Network effect

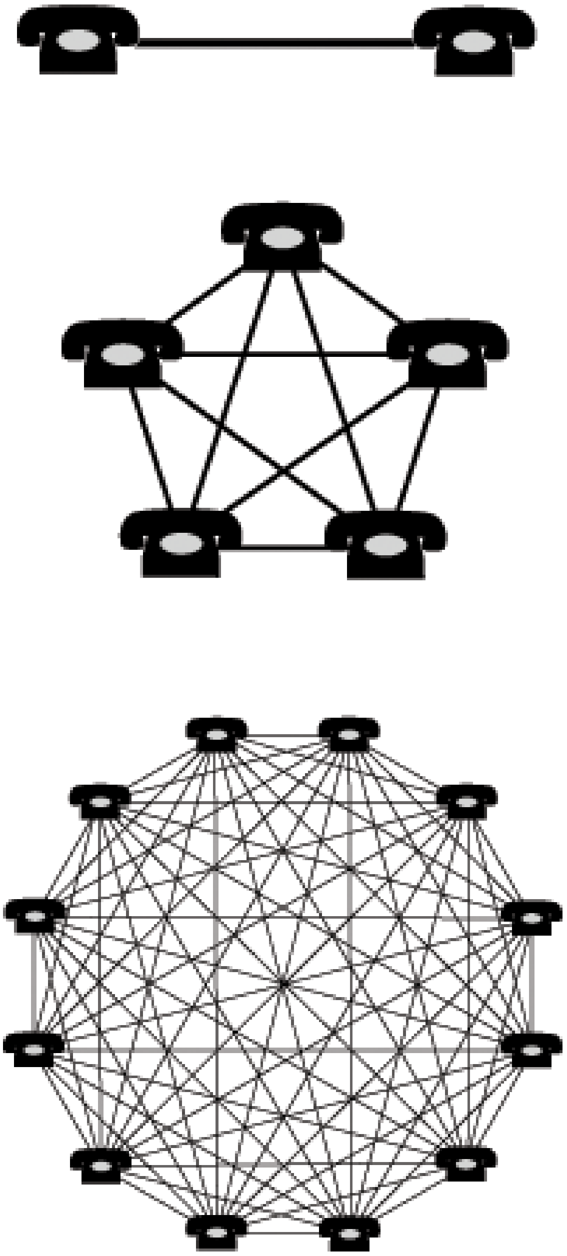


Diagram showing the network effect in a few simple phone networks. The lines represent potential calls between phones.

In economics and business, a **network effect** (also called **network externality** or **demand-side economies of scale**) is the effect that one user of a good or service has on the value of that product to other people. When a network effect is present, the value of a product or service is dependent on the number of others using it.[1]

The classic example is the telephone. The more people who own telephones, the more valuable the telephone is to each owner. This creates a positive externality because a user may purchase a telephone without intending to create value for other users, but does so in any case. Online social networks work in the same way, with sites like Twitter and Facebook becoming more attractive as more users join.

The expression "network effect" is applied most commonly to positive network externalities as in the case of the telephone. Negative network externalities can also occur, where more users make a product less valuable, but are more commonly referred to as "congestion" (as in traffic congestion or network congestion).

Over time, positive network effects can create a bandwagon effect as the network becomes more valuable and more people join, in a positive feedback loop.

1 Origins

Network effects were a central theme in the arguments of Theodore Vail, the first post patent president of Bell Telephone, in gaining a monopoly on US telephone services. In 1908, when he presented the concept in Bell's annual report, there were over 4,000 local and regional telephone exchanges, most of which were eventually merged into the Bell System.

The economic theory of the network effect was advanced significantly between 1985 and 1995 by researchers Michael L. Katz, Carl Shapiro, Joseph Farrell and Garth Saloner.[2]

Network effects were popularized by Robert Metcalfe, stated as Metcalfe's law. Metcalfe was one of the co-inventors of Ethernet and a co-founder of the company 3Com. In selling the product, Metcalfe argued that customers needed Ethernet cards to grow above a certain critical mass if they were to reap the benefits of their network.[3]

According to Metcalfe, the rationale behind the sale of networking cards was that (1) the cost of the network was directly proportional to the number of cards installed, but (2) the value of the network was proportional to the square of the number of users. This was expressed algebraically as having a cost of N, and a value of N^2. While the actual numbers behind this definition were never firm, the concept allowed customers to share access to expensive resources like disk drives and printers, send e-mail, and access the Internet.

Rod Beckstrom presented a mathematical model for describing networks that are in a state of positive network effect at BlackHat and Defcon in 2009 and also presented the “inverse network effect” with an economic model for defining it as well.[4]

2 Benefits

Network effects become significant after a certain subscription percentage has been achieved, called critical mass. At the critical mass point, the value obtained from the good or service is greater than or equal to the price paid for the good or service. As the value of the good is determined by the user base, this implies that after a certain number of people have subscribed to the service or purchased the good, additional people will subscribe to the service or purchase the good due to the value exceeding the price.

A key business concern must then be how to attract users prior to reaching critical mass. One way is to rely on extrinsic motivation, such as a payment, a fee waiver, or a request for friends to sign up. A more natural strategy is to build a system that has enough value *without* network effects, at least to early adopters. Then, as the number of users increases, the system becomes even more valuable and is able to attract a wider user base.

Beyond critical mass, the increasing number of subscribers generally cannot continue indefinitely. After a certain point, most networks become either congested or saturated, stopping future uptake. Congestion occurs due to overuse. The applicable analogy is that of a telephone network. While the number of users is below the congestion point, each additional user adds additional value to every other customer. However, at some point the addition of an extra user exceeds the capacity of the existing system. After this point, each additional user decreases the value obtained by every other user. In practical terms, each additional user increases the total system load, leading to busy signals, the inability to get a dial tone, and poor customer support. The next critical point is where the value obtained again equals the price paid. The network will cease to grow at this point, and the system must be enlarged. The congestion point may be larger than the market size. New Peer-to-peer technological models may always defy congestion. Peer-to-peer systems, or “P2P,” are networks designed to distribute load among their user pool. This theoretically allows true P2P networks to scale indefinitely. The P2P based telephony service Skype benefits greatly from this effect (though market saturation will still occur).

Network effects are commonly mistaken for economies of scale, which result from business size rather than interoperability. To help clarify the distinction, people speak of demand side vs. supply side economies of scale. Classical economies of scale are on the production side, while network effects arise on the demand side. Network effects are also mistaken for economies of scope.

The network effect has a lot of similarities with the description of phenomenon in reinforcing positive feedback loops described in system dynamics. System dynamics could be used as a modelling method to describe phenomena such as word of mouth and Bass model of marketing.

Network effect is a benefit to society as a whole because it positively relates to and affects the Intellectual Commons, Property Rights, and Cultural Commons of the world. One form of network externality is social media, which is a peer-to-peer network ran by a privately held for profit business. Although the creation of a large network creates a barrier to entry according to Porters five forces and may prevent a few from creating a new form of P2P networking, it largely benefits society as whole and provides a new form of a common-pool resource solargely scalable that the entire world has the ability to use it. Although the barrier to entry may be high, there is no true form of monopoly in the P2P social sharing market. For example, Facebook holds a large stake in the P2P social sharing market, but it is not mutually exclusive, meaning users can have an account on Facebook and also have an account on Twitter. Furthermore, there becomes no true critical mass in this space due to the ability for technology and innovation to constantly adapt to different environments, market for underdeveloped countries to integrate with social sharing is unlimited.

Network effect relates to the intellectual commons in a positive way. Through P2P networks users are able to share their intellectual property in a way that can benefit society as a whole.The sharing of intellectual property ultimately relates to, economic growth due to the ability for creators to share information and still possibly benefit financially from it. Through P2P networks people are able to share types of education like scholarly articles, becoming a new form of public commons. Network externality like Ted.com is an example of how intellectual commons with the use of network externality benefits society as a whole. Those who present intellectual property at Ted conferences are sharing their education on a public forum that benefits whoever will listen. Therefore, the larger Ted.com network becomes positively correlates to those who benefit from its common-pool resources.

P2P networks positively affect property rights. In reference to property rights, it enables those who create the intellectual property: The right to use the good, The right to earn income from the good, The right to transfer the good to others, The right to enforcement of property rights. Through P2P networks those who provide intellectual property not only have these rights, but they also possess the right to claim their information on a public forum. Due to these rights sharing benefits the intellectual property holders and promotes P2P sharing in a positive way. Those who consume the intellectual property also benefit positively from the sharing of it because they are able to use the information freely with respect to the person who created it. An example of this system in effect is a company called Music Vault. Music Vault operates on the P2P network Facebook, enabling users who create music to openly and freely collaborate with other artists content. This is a form of remixing that benefits both parties. This is an example of how a P2P network positively affects the sharing of property rights. In Joseph E. Stiglitz essay *Prizes, Not Patents*, he suggests that the creation of intellectual property should be rewarded with by social gratification and rewards instead of patents preventing others from duplicating the creation and sharing it as a common-pool resource. This can be related to P2P networking because it creates a greater incentive for those who create intellectual property to share it is a common-pool resource. As a P2P sharing network becomes larger the gratification of being rewarded on a global public forum would compete with a patent. It is through large P2P networks and network externality that humans can create a reward system large enough to deter seekers of patents to be rewarded in different ways.

Network Externality positively affects the cultural commons in many ways. The reward for being part of a group, society, and even the world through a P2P network is one of the greatest benefits that a modern common-pool resource can provide.The ability to connect and create with people from different cultures, ethnicities, and beliefs is something thought to be impossible 100 years ago. Without network externality this form of communication would have been impossible. Through P2P sharing the world as a culture are able to learn and teach each other through public forums. In Sugata Mitra's Ted talk, "The child-driven education" he placed a computer in the a third world town and left it there to see what would happen. To his amazement children were able to quickly figure out how to use the computer and educate themselves on its inner workings.[5] This example is a benefit to society for several reasons. The first is the relationship between Sugata Mitra and the P2P network which led him to place the computer in a third world town, along with the ability to present his findings on a public forum. Secondly, it is those who consumed his ted talk and benefited from the knowledge that those in third world countries just need a chance to learn and they will take it. This experiment as a whole brings the culture of the world together and connects us with those we thought impossible due to the P2P network and network externality that led individuals to the Ted talk.

3 Technology lifecycle

See also: Technology lifecycle

If some existing technology or company whose benefits are largely based on network effects starts to lose market share against a challenger such as a disruptive technology or open standards based competition, the benefits of network effects will reduce for the incumbent, and increase for the challenger. In this model, a tipping point is eventually reached at which the network effects of the challenger dominate those of the former incumbent, and the incumbent is forced into an accelerating decline, whilst the challenger takes over the incumbent's former position.

4 Lock-in

Not surprisingly network economics became a hot topic after the diffusion of the Internet across academia. Most people know only of Metcalfe's law as part of network effects. Network effects are notorious for causing lock-in with the most-cited examples being Microsoft products and the QWERTY keyboard.[6]

Vendor lock-in can be mitigated by opening the standards upon which users depend, allowing competition between implementations. This does not, however, mitigate industry-wide lock-in to the standard itself. Indeed, as there are now multiple vendors driving down the price and increasing the quality, more users are likely to adopt the standard thereby creating greater industry-wide lock-in to the standard.

5 Types of network effects

There are many ways to classify networks effects. One popular segmentation views network effects as being of four kinds:[7]

- Two-sided network effects: An increase in usage by one set of users increases the value to and participation of a complementary and distinct set of users, and vice versa. An example is developers choosing to code for an operating system with many users, with users choosing to adopt an operating system with many developers. This is a special case of a two-sided market.[8]
- Direct network effects: An increase in usage leads to a direct increase in value for other users. For example, telephone systems, fax machines, and social networks all imply direct contact among users. In two-sided networks, a direct network effect is called a **same-side** network effect. An example is online gamers who benefit from participation of other gamers as distinct from how they benefit from game developers.
- Indirect network effects: Increases in usage of one product or network spawn increases in the value of a complementary product or network, which can in turn increase the value of the original. Examples of complementary goods include software (such as an

Office suite for operating systems) and DVDs (for DVD players). This is why Windows and Linux might compete not just for users, but for software developers.[9] This is more accurately called a **cross-side** network effect in order to distinguish network benefits that cross distinct markets.[10]

- Local network effects: The structure of an underlying social network affects who benefits from whom. For example, a good displays local network effects when rather than being influenced by an increase in the size of a product's user base in general, each consumer is influenced directly by the decisions of only a typically small subset of other consumers, for instance those he or she is "connected" to via an underlying social or business network.[11] Instant messaging is an example of a product that displays local network effects.

Additionally, there are two sources of economic value that are relevant when analyzing products that display network effects:

- Inherent value: I derive value from my use of the product
- Network value: I derive value from other people's use of the product

6 Negative network effects

See also: Negative feedback

Negative network effects, in the mathematical sense, are those that have the opposite effect on stability compared to normal (positive) network effects. Just like positive network effects cause positive feedback loops and exponential growth, negative network effects create negative feedback and exponential decay. In nature, negative network effects are the forces that pull towards equilibrium, are responsible for stability, and are the physical limitations preventing states from reaching infinity.

- Congestion occurs when the efficiency of a network decreases as more people use it, and this reduces the value to people already using it. Traffic congestion that overloads the freeway and network congestion over limited bandwidth both display negative network externalities.
- Braess' paradox occurs when the following counterintuitive phenomenon: removing edges from a selfish routing network can decrease the latency incurred by all of the traffic at equilibrium.[12]

7 Interoperability

Interoperability has the effect of making the network bigger and thus increases the external value of the network increasing appear to consumers. Interoperability achieves this primarily by increasing potential connections and secondarily by attracting new participants to the network. Other benefits of interoperability include reduced uncertainty, reduced lock-in, commoditization and competition based on price.[1]:229

Interoperability can be achieve through standardization or other cooperation. Companies involved in fostering interoperability face a tension between cooperating with their competitors to grow the potential market for products and competing for market share.[1]:227

8 Open versus closed standards

In communication and information technologies, open standards and interfaces are often developed through the participation of multiple companies and are usually perceived to provide mutual benefit. But, in cases in which the relevant communication protocols or interfaces are closed standards the network effect can give the company controlling those standards monopoly power. The Microsoft corporation is widely seen by computer professionals as maintaining its monopoly through these means. One observed method Microsoft uses to put the network effect to its advantage is called Embrace, extend and extinguish.

Mirabilis is an Israeli start-up which pioneered instant messaging (IM) and was bought by America Online. By giving away their ICQ product for free and preventing interoperability between their client software and other products, they were able to temporarily dominate the market for instant messaging. Because of the network effect, new IM users gained much more value by choosing to use the Mirabilis system (and join its large network of users) than they would using a competing system. As was typical for that era, the company never made any attempt to generate profits from their dominant position before selling the company.

9 Examples

9.1 Financial exchanges

Stock exchanges and derivatives exchanges feature a network effect. Market liquidity is a major determinant of transaction cost in the sale or purchase of a security, as a bid-ask spread exists between the price at which a purchase can be done versus the price at which the sale of the same security can be done. As the number of buyers and sellers on an exchange increases, liquidity increases, and transaction costs decrease. This then attracts a larger number of buyers and sellers to the exchange.

The network advantage of financial exchanges is apparent in the difficulty that startup exchanges have in dislodging a dominant exchange. For example, the Chicago Board of Trade has retained overwhelming dominance of trading in US Treasury bond futures despite the startup of Eurex US trading of identical futures contracts. Similarly, the Chicago Mercantile Exchange has maintained a dominance in trading of Eurobond interest rate futures despite a challenge from Euronext.Liffe.

9.2 Software

There are very strong network effects operating in the market for widely used computer software.

Take, for example, Microsoft Office. For many people choosing an office suite, prime considerations include how valuable having learned that office suite will prove to potential employers, and how well the software interoperates with other users. That is, since learning to use an office suite takes many hours, they want to invest that time learning the office suite that will make them most attractive to potential employers and clients, and they also want to be able to share documents. (Additionally, an example of an indirect network effect in this case is the notable similarity in user-interfaces and operability menus of most new software – since that similarity directly translates into less time spent learning new environments, therefore potentially greater acceptance and adoption of those products.)

Similarly, finding already-trained employees is a big concern for employers when deciding which office suite to purchase or standardize on. The lack of cross-platform user-interface standards results in a situation in which one firm is in control of almost 100% of the market.

Microsoft Windows is a further example of network effect. The most-vaunted advantage of Windows, and that most publicised by Microsoft, is that Windows is compatible with the widest range of computer hardware and software. Although this claim is justified, it is in reality the result of network effect: hardware and software manufacturers ensure that their products are compatible with Windows in order to have access to the large market of Windows users. Thus, Windows is popular because it is well supported, but is well supported because it is popular.

However, network effects need not lead to market dominance by one firm, when there are standards which allow multiple firms to interoperate, thus allowing the network externalities to benefit the entire market. This is true for the case of x86-based personal computer hardware, in which there are extremely strong market pressures to interoperate with pre-existing standards, but in which no one firm dominates in the market. Also, it is true for the development of enterprise software applications where the Web (HTTP), databases (SQL), and to a moderate degree, service-oriented message buses (SOA) have become common interfaces. Further up the development chain there are network effects as well in language backend base platforms (JVM, CLR, LLVM), programming models (FP, OOP) and languages themselves.[13]

In 2007 Apple released the iPhone followed by the app store. Most iPhone apps rely heavily on the existence of strong network effects. This enables the software to grow in popularity very quickly and spread to a large userbase with very limited marketing needed. The Free-mium business model has evolved to take advantage of these network effects by releasing a free version that will not limit the adoption or any users and then charge for "premium" features as the primary source of revenue.

9.3 Telecommunications

The same holds true for the market for long-distance telephone service within the United States. In fact, the existence of these types of networks discourages dominance of the market by one company, as it creates pressures which work against one company attempting to establish a proprietary protocol or to even distinguish itself by means of product differentiation.

9.4 Web sites

Many web sites also feature a network effect. One example is web marketplaces and exchanges, in that the value of the marketplace to a new user is proportional to the number of other users in the market. For example, eBay would not be a particularly useful site if auctions were not competitive. However, as the number of users grows on eBay, auctions grow more competitive, pushing up the prices of bids on items. This makes it more worthwhile to sell on eBay and brings more sellers onto eBay, which drives prices down again as this increases supply, while bringing more people onto eBay because there are more things being sold that people want. Essentially, as the number of users of eBay grows, prices fall and supply increases, and more and more people find the site to be useful.

Social networking websites are also good examples. The more people register onto a social networking website, the more useful the website is to its registrants.[14]

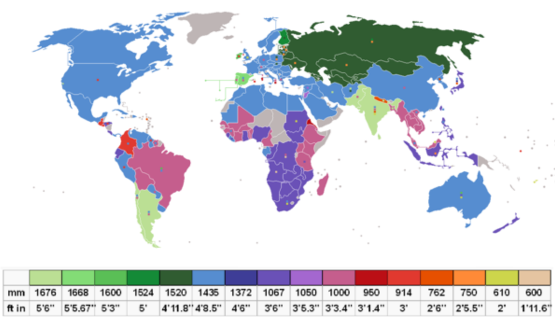
By contrast, the value of a news site is primarily proportional to the quality of the articles, not to the number of other people using the site. Similarly, the first generation of search sites experienced little network effect, as the value of the site was based on the value of the search results. This allowed Google to win users away from Yahoo! without much trouble, once users believed that Google's search results were superior. Some commentators mistook the value of the Yahoo! brand (which does increase as more people know of it) for a network effect protecting its advertising business.

Alexa Internet uses a technology that tracks users' surfing patterns; thus Alexa's Related Sites results improve as more users use the technology. Alexa's network relies heavily on a small number of browser software relationships, which makes the network more vulnerable to competition.

Google has also attempted to create a network effect in its advertising business with its Google AdSense service. Google AdSense places ads on many small sites, such as blogs, using Google technology to determine which ads are relevant to which blogs. Thus, the service appears to aim to serve as an exchange (or ad network) for matching many advertisers with many small sites (such as blogs). In general, the more blogs Google AdSense can reach, the more advertisers it will attract, making it the most attractive option for more blogs, and so on, making the network more valuable for all participants.

Network effects were used as justification for some of the dot-com business models in the late 1990s. These firms operated under the belief that when a new market comes into being which contains strong network effects, firms should care more about growing their market share than about becoming profitable. This was believed because market share will determine which firm can set technical and marketing standards and thus determine the basis of future competition.

9.5 Rail gauge



The dominant rail gauge in each country shown

There are strong network effects in the initial choice of rail gauge, and in gauge conversion decisions. Even when placing isolated rails not connected to any other lines, track layers usually choose a standard rail gauge so they can use off-the-shelf rolling stock. Although a few manufacturers make rolling stock that can adjust to different rail gauges, most manufacturers make rolling stock that only works with one of the standard rail gauges.

10 See also

- Anti-rival good
- Beckstrom's law
- Betamax
- Cluster effect
- Economies of density
- First-mover advantage
- Market failure
- Metcalfe's law
- Monopoly
- Monopsony
- Oligopoly
- Open format
- Open system (computing)
- Reed's law
- Returns to scale (increasing returns)
- Semantic Web
- Two-sided market
- Unfair competition

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12 External links

- Coordination and Lock-In: Competition with Switching Costs and Network Effects, Joseph Farrell and Paul Klemperer.
- Network Externalities (Effects), S. J. Liebowitz, Stephen E. Margolis.
- An Overview of Network Effects, Arun Sundararajan.
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