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ECON 3030: Creative Project

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Market Description

The iPhone Market

We have chosen to model and analyze the iPhone as a collection of products within the smartphone market. The iPhone market is part of the massive smartphone movement happening across the globe. Therefore, the market we have chosen is of global scale. Smartphones are constantly being bought and sold globally, especially iPhones. In this market the main agents are Apple, the iPhone producer, and the customer. Customers can include iPhone owners looking to upgrade to the latest phone, smartphone owners who do not own an iPhone, and anyone who does not already own a smartphone. There are many types of smartphones in the world so the iPhone has many competitors. Samsung and LG are two main competitors to Apple. Typically, Apple only releases several versions of the iPhone at a given time, while the competitors have many more different smartphone options. One main benefit Apple has is that by making the iPhone market a global one, Apple not only can sell more phones but Apple can also choose where to produce their product. By being able to span the production of the iPhone across many countries, Apple can avoid or take advantage of certain regulations and laws of each country. Taking advantage of these regulations allows Apple to keep costs to a minimum and gain market power.

Externalities

The market for iPhones has major positive externalities in its software, namely its communication applications of Facetime and iMessage. By making it simpler and quicker for iPhone users to communicate by quicker text messages and group chats and high quality audio and video calls, Apple effectively sets up an example of the network effect. These features are exclusive to only iPhones, so given a well-established group of iPhone users, people will want an iPhone to benefit from the enhanced communication with friends, family, and peers. These are also called "network" externalities

Pricing and Contracts

Another important concept unique to this market is the complex pricing. Nowadays, all phones are financed by cellular service providers, thus adding an element of imperfect information for the consumer. The true cost of the Iphone is spread out over the duration of the contract, which shifts much of the cost burden away from the consumer. This must be considered when modeling pricing of the Iphone into the model of the market. In addition to this, the tranches of pricing for the various Iphone models is strategic, updates frequently, and has various intended psychological effects. Apple utilizes a tiered pricing system to clearly delineate levels of luxury and to efficiently shift out older models while making them more available

mine is not...

do they end up paying more for it though?

to lower income consumers, thus grabbing an even wider market share. This, coupled with frequent updates in quality of features, has enabled Apple to incentive upgrades to newer iPhone models despite the high prices of the new models.

Competitors and Market Share

As mentioned before, even though the use of iPhone is ubiquitous nowadays, its global market share compared to other smartphone giants has dropped from the previous years. Apple iPhones share of new smartphone sales worldwide reached its peak at 23 percent in year 2012 to 2013. After that, the market share dropped and stabilized at around 19 percent. The newest data for its market share is 18.7 percent in the fourth quarter of 2016. There might be various reasons behind this reduction in market share such as the iPhones relatively high pricing and other brands innovations to become close substitutes or better products than the iPhone. The most substantial one of them is Samsung which still holds the largest market share of the global smartphone market. Huawei is an up-and-rising Chinese smartphone brand that is also competiting strongly with Apple. Anyway, the emergency of iPhone and its iOS system is influential and this is why our eyes are caught by this market. By means of modeling and analyzing the market, we look forward to digging deeper for a better vision on how iPhones market works and how it succeeded.

Preferences and Production

Market for Consumers

Consumers and Elasticity The global scope of the smartphone market, the large economies of scale within the industry, and the increase in consumers disposable income has allowed smartphones, specifically the iPhone, to reach peak consumer penetration. The consumers of iPhones have very little bounds in age outside of being too young to understand it or too old to operate the device. Thus, the age of consumers is not important in terms of understanding them. However, income does play a role of whether consumers enter the smartphone market in general; those consumers with very little disposable income will not gain enough utility from the aspects of a smartphone to justify its purchase over a feature phone. Although income does play a major part in purchasing an iPhone in general, many iPhone retailers such as Verizon and ATT have begun offering financing programs ~~for them,~~ thus spreading the cost over many months. This broadens the iPhone market to a wider range of people and enables most consumers to be present in the market. Furthermore, many consumers view iPhones as a necessary good because of its ability to connect to important social media applications and email applications, while also providing a quick method of accessing both work and leisure. Because the key features consumers use to evaluate are assumed to be homogeneous across the smartphones, we understand that iPhones are own-price elastic and cross-price elastic. That is, a significant increase in the price of Samsung phones will increase the demand for iPhones.

how big do you think this is?

Demand and Marginal Utility The demand in the iPhone market is much like that of other markets in that it is negatively sloping. That is, when the price of an iPhone goes down, the quantity demanded goes up. However, a key feature of iPhone demand is that as price becomes significantly lower, the demand increases at a decreasing rate. This is due to the lack of need for numerous iPhones because of a redundancy in their features. This features is closely related to a uniquely behaving marginal utility of consumption function for iPhones. In this market, the marginal utility increases at a decreasing rate; the marginal utility in moving from consuming 0 iPhones to consuming 1 iPhone is massive. However, consuming one additional iPhone will provide you with nearly negligible utility.

But what about the aggregate demand?

Substitutes and Complements In terms of other smartphones in the iPhone market, there exist very close substitutes. Samsung phones are viewed as near perfect substitutes because they almost nearly mirror the key features used for evaluating the effectiveness of a smartphone. However, it would not be accurate to call them perfect substitutes because of various factors such as brand loyalty, distinct competitive advantages between brands in software and hardware functionalities, and unique network effects (particularly in the case of iPhones). Also, if prices become too high or consumer income is very low, consumers will consider very cheap Android phones or feature phones. Complements are relatively significant in the iPhone market,

where there exist many network effects. Complements include goods such as the Macbook and iPad, all of which of unique functionalities of connecting and working with the iPhone.

Utility Function

When considering this market, we make simplifying assumptions to consider three choice variables: the consumption of Apple phones, the consumption of Samsung phones, and all other consumption. We first consider the utility between consumption on phones in general and consumption of everything else. The consumption between these two are neither substitutes nor complements, and an adequate way to model this relationship would be the Cobb-Douglas function.

$$U(c,x) = c^{\gamma}x^{1-\gamma} \text{ s.t. } p_c c + p_x x = I$$

where c is all other consumption and x is consumption of phones in general. Next, we focus on the two largest smartphone companies, Apple and Samsung. Intuitively, one might think that for a single customer, the utility function is strictly binary like the max function:

$$U_x(x_a, x_s) = max\{x_a, x_s\}$$

where x_a, $x_s \in \{0,1\}$ because one would rarely have any use for more than one phone or both types of phones at the same time. However, when considering the utility function of the average of a heterogeneous group of people, the underlying utility function should be quasiconcave. Some people derive benefits from having both types of phones, and some people derive benefits from more than one of the same type of phone as well. Thus, the utility function of the average person of a heterogeneous population would be closer to:

$$U_x(x_a, x_s) = (\alpha x_a^{-\rho} + \beta x_s^{-\rho})^{-\frac{1}{\rho}}$$

where x_a is consumption of Apple phones, x_s is consumption of Samsung phones. If we choose ρ as some number just above -1 such as -0.8, we can model the utility function of Apple and Samsung phones as a CES function that represents x_a and x_s as near perfect substitutes. This is accurate in this case because both classes of smartphones perform very similar functions, yet they still differ in aesthetic and minute software/hardware details. α and β map greater preferences to either Apple or Samsung, but we can assume in this case that there is no clear victor, so both values are 0.5. Thus, we arrive at one possible utility

What about the different iPhone models? State your simplifying assumptions clearly

function for the average consumer of a heterogeneous population.

$$U_x(x_a, x_s) = (0.5x_a^{-0.8} + 0.5x_s^{-0.8})^{-\frac{1}{0.8}}$$

Still, we prefer to use the general utility function to model the situation because we have no data and are basing the parameters on assumptions.

Consumer Optimization

There are two levels of utility maximization in this problem. First, the consumer would want to choose the optimal consumption of phones and consumption of everything else. The problem becomes:

$$\max_{c,x} U_x(c, x) = c^{\gamma}x^{1-\gamma} \text{ s.t. } p_c c + p_x x = I$$

Explain what p_c and p_x are

We assume that γ is sufficiently high such that most of income isn't spent on phones. The optimal consumptions of c and x would be

$$c^* = \frac{\gamma I}{p_c}$$

$$x^* = \frac{(1-\gamma)I}{p_x}$$

Next, the consumer wants to choose the optimal level of consumption of Apple and Samsung phones given the total expenditure on phones, $p_x x^* = (1-\gamma)I$.

$$\max_{x_a,x_s} U_x(x_a, x_s) = (\alpha x_a^{-\rho} + \beta x_s^{-\rho})^{-\frac{1}{\rho}} \text{ s.t. } (1-\gamma)I = p_a x_a + p_s x_s$$

We assume that p_a and p_s are sufficiently large relative to total phone expenditure such that most people will choose against purchasing more than one phone. In this case, the optimal consumption of Apple phones versus Samsung phones will be:

$$x_a = \frac{(1-\gamma)I}{p_a + (p_a\frac{\beta}{\alpha})^{(\frac{1}{\rho+1})}p_s^{(\frac{\rho}{\rho+1})}}$$

$$x_s = \frac{(1-\gamma)I}{p_a + (p_a\frac{\beta}{\alpha})^{(\frac{1}{\rho+1})}p_s^{(\frac{\rho}{\rho+1})}}(\frac{p_a}{p_s}\frac{\beta}{\alpha})^{(\frac{1}{\rho+1})}$$

However, there is the second constraint that consumption of Apple or Samsung phones must be positive integer values because it is impossible to have a fraction of a phone or a negative consumption of a phone.

$$x_a, x_s \in \mathbb{Z} \geq 0$$

Can you connect your assumptions about the elasticity of demand to the model?

Rarely is the optimal point, or the point at which the marginal rate of substitution equals the price ratio, an integer value for both consumptions. This constraint pushes the individual consumer to purchase the maximizing bundle as the closest integer ordered pair under the budget constraint. For now, we do not consider this constraint because the utility function models the average of the aggregation of many people in the heterogeneous population. Consumptions for many people can average to non-integer values.

Market for Producers

Production Process. The producers in our market are the ones that make the phones: Apple and Samsung. Both producers, however, are the only ones that make each type of their phone. For instance, Apple is the only company that produces an iPhone. Therefore, Apple can set any price that they see fit for the iPhone. The same goes for Samsung and their line of smartphones. But because the Apple and Samsung phones are so similar there is still some competition between them so that the prices wont just skyrocket. Apple and Samsung both have very similar production processes. The production process is quite simple once the technology and design have already been created. Most of the hard work comes in the designing of the phone and the research behind the technology. Each new phone that is produced has better technology and a better design than the previous one. Once the technology and design are completed the phone is then assembled. Majority of the time, different parts of the phone are assembled in different factories and then all parts shipped to another factory to be put into one phone. Other times, the phone is assembled in the same place with different skilled workers working on various aspects of the phone. This type of production process calls for very high fixed costs. The company needs to have very good facilities for producing the goods. It is also inevitable that the company will be employing many workers and those salaries, even if they are low from worker to worker, will add up to be a large cost. Since majority of the work comes in the designing phases the company will most likely have many patents costing a large sum of money. Lastly for the fixed costs, after putting so much time, research, and labor into the product the company will spend substantial money on advertising their product to sell it. The variable costs are very low relative to the fixed costs. The only variable costs are the costs of the individual pieces that make up an individual phone. The production inputs for the phone can lie in two categories: capital and labor. Capital in this setting encompasses a vast amount of highly important aspects of producing a phone. There is very productive human capital: the engineers. Also, there is massive capital expenditures that can have substantial productivity boosts as they get better over time, like factories and machines.

capital & labor may also produce variable costs. Energy?

Production Function. The production functions for both Samsung and Apple can be modeled simi-

These companies also buy some parts from third party companies (Apple buys screens from Samsung itself)

larly but are not the same. These production functions can by modeled by a Cobb-Douglas production function.

$$Q(L,K) = L^{\alpha}K^{\beta} \text{ where } \alpha + \beta > 1$$

This would be the same function for both Apple and Samsung but the constants and exponents will be slightly different. This is a good model because Cobb-Douglas production functions are useful in describing the relationship between two or more inputs but particularly capital, K, and labor, L, and those are the two productions inputs here. Additionally, the constraint that $\alpha + \beta > 1$ is due to the increasing returns to scale. In this production function increasing capital will raise the production substantially. If an investment into a newer and more advanced piece of machinery is made then the production would raise exponentially.

Why this assumption?

Note: this is not describing increasing returns to scale. Those happen when you raise the amount of ALL the inputs.

Cost function. Now, we assume labor wage is w and rental rate of capital is r. These are the prices of labor and capital. The cost function can be derived from the production function and prices and inputs. Since we are in a short-run, capital cannot be adjusted so it stays constant. We can therefore give K a value for simplicity, $\bar{K}$. We first solve for labor in terms of production and the fixed capital.

OK. So it seems like you are not modeling R&D or product development at all.

$$Q(L,K) = L^{\alpha} * \bar{K}^{\beta}$$

$$L = \frac{Q^{\frac{1}{\alpha}}}{\bar{K}^{\frac{\beta}{\alpha}}}$$

Next, total costs are equal to variable costs and fixed costs. In the short run, labor is variable and capital is fixed. Thus, we have:

$$TC = VC + FC$$

$$TC = wL + rK$$

Are there any other fixed costs? See my comment above on R&D

In terms of Q, since all others are constants:

$$C(Q) = w * \frac{Q^{\frac{1}{\alpha}}}{\bar{K}^{\frac{\beta}{\alpha}}} + \bar{K} * r$$

Profit Maximization Problem. Except the special cases like nonprofit organizations or charities, the main purpose of a firm to take in inputs such as Labor and Capital and to produce outputs such as iPhone in our case is to maximize its profit. Therefore, after deriving the total cost function, the model Apple Co. wants the most is its profit maximizing model. Even though Apple Co. has a monopoly on iPhone, Apple Co. is still facing drastic competitions from other smartphone companies such as Samsung when the global

smartphone market is taking into account. For this reason, the price of iPhone is not completely determined by Apple Co. To a large extent, the price is still derived from this global market so in the profit-maximizing problem we are going to set up, we take price as a constant p. Then, we have profit is equal to total revenue minus the total cost. Using the cost function we derived earlier and the output prices, the specific profit maximizing problem can be constructed and analyzed.

$$\max_{Q} P(Q) = R(Q) - C(Q) \text{ s.t. } Q = L^{\alpha} * \bar{K}^{\beta}$$

After substitution:

$$\max_{Q} P(Q) = p * (\frac{Q^{\frac{1}{\alpha}}}{\bar{K}^{\frac{\beta}{\alpha}}})^{\alpha} * \bar{K}^{\beta} - w * \frac{Q^{\frac{1}{\alpha}}}{\bar{K}^{\frac{\beta}{\alpha}}} - \bar{K} * r$$

If we want to maximize the profit, we can find the FOC of the function shown above and find the relationship between Q and w, r, p, α, β. These symbols represent the constants so when Apple Co. plugs in real number in different circumstances, the function will give Apple Co. an estimation of what is the amount of iPhone to produce in this specific period to maximize companys profit. When the company knows the number of iPhones they should produce, they can just simply plug this number in the original $P(Q)$ function to predict the maximizing profit.

What about Samsung ?

Comment: you frame this as the market for iPhones, but it's really a market for smartphones where you used simplifying assumptions (only 1 iPhone model, only 1 major competitor, etc.)