations.

At this point, it is pertinent to ask whether the monopolist would optimally introduce a product described in subcase 2 into the market at all. This is because the alternative is to sell the higher utility older generation to the new customers and extract a greater profit from them because of the higher value. We find that such an introduction is possible provided the new generation has a quality above a base quality Q^* and the older generation has a remaining quality below a threshold level q^*.

Further, we can analyze the optimal pricing policy in case when the monopolist cannot price discriminate by a similar approach as used above. We again have some interesting results e.g. if the new generation is below a quality level Q_w, then the wait policy dominates over the policy of providing a low price to sell to all customers at time 0.

We intend to carry this analysis along new dimensions by analyzing cases where the older generation of customers is of two types: one who communicate with others and so incompatibility hurts them and others, who do not and so incompatibility is not that much of an issue for them. Further, we also want to refine our analysis to include a case where the decision of not upgrading by older customers hurts the new customers too because while the new customers can use files of older generation, they are not able to send their own files to the older generation.

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