

Study on the Concept and Mechanism of Network Effect

Xianfeng Wu, Shanshan Xia

School of Economics and Management, Chongqing University of Posts and
Telecommunications, Chongqing 400065, China

Abstract

network effect is the essential attribute of network economy, and clearly defined conceptual system is the theoretical basis of network effect research. Based on this, this paper reviews the existing representative literature at home and abroad on the concept of network effect, puts forward a relatively complete concept of network effect, and analyzes the mechanism of direct network effect and indirect network effect.

Keywords

direct network effect; Indirect network effect; Concept; Mechanism of action.

1. Introduction

Under the influence of network effect, the market has the economic characteristics different from the traditional market, such as decreasing marginal cost and increasing marginal return. Since the 1970s, great achievements have been made in the study of network effects, but most scholars focus on technical compatibility, standard competition, pricing strategies and other aspects, which still have certain limitations. The reason lies in the lack of profound understanding and research on the meaning and mechanism of network effect in the existing literature, which limits the development of network effect research. This paper attempts to summarize the concepts of network effect in existing literature at home and abroad, and puts forward corresponding opinions on relevant concepts. On this basis, it conducts in-depth research and analysis on the concepts of network effect, and studies the mechanism of action of direct network effect and indirect network effect respectively, so as to establish a theoretical basis for subsequent related researches.

2. Literature Review on the Concept of Network Effect

2.1. The Meaning of Network

Network is the basis of network effect. In the following comments, the market with network effect attribute is called network market. To study network effects in relevant markets, we must first understand the meaning of network in the field. First discusses the concept of network effects in the market is Katz and Shapiro (1985)[2], they from the Angle of the compatibility on the problem of "related network", think that the Internet is the user through the use of a specific product, and form the user network, the form element is a user, and with no physical connection of the network node based on the network is divided into communication network and hardware-software "paradigm" two kinds. Economides(1996)[1] argues that from the perspective of production structure, the network is composed of connections between nodes, and different components of the network need to be combined to provide standard services, so the connections between different components are complementary. Guo Shuihui (2011) [10] understood the network from both abstract and concrete perspectives. He believed that the user network mentioned by Katz and Shapiro was a specific product demand network, while the essence of the network was an abstract model composed of nodes and connections.

Any network is connected between nodes in some way, so it can be seen that the network is determined by two factors: nodes and connection mode. Different ways of connection, different ways of classification. According to the internal connection direction of the network, it can be divided into one-way network and two-way network [7]. According to whether the network has physical connection, it can be divided into virtual network and physical network[9]. In the network market, there are two-way networks such as communication network and one-way networks such as Windows system, which are composed of multiple components. At the same time, there are not only the physical hardware network which constitutes the communication network, but also the virtual network which constitutes the user communication and exchange information.

Different market areas have different understandings of nodes. In the network market, the users who enter the market are the main body of the network, and the connection between these users is the most important factor to form the network effect. Therefore, in this paper, users in the network market are regarded as nodes in the network from the perspective of Katz and Shapiro(1985). The ultimate purpose of the connection between nodes is to establish connections between users and other nodes in the network. According to the different connection modes between user nodes in the network, the network in the network market can be divided into direct network and indirect network. Among them, direct network refers to the network (such as telephone network) formed by direct contact between users in the network through the use of the same product or service. Indirect networks are networks (such as hardware/software paradigm networks) in which users are connected to each other only through the use of complementary components of the underlying product or service.

2.2. Concept Review and Review of Network Effect

The earliest discovery of network effect can be traced back to the 1950s of last century. Leibenstein(1950)[11] called the phenomenon of consumer demand interaction as the "float effect", but at that time he believed that the reason for this phenomenon was the psychological effect of consumers following the trend or keeping up with the jess. Until the 1970s, Rohlfs[12] found in communication networks that "the utility a user gets from a communication service increases with the number of people joining the system" and called this phenomenon "the external economy of consumption". The literature of Rohlfs can be called the new century work of the formal study of network effects, which has inspired a large number of scholars to carry out relevant research. Then Metcalfe, the "father of Ethernet", proposed in his sales practice that the value of the network grew at the rate of square users. This idea, known as Metcalfe's law, points not only to the decisive role of user size in the value of a network, but also to how quickly network effects can spread.

However, the early relevant studies mainly focused on standard competition, market equilibrium, technology compatibility, etc.) lack of in-depth exploration and analysis of the connotation of network effect, resulting in the vagueness of the concept of network effect and the generalization of its application scope, and some scholars even believed that network effect was ubiquitous[5]. This has led some scholars to discuss the concept of network effect, but not many scholars are really devoted to the research and analysis of the concept of network effect.

The meaning interpretation of network effect originated earlier in foreign countries. Katz and Shapiro (1985)[2] defined network effect as "the utility a user obtains from the consumption of a product increases with the number of other consumers consuming the product", which is the most influential and classical definition of the concept of network effect and has been used by most relevant scholars since. The definition emphasizes the interdependent relationship between the user utility (or product value) and the number of user nodes in the same network, that is, the more nodes, the greater the user utility, and the greater the user utility will

stimulate the increase in the number of user nodes. Later, some scholars equated network externalities with network effects and made no distinction between the two concepts (e.g. Brynjolfsson(1996)). Liebowitz and Margolis (1994)[5] questioned this and differentiated network effects from network externalities based on the theory of externalities. They believed that network effects were called network externalities only when they could not enter the benefit-cost function through the price mechanism. According to the existing research, "network effect" usually refers to the economic effect between the actors, while "network externality" refers to the situation where the market cannot completely internalize the network effect.[13]

On the basis of western studies, domestic scholars have discussed the origin and nature of network effect. Wen Zhong (2000)[6] divides the value obtained by consumers from network products into two different parts: self-sufficiency value and network value, and believes that the latter is the essence of network effect, that is, the value obtained by consumers through a certain connection with other consumers in the network. Lei Yichuan (2005) [14] conducted a framework analysis of network effects from the two aspects of "quality" and "quantity", and fundamentally agreed with Wen Zhong's view on the nature of network effects (Lei Yichuan used "collaborative value"), believing that there would be no network effects without "collaborative value". This view is basically consistent with Zhou Wenhui's (2015) [15] understanding of the nature of network effects. Zhai Shanshan (2008) [16] believed that network value was only the embryonic form of network effect, not the root cause of network effect. Li Zhen (2016) [17] believed that the prototype of network effect was the trend effect proposed by Leibenstein, and generally summarized the network effect as "the positive feedback of product value and consumer number generated by the combined effect of trend effect, scale effect, herd effect, market intermediary effect and locking effect". It is undeniable that the above mentioned "collaborative value", "trend effect" and "herd effect" all have the same meaning as network effect, that is, consumer utility changes with the size of users. However, these effects are different from network effects in nature: "collaborative value" emphasizes the effect of new users' joining on the benefit of old users, while "network effect" emphasizes the effect of network size on the utility of each network user. Both "trend effect" and "herd effect" emphasize the influence of user scale on users' psychological factors (such as following the fashion, following the trend, etc.), while network effect emphasizes that users can meet their actual needs (such as exchanging information, etc.) through user scale and obtain tangible benefits.

In addition, a number of scholars regard network effect as a demand-side economy of scale. However, some scholars put forward that demand-side economies of scale cannot emphasize the interdependence and mutual influence between users. The author thinks that demand-side scale economy is the essence of network effect. Demand-side economies of scale are different from general (supply-side) economies of scale in that innovation in technology or services increases the number of consumers and thus the value of products. The main way to improve consumer utility is to increase the number of complementary varieties and consumers.

Two key messages can be extracted from the existing literature: first, network effect is a phenomenon; Second, this phenomenon is the influence relationship between user utility and user size (most cases consider the positive impact). However, these definitions only describe network effect abstractly, and do not explain and limit the conditions and scenarios required by network effect. According to the above definition, network effects exist in most markets. For example, in terms of China's economic development, job seekers prefer cities with large population base, such as Beijing, Shanghai and Guangzhou, because the larger the population base, the more labor force, the more rapid the economic development, the greater the

employment opportunities, attracting more job seekers. Obviously, the phenomenon that the increase in the number of users affects the choices of other users is not a network effect.

2.3. Define Network Effects

Based on the existing research conclusions, it is not difficult to find that the research on the concept of network effect in the existing literature is essentially analyzing the influence relationship between user size and user utility (or product value). According to the previous classification of network, the utility of users in a direct network is interrelated and affects each other. In other words, users' entry and exit decisions will affect the utility of other users, resulting in direct network effect. The influence between users in the indirect network is mediated by the diversity of complements, that is, the decision of users to enter and exit affects the diversity of complements, and the diversity of complements will affect users' utility, resulting in the indirect network effect. It is undeniable that, whether directly or indirectly, in a market with network effects, the fundamental source of user utility is user size. However, the two connections make the direct source of the user's utility different. In direct network effect, user utility is directly derived from user size. The user utility in indirect network effect is directly derived from software diversity. In this paper, starting from the direct source of user utility, user scale (N) and software diversity (M) are collectively referred to as network scale (n), and network effect in the network market refers to: $n = \alpha N + \beta M$, network effect refers to the degree to which the network scale of network products in the network market satisfies the needs of similar users. Generally, the larger the network scale, the higher the user satisfaction and the higher the product value, which is usually divided into two types: direct network effect and indirect network effect. Its mathematical expression is: $U = f(n)$, where $\partial U / \partial n > 0$. According to the way network effects are defined in this paper, we regard user utility as a function of the interaction between user size and the diversity of complements, and can flexibly consider the situation where only direct network effects ($\beta = 0$) or indirect network effects ($\alpha = 0$) exist. In this definition, we can understand the network effect from three points: first, the scenario and conditions of network effect are network market; Second, the economic subject of network effect is the user; Third, there is a certain connection between economic entities (direct/indirect); Fourth, it is the scale of the network that affects the main body of the economy. These four points can be used as the judging basis for network effect. For example, the example of job-seekers' preference for cities with large population listed above does not occur in the network market in the first place, and there is no connection between job-seekers and other urban populations, so this phenomenon does not belong to network effect.

3. The Mechanism of Network Effect

Katz and Shapiro(1985)[2] for the first time divided network effects into direct network effects and indirect network effects, and believed that there were significant differences between the two. Both direct networks and indirect networks have network effects, but the mechanism of network effects varies with different networks. Distinguishing the action mechanism of different network effects is helpful to understand the connotation of network effects.

3.1. Mechanism of Direct Network Effect

Direct network effect refers to the effect of the number of consumers consuming the same product or compatible product on consumer utility (or product value) [5][15]. In the direct network effect, it emphasizes the direct effect of the change of the existing user scale on the utility of users joining the network. The size of the utility the user gets on the network also affects the size of the network's user base (see figure 1). Take instant messaging service

network as an example, assume that the total number of users on the network (that is, user scale) is N , which means that each user can connect and communicate with $(n-1)$ individuals to realize information transfer. If the utility brought by communication with each unit of users is denoted as 1, then the utility gained by each user is $(n-1)$. When the total number of network users increases by k units, the size of network users becomes $(N+k)$, and the utility gained by each user becomes $(N+k-1)$. And the increase in user utility will attract more potential users to join the instant messaging service network, resulting in a corresponding increase in user size.



Figure 1. mechanism of direct network effect

It should be emphasized that the economic subject of direct network effect is the demand side of network products on the same side of the market. Direct network effects actually describe the phenomenon that as the number of users on the same side increases (or decreases), the number of users on that side increases (or decreases). With direct network effects, user adoption decisions are largely influenced by the "installed base" (that is, user size).[10] Swann (2002) discussed that under certain conditions, direct network effect has linear function expression, $U = \alpha_0 + \alpha_1 N$, where $\partial U / \partial N > 0$. [18] in addition, since direct network effects come from interactions between consumers that occur outside the market mechanism, the direct network effect model believes that direct network effects lead to "technical externalities". [5] Liebowits and Margolis (1994) [5] argue that direct network effects can have effects beyond the market, which provides a basis for later discussions on whether direct network effects can produce externalities.

3.2. Mechanism of Indirect Network Effect

Economides(1996)[1] regards a product consisting of two or more components (products) as a composite product, in which the increase of consumer demand for components will lead to an increase in the number of components in the market and at the same time to an increase in the number of conforming products. Indirect network effects arise from the technical complementarity between the base products and ancillary products, as well as consumers' preference for the variety of ancillary products available to the base products, such as operating systems and applications, game consoles and game discs. [19] Indirect network effects differ from direct network effects in that the utility a consumer gains "is not directly dependent on the network size of the product (the sum of the number of consumers buying the same or compatible product), but indirectly depends on the type and number of complementary products". [20] In particular, the indirect expression of the network effect is such a situation: user scale up of selected network products and achieve a certain scale, the user of the product function complementary products demand will increase, while the network product will increase the number of complements, the complements of increased the effectiveness of the user, to attract new users to select the network products, network products of users and to expand the scale. In this way, user size indirectly affects user utility through the diversity of complements (see figure 2). The diversity of the complementary products of instant messaging services is reflected in the diversity of access methods of instant messaging services and integrated Internet business types. The richness of these compatible products plays an obvious role in promoting the usage of instant messaging services and attracting new users to join the instant messaging network.[21]

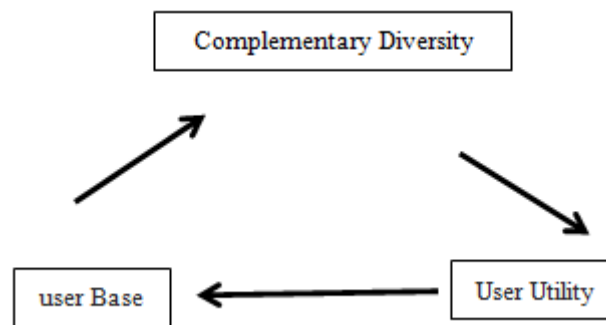


Figure 2. mechanism of indirect network effect

It is not difficult to find that the economic subject of indirect network effect is still the users in the network, and the economic subject is still influenced by the user scale eventually, but must take the diversity of complementary products as the medium. Therefore, indirect network effect is also a market intermediary effect. [22] In such a transmission process, the indirect network effect of instant messaging service directly affects the diversity of complements, so the indirect network effect can be expressed as the functional relationship between utility and the diversity of complements, and the expression is: $U = f(M)$, and $\partial U/\partial M > 0$. Therefore, some scholars have proposed that in the competition of the network market, enterprises can implement vertically integrated operation if they want to gain competitive advantage or even gain monopoly position [3]. In addition, since the indirect network effect is a "market regulation effect" [22], the indirect network effect can be internalized by adjusting the price of complements, so the indirect network effect belongs to "monetary externality".

Table 1. differences between the two network effects

	Direct Network Effects	Indirect Network Effects
Economic Entity	User	User
Direct Source	User Scale	complementary variety class
Network Internal Connection	Direct	Indirect
Externality Type	Technical Externality	Monetary Externality

Both direct and indirect network effects reflect how user size affects user utility, and how user utility reacts on user size. Therefore, network effect is an economic phenomenon that originates from users and ACTS on users.

4. Conclusion

The complete definition of the concept and the in-depth study of the mechanism of action have important theoretical significance for the research of network effect. Through sorting out and summarizing the concept of network effect and studying the mechanism of action, it can be found that, on the one hand, the definition of network effect is not clear at present, and research results are scarce; on the other hand, network effect can explain new phenomena that cannot be explained by traditional economic theories, and can provide impetus for the development of new economy.

References

- [1] Economides N S, Encaoua D. Special issue on network economics: Conduct and market structure[J]. *International Journal of Industrial Organization*, 1996, 14(6):669-671.
- [2] Katz M L, Shapiro C. Network Externalities, Competition, and Compatibility[J]. *American Economic Review*, 1985, 75(3):424-440.
- [3] cheng Guisun, Chen Hongmin, Sun Wujun. Analysis of network externalities and vertical merger of enterprises [J]. *China science of management*, 2005,13 (6): 131-135.
- [4] Xing Hongjian, Zang Xuheng. Expression of network effect and analysis of research framework [J]. *Dongyuelancong*,2008(02):64-68.
- [5] Liebowitz S J, Margolis S E. Network Externality: An Uncommon Tragedy[J]. *Journal of Economic Perspectives*, 1994, 8(2):133-150.
- [6] Wen Zhong, Chen Jian. Network effect and network externality: discussion and analysis of concept [J]. *Contemporary economic science*,2000(06):13-20.
- [7] Zhu Tong. Economic theory of network effect: literature review and review [J]. *Teaching and research*,2003(12):66-70.
- [8] Zhu Tong. Externalities, network externalities and network effects [J]. *Economic theory and economic management*,2001(11):60-64.
- [9] Shapiro C, Varian H R. *Information rules: a strategic guide to the network economy*[M]. Harvard Business School Press, 1998.
- [10] Guo Shuiwen, Xiao Wenjing. mechanism of network effect [J]. *Economic review*,2011(04):14-22. (in Chinese).
- [11] Leibenstein H. Bandwagon, snob, and Veblen effects in the theory of consumers' demand[J]. *Quarterly Journal of Economics*, 1950, 64(2):183-207.
- [12] Rohlfs, J. A Theory of Interdependent Demand for a Communications Service[J]. *Bell Journal of Economics*, 1974, vol.5, no.1.
- [13] Chou C, Shy O. Network effects without network externalities[J]. *International Journal of Industrial Organization*, 2004, 8(2):259-270.
- [14] Lei Yichuan. "quality" and "quantity" of the network effect analysis [J]. *Market modernization*, 2005 (01): 108-137.
- [15] Zhou Wenhui, Qiu Yunjin, Jin Keke, Li Yuwen. Interaction mechanism of e-commerce platform and bilateral market value on network effect -- based on a case study of Taobao [J]. *Soft science*, 2015, 29(04): 83-89.
- [16] Zhai Shanshan. Research on network effect and network externalities [J]. *Modern commercial and trade industry*,2008(04):216-217.
- [17] Li Zhen, Wang Xinxin. Study on the mechanism of in-platform network effect and cross-platform network effect [J]. *Science and technology progress and countermeasures*,2016,33(20):18-24.
- [18] Swann G M P. The functional form of network effects[J]. *Information Economics and Policy*, 2002, 14(3):0-429.
- [19] Shuai xun, Chen Hongmin. Research on indirect network externalities based on hardware/software paradigm [J]. *Systems engineering theory and practice*, 2004, 24(2):25-30.
- [20] Fu Yu. Network scale, diversification and bilateral market strategy -- review of platform competition strategy under network effect [J]. *Science and technology management research*, 2013, 33(06):192-196.
- [21] Liu Ge. Research on IM market competition of telecom operators based on network effect [D]. *Beijing university of posts and telecommunications*,2009.
- [22] Wu Sizong, Jiang Haihua. Economic analysis of network externalities [J]. *Journal of Tongji university (social science edition)*,2002(06):70-77.
- [23] Weng Jin, Chen Linsheng. A monopoly competition model based on two-tier CES utility function [J]. *Journal of central China normal university (natural science edition)*, 2006, 40(3).