

A Time Value Modeling Approach to Service Valuation in Social Networks

Abstract

With the prevalence of social network systems, more management researches were focusing on the network effects in the service market. A basic problem is that traditional methodologies of product-based pricing could no longer explain the value of the service systems characterized by social networks with open information. This paper proposes the approach to time value modeling for service science by providing a new method for service valuing in social networks. A new framework of service system modeling and a new formula of valuation of social capital were discussed. The time value of people or organizations can be measured by quantitatively analyzing social relationships. The interactions among stakeholders with different time values can be analyzed. We conducted empirical studies with real social network data to explain and verify the framework.

Keywords: Service, social network, social capital, time value

1 INTRODUCTION

The studies of the price and value have been the focus of management and economics for many decades. Yet they remain among the controversial issues of social science since innovations constantly change the ways of businesses. The advent of information technologies and social network systems for service market has had a significant impact on the management sciences and information systems. With the development of mobile communication technologies, more researches were focusing on the network effects across organizational boundaries. A basic problem is that the traditional methods of price and value for commodity market and manufacturing-type enterprises could no longer explain the value creation of service systems. Studies started in the 1980s, seeking to measure the value of the network, founded on the crisis of Internet bubble. Recently, researchers from emerging fields, such as Web sciences and Internet economy, started a new wave of researches on value science, seeking to explain the mechanism of value creation through network and social communication factors.

The aim of this paper is to redefine the basic framework of service science in the view of time value theory and give an approach to calculate the time value of people in the social network which can be used for valuing services in the social network. Human economic conduct is reconsidered using a time-space reference that objectively improves our conventional understanding of price, cost and value and the traditional valuation approaches. A new approach to analyzing the service systems can be built. The network effects can be quantitatively measured and analyzed. In the first part, we introduced a new modeling framework of measuring “time value” to access the relative scarcity of services in social network. Then we built a model to define the service and brought up the Time Value Rank algorithm based on the models. This paper also provided empirical studies to verify and illustrate the approach and model.

2 PREVIOUS REVIEWS

Many traditional approaches to price valuing focused on the supply and demand of products in the goods economy. The two most widely used theories are game theory and contract theory. However, they cannot explain the service, which involves continuous interaction and social choice valuing and totally different from products. More and more researches studied on service valuing (Huang, 1999; Arnold, D. R., Hoffman, K. D., & McCormick, J. 1989; Essegaier, S., Gupta, S., & Zhang, Z. J. 2002). Some considered it in aspects of psychology, for example, pricing by measuring perceived value of customers. (Sheng Min, 2005) Some studied on the service providing companies’ strategies on pricing, which was actually still based on the supply-demand model. (Essegaier, S., Gupta, S., & Zhang, Z. J. 2002) With the development of information technology and social network systems, the boundary between human psychology and information accessibility blurs. Information became widely accessible and web services eliminated the scarcity of services. This change queried the basic assumptions of the traditional supply-demand pricing paradigm. Thus, it is indispensable to

find a fundamental approach on service pricing through reconsidering service from the very start and extending some famous algorithms, like Page Rank (Larry Page, Sergey Brin, 1998) and HITS (Kleinberg, J.M, 1998), into service pricing, which have been used in web science or sociometry (John R. Seeley, 1949; Leo Katz, 1953).

The concept of service science was investigated quite intensively in recent years. Service science is an interdisciplinary field that “combines organization and human understanding with business and technological understanding to categorize and explain various types of service systems. It investigates how service systems interact and evolve to co-create value” (PP Maglio and Spohrer 2008). Service systems are “value co-creation configurations of people, technology, value propositions connecting internal and external service systems, and shared information” (PP Maglio and Spohrer 2008). Service systems are modeled as value chains that support information and money transferred. The problem of pricing or value creation in networks has been studied by other investigators. Some researchers explored the use of the value chain concept suggested by Porter as a tool in establishing service operations strategy, adapted it to emphasize the operational context and to produce a framework that considered service delivery to meet strategic objectives (Colin G Armistead & Graham Clark, 1993). Phillip Olla and Nandish V Patel (2002) developed a value chain model for mobile service providers like UK Mobile telecoms. Stuart J. Barnes (2002) created the mobile commerce chain which analyses the key players and technologies that form part of the m-commerce value chain, providing a foundation for future strategic analysis of the industry. Steven Alter (2008) provided a framework to describe service system fundamentals: work system, value chain, and life cycle, identify basic building blocks, organize important attributes and change processes that apply across all service systems. However, these studies were based upon classical supply demand paradigm. The supply chain and manufacturing enterprises approaches assume the production and consumption of goods are separated in different time phases. But service interaction usually contains the simultaneous involvement between providers and receivers. Besides, little is understood about how social interactions in various social networks create non-monetary value in marketing and servicing contexts.

Another group of researchers are looking for new ways to define and explain the value of services in social network based on the social capital theory (Nan Lin 1999; Fukuyama, 1995; Putnam, 1995). Social capital has been addressed as trust in social relations (Fukuyama, 1995), as civic engagement created through participation in voluntary associations (Putnam, 1995), and as a social fabric that creates a willingness to cooperate in the development of physical capital (Ostrom, 1994). In the view of social capital theory, services are the share of times between people during which some resources (on social capital level) are exchanged. Although many researches have focused on the social capital theory, they did not address the relation between information structure and social capital. The accessibility and topology of information are not just consequences of social structure and social capital, but also causes of the interchange of services (Cai, et. al., 2007). Besides, there is limited empirical work that describes how to measure and calculate it in social networks.

To explain this problem, we proposed an approach to service valuation and pricing. We also

developed a methodology to calculate and rank people's social capital using Time Value Algorithm (TVA), which was improved from Google's Page Rank Algorithm (Larry Page, Sergey Brin, 1998). Actually, similar models have already been used in the study of sociometry half a century ago (John R. Seeley, 1949; Leo Katz, 1953). We also referred to the thoughts of another famous webpage ranking method, Hypertext Induced Topic Search (HITS), which is different with Page Rank by considering each page with two characters: authority and hub (Kleinberg, J.M, 1998). In a social network, the relationships of people are similar to the links among pages on the Internet. It is interesting to question that whether the social capital of people is similar to the importance of the pages. In fact people are different from pages since they are self-motivated in the social environment. The value of people's services can hardly be modeled just as one ranking. People may refuse a service demand while the website could not forbid any page link to it. Therefore we need to at least describe his/her contribution and consumption in the social network, and gain a better understanding of the fundamental information and social factors in service exchanges.

3 TIME VALUE MODEL OF SERVICES AND SERVICE VALUATION

3.1 Time Value of Services in Social Network

Service is one or a series of activities with intangible characteristics, which always happens between the interaction of the suppliers and customers (Valarie A. Zeithaml, 1996). Service is an intangible experience within which customers are co-producer, disappearing over time (James Fitzsimmons, 2007). Based on these opinions, we defined the service value in the situation below.

Firstly, we define a service process as following. In the simplest case, a service includes three parts, one supplier, one receiver and the service time they shared.

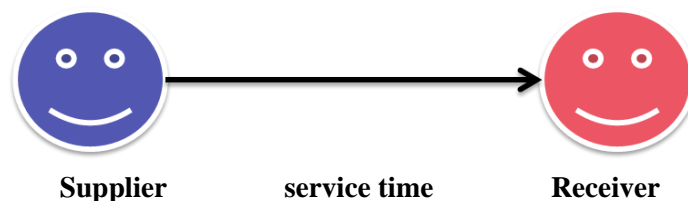


Figure 1. The composition of the service

Secondly, let's consider a two people system in which they serve each other. The structure is as below:

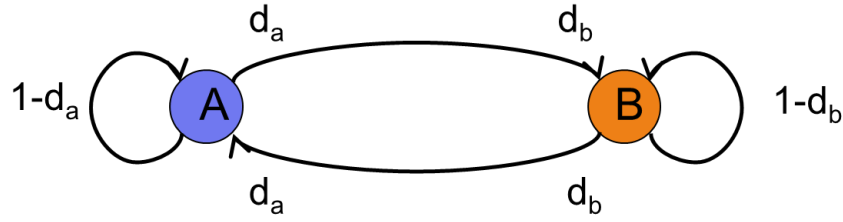


Figure 2. The service structure between two people

We assume that A has a possibility $1-d_a$ to serve himself during a certain period time and d_a to serve B. B also has the same time allocation possibility d_b . Then we can calculate the service A supposed to get in this period by:

$$S'_a = (1 - d_a)v_{aa}t + d_av_{ba}t$$

Similarly,

$$S'_b = (1 - d_b)v_{bb}t + d_bv_{ab}t$$

By the same time, the total service A and B give out during this period is:

$$S_a = (1 - d_a)v_{aa}'t + d_av_{ba}'t$$

$$S_b = (1 - d_b)v_{bb}'t + d_bv_{ab}'t$$

Here, v_{ij} means the unit value of service i provides to j and v_{ij}' means the unit value of service i gains from j.

Now we extend this idea to the service systems of a social network.

For N people who serve each other, they form a social network with the relationships of services. We define the following variables:

- S: the measure of the service one provides to others, counted as person-time.
- S': the measure of the service one receives from others.
- v: the relative value of a person who serves.
- v': the relative value of a person who receives.

Thus, the service that one with time value of v provides during a time period can be calculated by:

$$S = v \cdot t$$

Therefore we make the following basic laws of the service exchanges.

Law1: The time value that anyone serves himself $v=1$.

This is also the opportunity cost of one's time. For a person stays with himself and does not serve anyone $s_{i,i} = t$.

Law2: The maximum time value for one cannot exceed N, which is the total number of the people in this service system.

For a closed service system with N persons, the maximum of people that one can serve at any given time cannot exceed the total number of people.

Law3: *Within one service in time t, the service value the receiver receives must equal to the service value the provider provides, that is, $S_i = S_j'$.*

For a network with only two persons who have service interactions with each other.

$$S_a' = S_b = v_b \cdot t, \quad S_b' = S_a = v_a \cdot t$$

S_a means the services “a” provides. S_b means the services “b” provides.

S_a' means the services “a” receives. S_b' means the services “b” receives.

For N people who serve each other, the service providers give services to the service receivers. Since everyone has his comparative advantage and is limited by the nature time, it is feasible to formulate that one must always both provide service for others and receive service from others as well.

At one point, a person is either in social interaction or alone. Hence he/she is either receiving services from others or consuming his own time. If one stands alone, the service he/she receives is t. Otherwise, it is the sum of all of the services received from others during t. If the probability of the social interaction is d, the expected services each person receives during time t can be calculated by:

$$S_i' = (1 - d)t + d \sum_{j=1, j \neq i}^n \frac{S_j}{c_j}$$

d: the common probability (or the average probability) that i receives services from others at any given time.

1-d: the probability that i serves himself/herself

c: the number of people that j can provide services

This is the expectation of the service that i can get according to the service network in this service system. It means that we can calculate the service value of any person when given people's service time value v_j and the service network.

Since

$$v = \frac{S}{t}$$

$$v_i' = (1 - d) + d \sum_{j=1, j \neq i}^n \frac{v_j}{c_j}$$

Let \mathbf{H} be the matrix which shows the relations among all the people (each node h_{ij} in this matrix is 0 or 1, standing for whether i service j or not), thus, we can rewrite this equation into matrix forms at period k,

$$\mathbf{v}'^{(k)} = \mathbf{H}\mathbf{v}^{(k-1)} + (\mathbf{1} - \mathbf{d}) \quad (1)$$

Similarly, we get,

$$S_i = (1 - d)t + d \sum_{j=1, j \neq i}^n \frac{v_j' t_{ij}}{c_j}$$

$$\mathbf{v}^{(k)} = \mathbf{H}^T \mathbf{v}'^{(k-1)} + (\mathbf{1} - \mathbf{d}) \quad (2)$$

So now, for everyone we can get two relative value v_i' and v_i as *time value ranking*, which

is also another expression of time value. One's *time value rank* will change during the interactions in social network. People's v_i' will increase when they are served by those who have higher v_i . Also, people's v_i increases when they serve others with a higher v_i' .

Here we show three simple service systems and calculate their time value. From the service relationship shown in Figure 3, we can get the matrix H in function (1) (2). According to the function (1) (2), we will get the Time Value Rank.

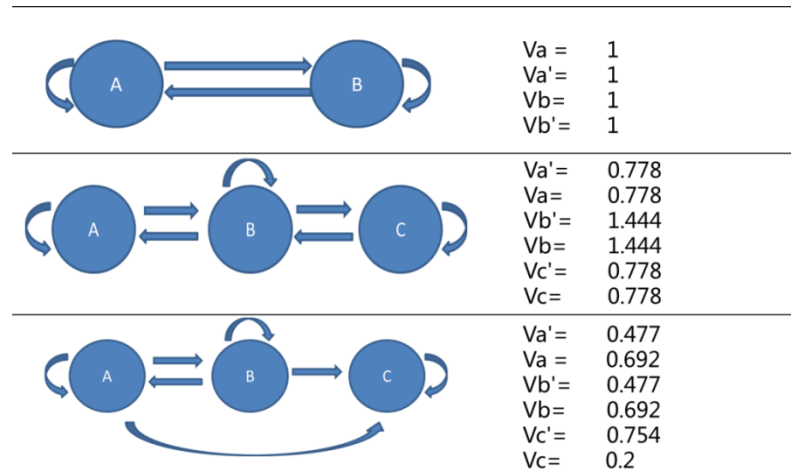


Figure 3. The Time Value Rank of three simple service systems

In Case 1, the result is obvious because these two people are the same. In Case 2, A and C are in the same position where they both serve only B and get service from B as well, so they have the same time value. B has bigger time value because he serves and gets services from two people, A and C. In Case 3, A and B are in the same position where they both serve C and each other, and only get service from each other, so they have the same time value. Their serving time value is bigger than their served time value because they both serve two people while they are only served by one. C has the biggest served time value and the smallest serving time value because he gets service from both A and B but serves nobody.

Based on the above definitions and analyses, we figured a way to calculate the time value of people in a service system or a social network by the Time Value Rank Algo. Now we will talk about the management and social meaning of the variables in this model.

1) d : the possibility of serve oneself.

According to our definition, this variable describes the possibility that one serves himself rather than serve others. In real life, d shows people's personality. Extroverts are likely to have a large d while introverts have a smaller d . In the economics, when referring to companies, a bigger d means it's a self-sufficient organization while small d companies are more likely to be resource integrating organizations such as service outsourcing companies. In fact, different people have different d values due to different personality, education, environment and other factors. This is the most difficult problem when using this approach in real world. We suggest getting these data from history records or questionnaire. And the easiest way is to just assume a same d when facing a certain problem.

2) v and v' : the different side of time value

Though export value v and import value v' are calculated in the similar way, they have quite different meanings. In our daily life, some people have a large v and a small v' (Service providers); some have a large v' and a small v (Service receivers); some have both large v and v' (Active users) and some have both small v and v' (Silent users). We can get the examples of these different kinds of people or organizations in almost every industry. For example, the government always has the largest v' and some countries also have a large v such as China and Russia. Most manufacturing enterprises have a bigger v since they have a lot of output while in the internet world, SNS websites are supposed to have both big v and v' .

Lastly, we want to clarify the differences between our model (TVA) and Page Rank. Page Rank is a famous algorithm used by Google's searching engine. The forms of mathematics of these two algorithms appear almost the same. But they have big differences. The most important one is that in Page Rank, the value of web pages contains only one variable. In TVA, people have two values, import value and export value. On the internet, web pages are free to link to each other. However, in social networks, people don't have this freedom. One may refuse another's service request for all kinds of reasons, which makes it necessary to distinguish the import value and export value.

3.2 Model of service interaction with TVA

It is the value of the stakeholders that determines the interaction among them. Traditionally people use game theory as the base for analyzing the interaction among different trading partners. One of the critical assumptions is the asymmetric information. Our model assumes that information accessibility is determined by the participants of the interaction. They decide the interaction and information sharing based on their context. The pattern of service when the supplier and the receiver have different time values is analyzed. Assume that people will give service supply if and only if it can improve their v or get extra value (money), while they agree to import value if and only if it can improve their v' or get extra value. So we can easily give the different patterns of service and their payoff as below:

receiver \ supplier	Both big v and v' $v_r > \bar{v}_r, v_r' > \bar{v}_r'$	Big v and small v' $v_r > \bar{v}_r, v_r' < \bar{v}_r'$	Small v and big v' $v_r < \bar{v}_r, v_r' > \bar{v}_r'$	Both small v and v' $v_r < \bar{v}_r, v_r' < \bar{v}_r'$
Both big v and v' $v_s > \bar{v}_s, v_s' > \bar{v}_s'$	Win-win (+, +)	Supplier dominates (+, -)	Win-win (+, +)	Supplier dominates (+, -)
Big v and small v' $v_s > \bar{v}_s, v_s' > \bar{v}_s'$	Win-win (+, +)	Supplier dominates (+, -)	Win-win (+, +)	Supplier dominates (+, -)

Small v and big v' $v_s > \bar{v}_s, v_s' > \bar{v}'_s$	Receiver dominates (-, +)	Lose-lose (-, -)	Receiver dominates (-, +)	Lose-lose (-, -)
Both small v and v' $v_s > \bar{v}_s, v_s' > \bar{v}'_s$	Receiver dominates (-, +)	Lose-lose (-, -)	Receiver dominates (-, +)	Lose-lose (-, -) (prisoner's dilemma)

Table 1. The different pattern of service with different Time Value Rank

(v_s, v_s' : the time value of supplier; v_r, v_r' : the time value of the receiver; \bar{v}_s, \bar{v}'_s and \bar{v}_r, \bar{v}'_r : the average time value of all the suppliers and receivers in the network)

Win-win: This pattern means that after this kind of service, both the supplier and the receiver will improve their v and v'. It happens when the supplier has a big v and receiver has a big v'. Under this pattern, the service will easily happen no matter whether there is any extra value exchange, for example, teaching between a good teacher and good student.

Lose-lose: This is not a very good pattern because both sides of the service lose. It happens when a small v supplier meets a small v' receiver. Considering the opportunity cost, both of them get worse after the service because they could at least make a couple with a person who has an average v or v'. In our daily life, this kind of service also exists, such as “the chess playing between two bad players”. There is also a special kind of lose-lose situation, which is between people with both small v and v'. Because they seem to be useless to the other people, they may have to serve each other as in a prisoner's dilemma. This phenomenon frequently happens in the poor area and lead to a vicious circle.

Supplier dominates: In this pattern, the supplier has a big v but the receiver has a small v' which means the receiver will profit at supplier's expense during the service. So in most cases, service receiver has to pay extra value, usually money, to the supplier if he wants this service happen. This pattern is the most popular pattern in our real life, including all kinds of the charged services.

Receiver dominates: This pattern is the most interesting one because different with “Supplier dominates”, the receiver gets more voice since they have a big v'. As a result, the service supplier has to pay; even that he is called a supplier. This pattern happens occasionally in our society, such as the conference holder invites a VIP to be an audience.

Hence, various services can be sorted into these four patterns. Since we have got the idea to find out people's Time Value Rank, what we should do before starting or agreeing a service is to figure out which kind of pattern our service is, and then choose the proper actions: admit, refuse, pay or charge. These models can be used in decision supporting systems to facilitate the pricing of services in the market.

3.3 Service pricing and other applications of time value in management

In the market there are many situations when people need to estimate the service price and negotiate about the future interactions they will deal with. Conflicts are inevitable due to

perspective differences and the asymmetric information. The mispricing of services has become a major cause of collaborative cost in the society. It hinders innovation and crumbles trust among people. The models of TVA and approach of service pricing can have many practical applications.

First of all, this method provides a new way of pricing the services in social networks. The export v , which stands for the relative rank of his time value provided to others, is calculated for evaluating the service capability. The import value v' , which stands for the relative rank of his time value received from others, is calculated for evaluating the consumption capability. Thus, we can get the service pricing procedure:

- 1) *Build the service systems models as social networks*
- 2) *Calculate the time value rank of everyone on a certain kind of service.*
- 3) *Price everyone's service according to their rank value.*
- 4) *Analyze their interaction among stakeholders with different values.*
- 5) *Go back to step1 to rebuild the service systems model for the next stage.*

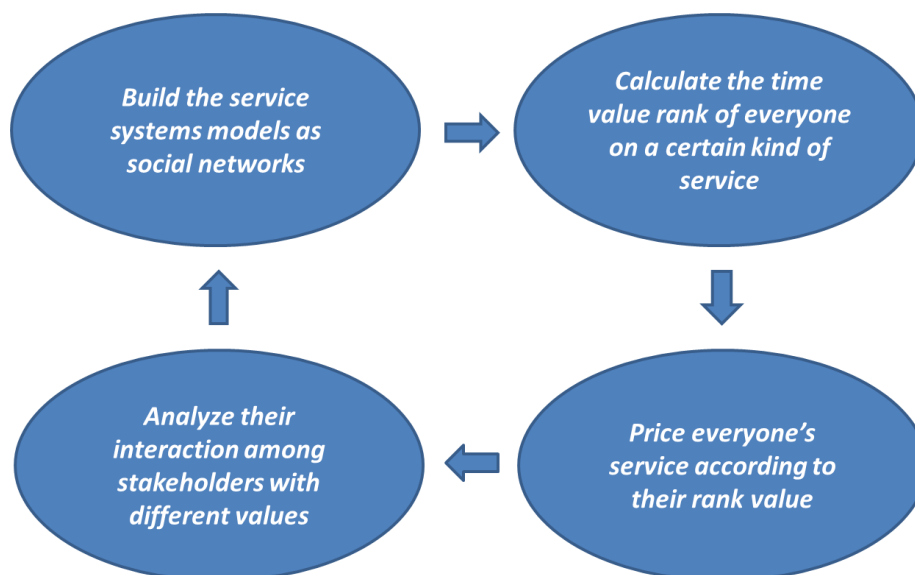


Figure 4. The service pricing procedure of TVA

The time value modeling approach can be applied into many categories of situations. Here we discuss in three applied fields. First, time value rank provides a mechanism for measuring social capital. Actually, time value rank has two ranks, one for v and the other for v' . We can understand these two numbers easily with the conception of social capital. The service supply rank v means the relative ability of supplying one kind of service in a certain social network. This is much like the conception of social capital. According to social capital theory, social capital is defined as the ability and resources one can get or achieve in the society. Besides, the import value of service v' represents human capital conception. This ability stands for the amount of service one can get from others. Social capital is gained by improving the relationships with others within the social network. And human capital is gained from

education and work experience, such as taking courses in the college. One can get a higher export value v in the future by improving his import value v' , that is, one may enlarge his social capital by increasing his human capital. This is the reason why we are always considering education as the most important investment for young people.

Second, the time value modeling approach clarifies the concepts of transaction cost and collaboration cost in the society. In the market, trading happens everywhere at any time. The most important and popular conception of the market are supply and demand and transaction cost. Supply and demand decides the price and quantity. The efficiency of economy can be improved by reducing transaction cost. But are there other forms of cost other than transaction in the market? Why some buyers have more influential power in a trade? We were told it is because he (demand) has high elasticity. The time value model shows that this phenomenon can be explained easily and clearly by the interaction model. In this case, it is a receiver dominating exchange. The brand and tractability of a person means a big import value v' . People who get the right of speech in the market acquire more relationships in the social network.

Third, the time value modeling approach bridges the management of government and market. In most cases, the government officials are expected to have a big export value v rather than a big import value v' because they are selected to serve people. But the public always mingle the two different values. The famous person with high buying powers sometime gets the vote of the people. In a right government performance evaluation system, those with high export value should always be awarded while on the opposite, those with small export value but big import value must be checked to see whether they are serving people soul and heart or accepting bribes at work.

4 THE TIME VALUE RANK OF A SOCIAL NETWORK ON SINA WEIBO

After the theoretic study, now we will give an empirical study to explain and verify our ideas. We take one social network, SINA Weibo, on the internet as an example. SINA Weibo is the most popular twitter in China. In this particular social network, we take each relationship (follow from one user to another) as a service process. That is to say people supply others when they follow others and receive service when they are followed by others.

We used the data of the social network on SINA Weibo, constructed with 1070 users, who are all real name users, and their follow relationships with each other. We got this sample directly from SINA Company for cooperative study, which was randomly cut from a database of more than 200 thousands users. During the analysis, we use Pajek to draw the topological graph and implement the algorithm (TVA) by Matlab.

The topological graph of this social network is as below, which shows that it's a typical social network:

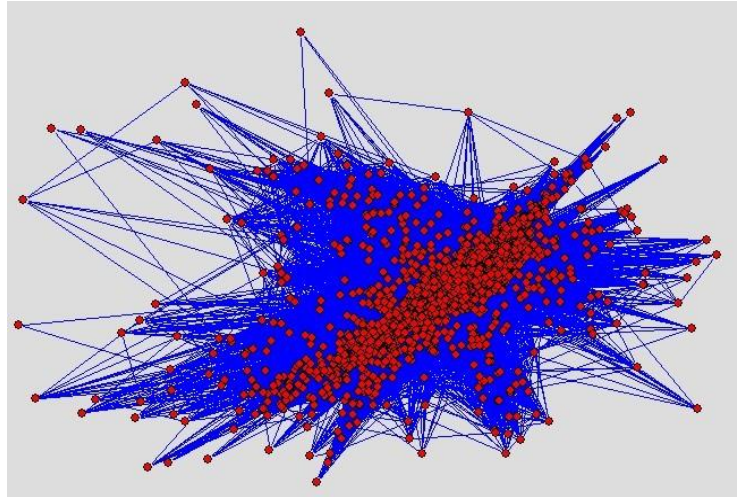


Figure 5. The topological structure of the 1070 SINA Weibo users' social network

According to the Time Value Algorithm, we calculate all the users' import value v' and export value v . The figure shows that import value (be followed) seems to be a scale free distribution while the export value (follow others) seems to be a normal distribution. This is because in the SINA Weibo, which is more like a media network, users are willing to get the news like the stars affairs. For a big node, like a popular star, there is no limit of the number of fans. Things go differently with the export value. Since everyone only has 24 hours a day, they cannot follow infinite nodes. This is the same for all the users. Now, since we have got the whole time value rank of this social network on SINA Weibo, we can find the users who have the highest values on v and v' . Thus, we can say they are the key people of this service system and their service values are the largest among all. And these people are totally different with the people who just have the most fans or follow the most people. From this view, we build another way to tell the values or the importance of the users on SINA Weibo, which is useful for pricing their services like promoting activities.

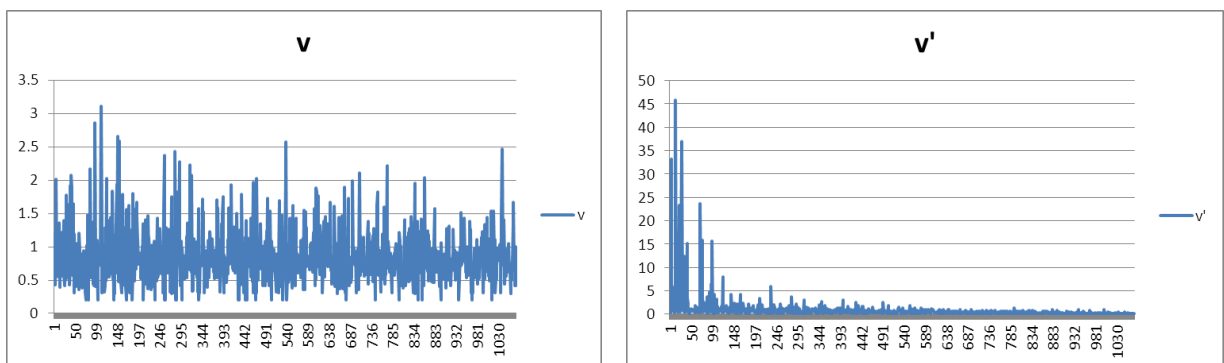


Figure 6. The time value rank of the 1070 SINA Weibo users ($d=0.8$)

5 Conclusions

This research, based on the web science and social capital theory, provides a new approach to measuring the value of service in social network. This paper gives the method to calculate the time value of service in social network, thus, proposes an approach to pricing the services.

In the theoretical circle, this paper starts a new field of service science by valuing through time value relativity. Besides, this paper extends the social capital theory into the service science and economics area. Different from the previous pricing theories and methods, this approach starts from the nature of service, time sharing and relationships of people. Therefore, we could value service neither rudely according to the traditional ways which we used for the products nor just by some subjective judgment, like customers' satisfaction. In the aspect of practice, this paper gives basic concepts for people and organizations to calculate their time value rankings and to see whether they should do some improvements according to their different personalities and contexts. And the most important, this is a useful and meaningful method to price the services in the market. The time value approach suggests us to rethink transaction cost, bargaining power, and government efficiency.

In this paper, we didn't consider the situation that people have different types of services of time value as they own different abilities on variable skills. In reality, different social network topologies will exist and coevolve simultaneously. Thus, how to calculate the exchange among the time value of different types of services is an important issue of future study. Then we can explore the ways to improve the service network's value as a social evolving network system.

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