CHALLENGING THE INCUMBENT: THE IMPACT OF PRODUCT QUALITY AND NETWORK EFFECTS

Research in Progress

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Abstract

This work explores the implications of product quality and network effect on the decision of a firm to enter a market with the goal of displacing an already entrenched incumbent. A conceptual model is developed to simulate a market of buyers and sellers. Simulations are carried out considering buying preferences based on product quality and network effects in conjunction with market characteristics like the prior existence of a customer base and population peculiarities. The simulation results are analysed to gain an understanding of conditions under which the new entrant might be able to displace the incumbent. In such situations a power law is observed to hold between the minimum quality of the product that must be offered by the entrant and the fraction of the population that favours product quality over herding inclinations. The findings contribute to the managerial understanding of the complex interactions between different forces that may affect market entry decisions.

Keywords: market entry, product quality, network effects, power laws.

1 Introduction

The decisions to enter a market with a new product may prove to be critical for firms, especially in a competitive environment. Further, devising a successful entry into the market when there is an existent dominant market player is a ‘difficult strategic problem’ (Carpenter and Nakamoto, 1990). However, successful displacement of the incumbent, where the entrant overtakes the incumbent as market leader, is not unheard of with personal computers and video games being famous examples. In addition, deciding when to enter the market becomes even more complicated when the product or service in question is amenable to network effects, especially because the installed base of the incumbent often acts as an entry barrier for the new entrant. In such scenarios, the quality of the product offered by the new entrant is expected to play an important role. But, previous research on the role of network effects and product quality in the success of products is inconclusive (Tellis et al., 2009). More importantly, research has shown that the impact of network effects, product quality and an existing installed base are not standalone.

The interaction between the network effects, quality and existing installed base motivates this research. To the best of the knowledge of the authors, there has not been any study that takes into account the impact of all the aforementioned factors in order to understand the dynamics of incumbent displacement. In an attempt to fill this research gap, this paper discusses a computer based model which simulates a competitive market for a product amenable to network effects (e.g. high-tech products). Though the market simulated is a simple one with only two products, the interplay between quality and network effects produces interesting results. This research finds that the relationship between the entrant's product quality and percentage of population favouring quality follows a power law. Further, the effect of the population size and population characteristics on the above relationship provide specific insights for managers who are either planning to launch a new product in the market in the presence of an established opponent or are defending their market position against an aggressive entrant.

2 Related Literature

The importance of a firm's timing of entry into the market has been highlighted in previous research. Specifically, the risk of premature entry must be balanced against the opportunity that may be missed due to late entry (Lilien and Yoon, 1990). First movers may reap advantages derived from technological leadership (learning curves, R & D, and patents), switching costs and pre-emption of scarce assets like input factors, geographic space and investment in plant and equipment (Lieberman and Montgomery, 1988). On the other hand, late movers may be able to gain advantage by identifying an overlooked product position, undercutting the incumbent, out-advertising and out-marketing the incumbent and continuously innovating the product (Shankar, Carpenter, and Krishnamurthi, 1998).

Literature also discusses the impact of network effects, defined as "the utility that a user derives from consumption of the good increases with the number of other agents consuming the good" (Katz and Shapiro, 1985) on market competition and consumption behaviour. Network effects promote customer lock-in, winner-take-all competition and encourage consumption based not only on intrinsic value, but also extrinsic value derived from outside the product itself, like installed base and existence of compatible and complementary products (Lee and O'Connor, 2003). The impact of network effects on the evolution of markets (Gupta et al., 1999), their influence on customer lock-in (Liebowitz and Margolis, 1995) and competition in the market (Farrell and Klemperer, 2007; Katz and Shapiro, 1985; Shankar and Bayus, 2003) along with their importance in protecting the market position of the incumbent (Mukherjee and Barua, 2011) are some of the streams that have been studied in literature. Srinivasan, Lilien, and Rangaswamy (2004) in their study show that network effects significantly decrease the survival duration of pioneers as the benefits derived by the pioneer from an installed base are outweighed by the increase in marginal utility over time and wait-and-watch behaviour of the customer in cases where network effects dominate.

In addition to network effects, quality effects have also emerged as an important theme of research over time. Product quality has been identified as a source of durable competitive advantage for new products (Cooper and Kleinschmidt, 1987; Lawless and Fisher, 1990). Product quality has been found to imply an aspect of comparison with competing products and to have a bearing on the ultimate success or failure of the product (Calantone and Benedetto, 1988). In fact, product quality forms an integral part of the 4 Ps of the marketing mix (McCarthy, 1978).

Previous studies have shown a complex interplay of network and quality effects on successful market entry. Product quality is found to positively influence market share of high-tech products (Tellis et al., 2009), while, market share has been shown to influence product quality through network externalities (Hellofs and Jacobson, 1999). Further, some researchers, like Etzion and Pang (2014), highlight the importance of product quality to derive benefits arising out of network effects, but, others show that network effects enhance the effect of quality (Tellis et al., 2009). Sun et al. (2004) in their research discuss optimal product strategy for firms in high tech industries with network effects. Wang et al. (2010) empirically examine the effect of cross-generation and within generation product compatibility on the survival of firms in 45 markets that exhibit network effects. In addition, an installed user base has been shown to have pre-emptive effects on entry similar to that of investment in capacity (Fudenberg and Tirole, 2000).

3 Methodology and Model

The predominant approaches identified in the stream of market entry are the empirically driven Marketing literature (Lilien and Yoon, 1990; Shankar and Bayus, 2003; Tellis et al., 2009; Wang et al., 2010) and the analytically driven Industrial Economics literature (Dhebar and Oren, 1985; Katz and Shapiro, 1985, 1986; Sun et al., 2004), both of which have discussed aspects of market share, order of entry, product compatibility, and advertising strategy. While both these approaches allow a static treatment to market entry, it has been argued that markets governed by network effects give rise to increasing returns where market outcomes are path-dependent and stochastic (Arthur, 1990). As a result, recourse towards computer simulations in such scenarios has been suggested (Weitzel et al., 2000). Given the dynamism and interactions between the factors influencing market entry, simulation was considered a fitting methodology to undertake this study. The simulation model developed herein mimics a simple market with buyers and sellers (typically selling a high-tech product or service). Individuals in the buyer population are divided into two mutually exclusive categories, viz. network effects favouring and quality favouring. Motivation for differently treating network effects favouring and quality favouring buyers may be drawn from real life illustrations of such markets. For example, the market for certain mobile applications and games, such as WhatsApp, Skype, Viber, Candy Crush Saga, etc. exhibits stronger network effects in comparison to quality effects. Contrarily, the markets for smart phones, tablets, etc. will exhibit stronger quality effects in comparison to network effects. In order to obtain meaningful yet tractable results based on the interplay of actions among the network effects favouring and quality favouring buyers, the marketplace is assumed to have only two sellers, one being the first mover / pioneer / incumbent and the other being the late-mover / follower / entrant.

During the course of the simulation, individuals in the buyer population are picked up sequentially and are expected to decide which of the two competing goods/services, offered by the incumbent and the entrant respectively, to buy. This decision is based on the population category to which the individual belongs. If the individual is quality favouring then the individual probabilistically chooses one of the competing goods/services in proportion of their quality. On the contrary, if an individual is network effects favouring, then the individual probabilistically chooses one of the two competing goods/services based on the proportion of individuals already subscribed to it.

The notational representation of the probability that an individual purchases either the product/service of the incumbent or the entrant is as follows. Let n_{ij} and n_{ej} be the number of individuals subscribed to the incumbent and the entrant respectively, immediately before an individual j chooses to subscribe to either of the incumbent or entrant. Further, let p_{ij} and p_{ej} be the probability that this individual j subscribes to the incumbent and the entrant respectively. Then $p_{ij} = \frac{n_{ij}}{n_{ij}+n_{ej}}(1-q) + \frac{q_i}{q_i+q_e}q$ and, $p_{ej} = \frac{n_{ej}}{n_{ij}+n_{ej}}(1-q) + \frac{q_e}{q_i+q_e}q$, where q is the percentage of population favouring quality, and q_i and q_e are the product/service quality of the incumbent and entrant respectively.

The intent of the simulation is to identify conditions which allow the entrant to displace the incumbent. Market share which is considered an important determinant of profitability (Branch, 1982) has been used to signify the winner between the incumbent and entrant. Further, in many real life markets, entrants may be young firms or start-ups which may be vying for venture capital funding by garnering a large enough market share (Mishra, 2015) rather than focusing on profitability. As a result, despite the limitations of market share as a measure of performance, it is a useful criterion for the purpose of this study. The winning condition for the entrant is when it is able to garner support from more than fifty per cent of the entire population, irrespective of any initial market share.

Each run of the simulation involved polling by all individuals of the population. That is to say that each run of the simulation consisted of iterations equal in number to the number of individuals in the population. In each iteration, an individual was randomly picked from the population of individuals who were not yet subscribed to any of the products or services on offer in the market. Depending on whether the chosen individual belonged to the percentage of population favouring quality or network effects, the individual probabilistically chose one of the two products or services. The iteration ended when all individuals in the population had subscribed to either of the two products. Several runs with the same set of parametric values were performed and the market shares garnered by the incumbent and the entrant were averaged over these runs. Subsequently, the entrant was considered a winner if, on an average, it had gathered a user base of more than fifty per cent of the total population.

Simulations with different parametric values were carried out and parameter values were recorded for those runs in which, at the end of the run, the entrant garnered an average market share of more than fifty per cent. In other words, scenarios which allowed the entrant to displace the incumbent were recorded. The list of the parameters and their ranges used to mimic different market scenarios are shown in Table 1.

Parameter	**Description**	**Range**
Population (N)	The total base of buyers which is of interest to the two sellers and each buyer buys exactly one product.	$N \in \{ 50, 100, 200, 500, 1000, 2000, 3000, 4000\}$
Incumbent Base (IB)	Subscriber population base of the incumbent at the time of entry of the entrant. Modelled as a fraction of population (N).	$0 \leq IB \leq 0.3$; step size 0.05
Entrant Base (EB)	Subscriber population base which is committed to purchase the product or service from the entrant. Modelled as a fraction of Incumbent base (IB).	$0 \leq EB \leq 0.9$; step size 0.05
Percentage of Population Favouring Quality (q)	Proportion of the prospective population (total population less the incumbent and entrant base) which prefers to buy a product on the basis of its quality	$0 \leq q \leq 1$; step size 0.02
Percentage of Population Favouring Network Effects (n)	Proportion of the total population which chooses one of the competing products or services on offer in the market on the basis of the number of other individuals in the population subscribed to the said products or services.	$1 - q$
Entrant Quality (Q)	Level of quality provided by the entrant as a multiple of the quality provided by the incumbent.	$1 \leq Q \leq 5$; step size 0.1

Table 1. Parametric ranges for simulations.

4 Results and Discussion

Of approximately 39000 unique simulation runs (with each unique simulation being an average of 100 runs with the same set of parameters), in 630 simulation runs the entrant was able to displace the incumbent. Henceforth, the minimum quality offered at which the entrant is able to displace the incumbent is referred to as Q*. Given the low success rate of approximately 1.6%, the decision to enter a market and compete with an incumbent in the presence of network effects is laden with high risks and therefore necessitates managerial attention.

4.1 Relationship between q and Q*

For a low value of q the entrant can displace the incumbent only when it can also garner support from the remaining population favouring network effects. For network effects to come into play, initial support from as many individuals favouring quality is necessary. By providing a much higher quality than the incumbent, the entrant is able to buy support of a larger proportion of the population favouring quality, which in turn drives the network effects. However, when q is high, the entrant who enters the market even with a marginally higher quality can expect to displace the incumbent, since it can exercise influence over a large percentage of the entire population which is constituted of individuals favouring quality.

When Q* was plotted as a function q, it was observed that the relationship follows a power law. For instance, when the incumbent base was 15% an exponent of 1.5 and an R^2 of approximately 0.97 was observed (Figure 1). Similar power law distributions and fit were observed for other values of incumbent base. Figure 1 also shows a region of inaccess, henceforth referred to as 'inaccessible market', where the entrant cannot displace the incumbent. The reason for power-law between q and Q* is the preferential attachment and rich get richer dynamics associated with network effects (Easley and Kleinberg, 2010). To displace the incumbent, incumbent base needs to be offset by a higher value of Q*. The strength of offset is moderated by the percentage of population favouring quality. However, because of the stochasticity and path dependence process, as indicated in the probability equation mentioned in Section 3, there is a nonlinear relationship between the probability of a customer opting for the new entrant's product and percentage of quality favouring population. This non-linearity gives rise to the observed power-law relationship.

Proposition 1: *The minimum quality required by the entrant to displace the incumbent increases exponentially as the the percentage of population favoring quality decreases.*

4.2 Effect of Incumbent's Base (IB) on relationship between q and Q*

An additional factor which may influence the value of Q* with respect to q is IB. As IB increases, the entrant has a smaller prospective population base to attract. Therefore, when IB is low, the entrant may be able to displace the incumbent with a lower additional quality, however, when IB is high, the entrant must enter with a much higher level of quality than the incumbent in order to favourably influence the prospective population base. As a result, when observed graphically, there is a north-eastward shift in the power law relation between q and Q* as the value of IB increases (Figure 2). As a result of this shift, the "inaccessible market" widens as IB increases. The increase in IB may also be a natural phenomenon happening over time. Therefore, the risk involved in entering the market increases as the decision to do so is postponed.

Proposition 2: *The minimum quality required by the entrant to displace the incumbent increases as the initial incumbent base increases.*

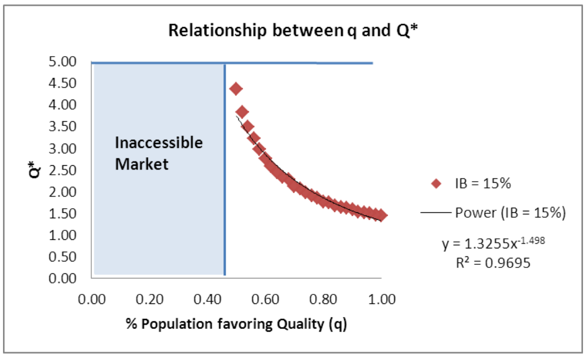

Figure 1: Power law relationship between q and Q

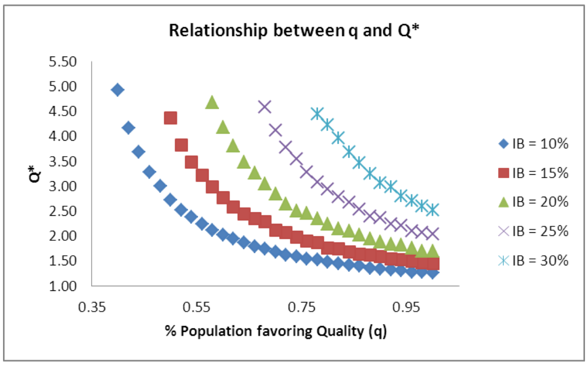

*Figure 2: The effect of IB on relationship between q and Q**

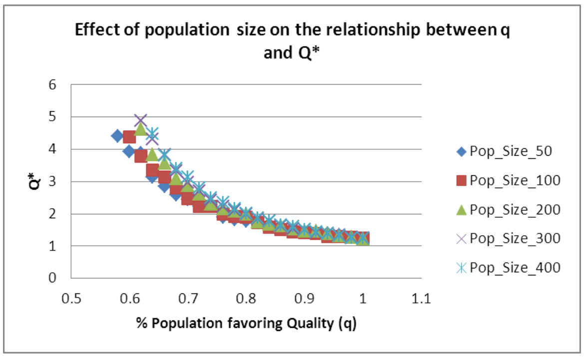

*Figure 3: Effect of N on relationship between q and Q**

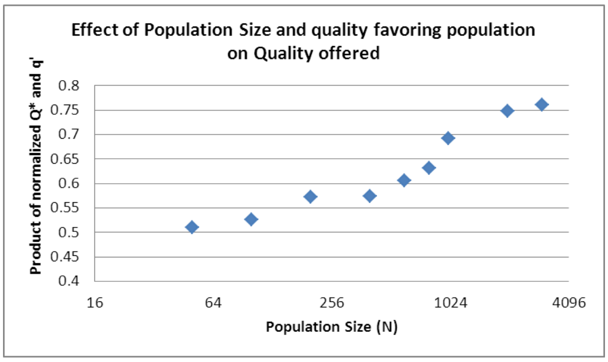

Figure 4: Increasing relation of (normalized Q x q') with N*

4.3 Effect of Population Size (N) on relationship between q and Q*

The relationship between q and Q* is also likely to be influenced by the size of the population in a market. For the same percentage of population favouring quality, the entrant may displace the incumbent in a smaller population market by providing a lesser quality than it needs to provide in a market with larger population. This is represented by the initial north-eastward movement of the power law in Figure 3. However, as the population size of the market increases, the power law distribution converges. The reason for this observation is that as the value of q increases, the strength of network effects in the population decreases such that no network effects exist when the entire population favours quality. Further, Figure 4 shows that the product of normalized Q* with the minimum value of population favouring quality (q') required to displace the incumbent follows an increasing function. This means that for the entrant to win in a larger population market, either it must provide a higher quality or the market must have a higher percentage of quality favouring people.

Proposition 3: *As the percentage of population favouring quality increases, the minimum additional quality required by the entrant to displace the incumbent in a larger market decreases.*

Proposition 4: *For a given product quality, when the population size is small, the entrant may displace the incumbent even if the percentage of population favouring quality is low. However, when the population size is large, the entrant may win only if the percentage of population favouring quality is high.*

5 Conclusion

This work aims at understanding the effect of quality and network effects on the decision to enter a market in the presence of an incumbent. The results show that there is a power law relationship between the minimum quality required to displace the incumbent and the percentage of population which favours quality. Further, it is found that as the initial size of the incumbent's base increases, only markets with higher percentage of population favouring quality remain accessible to the entrant. In addition, for markets with smaller population size, the entrant may be able to displace the incumbent only when it either provides a higher quality or a large percentage of people favour quality in this smaller market. Converse results are observed for markets with larger populations. Though the model is parsimonious and is still in its infancy, the results obtained are important for firms which are planning to enter a product market in which an incumbent already exists and the product is prone to network effects. However, the model in its current form is limited and does not account for different strategic and investment considerations made by the incumbent and the entrant. Further, the survivability of the entrant after displacing the incumbent is not accounted for. It must also be noted that in a real market, it is hard to come across categories of buyers which are mutually exclusive. The assumption about merely two sellers is also unrealistic. However, the model succeeds in its intent to qualitatively provide directions for market entry subject to population characteristics, product quality, and initial market share. In this ongoing work, implication of price and cost structures on market entry decisions is being explored and relaxing the assumption of mutually exclusive population categories is being considered.

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