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Valuation of Online Social Networks Taking into Account Users' Interconnectedness

by

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Abstract:

Online social networks have been gaining increasing economic importance in light of the rising number of their users. Numerous recent acquisitions priced at enormous amounts have illustrated this development and revealed the need for adequate business valuation models. The value of an online social network is largely determined by the value of its users, the relationships between these users, and the resulting network effects. Therefore, the interconnectedness of a user within the network has to be considered explicitly to get a reasonable estimate for the economic value. Established standard business valuation models, however, do not account for these aspects sufficiently. Thus, we propose an economic model for the valuation of online social networks, which takes into account the users' interconnectedness within the network. Furthermore, we analyze different centrality measures, which can be used to quantify users' interconnectedness in online social networks and propose a measure which is based on the PageRank-algorithm. Finally, the practical application of the model is illustrated by an example of the major European online social network XING.com.

Keywords: online social networks, economic valuation, business case, centrality measures, PageRank

1 Introduction

Thanks to a variety of online social applications, including blogs, user-generated content sites like YouTube.com and countless online communities across the World Wide Web (WWW), people are connecting and communicating more and more online with one other (Bernoff and Li 2008, Gross and Acquisiti 2005; Kazienko and Musial 2006). Along with these changes in the use of the Internet, formerly passive information users are becoming actors, which create the content of the WWW themselves. In this context, online social networks (OSN) are currently of particular interest. Therefore, networking platforms such as MySpace.com and Facebook.com have spurred enormous attention among researchers and practitioners. This attention is mainly induced by the great popularity and active use of OSN both in private and corporate context. According to a study recently published by the European Interactive Advertising Association (EIAA), 42% of all European Internet users participate in OSN (EIAA 2008). Moreover, Emarketer.com states that 37% of US adult and 70% of US teenage Internet users used OSN every month in 2007 (Williamson 2007). With the growing number of users, this technical and social phenomenon generates an increasing economic impact. Thus, media and IT companies have been acquiring OSN for considerable amounts to adapt their business models to the new environmental conditions and to reorganize their companies for the future. In 2005, for example, the media company News Corporation acquired the OSN MySpace.com for US$ 580 m (BBC 2005). Two years later, Microsoft paid US$ 240 m for a 1.6% minority interest in the OSN Facebook.com (Hofmann and Knahl 2008). The extrapolated value of this company thus amounts to staggering US$ 15 billion. However, the enormous purchase prices for OSN are also being considered critically and experts compare the situation with the speculative dotcom bubble before the turn of the millennium. Martin Sorrell for instance, CEO of the WWP Group is seriously questioning the valuation of Facebook.com at US$ 15 billion (Lambrecht 2008).

What makes the economic valuation of OSN particularly difficult is that their value is largely determined by the value of their users, the relationships between these users, and the resulting network effects. For instance, with a growing number of individual contacts, the user's perceived attractiveness of the OSN increases. Thus, a well-connected user might be using an OSN more actively and might be attracting new contacts within and beyond the network. Furthermore, the loyalty of a user strongly depends on his or her integration into the OSN, since every additional individual contact raises the barrier to leave the network (Algesheimer and Von Wangenheim 2006). Consequently, the interconnectedness of each user in the OSN has to be considered explicitly to get a reasonable estimate for the firm value (cf. Gneiser et al. 2009b). Currently, established standard business valuation models do not consider this aspect sufficiently. Thus, the important question of how an OSN can be valued using well-founded valuation methods while considering the interconnectedness of its users has not been answered yet. Therefore, the focus of this paper is first to develop an economic model for the valuation of OSN which takes into account the users' interconnectedness in OSN, and second to provide an adequate centrality measure in order to quantify users' interconnectedness in OSN which is important for the feasibility and applicability of the model. Third, we illustrate the practical application of the model to the OSN XING.com using only publicly available data.

The paper is structured as follows: In section 2 we define and describe characteristics of OSN and briefly review existing valuation approaches. In section 3 we develop our own quantitative valuation approach for OSN. Then, we analyze common centrality measures regarding their ability to quantify users' interconnectedness for the economic valuation of OSN and provide a new measure which is based on the PageRank-algorithm in section 4. The practical application of the new model is extensively illustrated by an example of the major European OSN XING.com in section 5. The last section highlights the general results, points out limitations and suggests areas for further research.

2 Related Work

2.1 Characteristics of Online Social Networks

Aroused by the web 2.0 boom, OSN have evolved into a new, mostly free of cost mass medium where users[1] present themselves to a wide public. Thereby, the users voluntarily reveal parts of their privacy and establish or maintain connections to other users. Besides the exponential growth of OSN, the way they are perceived has changed over the last years. OSN are not simply forums in which individuals congregate. They rather "create substantial value for the individuals who participate in them, the organizations that sponsor them, and the larger society in multiple ways" (Agarwal et al. 2008). Thus, the community idea itself, which was long known and extensively researched especially in the field of social sciences (see Bagozzi and Dholakia 2006) and in social network analysis in general (Milgram 1967; Granovetter 1973; Watts 2003), took on new dimensions with the development of the Internet and the emergence of OSN.

In the following we define OSN according to Boyd and Ellison (2007) as "web-based services that allow individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system". Thereby, OSN provide a basis for "maintaining social relationships, for finding users with similar interests, and for locating content and knowledge that has been contributed or endorsed by other users" (Mislove et al. 2007). Thus, the aspect of networking, i.e. establishing and maintaining relationships between users, plays a decisive role. Currently, there are a lot of OSN both for business (e.g. Doostang.com, LinkedIn.com) and private purposes (e.g. Facebook.com, MySpace.com) aiming at different target groups. Moreover, they differ in size and in the degree of privacy, i.e. who can see your profile and how much of it is visible (Howard 2008). While the culture that emerges around OSN varies, the maintenance of individual contacts and most of the key technological features are fairly consistent (Boyd and Ellison 2007). Furthermore, in most cases the community idea is actively lived over forum and group functions and network structures are observable (Xu et al. 2008).

[1] The terms customer and user are used synonymously.

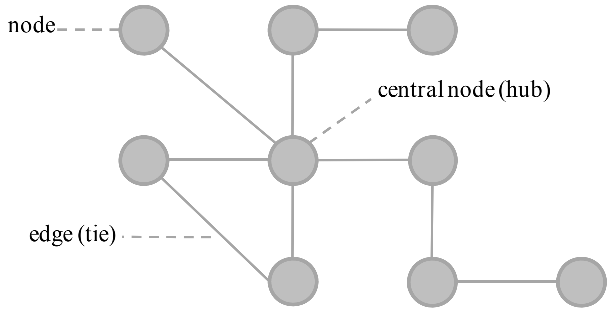

Fig. 1 Visualization of the network structure

An in-depth understanding of the network structure invoked by the connections between users is necessary to analyze various aspects of OSN, e.g. to valuate current OSN or to design future OSN based systems (Mislove et al. 2007). For the valuation of OSN, we refer to the social network analysis, where the network structure is perceived as a set of actors, which are represented by nodes, and a set of edges (ties) linking pairs of nodes (Adamic and Adar 2003; Bampo et al. 2008; Wasserman and Faust 1994). The edges represent connections between actors and describe social interactions or relationships. The nodes and edges are usually presented by a graph (Hanneman and Riddle 2005), as shown in Fig. 1. Thereby, the visualization especially highlights so-called hubs (Bampo et al. 2008), i.e. actors who have a particularly large number of connections to other actors. The specific network structure has to be considered when determining the economic value of OSN.

2.2 Economic Valuation of Online Social Networks

A plethora of articles and books on the valuation of companies in general has been published (Brealey and Myers 2008; Koller et al. 2005). However, according to the predominant view in literature standard business valuation approaches are very restricted in their ability to value young, fast growing companies in a dynamic environment, such as Internet companies (see e.g. Gollotto and Kim 2003). Reasons are, for instance, the backward orientation using traditional financial balance sheet figures (e.g. liquidation value, substantial value, (adjusted) book value), a lack of acceptance and application in business matters (e.g. real option approach), a lack of academic foundation (e.g. venture capital approach), and the limited history to draw on for future cash flow projections and the handling of just negative cash flows (e.g. discounted cash flow approach). For OSN, the economic valuation is even more difficult, since users, relationships between users, and the resulting network effects represent a major part of the firm value. Hence, the value of each user per se and the importance (integration) of a user within the OSN have to be considered explicitly to get a reasonable estimate for the firm value.

Established standard business valuation models do not comprehensively take these aspects into account yet. In recent years, however, new approaches have been developed, which consider the value of customers as the most important factor for a company’s valuation (see e.g. Bauer and Hammerschmidt 2005; Gupta et al. 2004; Krafft et al. 2005). Although these models are still based on the discounted cash flow approach, the focus has shifted from the projection of cash flows on a company level to the projection of cash flows obtained from the existing and future customer relationships. The basic idea behind these valuation methods is to measure the value of the customer base by summing up all discounted cash flows (in and out cash flows) arising from all existing and future customer relationships. The obtained value of the customer base represents the entire value of the discounted operating cash flows of a company. Finally, the value of the customer base "and all cash flows generated from non-operating assets yield the overall value of the company" (Bauer and Hammerschmidt 2005). This change of perspective is quite beneficial for the valuation of OSN. Nevertheless, these valuation approaches have a major drawback concerning their application to OSN: network effects resulting from relationships between users are ignored. This is crucial, since a user, providing no direct financial return to a company, might have – if considered isolated – a low (or even no) value. Yet, he or she might affect many other users by interacting with them and hence, for instance, motivate them to stay members of the network (Kiss and Bichler 2008).

In general, network effects and in particular the importance of relationships between users within a social network have been an extensively and well-researched field in (social) network analysis. Network effects are thereby characterized by dependencies between the increasing utility that a user derives from consumption of a good and the growing number of other agents consuming this good (Katz and Shapiro 1985; Katz and Shapiro 1994; Shapiro and Varian 1998). Bass (1969) thereby differentiates between innovators, i.e. agents adopting an innovation independently of others in a social system, and adopters. Individual utility models of the diffusion of innovations state that people adopt new technologies if benefits from adoption and use exceed the costs (Rogers 2003). Besides the social component that influences this utility – e.g. the number of others using an innovation – normative models play a decisive role (Kraut et al. 1998). Especially adopters are influenced by the pressure of the social system that increases with the number of previous adopters (Bass 1969). Therefore, an individual's social influence on the adoption process of other users is likely to be highly dependent on the individual's position in a social network (Kraut et al. 1998; Rice and Aydin 1991). The spread of a certain behavior or innovation in a social network, however, is not always invoked by a group of well-connected hubs (Watts 2007). Only if a critical mass of users is exceeded (Arthur 1989; Morris and Ogan 1996), new users are attracted and a stronger interconnectedness of users leads to so-called lock-in-effects (Farrell and Shapiro 1989; Shapiro and Varian 1998). A central position of an individual nevertheless positively affects his or her influence in a network and hence his or her value for a network. Consequently, not only the number of users, but also their interconnectedness, i.e. the relationships between the users, are crucial factors for the value of an OSN (Algesheimer and Von Wangenheim 2006).

Particularly in the social network literature authors have focused on analyzing networks of relationships, for instance by tracing the flow of information through them and discovering the effects of relations and networks on people and organizations (Wasserman and Faust 1994; Berkowitz 1982). Granovetter (1973), for example, analyzed the strength of relationships (ties) between people in detail, classifying them to be strong, weak or absent. He remarks, that strong ties have greater motivation to be of assistance and are typically more easily available. However, weak ties provide people with access to information and resources beyond those available in their own social circle (Granovetter 1973; Granovetter 1983) and bridge cliques of strong ties (Constant et al. 1996). Hence, OSN allow users to draw on resources from other users in the network and to leverage connections from multiple social and geographically dispersed contexts (Haythornthwaite 2002). Furthermore, Watts and Strogatz (1998) found and further studies confirmed (Barabási und Bonabeau 2003; Kumar et al. 2006; Mislove et al. 2007) that almost all social networks, and in particular OSN, are scale-free. This means that OSN have a structure with many nodes having only few connections and some hubs creating short cuts between nodes which otherwise would be far away from each other. Part of the success of social networks can be attributed to a phenomenon invoked by this structural characteristic (Kautz et al. 1997), which goes back to Stanley Milgram (1967), who provided first empirical support for the notion that everyone is just a few steps apart in the global social network. A number of experiments, constructing paths through social networks to distant target individuals (e.g. Dodds et al. 2003; Garfield 1979; Korte and Milgram 1970) and current studies (e.g. Leskovec and Horvitz 2008) confirm the so-called "small world" effect regarding modern networks such as the Internet and OSN. Thus, even though there might be gaps between individuals within large OSN, i.e. there are no direct (strong or weak) ties among all participants, well-connected users tie together sub-networks and offer easy access to relevant information or contact to other users. Hence, a connection to a well-connected user can yield more benefit than a connection to a sparsely connected user. Consequently, every additional direct or indirect contact raises a user's barrier to leave the network (Algesheimer and Von Wangenheim 2006) and conversely, he or she might affect many other users to stay members of the network. The OSN XING.com for instance reports that well-connected users have a higher retention rate (i.e. they are less inclined to leave the network) and lead to a higher activity among users, which leads them to attract new users to a greater extent (XING 2006; XING 2008). Therefore, each user's interconnectedness has to be taken into account adequately when valuating OSN.

It is remarkable that despite the extensive research in network theory – to the best of our knowledge – no approach for the economic valuation of OSN, which adequately takes into account users' interconnectedness in OSN has been developed so far. Based on the findings from previous research in customer-based valuation and network theory, we therefore develop an economic model for the economic valuation of OSN that explicitly considers users' interconnectedness in OSN.

3 Design of the Economic Model

The long-term value of OSN is largely determined by the value of its users, the relationships between these users, and the resulting network effects, since tangible assets usually play a marginal role. Hence, the existing and future customers of the OSN provide its most reliable source of future revenues. The sum of those customer relationships' values is denoted as the customer equity (CE) (Blattberg and Deighthon 1996; Rust et al. 2004). To determine the value of a single customer the widely accepted customer lifetime value (CLV) approach is used, which is similar to the discounted cash flow approach in firm valuation (Koller et al. 2005; Damodaran 2002). The CLV is defined as the present value of all existing and future cash flows generated by a certain customer (Berger and Nasr-Bechwati 1998).

Employing the CLV approach for determining the value of the OSN, we first partition all existing and future customers into different cohorts c (with c=0, 1, …), where c denotes the period in which the customer joined or will join the OSN. Then customers are referred to as i=1, …, N_c for each cohort c, whereas all existing customers at the instant of valuation are assigned to cohort c=0. With this notation, the CE of an OSN can be expressed as the sum of discounted CLVs of all existing (cohort c=0) and future (cohorts c=1, 2, …) customers[2]:

$$CE = \sum_{c=0}^{\infty} \frac{\sum_{i=1}^{N_c} CLV_{c,i}}{(1+d)^c}, \tag{1}$$

where CE denotes the total value of all existing and future customer relationships,
$CLV_{c,i}$ the CLV of customer i of cohort c,
N_c the number of customers in cohort c (with $N_c \in$ IN) and
d the periodical discount rate (with $d \in$ IR$^+$).

In order to determine the CLV of customer i of cohort c ($CLV_{c,i}$), we obtain the present value at the beginning of period c of all cash flows $CF_{c,i,t} \in$ IR that the OSN expects to receive from the customer over the entire relationship (Berger and Nasr-Bechwati 1998). With t indicating the period of the customer relationship (for existing customers: period since the instant of valuation) and $T_{c,i} \in$ IN as the duration of the customer's relationship (for existing customers: remaining duration), $CLV_{c,i}$ can be expressed as follows:

$$CLV_{c,i} = \sum_{t=0}^{T_{c,i}} \frac{CF_{c,i,t}}{(1+d)^t}, \tag{2}$$

where $CF_{c,i,t}$ denotes the cash flow in period t of the customer relationship for customer i of cohort c and
$T_{c,i}$ the duration of the customer relationship for customer i of cohort c.

However, the implementation of formula (2) is not easy, because it requires detailed information regarding both the future cash flows $CF_{c,i,t}$ and the duration of the customer relationship $T_{c,i}$ for every single (future) customer. Therefore, we use a common approach to bypass the estimation of the concrete duration of the customer relationship $T_{c,i}$ and consider retention rates $r_{c,i,t}$ (cf. for example Berger and Nasr-Bechwati 1998; Gupta et al. 2004). The retention rate $r_{c,i,t}$ of a customer i of cohort c for a period t (with $t \geq 1$) is defined as the (conditional) probability that the customer remains in the OSN in period t, given that the customer has been a member in the previous period (t-1). In literature, an undifferentiated approach calculating average retention rates for the whole customer base is often used. However, as discussed above, well-connected users tend to have higher retention rates in the context of OSN. To account for that crucial characteristic, we compute individual retention rates for each customer, considering his or her individual degree of interconnectedness in the OSN. Thereby, the degree of interconnectedness of a customer i of cohort c in period t can be expressed through the variable $m_{c,i,t} \in$ IR$^+$ (for a detailed discussion of how to quantify a user's interconnectedness in OSN and how to operationalize this variable see section 4). Finally,

[2] Strictly speaking all determined values are expected values. For simplification we avoid to state all determined values as expected values.

regarding the estimation of the individual retention rate $r_{c,i,t}$ for customer i the following aspects (A) have to be considered[3]:

A.1 For a customer i with a higher degree of interconnectedness the individual retention rate should be ceteris paribus higher than for a less interconnected customer j with a lower degree of interconnectedness (*lock-in effect*). This results in a strict monotone increasing retention rate function depending on the degree of interconnectedness (i.e. $m_{c,i,t-1} > m_{c,j,t-1}$ implies $r_{c,i,t}(m_{c,i,t-1}) > r_{c,j,t}(m_{c,j,t-1})$).

A.2 An increase of the degree of interconnectedness by ε leads to a ceteris paribus less marginal change in the individual retention rate of customer i with a higher degree of interconnectedness than in the individual retention rate of a less interconnected customer j with a consequently lower degree of interconnectedness. This results (in combination with A.1) in a decreasing marginal utility of an increase in the degree of interconnectedness regarding the retention rate (i.e. $m_{c,i,t-1} > m_{c,j,t-1}$ implies $r_{c,i,t}(m_{c,i,t-1}+\varepsilon) - r_{c,i,t}(m_{c,i,t-1}) < r_{c,j,t}(m_{c,j,t-1}+\varepsilon) - r_{c,j,t}(m_{c,j,t-1})$ with $\varepsilon>0$).

Taking A.1 and A.2 as a starting point, we intensively searched for an appropriate function for our model. The arctangent based formula (3) considers both aspects for all degrees of interconnectedness $m_{c,i,t-1}$ and can therefore be used for our purpose. We compress the arctangent function (*arctan*) to restrict the obtained values for $r_{c,i,t}(m_{c,i,t-1})$ to the interval [0; 1]. Then the individual retention rate for a customer i of cohort c in period t can be defined as a function of the degree of interconnectedness as follows:

$$r_{c,i,t}(m_{c,i,t-1}) = \frac{arctan\left(\alpha_{t-1} \cdot m_{c,i,t-1}\right)}{\pi/2}, \tag{3}$$

where $r_{c,i,t}$ denotes the retention rate for customer i of cohort c in period t,
$m_{c,i,t-1}$ the degree of interconnectedness of customer i of cohort c in period t-1 and
α_{t-1} the calibration factor for the degree of interconnectedness in period t-1.

Note that the parameter $\alpha_{t-1} \in \mathrm{IR}^+$ is used to calibrate the model in regard to the empirical observed average retention rate of the particular period t of the customer relationship (the empirical observed average retention rate can be interpreted as the fraction of customers that had been members for t-1 periods and remained in the OSN in period t). Fig. 2 illustrates the function $r_{c,i,t}$ depending on the degree of interconnectedness $m_{c,i,t-1}$ for different values of the calibration factor α_{t-1}.

[3] Cf. e.g. Varian (2003), where a detailed literature overview of network effects is given.

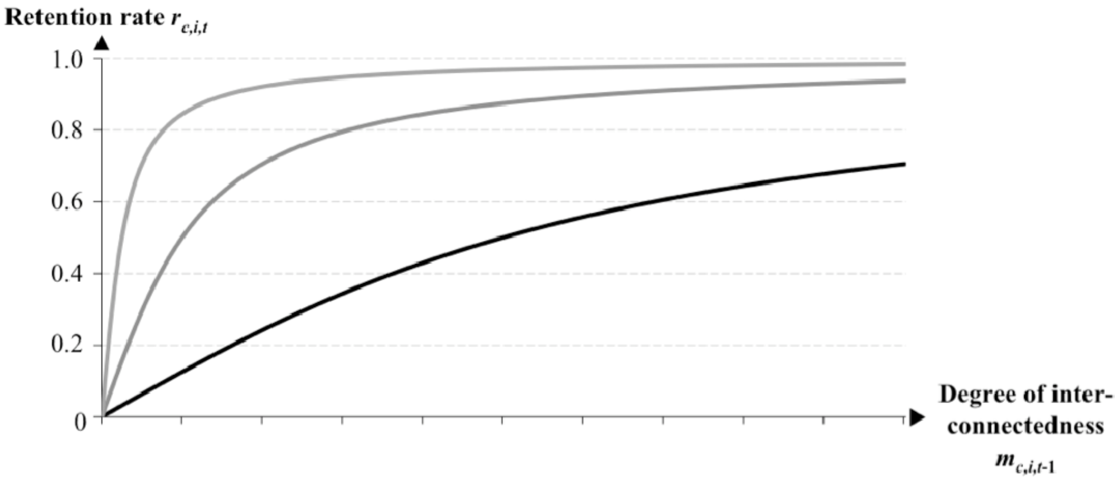

Fig. 2 Retention rate as a function depending on the degree of interconnectedness

Taking into account the customers' individual retention rates $r_{c,i,t}(m_{c,i,t-1})$ we can derive formula (4) for the CE of an OSN[4]. Since the future degree of interconnectedness of a customer i is unknown, his or her recent degree of interconnectedness has to be used for a forecast. We will demonstrate a corresponding procedure as well as how to determine all other parameters of the model in detail in section 5 using the case of XING.com.

$$CE = \sum_{c=0}^{\infty} \frac{\sum_{i=1}^{N_c} CLV_{c,i}}{\left(1+d\right)^c} = \sum_{c=0}^{\infty} \frac{\sum_{i=1}^{N_c}\sum_{t=0}^{\infty}\left(\frac{CF_{c,i,t} \cdot \prod_{l=1}^{t} r_{c,i,l}(m_{c,i,l-1})}{\left(1+d\right)^t}\right)}{\left(1+d\right)^c} \tag{4}$$

Finally, we obtain the corporate value of an OSN, applying the approach of Bauer and Hammerschmidt (2005), by adding the value of the non-operating assets and by subtracting the value of all non customer-specific costs as well as the market value of debt[5]. However, according to empirical research, for some companies the CE is already "a useful proxy for firm value" (Gupta et al. 2004). This holds true to the extent that the customer base, as given for OSN, constitutes a large part of the company's overall value and can be seen as its key determinant.

In order to demonstrate feasibility and applicability of the model for the valuation of OSN, we discuss measures for the quantification of users' interconnectedness in OSN in the following section. Afterwards, in section 5, we illustrate the application of the model using publicly available data of XING.com, one of the largest and well-known OSN in Europe.

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4 As it is not possible to draw a conclusion of the customer's individual retention rate directly after his or her initial registration to the OSN (t=0) an average value for the rate $r_{c,i,1}(m_{c,i,0})=r_{c,\varnothing,1}$ is used. For l>1 see (3).

5 Approaches for the valuation of non-operating assets can be found, for instance, in IDW (2008). For the determination of the market value of debt see e.g. Damodaran (2002).

4 Quantifying Interconnectedness in Online Social Networks

As already discussed in the previous sections, quantifying a user's interconnectedness is an indispensible step towards an adequate economic valuation of OSN and the users' individual degree of interconnectedness is an integral part of our economic model (cf. formula 3). Hence, a concrete measure for the quantification of a user's interconnectedness is essential to operationalize the developed valuation model. For this purpose, in this section we derive a set of requirements which an adequate measure for quantifying a user's interconnectedness in OSN has to fulfill. Then, we briefly review existing centrality measures and propose a new quantitative measure based on the PageRank-algorithm.

4.1 Requirements for Quantifying Interconnectedness in Online Social Networks

The first and perhaps most intuitive requirement when determining a user's interconnectedness in OSN is the consideration of direct contacts, as a user can communicate and interact directly with these contacts.

R.1 [*Consideration of direct contacts*] A user's direct contacts have to be taken into account adequately when quantifying his or her interconnectedness.

However, as discussed in section 2, not only direct contacts are important for a user's interconnectedness, as a user also benefits from indirect contacts (e.g. through additional information or by acquiring new contacts). Furthermore, Benevenuto et al. (2009) found, that users not only interact with direct contacts, but also have significant exposure to users "that are 2 or more hops away". Thus, a connection to a user with many contacts is more valuable than to a user with only one or no further contact (Kiss and Bichler 2008). Hence, the interconnectedness of a user's direct contacts (i.e. his or her indirect contacts) has to be considered when quantifying the user's interconnectedness.

R.2 [*Consideration of indirect contacts*] The interconnectedness of a user's contacts (indirect contacts and their network) has to be considered adequately when quantifying his or her interconnectedness.

Besides these two requirements regarding the consideration of direct and indirect contacts, another requirement is the applicability of the measure in real-world scenarios.

R.3 [*Feasibility*] The measure should be based on determinable input data, its computational complexity should be manageable, and from an economic point of view it is required that the measurement can be accomplished at a high level of automation.

Having derived this set of requirements, we can use it to analyze common centrality measures regarding their ability to quantify a user's interconnectedness in an OSN.

4.2 Analysis of Common Centrality Measures

If we resort to scientific literature centrality measures can be found in multiple contexts, since the quantification of interconnectedness in networks has attracted attention not only in social network analysis but also in many other fields (e.g. biology, physics). For social networks in general, the most common centrality measures to quantify the importance of a certain node within a network are presented in Freeman's article "Centrality in Social Networks" (Freeman 1979). In the following, we provide the definition of each of the three measures presented by Freeman and analyze their capability to quantify a user's interconnectedness in the context of OSN with respect to the requirements R.1-R.3.

Degree Centrality

The basic idea of degree centrality is that a node with many direct connections to other nodes is central to the network (Sparrowe et al. 2001). Thus, this measure is based upon the number of a node's direct contacts. For a node $i \in \{1,...,n\}$, degree centrality is defined as:

$$C_D(i) = \sum_{\substack{j=1 \\ j \neq i}}^{n} a_{ij} \ ,$$

where $n \in \mathrm{IN}$ is the number of nodes in the network and $a_{ij} \in \{0,1\}$ is an element of the adjacency matrix which is 1 if and only if there exists an edge between the nodes i and j (otherwise it is 0) (Freeman 1979). Degree centrality considers direct contacts (R.1) and is easy to compute from network data (R.3). However, indirect contacts are not considered at all. Therefore R.2 is not fulfilled.

Betweenness Centrality

Betweenness centrality quantifies the ability of a node to reach other nodes in the network. Freeman (1979) defines this measure as the frequency with which a node falls between all unordered pairs of other nodes on the shortest paths connecting them. For a node $i \in \{1,...,n\}$ within a connected network, betweenness centrality is defined as:

$$C_B(i) = \sum_{\substack{j=1 \\ j \neq i}}^{n} \sum_{\substack{k=j+1 \\ k \neq i}}^{n} \frac{g_{jk}(i)}{g_{jk}} \ ,$$

where $g_{jk} \in \mathrm{IN}$ is the number of shortest paths linking j and k and $g_{jk}(i) \in \mathrm{IN}$ is the number of these paths containing node i. Betweenness centrality does not take into account direct or indirect contacts adequately for the economic valuation of OSN as all connections between users are important in OSN (not only the shortest paths). In Fig. 3, for example, the interconnectedness score calculated with betweenness centrality is 0 for node 1 and 2, although both nodes have direct and indirect contacts. Furthermore, the values are the same for node 1 and 2, although node 2 has more direct contacts. In conclusion, neither R.1 nor R.2 is completely fulfilled. As there exist adequate algorithms to overcome computational performance problems R.3 is fulfilled.

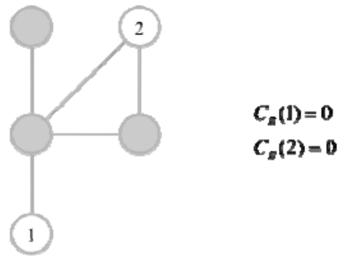

Fig. 3 Betweenness Centrality (Example)

Closeness Centrality

In the concept of closeness centrality a node is considered as central, if it is at short distance to all other nodes in the network. For a node $i \in \{1,...,n\}$ closeness centrality is defined as the reciprocal value of the sum of the length of the shortest paths from a node to all other nodes in the network and can be denoted as:

$$C_C(i) = \frac{1}{\sum_{\substack{j=1 \\ i \neq j}}^{n} d(i,j)},$$

where $d(i,j) \in \mathrm{IN}$ is the minimum length of any path connecting i and j (Freeman 1979). It accounts for direct contacts and thus fulfills R.1. However, indirect contacts are not considered adequately, as the interconnectedness of a user's direct contacts is not taken into account consistently. In Fig. 4, for instance, closeness centrality returns the same values for node 1 in network a) and b), although the interconnectedness of the contacts of node 1 in network b) is much higher (additional edges). Thus, R.2 is not completely fulfilled. Although closeness centrality is relatively difficult to calculate, adequate algorithms for computing distances in a network exist (Kiss and Bichler 2008). Therefore R.3 is fulfilled.

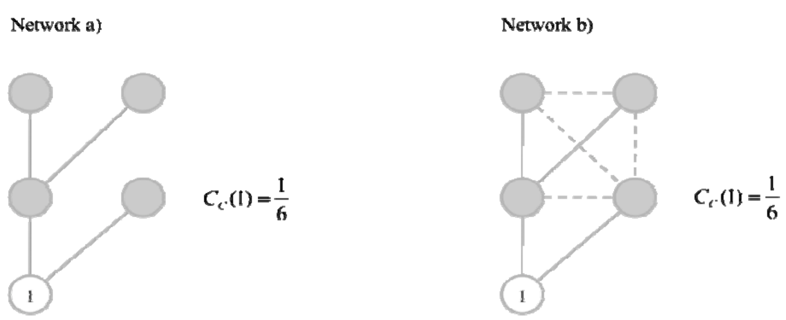

Fig. 4 Closeness Centrality (Example)

Table 1 summarizes the results of the analysis of centrality measures regarding their ability to quantify a user's interconnectedness in OSN on the basis of the requirements R.1-R.3.

Table 1 Summary of the results

Requirement	*Degree centrality*	*Betweenness centrality*	*Closeness centrality*
R.1 *Consideration of direct contacts*	**yes**	**no**	**yes**
R.2 *Consideration of indirect contacts*	**no**	**no**	**no**
R.3 *Feasibility*	**yes**	**yes**	**yes**

As Table 1 illustrates, none of the centrality measures discussed so far fulfills all requirements (R.1-R.3) for quantifying interconnectedness in the context of OSN. Particularly R.2 is never fulfilled, since indirect contacts are not considered adequately by any measure. However, this is crucial with regard to OSN, as a connection to a node with high interconnectedness (i.e. with many direct and indirect contacts) is – as already discussed – more valuable than a connection to a sparsely connected node. Thus, we propose a new quantitative measure, derived from a very similar application domain: the ranking of websites.

4.3 A PageRank Based Centrality Measure for Online Social Networks

In 1998, Brin and Page, the founders of the Google Internet search engine, developed the popular PageRank-algorithm to rank the importance of Web pages, a problem very similar to the quantification of a user's interconnectedness in OSN. The general idea of PageRank relies on a graph where Web pages are nodes and (directed) edges represent the links between them. Thereby, PageRank uses the link structure as an indicator of an individual page's importance in the structure of the WWW relative to other pages by interpreting a link from page A to page B as a vote by page A for page B. Brin and Page (1998) define the PageRank for a page *i* as:

$$PR(i) = v \cdot \sum_{j \in B_i} \frac{PR(j)}{O_j} + v \cdot E(i), \tag{5}$$

such that v is maximized and $||PR||_1=1$ ($||PR||_1$ denotes the L_1 norm of PR). In formula (5), O_j is the number of outgoing links from page j. B_i denotes the set of pages pointing to page i and $E(i)$ corresponds to an additional source of rank over the Web pages. The factor v is used for normalization, so that the total rank of all Web pages is constant (Brin and Page 1998). The first part of formula (5) can be interpreted as the behavior of a "random surfer" clicking randomly on successive links. It corresponds to the standing probability distribution of a random walk on the graph of the Web. However, it can be assumed that a real Web surfer gets bored after several clicks or that he gets into a loop of pages. In those cases, he is unlikely to continue forever. Instead, the surfer will jump to a random page. This behavior is modeled by the second part of formula (5). Methodically PageRank is a variant of eigenvector centrality. The basic idea of eigenvector centrality is that the centrality of node i is a function of the centralities of all nodes connected to i. Therefore, in the first part of formula (5) node i inherits a proportion of rank from all nodes pointing to it, i.e. all nodes connected to i by ingoing edges. To calculate the proportion which node i inherits from each node j in B_i, node j's rank is divided by the number of j's outgoing edges. Hence, node j contributes equally to the ranks of all pages it points to. In the second part of formula (5), $E(i)$ represents an additional source of rank for node i and can be used to adjust page ranks individually.

Due to these characteristics the general concept of PageRank is appropriate regarding the proposed requirements for the quantification of a user's interconnectedness in OSN. However, a general difference between interconnectedness in the WWW and in OSN exists: While relationships in the WWW are directed (ingoing and outgoing edges), relationships in OSN are usually symmetric (undirected). Therefore, we adapt the PageRank-formula as follows: B_i (set of nodes connected to i by ingoing edges) is substituted by F_i (set of nodes connected to i). Furthermore, to assure that requirement R.2 is fulfilled and to avoid a decrease of the interconnectedness score inherited from node j as the number of j's contacts grows, the dominator O_j is removed. The adapted formula is denoted as:

$$S(i) = v \cdot \sum_{j \in F_i} S(j) + v \cdot E(i), \tag{6}$$

such that v is maximized and $||S||_1=1$. F_i represents the set of user i's direct contacts. The first part of formula (6) shows the interconnectedness score, which a node i inherits from its contacts. Due to the summation over F_i, all direct contacts contribute to $S(i)$. Furthermore, the (adapted) PageRank $S(i)$ of a node is calculated recursively. Thus, a node ceteris paribus inherits a higher interconnectedness score from a well-connected node than from a sparsely connected one. Therefore, direct (R.1) and indirect contacts (R.2) are considered consistently and adequately. As in the original PageRank-formula, $E(i)$ represents an additional source of rank and can be used to account for further individual parameters (besides direct and indirect contacts) that influence a node's interconnectedness (e.g. group memberships, etc.) in an OSN. However, $E(i)$ can be set equal to 0 if an additional source of rank is absent or ignored. As the computation of the adapted PageRank can be traced back to the problem of finding an eigenvector (cf. e.g. Brin and Page 1998) the computational complexity can be reduced to $O(n^2)$ which is feasible with today's computing power. Therefore R.3 is fulfilled (for an example of the calculation of a user's interconnectedness using the adapted PageRank cf. Gneiser et al. 2009a). Table 2 summarizes the analysis of all the discussed centrality measures regarding the requirements R.1-R.3.

Table 2 Analysis of centrality measures regarding the requirements R.1-R.3

Requirement	*Degree centrality*	*Betweenness centrality*	*Closeness centrality*	*Adapted PageRank*
R.1 *Consideration of direct contacts*	**yes**	**no**	**yes**	**yes**
R.2 *Consideration of indirect contacts*	**no**	**no**	**no**	**yes**
R.3 *Feasibility*	**yes**	**yes**	**yes**	**yes**

As illustrated in Table 2, the adapted PageRank is the only centrality measure in our analysis that sufficiently fulfills all requirements R.1-R.3. Hence, assuming complete information about the whole network structure, the adapted PageRank allows an adequate quantification of a user's interconnectedness in OSN. Since OSN providers themselves can easily access information about their network (Dwyer et al. 2007; Xu et al. 2008), they can use the adapted PageRank for quantifying a user's interconnectedness, e.g. for specific marketing activities. However, in particular for external stakeholder groups (e.g. investors, creditors), which rely mostly on solely publicly available data, the selection of an adequate measure may be restricted, as many measures require non-public data, e.g. detailed information about the whole network structure.

In order to demonstrate the practical application of the economic valuation model, the following section illustrates the valuation of the OSN XING.com, one of the largest and most well-known OSN in Europe, on the basis of publicly available data.

5 Application of the Economic Model

5.1 The Online Social Network XING.com

XING.com (in the following referred to as XING) was founded in August 2003 under the name OPEN Business Club. It is one of the leading OSN within the realms of professional online networking platforms in Europe. At the end of 2007, XING counted over 5.7 m members worldwide. These customers use XING predominantly to find useful business contacts, new business opportunities, employees, jobs and ideas by posting a profile on the Internet platform. In addition to the free of cost Basic Membership, XING offers a Premium Membership with additional functionalities for a monthly fee of € 5.95. The concept of Premium Membership is the backbone of the business model and booked by 362,000 members (December 31st 2007). Besides these membership fees we disregard additional revenue generating sources like banner-ads and e-commerce in a first step as so far these sources of revenue are not crucial to the XING business model[6].

5.2 Determination of the Parameters of the Model

To illustrate the application of the model designed in section 3 we determine the corporate value of XING on January 1st 2008. As XING is a publicly listed corporation (IPO in 2006), we can resort to data published in the annual reports from 2006 and 2007 for our valuation. Hence, in contrast to other studies in the context of OSN that use internal data provided by an OSN (e.g. Ahn et al. 2007; Golder et al. 2007; Kumar et al. 2006), we use only publicly available data in order to illustrate transparently the application of the model as well as the determination of the parameters of the model (e.g. by an external stakeholder).

Determination of the Number of Members

Starting from the IPO at the end of 2006, XING reports a compound annual growth rate of XING's Premium Members of 64% (Xing 2007). As corporate cash flows are almost exclusively generated by Premium Members, we only consider Premium Members' cash flows in our model. Nevertheless, Basic Members contribute indirectly to the value of the OSN: On the one hand they are "potential contacts" for Premium Members and therefore increase the attractiveness of the network. On the other hand Basic Members are also "potential Premium Members" in future periods. However, a projection of a compound annual growth rate for Premium Members of 64% seems to be not reasonable in the long run. For instance, mature Internet companies like Amazon, Ameritrade, Capital One, eBay, and E*Trade usually show compound annual growth rates in the range of 15% to 25% (Gupta et al. 2004). A survey of the Global Industry Analysts Group (Xing 2006) projects an annual growth rate of 21.1% for chargeable Internet services within the next years. Moreover, from 2007 to 2008 the number of OSN users increased by 25% to 580 m users worldwide

[6] In 2007 94% of XING's revenues were generated by Premium Memberships (Xing 2007).

(ComScore 2008). Thus, we adjust the annual growth rate for XING to 25% for the years 2008 to 2010 (cf. Table 3). For the subsequent time period up to 2017, we project a more conservative growth rate of 10%. Beyond the year of 2018 we do not assume any network growth for XING, i.e. numbers of new members and numbers of members leaving the OSN are the same.

Table 3 Number of Premium Members of XING 2006 to 2010 (cf. Xing 2007)

Year	2006	2007	2008e	2009e	2010e
Premium Members	221,000	362,000	452,500	565,625	707,031

Determination of the Individual Retention Rates

To avoid an undifferentiated valuation of XING based on average values disregarding essential information such as the customers' individual degree of interconnectedness we drew a feasible sample of 1,000 customers (Premium Members) on December 31st 2007. By choosing the members randomly (using the search for "random members" provided by XING), it is assured that the sample is eligible to be characteristic for the whole network. Based on this data, we determined each customer's individual CLV considering the individual degree of interconnectedness and the initial year of registration at XING[7].

As described in section 3, retention rates for $t \geq 1$ represent the probability that a Premium Member generating cash flows up to period t-1 will still be a Premium Member in period t. First of all, we determine average retention rates $r_{0,\varnothing,t}$ for the Premium Members derived from the published fraction of members still remaining at the beginning of year (or period) t after their year of registration (cf. Table 4). As the Premium Membership fees for XING are payable in advance, we assume that all customer cash flows are generated at the beginning of a period. Considering this, we derive an average retention rate of 100% ($r_{0,\varnothing,1}$=100%) for the first year of membership (=first period), as all new customers generate cash flows in their first year. For the second year we consequently consider only those customers, that are still Premium Members of the OSN at the beginning of the second year ($r_{0,\varnothing,2}$=82%). Furthermore, the average retention rate for the third year $r_{0,\varnothing,3}$ is determined to 93% (=76%/82%), as 76% of Premium Members remain in the OSN in the third period (paying members in t=3) after 82% remained in the second period (paying members in t=2). Starting from year 4 onwards, we assume $r_{0,\varnothing,t}$ being constantly 99% (=75%/76%).

Table 4 Rate of remaining Premium Members and average retention rates

Period *t* (year of membership)	1	2	3	4 etc.
Fraction of remaining Premium Members at the beginning of period *t*	100%	82%	76%	75%
∅ retention rate for period *t* ($r_{0,\varnothing,t}$)	100%	82%	93%	99%

In a second step, we determine individual retention rates taking into account the individual degree of interconnectedness of each Premium Member. Here, as discussed in section 4, the adapted PageRank would be the preferred measure for quantifying a user's interconnectedness

[7] We assume that all Premium Members joined the network on January 1st within their year of registration. Note that the year of registration is publicly available for each member (cf. www.xing.com).

in the OSN. However, only OSN providers can easily access the data necessary for applying this measure as information about the whole network structure is needed. Since it is the primer goal of this section to transparently illustrate the applicability of the economic model and the determination of its parameters, we decided – in consistency with the determination of all other parameters – to use only publicly available data (i.e. external stakeholder's point of view) for the determination of the individual degree of interconnectedness of each Premium Member (note that based on data about the whole network structure the adapted PageRank can be calculated easily (cf. Gneiser et al. 2009a)). Hence, we refrain from applying the adapted PageRank and use degree centrality to quantify a Premium Member's degree of interconnectedness instead. In contrast to the adapted PageRank (and in contrast to betweenness and closeness centrality), the degree centrality of each Premium Member in our sample could be easily determined by counting each member's direct contacts (no further information about the network structure is needed). Based on the degree centrality $m_{c,i,t\text{-}1}$ of a Premium Member, i.e. the number of its direct contacts, and on the calibration factor for a specific period $\alpha_{t\text{-}1}$ we determine individual retention rates (cf. formula (3)). For the determination of the calibration factor, we use the average retention rate. In detail, we choose $\alpha_{t\text{-}1}$ so that the overall average of the individual retention rates for period t (i.e. the average of all $r_{0,i,t}(m_{0,i,t\text{-}1})$) corresponds to the observed average retention rate for this year of membership $r_{0,\varnothing,t}$ (cf. Table 4: e.g. 82% for the second year of membership). The results of this calibration for the periods 1 to 3 are illustrated in Table 5. For further periods we do not need this calibration factor, as starting from period 4 onwards we assume constant individual retention rates.

Table 5 Calibration factors for the calculation of the individual retention rates

Period *t* (year of membership)	**1**	**2**	**3**
Calibration factor for period *t* (α_t)	0.0643	0.1560	0.4170

To calculate the individual retention rates for the existing customers (using formula (3)) not only for the next period t (based on $m_{0,i,t\text{-}1}$) but also for further periods (t+1, t+2, …) we have to forecast the individual degree centralities ($m_{0,i,t}$, $m_{0,i,t+1}$, …) or rather the individual numbers of direct contacts. For this projection, we calculate in a first step the average number of contacts depending on their individual period of membership t (e.g. 126 for the second period after registration). Thereon, we derive average growth rates respectively. For example we obtain an average growth rate of 29.9% (=126/97-1) from t=1 to t=2. The rates are presented in Table 6, whereas these are only relevant for the periods 1 to 3. This procedure allows us to forecast the number of contacts for future periods, and thus the users' individual degree centralities for future periods.

Table 6 Average growth of the number of contacts

Period *t* (year of membership)	**1**	**2**	**3**
∅ contacts for period *t*	97	126	230
∅ growth of number of contacts from period *t*-1 to *t*	-	29.9%	82.5%

Finally, we can determine the individual retention rates using the calibration factors α_t (cf. Table 5), the individual information about the year of registration (to determine period t), the current degree centrality and the average growth rates of contacts (cf. Table 6). The latter is essential for the forecast of the degree centrality for a Premium Member in the following periods. Table 7 illustrates exemplarily individual retention rates for Premium Members A1 and A2.

Table 7 Example for the calculation of individual retention rates

	Year of membership in 2007	Degree centrality 2007	Retention rate 2008e	Degree centrality 2008e	Retention rate 2009e	Degree centrality 2009e	Retention rate 2010e etc.
A1	1	50	80.8%	65	93.7%	119	98.7%
A2	1	150	93.4%	195	97.9%	356	99.6%

For a better understanding, we illustrate the calculation following the example of the Premium Member A2. A2 has a degree centrality of $m_{0,\mathrm{A2},1}$=150 at the end of his first year of membership. Using the calibration factor α_1=0.0643 and formula (3) we determine the individual retention rate $r_{0,\mathrm{A2},2}(m_{0,\mathrm{A2},1})=arctan(0.0643\cdot150)/(\pi/2)\approx93.4\%$. Hence, the probability that A2 still remains Premium Member in the next period (i.e. in 2008) is 93.4%. For the calculation of the individual retention rate of A2 for 2009, we project the degree centrality or rather the number of contacts by the end of 2008 as follows: $m_{0,\mathrm{A2},2}=150\cdot(1+29.9\%)\approx195$. This leads to an individual retention rate of $r_{0,\mathrm{A2},3}(m_{0,\mathrm{A2},2})= arctan(0.1560\cdot195)/(\pi/2)\approx97.9\%$. The individual retention rates of further years (e.g. for 2010) can be calculated analogically. For the determination of retention rates of future customers, we have to use average degree centralities (cf. Table 6) as their individual numbers of contacts are unknown.

Determination of the Cash Flows

The revenue generated per Premium Member is € 5.95 per month, which amounts to € 71.40 per year. In order to project future cash flows, we determine in a first step the EBITDAM-margin (Earnings Before Interest, Tax, Depreciation, Amortization, and Marketing) based on figures published in the annual report 2007 (Xing 2007) amounting to (€ 6.894 m+€ 1.651 m)/€ 19.609 m≈43.6%. Due to the negative margin of the previous year and the long-term rather truncating growth we use a more conservative margin which is extrapolated to a constant figure of 35%[8]. With regard to the amount of marketing spending we have to rely on an assumption, as we could not find precise information in the annual reports about the allocation to existing and to new customers. Therefore we follow the often used rule-of-thumb (cf. Greenberg 2001) and assume that it is five times more expensive to win new customers than to keep existing ones. Taking into account the customer distribution of existing and new customers in our sample of 2007 (55% of the sample are existing customers and 45% are new customers), we allocate marketing-spending of € 8.14/year for new customers and € 1.63/year for existing customers. Thereon, we determine the cash flow per Premium Member amounting to $CF_{c,i,1}$=€ 71.40·35%-€ 8.14=€ 16.85 for the first year of membership[9] and to $CF_{c,i,t}$=€ 71.40·35%-€ 1.63=€ 23.36 € for the following years (t>1).

[8] This extrapolation is consistent with the projected EBITDA-margin according to the XING guidance.
[9] As cash flows $CF_{c,i,t}$ are generated at the beginning of each period, we discount the values contrary to formula (4) by t-1 periods and assign acquisition payments to period t=1. In period t=0 there are no cash flows.

Determination of the Discount Rate

Due to the dominating equity financing[10] of XING, we assume in a simplified model that the weighted average cost of capital (WACC) is solely based on equity. The cost of equity capital is derived by applying the after-tax CAPM using the average yield of a 10-year European government bond of 4.4% for the base rate (European Central Bank 2007). Applying a common used income tax rate of 35% the tax adjusted risk free rate accounts to 2.86%. Furthermore we assume an expected risk premium of the stock market after taxes of 5.5% (Stehle 2004). Taking into account that OSN bear more risk than traditional software companies and the fact that XING is relatively small, we increase the published beta-factor of 1.27 for software-companies (Drukarczyk and Schüler 2007) to 1.48. In summary after applying the after-tax CAPM, we derive a discount rate of 11% (=2.86%+(5.5%·1.48)).

5.3 Key Findings of the Application

Applying the economic model to XING using only publicly available data, we obtain a CE of € 219.14 m. The value of the existing members sums up to € 63.89 m. In contrast, the value of the future members consists of the discounted cohort values of all acquired members up to the year 2026 (amounting to € 151.77 m) and of the discounted terminal value[11] (amounting to € 3.48 m). Table 8 gives an overview of the key findings. With our results we help external stakeholders (e.g. investors) to receive information about the approximate firm value on the basis of publicly available data, e.g. to make well-founded investment decisions. If we take into account that further residuals such as the value of the non customer-specific cash flows, fixed costs that are not attributable to the individual customer and the value of the non-operating assets are negligible, the corporate value equals the CE. Comparing this value with the market capitalization in the amount of € 229.89 m on January 1st 2008, we can state only a slight difference of 4.7% from our findings. This difference can be explained on the one hand by general volatility of the stock market and divergent estimation of valuation parameters by the stock market. On the other hand we neglected additional revenue sources such as advertisements, e-commerce or merchandising products as these sources of revenue are (so far) not crucial to the XING business model. Furthermore, we calculated the users' interconnectedness using the common centrality measure degree centrality. So, even though the adapted PageRank is more sufficient in fulfilling the requirements for quantifying a user's interconnectedness in OSN in general – as shown in section 4 – for reasons of transparency and to be able to calculate a user's interconnectedness based on publicly available data, we chose degree centrality when applying the model. This simplification might cause a deviation of the calculated retention rates and consequently a variation of the individual CLV and the CE, too. However, a stock price of € 44.21 at the instant of valuation seemed to be quite reasonable.

[10] XING reports equity of € 41.5 m and long-term debt of € 0.85 m in 2007 (Xing 2007).

[11] From the year 2018 on we assume a net growth of zero relating to the number of members. Therefore the cohort values are almost constant from the year 2027 on, so that we can take a terminal value based on the perpetuity.

Table 8 Key findings of the application to XING

Year of registration / Cohort	≤2007 / 0	2008 / 1	2009 / 2	2010 / 3	…	2026 / 19
Existing Premium Members	362,000	452,500	565,625	707,031	…	1.377,804
New Premium Members	164,710	129,180	147,714	178,530	…	17,651
Discounted value of cohort [m€]	63.89	20.32	20.93	22.79	…	0.42
Discounted terminal value [m€]	3.48					
Customer equity (CE) [m€]	**219.14**					

6 General Results, Limitations, and Further Research

The increasing economic relevance of OSN and numerous recent acquisitions priced at enormous amounts revealed the need for adequate valuation models. However, traditional valuation approaches are restricted in their ability to value young and fast growing Internet companies such as OSN. Thus, we developed an economic model for the valuation of OSN taking into account their specific characteristics, e.g. the users' interconnectedness in the network. As quantifying users' interconnectedness is an indispensible step towards an adequate economic valuation of OSN and therefore is an integral part of the economic model, we further derived a set of requirements which a measure to quantify interconnectedness in OSN has to fulfill. As none of the common centrality measures we discussed fulfills all these requirements, we also developed a new PageRank based approach for quantifying users' interconnectedness in OSN. The practical application of the model was illustrated by an example of the major European OSN XING. Thereby, we only used publicly available data and demonstrated that the model even allows external stakeholders to estimate whether the purchase prices realized on the market are justifiable. In the case of XING, the result of our model was in the range of the market capitalization at the instant of valuation. Here, we illustrated that, although some assumptions in the process of the application of the valuation model to XING were necessary, publicly available data in connection with specific market data can be sufficient to get reasonable results, which might help investors to make well-founded investment decisions.

However, the proposed economic model and the new PageRank based approach to quantify users' interconnectedness in OSN are only first steps towards a well-founded valuation of OSN. Concerning the economic model, future research may focus on the application of the approach to other business models of OSN as in a first step only membership fees which are the basis of XING's revenue model were considered in section 5. For example, OSN without membership fees often face the problem that users are not leaving the network but instead simply quit using it (i.e. they are becoming passive users with low or no value for the company). Thus, the model could be extended, for example to account for a user's activity (e.g. frequency of login, forum and chat contributions etc.) in an OSN. Furthermore, we assumed average retention rates for future customers so far. This assumption could be released by accepting more computational complexity when determining the customers' individual retention rates. For instance, this could be achieved through network simulations approaches. But there is also room for further research concerning the new PageRank based approach for quantifying users' interconnectedness in OSN. In this context, an evaluation of the adapted PageRank-algorithm using empirical datasets is essential. Hence, we are currently working on an evaluation using publicly available social network datasets. Moreover, we aim at applying the economic model using internal data (including data about the network structure) provided by an OSN to improve the estimations of the parameters of the model and to be able to integrate the newly developed PageRank based approach to quantify interconnectedness properly.

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