The value of a network in the digital era: insights about Doctor Chat case study

Davide Di Fatta*

Department SEAAM,
University of Messina,
Via dei Verdi, 75, 98122, Messina, Italy
Email: difatta.davide@gmail.com
*Corresponding author

Francesco Cupido

Department DICHIRONS,
University of Palermo,
Via Librio Giuffrè, 5,
90127 Palermo, Italy
Email: francesco.cupido@unipa.it

Gandolfo Dominici

Department SEAS,
University of Palermo,
Viale delle Scienze ed. 13,
90128 Palermo, Italy
and
Business Systems Laboratory,
viale Fr. Scaduto 2/d, 90144, Palermo, Italy
Email: gandolfo.dominici@unipa.it

Abstract: Networks are ubiquitous in our lives in their social, physical, and digital forms. A growing number of firms today rely entirely on networking and lack a physical location or material infrastructure; they are, so to speak, 'liquid'. Through a theoretical analysis and its application to the case of Doctor Chat mobile app, this paper aims to analyse the fundamental laws of networks and to answer the following questions: 1) are the traditional methods to estimate the network value still valid in the current digital age and in particular for mobile applications?; 2) how do the laws of networks work when networks expand? We conclude with some suggestions for a research agenda in order to inspire further researches on the topic.

Keywords: network theory; mobile app; Sarnoff's law; Metcalfe's law; Reed's law; Odlyzko and Tilly's law.

Reference to this paper should be made as follows: Di Fatta, D., Cupido, F. and Dominici, G. (2017) 'The value of a network in the digital era: insights about Doctor Chat case study', *Int. J. Electronic Marketing and Retailing*, Vol. 8, No. 4, pp.301–315.

Biographical notes: Davide Di Fatta is a PhD student of Economics and Management in the Department SEAAM at the University of Messina, Italy. He also collaborates with the SEAS Department at the Polytechnic School of the University of Palermo, Italy. He is a junior member referent in the Business System Laboratory. His main research fields are systems thinking, digital marketing and social media marketing.

Francesco Cupido is a researcher at DICHIRONS (surgical disciplines, oncology and oral medicine) at the University of Palermo. He is also active as an entrepreneur in the field of medical app.

Gandolfo Dominici is an Associate Professor of Marketing in the Department SEAS at the Polytechnic School, University of Palermo, Italy. He is co-Founder and Scientific Director of the Business Systems Laboratory. He is a member of the Board of Directors of the World Organisation for Systems and Cybernetics (WOSC) and a board member of the Italian Universities Consortium of Industrial Economics and Management (CUEIM) and of the International Society for the Systems Sciences (ISSS). He is the Editor-in-Chief of the *International Journal of Electronic Marketing and Retailing*, *International Journal of Digital Culture and Tourism* and *International Journal of Markets and Business Systems* and the editorial board member of a number of international journals. His main research topics are marketing and systems thinking.

1 Introduction

The academic literature does not contain a universally accepted definition of network value, though there is a certain consensus that it is linked to the number of users (Rosenbaum et al., 1990; Metcalfe, 1995; Reed, 2001; Domingos and Richardson, 2001; Odlyzko and Tilly, 2005; Peppard and Rylander, 2006; Briscoe et al., 2009; Di Fatta et al., 2016a).

The lack of a commonly shared definition of network value calls for a more in-depth study to (re-)adapt the best methodologies to the digital era (Doerr and Powell, 2005; Dominici, 2009a, 2009b) and, specifically, in network markets (Van Hove, 2013; McIntyre and Chintakananda, 2014).

The aim of our theoretical study is to examine the problems related to the application of network laws (such as Sarnoff's Law, Metcalfe's Law, and Reed's Law) in order to find a definition and a method for estimating the network value in the digital context. To this end, we review the previous literature, also considering Odlyzko and Tilly's (2005) reformulation of Zipf's (1936, 1946) Law and set up Doctor Chat case study. In other words, our research questions can be formalised as follow:

RQ1 Can we use these rules to estimate the value of a network in the digital era?

In order to answer this first question, we examine the literature on network value, beginning with the early decades of twentieth century when Sarnoff dealt with television networks. We thus come to the second research question:

RQ2 How do the laws proposed by Sarnoff, Metcalfe, and Reed, work when networks expand?

In order to answer these questions, we will consider the application of the above-mentioned rules to the World Wide Web (WWW) and specifically to the mobile app market, taking into account the network's expansion in Doctor Chat case study.

Doctor Chat is a network of physicians characterised by an instant messaging mechanism for the sharing of clinical cases. Its aim is to contribute to the dissemination of knowledge in a fast and free way, by exploiting the potential of the web able to connect in a few seconds' people worldwide.

After this premise, could be useful to spend a couple of word about the structure of the paper: next section (Section 2) is a literature review about the value of a network; Section 3 deals with Doctor Chat case study explaining methodology and data collection; in the final section (Section 4), we conclude with some considerations also providing a research agenda: basically the idea is to highlight some unresolved questions, that may serve as starting points for further studies.

2 Literature review

Using Bauman's (2003) words, our society moved away from a 'heavy' and 'solid' hardware-focused economy, to a 'light' and 'liquid' software-based modernity. The concept of a value chain assumed a dominant position in the strategic analysis of industries, but nowadays this concept is underpinned by a particular value creating logic (Peppard and Rylander, 2006).

Adopting a network perspective, more suited to the 'liquid modernity', we have to consider that the products and the services, the supply and the demand chain are often digitalised (Gummerus, 2013) and interconnected inside the net (Skalén et al., 2015; Di Fatta et al., 2016b).

The necessary starting point relies on the previous literature on network economy (Anderson et al., 1994; Wilson, 1995; Achrol and Kotler, 1999) and market networks (Mattsson and Johanson, 2006; Baffour Awuah et al., 2011). Basically, the idea is that now more than ever, we must consider the value of a network in our digital era (Van Hove, 2013).

In this literature review we are going to focus on the above-mentioned laws for estimating network value by Sarnoff, Metcalfe, Reed, Odlyzko and Tilly (in chronological order) in Sections 2.1 to 2.4. Then, we will discuss about network value in the digital era (Section 2.5).

2.1 Sarnoff's law

The first definition of the value of a network dates back to the early decades of the twentieth century. According to Kovarik (2015), David Sarnoff was the first to study mass media networks. He stated that the value of a broadcast network is directly proportional to the number of viewers.

According to Sarnoff, there is thus a linear relation between the number of users and the value of a network. In its simplicity, Sarnoff's Law represented a cornerstone of the subject as it was the first attempt to quantify the value of a network, thus paving the way towards a new research stream (Bilby, 1986).

Rohlfs (1974) suggested that the value of a network is a function of the interdependence inside the network, arguing that Sarnoff's Law thus underestimated the network value. In other words, considering a communications network, the utility that a user derives from adopting the service increases when other members join the system. This concept is on the basis of the network externality studies (Basu et al., 2003; Nair et al., 2004).

2.2 Metcalfe's law

Based on the critical point outlined by Rohlfs, Bob Metcalfe in 1980 shifted the focus from users to 'compatible communicating devices' (e.g., fax machines or telephones). Some years later, this rule was named 'Metcalfe's Law' by Gilder (1993).

Regardless of the name, the theoretical arguments behind Metcalfe's reasoning stated that, in a general communication network with n members, there are $n(n-1)/2$ possible connections between the participants. If all these connections are equally valuable, the total value of the network is proportional to $\frac{n(n-1)}{2}$; that is, making a rough approximation, proportional to something like n^2. Indeed, a review of the subject expressed Metcalfe's (1995) law in terms of triangular numbers that converge asymptotically to n^2.

In other words, Metcalfe's law states that the value of a telecommunications network is proportional to the square of the number of connected users of the system, or in other words, is proportional to the size of the network.

Even though Metcalfe's law is widely accepted for mass media communications networks (e.g., radio and television), a stream of literature suggests that it does not apply to internet networks (Odlyzko and Tilly, 2005; Briscoe et al., 2009; Shapiro et al., 1999; Hendler and Golbeck, 2008).

There are nonetheless some scholars who have argued that Metcalfe's law can be applied to the internet, finding that Metcalf's law can be validated by an analysis of Facebook data (Madureira et al., 2013; Van Hove, 2014, 2016; Zhang et al., 2015).

2.3 Reed's law

Reed (1999) expanded on Metcalfe's reasoning, arguing that the network value is determined not only by the number of node-to-node connections, but also by the interactions between subgroups of nodes within the network (Coughlin, 2008).

Reed's law is based on the assumption that, given a set of n people in a network and supposing that all subsets of the network have the same value, it is possible to count 2^n possible subsets.

This consideration includes the empty set and n subsets composed of a single element. The well-known formulation of Reed's (2001) law subtracts from the maximum number of all possible subgroups (2^n), the n subsets composed of a single element and the empty set, as they do not represent connections:

$$2^n - n - 1$$

From the mathematical point of view, Reed's law, as n increases, tends asymptotically towards 2^n. Therefore, we can use this approximation for further reasoning.

The fundamental fallacy underlying Metcalfe's and Reed's law is the assumption that all connections are equally valuable (Odlyzko and Tilly, 2005; Briscoe et al., 2006; Arakji and Lang, 2007).

2.4 Zipf's and Odlyzko and Tilly's laws

Criticising the previous formulation by Metcalfe, Odlyzko and Tilly (2005) proposed an alternative rule consistent with Zipf's (1946) law. Their proposal for estimating the value of the network is:

$$n\log(n)$$

In this case, the growth rate is slower than Metcalfe's law, but faster than the linearity of Sarnoff's law. As mentioned, this rule is an elaboration of the empirical Zipf's law, which stated that if we order the elements of some large collection by frequency or size, the second element will be about half as frequent as the first; the third about one-third, and so on. Generally speaking, the k^{th} element will measure about $1/k$ of the first one (Li, 1992; Newman, 2005).

A typical example is the English language (Zipf, 2013) in which the most popular word is 'the', accounting for 7% of occurrences. The second most popular world is 'of', making up 3.5% of occurrences. The third most popular word is 'and', counting 2.8%. These percentages show the $1/k$ sequence: 1/1, 1/2, 1/3.

Briscoe et al. (2006) proposed applying this law to the e-mail network: mail senders can be ranked by their number of received messages. The person ranked number 1 has the highest number of messages; the person ranked number 2 has the second highest number of messages, and so on. Denoting the person's rank by k, each person contributes to $1/k$ to the total value of the mail network. Taking n to be the total number of people in the mail network, in such way, the value of the network for person i will be:

$$1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \ldots + \frac{1}{n-1}$$

From the mathematical point of view, this is something like log(n). The total value of the whole network will be the sum over all the individual networks:

$$\left(1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \ldots + \frac{1}{n-1}\right) * n \approx n\log(n)$$

Other applications of Zipf's law include cities (Gabaix, 1999a, 1999b; Ioannides and Overman, 2003; Soo, 2005), where the number of cities with a population greater than S is proportional to $1/S$; and income distribution (Okuyama et al., 1999), where a distribution of income consistent with Zipf's law can be traced in Japanese companies over more than three decades.

These findings are consistent with another rule of thumb – that of the long tail. This rule suggests that, given a million items, the most popular 100 will contribute a third of the total values, the next 10,000 another third, and the remaining 989,900 the final third (Montroll and Shlesinger, 1982; Briscoe et al., 2006).

Odlyzko and Tilly's law is also supported by Westland (2010), who developed a robust measure of the connectedness of members inside social networks: these values are consistent with $n(\log)n$.

Summarising, Reed's law grows exponentially, Metcalfe's law quadratically, and Sarnoff's law linearly; the $n(\log)n$ growth lies between Metcalfe's and Sarnoff's laws.

Table 1 Laws concerning network value

Formula	*Author(s)*	*Growth rate*	*Supporting references*
n	Sarnoff	Linear	Bilby (1986) and Kovarik (2015)
$n\log(n)$	Odlyzko and Tilly	Faster than linear	Odlyzko and Tilly (2005), Briscoe et al., (2006, 2009), Westland (2010) and Odlyzko (2010)
$\frac{n(n-1)}{2}$	Metcalfe	Quadratic	Gilder (1993), Metcalfe (1995), Madureira et al. (2013), Van Hove (2014, 2016) and Zhang et al. (2015)
$2^n - n - 1$	Reed	Exponential	Reed (1999, 2001) and Coughlin (2008)

2.5 Network value in the digital era

The advent of the internet has led to changes in our lives and, in parallel way, the study of the WWW has stimulated the interest of academic researcher (Di Fatta et al., 2016a, 2016b).

Some scholars (Barabási and Albert, 1999; Adamic and Huberman, 2000; Adamic et al., 2001) have found that the numbers of nodes and connections in the web are related the power law – a functional relationship between two quantities in which, when one quantity (the independent variable) changes, the dependent variable changes faster than proportionally (Newman, 2005).

The occurrence of the power law on the web is consistent with the study of Faloutsos et al. (1999) of website topology. These authors found that, whenever the number of connections doubles, the number of nodes with this number of connections decreases by a factor of five.

Other scholars studied the diameter of the web (Albert et al., 1999; Albert and Barabási, 2002); though Odlyzko (2012) argued that considerations of the volume of information should not be divorced from the value of information.

Therefore there are many gaps to be filled: an approach considering both the size and value of the network is still required (Odlyzko, 2010); we moreover need also to consider the Web 2.0 (i.e., the network as platform), which spans all the connected devices delivering software as a continually-updated service that improves as more people use it (O'Reilly, 2007).

In other words, the Web 2.0 is based on consuming and remixing data from multiple sources, including individual users (user-generated content), thus generating network effects that go far beyond those of the simple pages on the Web 1.0.

This process determines the new user-generated content on the web and creates a new kind of information. Wikipedia is the best-studied case of such user-generated content, (Welser et al., 2011; Ransbotham et al. 2012; Jullien, 2012; Muñoz, 2012). Wikipedia is not just a website; it has created a new model based on the free exchange of information created and shared by users (Welser et al., 2011). The process is controlled by other users who revise and moderate these contents: these are therefore the main judges, as are the users themselves.

This mechanism involves a process of continuous improvement aimed at refining the information and purifying it from any possible distortions: this is a typical example of a Web 2.0 process with user-generated content.

Although there are many other examples such as OSNs (Smith et al., 2012), the reference to Wikipedia is useful for our aim, as it emphasises the way towards network expansion: increasing the number of members (or the amount of content) that is a part of the network, self-regulating by a process of moderation.

3 Doctor Chat case study

With this in mind, we can formalise some consideration on how the network laws function when the network expands. Generally speaking, it is possible to identify two theoretical expansion modes for a network:

a an increase in the number of members of the network (i.e., Doctor Chat case that will be analysed in the next section)

b the merging of two or more networks (that will be analysed from a theoretical point of view).

More in depth: let us consider the situation (a). When a new member joins the network, all the other members benefit from an increase in the general value: this phenomenon is easily explained by the relationship between the value of the network and its elements (regardless of whether the scaling is taken to be linear, quadratic, or exponential).

In our case, following a boom in subscriptions, Doctor Chat founder and CEO, which also is a researcher at the University of Palermo (Faculty of Medicine), has set itself the problem of determining the value of its own mobile application and hence the value of its network.

3.1 Methodology and data collection process

Since July 2015, we started data collection: case study allow the qualitative research to engage with rich data using multiple sources (such as direct and participant observation, in depth interviews, documents, archival records, artefacts) within a single research setting (Eisenhardt, 1989; Eisenhardt and Graebner, 2007).

Previous studies (Yin, 1989; Freebody, 2003) highlighted the decision to focus on a single case study allows the researcher a greater level of detail on a specific exploration theme; instead the multiple case studies are best suited for confirmatory research.

Our investigation began with an in depth interview with the CEO of Doctor Chat, Francesco Cupido. During his interview, once summarised the origins of the business idea and the actual situation of the firm, he explained the problem: Doctor Chat network is expanding day by day, hot to manage this?

We spent six months attending the headquarters and the offices, actively participating in the top management summit: direct and participant observation (Becker and Geer, 1957; Jick, 1979; Jorgensen, 1989). Participant observation is useful to know what orders of information escape us when we use other methods: for example, during an interview, the interviewee might have some misgivings. Through participant observation, the researcher has the opportunity to check how the actors behave in everyday situations (Crabtree and Miller, 1999).

Suitable information have been collected by direct observation and participant, but we also considered corporate documents and related materials, having free access to the archives and the app database.[2]

3.2 Findings and discussion

With respect to point (A), i.e., an increase in the number of members of the network, our first consideration is that the main limitation to Reed's and Metcalfe's laws involves the value of the interconnections (Odlyzko and Tilly, 2005): they are not equally valuable, since we can find both strong and weak ties in social networks (Granovetter, 1973, 1983); these give rise to subgroups with different values.

In particular, strong ties are those that constitute the connection between the closest elements in our network – for instance, subgroups of family, friends, and colleagues. The weak ties connect distant elements to the network and sometimes play the role of bridges between subgroups.

All other things being equal, users in online social networks (OSNs) are inclined to communicate more with some elements than with others (Ellison and Lampe, 2008): this mechanism tends to replicate the social structure of strong and weak ties (Granovetter, 1973).

Azizifard (2013) proposed a clustering procedure for OSNs based on a random walk: this consists of a process that, starting from one node in the network, progresses to neighbouring nodes to find communities and subgroups.

When OSNs are strongly clustered and grow organically (Azizifard, 2013), $n\log(n)$ seems to be the best description of the value of a network (Briscoe et al., 2007).

However, this formulation has some problems. To see this, let us consider the second expansion mode of a network: (B) the union of two (or more) networks. Define n and m to be values of two networks such that $n > m$.

Appling Metcalfe's Law, the values after merging will be, respectively, $n(n + m)$ and $m(n + m)$ meaning that each network gains nm: in other words, the size of the network does not affect the gain resulting from the merger. Applying Odlyzko and Tilly's Law, the values after merging will be, respectively, $n\log(n + m)$ and $m\log(n + m)$.

Network n will thus gain $n[\log(n + m) - \log(n)]$ and network m will gain $m[\log(n + m) - \log(m)]$. Generally speaking, when one network is larger than another, it usually resists interconnection because the smaller one will gain more.

The evidence supports these findings (Briscoe et al., 2007), as a larger network usually requires some sort of compensation (e.g., payment incentives) for interconnecting with a smaller one.

Accordingly, Metcalfe's Law is again rejected and Odlyzko and Tilly's law fits better. However, as mentioned above, this formula does not always work: when clustering is weak, the value of connecting separate network can be higher than $n\log(n)$ (Briscoe et al., 2009).

This phenomenon highlights the strength of weak ties (Granovetter, 1973). An example can help clarify this issue: suppose we plan to build roads to link 50 cities to each other; from a strictly mathematical point of view, there 1,225 different combinations of roads that will do this. From a practical point of view, it is not necessary that every city is linked with all other cities. Erdos and Renyi (1961) showed that building 98 roads (only 8% of the total combinations) ensure the connection of the vast majority of points. The remaining cities are linked by passing through other cities: we thus have subgroups of cities linked to each other (by strong ties) by small roads, and we also have large highways (weak ties) liking subgroups of cities with other subgroups.

In this case, the weak tie becomes a bridge. Broadly speaking, in social network, a weak tie is a bridge when it links subgroups that are strictly connected internally (by strong ties) and less connected externally (weak ties).

De Meo et al. (2014) pointed out that, on Facebook, most ties are weak, and therefore neither Metcalfe's law nor Odlyzko and Tilly's law are adequate. In summary, the $n\log(n)$ rule is able to explain the union of two or more networks better than Metcalfe's Law when networks are strongly clustered.

Concluding this section, it is important to note that manage network competences is a key factor for success according to Ritter and Gemünden (2003). In the next section, practical implications will be explained more in detail.

4 Conclusions and research agenda

This paper has examined the literature on network values, considering the fundamental Laws by Sarnoff, Metcalfe, Reed, Zipf, and Odlyzko and Tilly. The results of this manuscript have a twofold advantage: from a theoretical point of view, the literature review helps to outline and better organise previous studies in order to contribute in the advancement of existing knowledge, also thanks to following a research agenda that focuses on the key points on which there is still to be investigated (next Section 4.1); from a practical point of view, managerial implications arise from the ability to turn these theoretical knowledge (network competences) in tangible benefits for the firm with the positive effects on innovation and start-up performance.

With respect to RQ1, we found that Metcalfe's Law has been widely applied in the world of communications, but it has recently shown its limitations (Briscoe et al., 2009): it does not consider the value of interconnection and it overestimates the value of the union of two or more networks by ignoring the size of each of them.

Also considering Doctor Chat case study, Odlyzko and Tilly's $n\log(n)$ formulation seems to be the best approximation of the value of a network and gives a partial answer to the above problem. However, it does not give an answer to the main problem – that of the merging of networks (RQ2).

When clustering is weak, Odlyzko and Tilly's law is unable to capture the real value of the merger, which may be higher than its estimate. In other words, it tends to underestimate the network value of the occurrence of a large number of weak ties in the network.

However, this manuscript is not without limitations. Single case study research could run the risk to (erroneously) generalise the results. In order to not to make this error, we conclude this paper placing some questions useful as a starting point for further studies, which will contribute to the consolidation of these results.

In other words, these limits emphasise the need for further studies on the subject. For this reason, this paper proposes a research agenda which may be useful for further research.

4.1 Research agenda and further researches

The first point concerns the main weakness of $n\log(n)$: future studies could find a weighting coefficient that would be able to consider the value of a merger when clustering is weak: "how to determine the value of a network when clustering is weak?" Fuentelsaz et al. (2015) considered how strategies could affect the value of a network by influencing expectations, coordination and compatibility. They proposed an adjustment that takes into account the probability of making on-net calls over off-net calls:

$$\frac{m_i}{1-m_i}$$

They thus proposed an adjusted network value of:

$$n\log(n)\frac{m_i}{1-m_i}$$

The value, however, will be higher when there are a large number of communications possibilities between network users and when firm i has a competitive advantage that gives it stronger network effects. These findings need to be tested, emphasising the need for further studies that could deepen this problem.

The rules described in our literature review are based on the hypothesis that all members in the network, and all links, are equally valuable: this is a very strong hypothesis that conflicts with evidence that there are many differences between network elements. "Is it possible to remove this hypothesis? What would be the 'cost' of this waiver?"

In answering these questions, further studies may consider the topic not only from the theoretical point of view, but also from a practical aspect. Let us consider mobile marketing. It could be useful to check whether these rules, which are relatively functional in the case of OSNs with the limitations discussed above, can be extended to the mobile world. The new paradigm in the development of social networks is through mobile devices and mobile apps: this is consistent with Peppard and Rylander (2006) and Palumbo et al. (2013).

Indeed, the mobile-app markets (and network markets more in general) are very competitive: there are over a million mobile apps in various marketplaces such as Google Play Store, Apple Store, etc. (Di Fatta et al., 2016b; Dominici et al., 2016). OSNs are the new dominant paradigm, but mobile app firms need more information about apps in order to quantify their value: "how to determine the value of a network for a mobile app?"

Generally speaking, the managerial implications of these arguments translate into a better ability to evaluate not only the value of a network, but the value of a whole firm. More in depth, developing network competences has a strong positive effect on the extent of inter-organisational technological collaborations and, therefore, on product and process innovation success (Ritter and Gemünden, 2003). Furthermore, network competences are crucial also during the start-up process because spin-off's performance is positively influenced by these competences.

Many companies are now fully digital, lacking even a headquarters or physical infrastructure, but simply being based on the network (Bauman, 2013): "how can the value of these new firms be determined?"

Table 2 Research agenda

Problems	*RQ for further studies*
The main weakness of $n\log(n)$ is when clustering is weak (Briscoe et al., 2009)	How to determine the value of a network when clustering is weak?
The main assumption of the Metcalfe, Reed, and Odlyzko and Tilly Laws is that all members of the network and all the links are equally valuable. This is a very strong hypothesis that conflicts with evidence that there are many differences between networks elements (Briscoe et al., 2006)	Can this assumption of equality be removed? What would be the 'cost' of this waiver?
Many companies are now fully digital, having neither headquarters nor physical infrastructure, but being simply based on the network (Bauman, 2013)	How can the value of these new firms be determined?
Mobile apps are the future not just for OSNs, but for the whole economy (Peppard and Rylander, 2006)	How to determine the value of a network for a mobile app?

References:

Achrol, R.S. and Kotler, P. (1999) 'Marketing in the network economy', *The Journal of Marketing*, Vol. 63, Special Issue, pp.146–163, doi: 10.2307/1252108.

Adamic, L.A. and Huberman, B.A. (2000) 'Power-law distribution of the World Wide Web', *Science*, Vol. 287, No. 5461, pp.2115–2115.

Adamic, L.A., Lukose, R.M., Puniyani, A.R. and Huberman, B.A. (2001) 'Search in power-law networks', *Physical Review E*, Vol. 64, No. 4, p.046135.

Albert, R. and Barabási, A. L. (2002) 'Statistical mechanics of complex networks', *Reviews of Modern Physics*, Vol. 74, No. 1, p.47.

Albert, R., Jeong, H. and Barabási, A.L. (1999) 'Diameter of the World Wide Web', *Nature*, Vol. 6749, No. 401, pp.130–131.

Anderson, J.C., Håkansson, H. and Johanson, J. (1994) 'Dyadic business relationships within a business network context', *The Journal of Marketing*, Vol. 58, No. 4, pp.1–15.

Arakji, R.Y. and Lang, K.R. (2007) 'Digital consumer networks and producer-consumer collaboration: innovation and product development in the digital entertainment industry', *40th Annual Hawaii International Conference*, p.211c.

Azizifard, N. (2013) 'Social network clustering', *International Journal of Information Technology and Computer Science*, Vol. 6, No. 1, pp.76–85.

Baffour Awuah, G., Abraha Gebrekidan, D. and Osarenkhoe, A. (2011) 'Interactive (networked) internationalization: the case of Swedish firms', *European Journal of Marketing*, Vol. 45, Nos. 7/8, pp.1112–1129.

Barabási, A.L. and Albert, R. (1999) 'Emergence of scaling in random networks', *Science*, Vol. 286, No. 5439, pp.509–512.

Basu, A., Mazumdar, T. and Raj, S.P. (2003) 'Indirect network externality effects on product attributes', *Marketing Science*, Vol. 22, No. 2, pp.209–221.

Bauman, Z. (2013) *Liquid Modernity*, John Wiley & Sons, Cambridge, UK.

Becker, H. and Geer, B. (1957) 'Participant observation and interviewing: a comparison', *Human Organization*, Vol. 16, No. 3, pp.28–32.

Bilby, K. (1986) *The General: David Sarnoff and the Rise of the Communications Industry*, HarperCollins, New York, USA.

Briscoe, B., Odlyzko, A. and Tilly, B. (2006) 'Metcalfe's law is wrong-communications networks increase in value as they add members-but by how much?', *Spectrum*, Vol. 43, No. 7, pp.34–39, IEEE.

Briscoe, B., Odlyzko, A. and Tilly, B. (2009) 'When a 'law' isn't a law at all', *International Commerce Review*, Vol. 8, No. 2, pp.146–149.

Briscoe, P.R., Ferstat, C.D., Ganis, M.R., Hammer, S.C., Hansen, G.B.K., Harp, S.A. and Snitzer, B.J. (2007) *U.S. Patent No. 7,216,149*, U.S. Patent and Trademark Office, Washington, DC.

Coughlin, T.M. (2008) 'Personal storage for mobile applications', *Journal of Magnetism and Magnetic Materials*, Vol. 320, No. 22, pp.2860–2867.

Crabtree, B.F. and Miller, W.L. (Eds.) (1999) *Doing Qualitative Research*, Sage Publications, London, UK.

De Meo, P., Ferrara, E., Fiumara, G. and Provetti, A. (2014) 'On Facebook, most ties are weak', *Communications of the ACM*, Vol. 57, No. 11, pp.78–84.

Di Fatta, D., Caputo, F., Evangelista, F. and Dominici, G. (2016a) 'Small world theory and the World Wide Web: linking small world properties and website centrality', *International Journal of Markets and Business Systems*, Vol. 2, No. 2, pp.126–140.

Di Fatta, D., Musotto, R., D'Aleo, V., Vesperi, W., Morabito, G. and Bue, S. L. (2016b) 'Weak ties and value of a network in the new internet economy', in Shaling, H-J. (Ed.): *Social Media Data Extraction and Content Analysis*, Chapter 3, pp.66–77.

Doerr, L.S. and Powell, W.W. (2005) 'Networks and economic life', *The Handbook of Economic Sociology*, Russell Sage foundation and Princeton University Press, Princeton.

Domingos, P. and Richardson, M. (2001) 'Mining the network value of customers', *Proceedings of the Seventh ACM SIGKDD International Conference on Knowledge Discovery and data Mining*, pp.57–66, ACM.

Dominici, G. (2009a) *E-marketing: analisi dei cambiamenti dai modelli di business al mix operative*, Franco Angeli. Torino, Italy.

Dominici, G. (2009b) 'From marketing mix to e-marketing mix: a literature overview and classification', *International Journal of Business and Management*, Vol. 4, No. 9, pp.17–24.

Dominici, G., Matić, M., Abbate, T. and Fatta, D.D. (2016b) 'Consumer attitude toward using smart shopping carts: a comparative analysis of Italian and Croatian consumer attitudes', *International Journal of Electronic Marketing and Retailing*, Vol. 7, No. 3, pp.229–244.

Eisenhardt, K. M. (1989) 'Building theories from case study research', *Academy of Management Review*, Vol. 14, No. 4, pp.532–550.

Eisenhardt, K.M. and Graebner, M.E. (2007) 'Theory building from cases: opportunities and challenges', *Academy of Management Journal*, Vol. 50, No. 1, pp.25–32.

Ellison, N.B. and Lampe, C. (2008) 'Social, capital, self-esteem and use of online social network sites: a longitudinal analysis', *Journal of Applied Developmental Psychology*, Vol. 29, No. 6, pp.434–445.

Erdos, P. and Renyi, A. (1961) 'On the strength of connectedness of a random graph', *Acta Mathematica Hungarica*, Vol. 12, No. 2, pp.152–163.

Faloutsos, M., Faloutsos, P. and Faloutsos, C. (1999) 'On power-law relationships of the internet topology', *ACM SIGCOMM Computer Communication Review*, Vol. 29, No. 4, pp.251–262.

Freebody, P. (2003) *Qualitative Research in Education: Interaction and Practice*, Sage, London, UK.

Fuentelsaz, L., Garrido, E. and Maicas, J.P. (2015) 'A strategic approach to network value in network industries', *Journal of Management*, Vol. 41, No. 3, pp.864–892.

Gabaix, X. (1999a) 'Zipf's law and the growth of cities', *The American Economic Review*, Vol. 89, No. 2, pp.129–132.

Gabaix, X. (1999b) 'Zipf's law for cities: an explanation', *Quarterly Journal of Economics*, Vol. 114, No. 3, pp.739–767.

Gilder, G. (1993) 'Metcalfe's law and legacy', *Forbes*.

Granovetter, M. (1973) 'The strength of weak ties', *American Journal of Sociology*, Vol. 78, No. 6, pp.1360–1380.

Granovetter, M. (1983) 'The strength of weak ties: a network theory revisited', *Sociological Theory*, Vol. 1, No. 1, pp.201–233.

Gummerus, J. (2013) 'Value creation processes and value outcomes in marketing theory: strangers or siblings?', *Marketing Theory*, Vol. 13, No. 1, pp.19–46.

Hendler, J. and Golbeck, J. (2008) 'Metcalfe's law, Web 2.0, and the Semantic Web', *Web Semantics: Science, Services and Agents on the World Wide Web*, Vol. 6, No. 1, pp.14–20.

Ioannides, Y.M. and Overman, H.G. (2003) 'Zipf's law for cities: an empirical examination', *Regional Science and Urban Economics*, Vol. 33, No. 2, pp.127–137.

Jick, T.D. (1979) 'Mixing qualitative and quantitative methods: triangulation in action', *Administrative Science Quarterly*, Vol. 24, No. 4, pp.602–611.

Jorgensen, D.L. (1989) *Participant Observation*, John Wiley & Sons, Inc., London, UK.

Jullien, N. (2012) *What We Know About Wikipedia: A Review of the Literature Analyzing the Project(s)*, 7 May 2012, doi: http://dx.doi.org/10.2139/ssrn.2053597, SSRN 2053597 [online] https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2053597 (accessed 8 June 2016).

Kovarik, B. (2015) *Revolutions in Communication: Media History from Gutenberg to the Digital Age*, Bloomsbury Publishing, USA.

Li, W. (1992) 'Random texts exhibit Zipf's-law-like word frequency distribution', *IEEE Transactions on Information Theory*, Vol. 38, No. 6, pp.1842–1845.

Madureira, A., Den Hartog, F., Bouwman, H. and Baken, N. (2013) 'Empirical validation of Mecalfe's law: how internet usage patterns have changed over time', *Information Economics and Policy*, Vol. 25, No. 4, pp.246–256.

Mattsson, L.G. and Johanson, J. (2006) 'Discovering market networks', *European Journal of Marketing*, Vol. 40, Nos. 3/4, pp.259–274.

McIntyre, D.P. and Chintakananda, A. (2014) 'Competing in network markets: can the winner take all?', *Business Horizons*, Vol. 57, No. 1, pp.117–125.

Metcalfe, B. (1995) 'Metcalfe's law: a network becomes more valuable as it reaches more users', *Infoworld*, 2 October.

Montroll, E.W. and Shlesinger, M.F. (1982) 'On 1/f noise and other distributions with long tails', *Proceeding of the National Academy of Sciences*, Vol. 79, No. 10.

Muñoz, C.L. (2012) 'More than just Wikipedia: creating a collaborative research library using a wiki', *Marketing Education Review*, Vol. 22, No. 1, pp.21–26.

Newman, M.E. (2005) 'Power laws, Pareto distributions and Zipf's law', *Contemporary Physics*, Vol. 46, No. 5, pp.323–351.

O'Reilly, T. (2007) 'What is Web 2.0: design patterns and business models for the next generation of software', *Communications and Strategies*, Vol. 1, No. 1, p.17.

Odlyzko, A. (2010) 'Social networks and mathematical models: a research commentary on 'critical mass and willingness to pay for social networks', in Westland, J.C. (Ed.): *Electronic Commerce Research and Applications*, Vol. 9, No. 1, pp.26–28.

Odlyzko, A. (2012) 'Info capacity – the volume and value of information', *International Journal of Communication*, Vol. 6, No. 16, pp.920–935.

Odlyzko, A. and Tilly, B. (2005) 'A refutation of Metcalfe's Law and a better estimate for the value of networks and network interconnections', Manuscript, March, p.2.

Okuyama, K., Takayasu, M. and Takayasu, H. (1999) 'Zipf's law in income distribution of companies', *Physica A: Statistical Mechanics and Its Applications*, Vol. 269, No. 1, pp.125–131.

Palumbo, F., Dominici, G. and Basile, G. (2013) 'Designing a mobile app for museums according to the drivers of visitor satisfaction', *Recent Advances in Business Management and Marketing – Proceedings of the 1st International Conference on Management, Marketing, Tourism, Retail, Finance and Computer Applications (MATREFC'13)*, WSEAS Press, Dubrovnik, Croatia.

Peppard, J. and Rylander, A. (2006) 'From value chain to value network: insights for mobile operators', *European Management Journal*, Vol. 24, No. 2, pp.128–141.

Ransbotham, S., Kane, G.C. and Lurie, N.H. (2012) 'Network characteristics and the value of collaborative user-generated content', *Marketing Science*, Vol. 31, No. 3, pp.387–405.

Reed, E.P. (1999) 'The sneaky exponential – beyond Metcalfe's law to the power of community building', *Context Magazine*.

Reed, E.P. (2001) 'The law of the pack', *Harvard Business Review*, Vol. 79, No. 2, pp.63–78.

Ritter, T. and Gemünden, H.G. (2003) 'Network competence: its impact on innovation success and its antecedents', *Journal of Business Research*, Vol. 56, No. 9, pp.745–755.

Rohlfs, J. (1974) 'A theory of interdependent demand for a communications service', *The Bell Journal of Economics and Management Science*, Vol. 5, No. 1, pp.16–37.

Rosenbaum, J.E., Kariya, T., Settersten, R. and Maier, T. (1990) 'Market and network theories of the transition from high school to work: their application to industrialized societies', *Annual Review of Sociology*, Vol. 16, No. 1, pp.263–299.

Shapiro, C., Varian, H.R. and Becker, W.E. (1999) 'Information rules: a strategic guide to the network economy', *Journal of Economic Education*, Vol. 30, No. 1, pp.189–190.

Skalén, P., Gummerus, J., von Koskull, C. and Magnusson, P.R. (2015) 'Exploring value propositions and service innovation: a service-dominant logic study', *Journal of the Academy of Marketing Science*, Vol. 43, No. 2, pp.137–158.

Smith, A.N., Fischer, E. and Yongjian, C. (2012) 'How does brand-related user-generated content differ across YouTube, Facebook, and Twitter?', *Journal of Interactive Marketing*, Vol. 26, No. 2, pp.102–113.

Soo, K.T. (2005) 'Zipf's Law for cities: a cross-country investigation', *Regional Science and Urban Economics*, Vol. 35, No. 3, pp.239–263.

Van Hove, L. (2013) 'Drivers of internationalisation in network industries: the case of electronic purse developers', *International Journal of Management and Enterprise Development*, Vol. 12, No. 3, pp.189–211.

Van Hove, L. (2014) 'Metcalfe's law: not so wrong after all', *NETNOMICS: Economic Research and Electronic Networking*, Vol. 15, No. 1, pp.1–8.

Van Hove, L. (2016) 'Metcalfe's law and network quality: an extension of Zhang et al.', *Journal of Computer Science and Technology*, Vol. 31, No. 1, pp.117–123

Welser, H.T., Cosley, D., Kossinets, G., Lin, A., Dokshin, F., Gay, G. and Smith, M. (2011) 'Finding social roles in Wikipedia', *Proceedings of the 2011 iConference*, February, pp.122–129, ACM.

Westland, J.C. (2010) 'Critical mass and willingness to pay for social networks', *Electronic Commerce Research and Applications*, Vol. 9, No. 1, pp.6–19.

Wilson, D.T. (1995) 'An integrated model of buyer-seller relationships', *Journal of the Academy of Marketing Science*, Vol. 23, No. 4, pp.335–345.

Yin, R.K. (1989) *Case Study Research: Design and Methods*, revised edition, Applied Social Research Methods Series, Vol. 5, London, UK.

Zhang, X.Z., Liu, J.J. and Xu, Z.W. (2015) 'Tencent and Facebook data validate Metcalfe's law', *Journal of Computer Science and Technology*, Vol. 30, No. 2, pp.246–251.

Zipf, G.K. (1946) 'Some determinants of the circulation of information', *The American Journal of Psychology*, Vol. 59, No. 3, pp.401–421.

Zipf, G.K. (2013) *The Psycho-Biology of Language: An Introduction to Dynamic Philology*, First published in 1936, Routledge, Milton Park, Oxon.