Competition and Sunk Costs

by

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We give an example of a simple economy in which ideas are developed, products embodying those ideas are produced, reproduced and distributed under conditions of perfect competition and without the possibility of downstream licensing agreements.

In this economy individuals live forever. There are many small consumers, indexed by $c > 0$. In each period, consumers either consume one unit of music, or not. The benefit to consumer c of consuming a unit of music is $c^{-\psi}$ with $\psi > 0$. In other words, consumers are ordered by how they value music: consumers for whom c is small value music highly. Consumers also prefer to consume music early rather than later: a unit of music consumed today is worth $\delta < 1$ of a unit of music consumed next period. In any period in which music is not consumed, consumer c receives a payoff equal to zero, independently of how much he/she likes music.

Initially, there is a single MP3, owned by the producer. Suppose that once this is sold, no downstream licensing is possible, so that conditions are competitive. Moreover, MP3's can either be listened to, or copied. Each copy takes one period to produce, and each MP3 that is copied produces β additional MP3's. Our interpretation of a technology such as Napster is that it increases β, that is, the number of MP3's that can be distributed (reproduced) to different consumers from a single master copy in a single time period is greatly increased.

Under competitive conditions, in the tth period MP3's sell for a single market price p_t. They may also be rented for a single period for a rental rate r_t. Notice that consumers for whom $c^{-\psi} > r_t$ value the song more highly than the rental cost, and will choose to listen to an MP3 that period; consumers for whom $c^{-\psi} < r_t$ will choose not to listen to the MP3: if they have a copy, they prefer renting out their copy to someone else to listening to it themselves. Notice how in a competitive environment, everyone is potentially a buyer and a seller.

We are interested in two primary questions. Is the price of the very first copy enough to compensate the producer for its sunk cost? Does the price of the first copy increase or decrease when technologies such as Napster increase β?

What is the sale price of an MP3? According to standard competitive theory, it is just the present value of the rental rates: $p_0 = \sum_{t=0}^{\infty} \delta^t r_t$. Since the rental rate is determined by the marginal consumer, this is just $p_0 = \sum_{t=0}^{\infty} \delta^t (c_t)^{-\psi}$, where c_t is the number of MP3s that are used for listening in period t.

Let x_t denote the stock of MP3s in period t, whether used for listening or for reproduction. Because the function describing buyers demand is of the type known as "constant elasticity of substitution," it is know that a competitive market will devote a fixed fraction ϕ of MP3's to listening each period, with the remainder used for reproduction of MP3's for next period. So the stock of MP3's next period will be $x_{t+1} = (1 + \beta(1 - \phi))\, x_t$. It follows that $x_t = (1 + \beta(1 - \phi))^t\, x_0$, or, since we start initially with just a single MP3, $x_0 = 1$, and $x_t = (1 + \beta(1 - \phi))^t$. Since $c_t = \phi x_t$, we also have that

$$\begin{aligned} p_0 &= \sum_{t=0}^{\infty} \delta^t (\phi\,(1 + \beta(1 - \phi))^t)^{-\psi} \\ &= \frac{\phi^{-\psi}}{1 - \delta(1 + \beta(1 - \phi))^{-\psi}} \end{aligned}$$

To conclude our calculation, we need to determine what is the fraction ϕ that the market listens to each period, and what is the fraction used for the reproduction and distribution of new MP3's. If, in the initial period an MP3 is used for listening, the value to the marginal listener is $(\phi)^{-\psi}$. If, instead, the MP3 is used to produce MP3's for next period, next period we will have an additional quantity β of MP3's. These MP3's will be valued by the marginal listener at

$$\delta\, [\phi(1 + \beta(1 - \phi))]^{-\psi}\,.$$

Competition will equalize these marginal values, yielding the equation

$$(\phi)^{-\psi} = \delta\beta\, [\phi(1 + \beta(1 - \phi))]^{-\psi}\,.$$

There are two things we may do with this equation. First we may simplify the formula for the initial price to

$$p_0 = \frac{\beta\phi^{-\psi}}{\beta - 1}.$$

Second, we may solve it to find the fraction of music devoted to listening

$$\phi = \frac{1+\beta}{\beta} - \delta^{1/\psi}\beta^{(1-\psi)/\psi}.$$

Plugging this back into the equation for the initial price gives our bottom line

$$p_0 = \frac{\beta\left(\frac{1+\beta}{\beta} - \delta^{1/\psi}\beta^{(1-\psi)/\psi}\right)^{-\psi}}{\beta - 1}.$$

To begin with, for finite values of β, p_0 is a nice positive and finite number. Since p_0 is what the producer can earn from the first sale when he has no downstream protection at all (in practice he should be able to do better than this) there is money to be made for producers of intellectual products.

It is also of interest to compute the rate at which the stock of MP3's grows over time

$$1 + \beta(1-\phi) = (\delta\beta)^{1/\psi}.$$

Notice that as the technology improves and β gets larger, stock of MP3's always grows faster.

Is this competitive value of intellectual products is enough to motivate the producers to spend the effort and time required? We do not know. To answer this question one needs to know the particular opportunity cost of time of the particular creator, which clearly varies from case to case. It seems to us, though, that producers demanding a government protected monopoly must make the case that this competitive value is insufficient compensation. They clearly have not done this.

But we also want to understand the impact of a technology such as Napster. Does it increase or decrease the value of intellectual products in a competitive market? Basically, the producers have argued that cheap copying makes it impossible for them to earn back their production costs. If, in a competitive setting, increasing β lowers p_0 they would be correct–without downstream protection, less music, books and works of art would be created as a result of the advent of the new technology.

So what does happen to p_0 as the technology as β grows larger? The answer depends on ψ. If $\psi < 1$ demand is elastic. This is the empirically interesting case. As β grows large and approaches $\overline{\beta}$, the solution of $1 + \overline{\beta} = \delta^{1/\psi}\overline{\beta}^{1/\psi}$, we have

$$\phi = \frac{1+\beta}{\beta} - \delta^{1/\psi}\beta^{(1-\psi)/\psi} \to 0.$$

Consequently

$$p_0 = \frac{\beta\phi^{-\psi}}{\beta - 1} \to \infty.$$

In summary, in the empirically interesting case where demand is elastic, improving the technology for reproduction increases the first sale price under competition without bound: The improved technology makes it much easier for a producer to recover sunk costs in a competitive market. This does not mean that the producer will argue against downstream licensing and in favor of increased competition: she will still be able to earn more revenue with a monopoly than under competition. But it is a good argument for not giving in to the producer and granting them the monopoly: the social benefit of the monopoly (the ability to cover sunk costs and produce a socially desirable good) is reduced by the new technology.

The case of inelastic demand, $\psi > 1$, is more complex. Revenue may go either up or down in response to the new technology. In the limit as $\beta \to \infty$ the fraction ϕ of MP3's consumed goes to one, the revenue approaches the rental value of a single MP3, which might be great or small, depending on the quality of the music. In other words, even in the inelastic case, the producer can still recover his opportunity cost, provided it does not exceed the social benefit of very few copies of the MP3.