Network Effect as a Competitive Edge: What Have We Learnt From the Literature?

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Network effect is defined as the value that an additional user of a product has on that product's value to others. In an industry exhibiting network effect, firms need to consider the possible role of the network being the establishment of a competitive edge. In this review, our goal is to synthesize the broad literature on network effects, and we put forward the argument that, in practice, network effect has quietly become a key factor in forming a firm's competing strategy. In the presence of positive network effects, consumers' willingness to pay is an increasing function of the network size.

Keywords: network effects, network externalities, path dependence, increasing returns

INTRODUCTION

Network externality is defined as a change in the benefit, or surplus, that an agent derives from a good when the number of other agents, consuming the same kind of good, changes. In other words, the utility, that the agent derives from the consumption of the good, changes with the number of other agents consuming the same good. Thus, network externalities exist when the value of a good or service is affected by the number of buyers or users.

A product displays positive network effects when more usage of the product by any user increases the product's value for *other* users. Although it is a more general concept than *network externality*, much of the theory underlying network effects was developed in order to study network externalities, and the two terms are still used interchangeably.

Network effects were first studied in the context of long-distance telephony in the early 1970's (e.g. Rohlfs, 1974). They are now widely recognized as a critical aspect of the industrial organization of IT industries, and are prevalent in a wide variety of sectors, including software, microprocessors, telecommunications, and e-commerce.

According to Katz and Shapiro (1985), there are several possible sources of network effect and the utility that a given user derives from the good, depends on the "scope" of the network. The scope of the network can include a unique firm and its product, or comprise of the outputs of all firms producing the same/similar goods.

Microsoft is an example of being the unique firm in a network. Its Office package dominates the market. An end user may benefit from using Office because of the number of other users employing the same

package. The automobile market is another example in which the sales of only one firm can constitute the relevant service network.

Examples of multiple firms (and products) forming the network include the telecommunications industry. In this industry, the various end users connect the phone line system together allowing them to exchange messages with one another. Joining such a network is valuable because many households and businesses together provide components for the overall system and, as a result, the value of membership is an increasing function of the size of the network (Katz & Shapiro, 1994). Hence, the network is shared by many firms providing the telephone service.

While network effect has received significant research effort, the attention focuses mostly on the market equilibrium and product compatibility decisions, either in a monopoly context (Oren & Smith, 1981) or in an oligopolistic setting (Katz & Shapiro, 1985). Several predictions emerge: firstly, if consumers expect a seller to dominate, then consumers will be willing to pay more for the firm's product, and the firm will, in fact, be dominant. Secondly, firms with good reputations or large existing networks tend to be against compatibility, while firms with small networks or weak reputations tend to favor product compatibility. Thirdly, firms may use up their allocated expenditure in order to influence consumers' expectations in an attempt to maintain or enlarge their networks.

Our goal, in this study, is to synthesize the broad literature on network effects with a focus on the possible role of the network being the competitive edge. We believe that, in practice, network effect has quietly become a key factor in forming a firm's competitive strategy. It is our hope that our review can stimulate further academic attention, particularly with regard to how firms formulate the competing strategies incorporating the concepts derived from the understanding of *network effect*. This is particularly true in some industries where a significant element of networking is a necessity for survival.

We do not claim to provide an exhaustive review of this literature, since our views, interests, and backgrounds largely influence our emphasis and inference. This review is structured as follows: Section 1 is the introduction; Section 2 provides a summary and discussion on the various aspects of *network effect*; Section 3 discusses compatibility and standardization; Section 4 deals with increasing returns and path dependence; and Section 5 provides a discussion and conclusion.

THE VARIOUS ASPECTS OF NETWORK EFFECT

A product's value, as perceived by consumers, can be separated into two distinct parts. The first component is the value generated by the product itself, even if there is no network effect. The second component is the additional value derived from the network, and it is this latter value that is the essence of network effects. There is a complex set of economics issues that underlies the characterization of network effects. Consider, for instance, the following:

Direct and Indirect Network Effects

There are direct and indirect network effects pertaining to the externality of the network. With the direct network effect, one user's purchase of the product impacts directly on the welfare of other users. The value of one user's membership is affected when other users join, and hence enlarge the network. The previously mentioned telecommunications network is a good illustration of this effect. However, it is the indirect network effect that emerges here as one user's use of the product has no direct impact on other users. Instead, the decision to adopt may have a lagging effect through the provision of related products that belong to the same network (Economides & White, 1994). The hardware/software paradigm in Katz and Shapiro (1994) exhibits the indirect network externality. In this context, the availability of compatible software greatly affects consumers' purchasing decisions of a durable hardware solution. The amount and variety of software that is available for purchase for a given item of hardware is an increasing function of the number of hardware units that have been sold. For instance, when consumers have positive expectations of a particular operating system, they will be more willing to purchase the computers that "operate" on or use the given system. In the example of personal computers, the indirect network effect may help justify the reason that over 95% of personal computers in the market are embedded with Microsoft's Windows

system while the system itself is not necessarily superior to other similar systems with respect to functionality.

Compatibility, Expectations, and Coordination

According to Katz and Shapiro (1994), there are three important issues for exploring the economics of networks: compatibility, expectations, and coordination. Firstly, with regard to the issue of compatibility, can a product designed to work in one system also work in another system? A large and well-connected set of users is essential for the survival of some particular products/systems. These interactions not only affect the evolution of the network, but also affect the demand and supply of the product or service. Compatibility often poses strategic trade-offs for firms. On one hand, the trade-offs are between the performance and backward-compatibility of evolving product lines. On the other hand, they are between openness and control of core technologies. Nevertheless, since ensuring the evolution of shared technology standards is critical in network industries, it can be difficult to have core technologies in control when competing firms each want their R&D to be well-represented.

Secondly, in many cases, the products purchased for a single system are spread over time. Hence, consumers must form expectations about the availability, price, and quality of other components that they will be purchasing in the future. Firms may need to exert effort in order to influence consumer expectations to ensure a competitive network size.

The final issue is coordination, an example of which is if a firm is contemplating whether to develop a new product they must know whether the complementary components will be available. In other words, the firm may gain little by introducing the product without obtaining some level of information or control over the development and availability of the other components. Coordination appears to be a complex issue and poses a great challenge for firms as well as for consumers. In order to make a purchasing decision of a product in the network, consumers not only form expectations about the other products but also must form predictions about the future of the associated network. As a result, consumers' willingness to pay is an increasing function of the expected size of the network.

The studies on systems competition tend to revolve around how compatibility, expectations, and coordination affect the decisions of consumers and firms. Let us consider, for instance, what forces determine consumers' choices among rival incompatible networks, and which firms will seek compatibility and which will not. When increases in usage cause an increase in value across all users, this creates a form of increasing returns, which changes the nature of competition substantially. Theories of competition in network industries emphasize the path dependence of outcomes and suggest that early leads are important. It is not unusual to see intrinsically inferior products dominate superior products, since the influencing of customer expectations plays a crucial role in "winning". It is these increasing returns that often lead to an equilibrium in which a single firm or product dominates an industry segment. A few related issues, from this perspective, include whether or not the emergence of a dominant firm/product is an efficient outcome, and would the installed base of users serve as the entry-deterrent (e.g. Fudenberg & Tirole, 2000; Sundararajan, 2003)?

COMPATIBILITY AND STANDARDIZATION

Compatibility

In a market where there is a network effect, users' decisions to purchase goods is related to the number of people that are directly or indirectly consuming them. The direct consumption concerns the purchase of the product, while the indirect consumption reflects the use of products that are compatible with it.

To gain access or to maintain supremacy in the market with network effects, firms must choose to compete in one of two different domains. In the first domain, firms would compete with one another on the basis of increasing the number of users in their own network, with the eventual goal of establishing a market-dominating network. Consider, for instance, the competition between Apple's iOS and Google's Android – the two companies' software development platforms. Both firms would try to build their own networks by involving both end users and software (i.e. APP) developers. Their platforms are incompatible

for the purposes of differentiation and "locking in" customers, and with the hope of multiplying the networks. While more developers join the network, more consumers would be willing to purchase the durable product, and vice versa.

In the second domain, firms decide to make their products compatible, which would move the competition to a different dimension. The aforementioned telecommunications industry is a good example. The network compatibility is valuable to the firms because the compatible phone line system allows the end users to exchange messages with one another. The value of membership is an increasing function of the size of the network. Thus, the firms providing the telephone service compete within the network with respect to price and quality of their services.

When competition is between two incompatible products, the characteristics of the "network markets" can lead to the dominance of one product, which may not necessarily be the better nor the cheaper product. According to Besen and Farrell (1994), consumers' decision to join the network has more to do with their expectation of the size of the network than with the quality of the product. Therefore, firms focus on influencing these "expectations" as part of the strategy to enter into or to remain in the industry. Since the ultimate goal for firms is to materialize profitability by increasing and maintaining a greater network size, only some firms find this strategy beneficial. Katz and Shapiro (1986) used the private and social costs of compatibility to determine the types of firms that are likely to favor "incompatibility". They found that firms that are already established (i.e. having a good reputation and/or a large existing network) will be against "compatibility", and those less established are likely to favor "compatibility". This preference holds even when compatibility is welfare-increasing for the former group.

Incompatibility, as a strategy, is a logical choice for the large established firms because it fits naturally into its ultimate goal of being the dominant firm on the market. Products that are incompatible across generations and even incompatible within a generation allow these firms to keep competition at bay. According to Besen and Farrell (1994), the cost of switching can be too high for consumers even if they suspect the product of the less established firm to be of better quality and price. Therefore, the more established firms can continue to enjoy primacy as they push competition out of the market. The authors mentioned that some firms use "penetration pricing", which is defined as the process of offering low prices to the newest customers who will be "locked in" for the long-run. These consumers are in for the long-run but will only consume the given products and all their auxiliaries because other products are not compatible. Firms may also use marketing schemes, like "puffery" to enhance their standing, price commitments to assure the clientele, and product pre-announcement to excite their customer base about a new and upcoming product. These tactics are all designed, not only to keep the firm's established base from shrinking, but to increase it by discouraging consumers from consuming competitors' products.

Although "incompatibility" may be used as a strategy by some firms to establish dominance, it is not necessarily a sustainable choice. On one hand, fierceness of competition can lead the firms that are trying to establish or maintain dominance to spend or forgo a portion of their potential profits in order to attain their goal. Economides (1989) showed that firms can charge higher prices and reap higher profits under a regime of compatibility in the absence of positive network externality. On the other hand, consumers may find the regime of incompatibility not only expensive, but restrictive, as they can only otherwise use the alternative products available in the market. Gandal (1995) illustrated that the number of compatible products in a specific network provides variety in the number of complementary goods, and this benefits consumers.

Additionally, Wang, Chen, and Xie (2010) divided the product incompatibility into two groups – *cross-generation* and *within-generation*, and asserted that the survival of the pioneer firms depended on this differentiation. They noted that under cross-generation incompatibility (between products of different generations), the leading firm has the advantage, as it can define the consumer preference. Consumers that are already "locked- in" may have to wait for the new technology until the leading firm releases it. New entrants into this market are able to introduce a new product, but it will not be easily accepted by the consumers. They also noted that "within-generation" incompatibility can lead to a negative impact on the pioneer's survival because the new entrant can introduce new and better-performing distinctive products.

The new entrants can appeal to the customers of the pioneer's network by fulfilling their demands, both in quality and price, since these are brand new products; although the switching costs can be high.

Moreover, Economides and White (1994) distinguished between compatibility and complementarity as they explain that "compatibility makes complementarity feasible". In their paper, they noted that complementarity can be divided into different degree categories and that firms can reduce or eliminate the complementarity of their product if they choose to do so. This is because the product (system) may have many components and the choice of making any of the components compatible (complementary) is solely up to the firm, and this can lead to "exclusion."

Finally, Economides (1989) noted that products are compatible if consumers are feasibly able to combine them inexpensively into a working system. Compatibility, depending on the circumstances, can be adopted, either independently by the participating firms, or through "explicit acts of coordination" (Encaoua, Michel & Moreaux, 1992). To make their products compatible, firms therefore agree on the standard. However, this move will shift the competition into new dimensions, including price, service, and product features (Besen & Farrell 1994).

Standardization

The literature of standards is imbedded with extensive studies on network effects. A primary concern is the choice of a correct standard in the presence of competition and network effects (e.g. Besen & Farrell, 1994; Farrell, 1996; Farrell & Saloner, 1985; Katz & Shapiro, 1985; Liebowitz & Margolis, 1996).

According to Farrell (1996), standards often are developed through a process of explicit consensus. When participants have little vested interest in particular outcomes, the process will be straightforward with only a possible free-rider problem. However, if participants have strong vested interests, it will be difficult to reach a consensus as each participant holds out for agreement on its preferred standard. Lemley (2002) argued that standardization can be achieved through a private organization that is open to all companies, and that sets the standard of interoperability between products. These standard setting organizations, although running the risk of creating an "anti-competitive" environment through collusion and exclusion, may be more desirable than the "de facto standardization" which is a result of market dynamics, such as firms responding to a change in consumer preferences. He believes that within third-party-initiated standardization, competition exists, but only for the products in compliance with the defined standards. However, the standard setting process may be influenced by the participation of the firms in external organizations or consortia (Leiponen 2008). Through cooperation in research and development, the consortia are mainly geared towards "knowledge accumulation", as opposed to standard setting organizations that can be influenced by connections (such as the relationships between SSO and the participating firms).

Under "de facto standardization", firms standardize in order to respond to a change in taste or consumer preferences. In such a situation, firms' strategies to standardize and compete depend on their relative strength and established networks. There are cases where firms opt for compatibility but with the caveat that their technology is to be used as the standard. This opens a new competition regime in which each firm wants others to adopt its technology. Besen & Farrell (1994) noted that firms get into bargaining games in resolving the issue with strategies, including commitments (investing in R&D) and concessions (low cost licensing, hybrid standard, joint venture, etc.). These are all designed to attract, to convince, and sometimes to reassure competitors that they are not going to be at a disadvantage.

There are also cases where the dominant firm(s) would prefer inter-technology competition, which normally leads to "incompatibility". However, the small firms, wanting to be part of the network, will push for compatibility by either committing to the technology or by simply imitating the leading firm. The leading firm may try to prevent the competing firms from forceful imitation by the enforcement of intellectual property rights and/or frequent changes of the technology (Besen & Farrell, 1994; Encaoua, Michel & Moreaux, 1992).

INCREASING RETURNS AND PATH DEPENDENCE

Increasing Returns

When increases in usage cause an increase in value across all users, this creates a form of increasing returns to scale in consumption and changes the nature of competition dramatically. The literature challenges the traditional view in economics of decreasing returns in production and grants primacy to economies of scale. As a result, firms in an industry exhibiting network effects will need to consider the confluence of two competing forces – the conventional decreasing returns in production costs and the increasing returns in consumption, due to network effects.

Positive network effects have impacts that are very similar to firm-level economies of scale. Network benefits give rise to demand-side economies of scale, which will vary with consumer expectations. The value, to a buyer, of an extra unit is higher when more units are sold, everything else being equal. This defies the Law of Demand, which states that consumers' willingness to pay for the last unit of a good decreases with the number of units sold. The existence of "network effects" implies that as more units are sold, the willingness to pay for the last unit may be higher. Assuming that firms are producing incompatible products, the firms with the larger market share will have an advantage over their smaller competitors. These increasing returns often lead to an equilibrium in which a single firm or product dominates an industry segment. A product from a firm with a large market share, therefore, is more valuable to consumers and hence leads to inequality of market shares among competitors.

Economides and Flyer (1998) showed the extent of market share inequality in network industries. As a benchmark, they assumed that all firms produce identical products except for whatever quality is added to them by network effects. They also assume that no firms have advanced technologies over others in terms of production and platform. In the extreme case of "pure network goods" where there is no value to the good in the absence of network effects, the equilibria they derive exhibit extreme inequality. The largest firm (in terms of market share) captures the majority of the total sales. Any entry (into the market) after the third firm has practically no influence on the output, prices, and profits of the top three firms, as well as the consumers' and producers' surplus. From the fourth one on, firms are so small that their entry hardly influences the market. Moreover, in Arthur's (1989) basic analytical framework, he treated "small events" as random. Those random events lead to early fluctuations in the market shares of competing networks. As one of the networks gain enough of a lead in market share, it will offer higher value to every consumer and become dominant.

Nevertheless, network effects are not sufficient to make a firm dominant. This is due to several reasons. Firstly, if production costs exhibit decreasing returns and if the decreasing return overwhelms the network effects, multiple competing incompatible networks will be possible instead of one dominant firm. Secondly, the network size may exhibit decreasing returns. If a network size reaches a point where additional participation does not provide additional value to participants, increases in scale would no longer be advantageous and it would then be possible for multiple firms and networks to compete in the market (Matutes & Regibeau, 1992). Thirdly, firms may have resource constraints. Radner (1992) formalized a model where the limitations of management restrict the size of the firm. The capacity constraints suggest the influence of resource limitations on the performance of a network. Fourthly, consumers may have heterogeneous tastes and assessments of different networks. The differences in consumer preferences make it feasible for competing networks to coexist in the market.

Path Dependence

The concept of network effect has also played a role in the literature of path dependence (e.g. Arthur, 1989, 1990; David, 1985; Liebowitz & Margolis, 1990, 1995). Path dependence is a related but different concept from mere increasing returns. It is used in many organizational research papers to describe a mechanism that connects the past and the future in an abstract way (Vergne & Durand, 2010).

Path dependence theory was originally developed by economists to explain technology adoption processes and industry evolution. With path dependence, an economic process may achieve one of several equilibria instead of progressing steadily toward some pre-determined and unique equilibrium. Both the

starting point and "accidental' events can have significant effects on the ultimate outcome. In some instances, inferior products can persist simply because of the legacy they have built up.

There are different forms of path dependence. The most trivial form is based simply on the durability of capital investments. An inferior capital good may remain in service simply due to the fact that its fixed costs are already paid for and there is an expensive switching cost. Path dependence can also emerge due to the increasing returns to the extent of use, for instance, the network effects. According to David (1985, 1987), there are three conditions for path dependence. The first condition is the technical interrelatedness of system components. The second, network effects, while the third is switching costs. Together, the three conditions may lead to a particular path of outcomes. Consider as a first example, the QWERTY vs Dvorak layout of a computer keyboard which shows how a standard that is first-to-market can become entrenched. According to David (1986), QWERTY's triumph over its initial revivals resulted largely from the happenstance that typing schools and manuals offered instruction in eight-finger "touch" typing first for QWERTY machines, which, in turn, encouraged office managers to buy QWERTY machines and typists to learn QWERTY. This network effect increased the QWERTY market share until it achieved dominance. As a second example, four feet 8 ½ inches is the standard gauge for railways throughout North America and throughout over half of the world's railway routes, yet the consensus of engineering opinion has usually favored gauges broader than four feet 8 ½ inches. One key reason leading to the preference for the sub-optimal standard gauge is the technical interrelatedness of railway tracks and the wheel sets of rolling stock. Since railways almost never replace all their track and rolling stock at the same time, the gauge, which was first adopted more than two hundred years ago, is the gauge now used for much more powerful freight shipments and faster passenger trains.

NETWORK EFFECT AS A COMPETITIVE EDGE

A firm's competitive advantage includes access to natural resources, highly skilled labor, an optimal geographic location, high entry barriers, and access to new technology. In a network industry, the network effect may, in fact, be the most important leverage the firm has over its competitors.

The feature of significant market share inequality does not imply that competition in a network industry is weak. Competition, on which firms will create the top platform and reap most of the benefits, is very intense. Firms compete with each other in the race to be the dominant firm. Consider the aforementioned example of "Apple vs Android" – the competition between Apple and Google. Both companies' future will be less about hardware and more about their "ecosystems" or "networks"— a combination of software, services, data and a plethora of partners.

If Apple were simply a hardware-maker, there would be reason to worry. It is losing market share to rivals, such as Samsung of South Korea and Xiaomi of China, which make cheaper devices, and to Google's Android operating system, which runs on 71% of the world's smartphones. The higher price is good for profits, but it makes Apple increasingly a niche player.

Still, many consumers are likely to stick with their iPhones and Apple Watch because of the firm's ecosystem. Apple is considered a laggard when it comes to its online offerings, especially since it bungled the launch of its map service. Its services and apps can be maddening. But iTunes, Apple's media store, now boasts more than 800 million active users. Apple's software and services category, which includes iTunes, Apps Store, and revenues from warranties, is growing steadily. The more Apple-gadget owners store their data in them, from photos to health information, the more they are locked in, and must stick with Apple. At the same time, Apple is trying to become more open to partners — a big change for the firm. There has always been huge tension between keeping control and opening up at Apple. The late Mr. Steve Jobs saw Apple products as complete works of art and never wanted them unbundled. Yet in 2003, iTunes became available on Windows (i.e. compatible) – a decision that dramatically increased sales of the iPod. This opening-up may need to go further, in order to keep up with Google's ecosystem. The internet giant's services still beat Apple's, and it not only lets device-makers modify Android, but also gives it away.

The installed base of users may serve as the entry-deterrent and the ignorance of network effect can be lethal. Fudenberg and Tirole (2000) developed a model of pricing to deter entry by a sole supplier of a

network good (i.e. the product that displays network effects). They showed that the installed base of a network good can fill a preemptive role similar to that of investment in physical capacity if the entrant's good is incompatible with the incumbent's good and there are network benefits in demand. In the market for video players, VHS overcame Betamax after only six years of a higher installed base by Betamax. It is clear that Sony mistakenly disregarded the network effects that arose from the availability of rental tapes of pre-recorded movies. In personal computers, Apple lost the battle against Microsoft because it refused to license its operating system to other hardware-makers.

The existence of an installed base of consumers favors an incumbent. However, potential entrants with significant product advantages, or a better pricing strategy, can overcome the advantage of an installed base. If entry occurs, consumers face a tradeoff between inherent quality and network benefits. The price the consumers are willing to pay depends on their forecast of future network benefits. A smaller network may reduce consumers' initial willingness to pay for the product.

However, while entry of competitors reduces prices and profits, the addition of their production to the size of the network improves the demand functions facing all network members. This allows all members (the entrants and incumbents) to sell higher volumes and allows them to charge higher prices. Thus, if this effect is strong enough, the network effect may overshadow the standard competitive effect of entry (Economides, 1996).

With the presence of network effects, firms need to include the decision of compatibility in their formulation of competing strategy. Compatibility can have positive and negative effects. Although compatibility may decrease the competition between firms at the technology level, it intensifies competition at the price, service and product features levels. Compatibility may also slow down the development and introduction of new technology to the market. Speculations suggest that it may reduce the development of new technology, yet many new technologies have been successfully introduced.

Nonetheless, in a network industry with incompatible products, the demand curves are more elastic when consumers derive positive value from increases in the size of the market (Liebenstein, 1950). When products are incompatible, consumers' expectations and firms' reputations play an important role in obtaining market equilibrium. Firms may extend their expenditure to influence consumers' expectation.

CONCLUSION

In this review, we synthesize the literature of network effects in the context of firms' competing strategy. Firms need to consider several variables in their strategic thinking including the presence of network benefits. Firstly, network effects give rise to demand-side economies of scale. The value of an extra unit, to a buyer, is higher when more units are sold and hence as more units are sold, the willingness to pay for the last unit may be higher. Therefore, a product from a firm with a large market share, is more valuable to consumers and hence leads to inequality of market shares among competitors.

Secondly, in order to make a purchasing decision of a product in the network, consumers must form expectations about the future of the network. The smaller the network, the less likely consumers are to purchase the product. Hence, from the firm's perspective, influencing customer expectations plays a crucial role in surviving a network market.

Thirdly, firms will need to include compatibility in their formulation of competing strategy. Compatible products intensify firms' competition in a network, however consumers will have more purchasing options thus improving the demand functions facing all network members. This allows all members to sell higher volumes and allows them to charge higher prices. Yet when products are incompatible, consumers' expectations and firms' reputation play an important role in developing their network.

This review suggests that a dynamic game theoretical model is needed to examine the competing behavior of firms in a market in which networks are necessary for survival. We note that the model will need to include network effect in a firms' production functions. With the presence of network effects, a firm's production function will exhibit decreasing returns to production costs and increasing returns to consumption. The network effect is then a function of compatibility decisions and consumers' expectations.

We believe that the dynamic nature of the model helps to explain why firms compete in the context of building up a network, influencing consumer expectations, and the decision of compatibility.

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