DETERMINING THE DEVELOPMENT AND SUSTAINABILITY OF ONLINE COMMUNITIES

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Abstract

This research examines the major antecedents of sustainable web-based fora. There exists a critical level of exchanged messages among members, below which an online forum will not be self-sustainable (Wasco et al., 2009). The topic of why people contribute to fora in general has been extensively studied, and can be traced back to the 1960' when Olson (1965) who noted that contribution only occurs for individuals when gains excess payments. Subsequently, critical mass theory (Oliver,1980; Marwell et al. 1988) leads to a more specific situation in which a small number of initial contributors can lead to mass collaboration. This theory can be true in online fora which are characterized by a scale-free complex system where several influential members play a vital role in the expansion of the forum. This study seeks explanations for the sustainability of online fora by incorporating critical mass theory into online statistics analysis. It tests the logical relationships among five variables which represent individual contribution motivations. Results indicates that the distribution also known as the probability of a member with K connections (here denoted as the maxim connections) follows the power law. Secondly, the logic of contribution behaviours initially presented by Oliver (1980) is suitable for the analysis in online fora. This research reflects a pioneering stream in social network analysis which takes into account the social capital factors as well as complex network theory.

Key words: Social Network, Voluntary Contribution, Critical Mass, Scale-free complex system, online fora

JEL Code: P0, M0

Introduction

Online fora have become important channels through which individuals seeking to gain information about a subject interact with those who wish to contribute information about that subject. They have been widely used by potential customers of an organisation to establish the expected trustworthiness of that organisation, typically relying on comments posted by existing customers who may have particularly favourable or unfavourable comments to make about it. Research has sought to understand why and how consumers consult online reviews posted on online fora (Burton & Khammash 2010), and the extent to which such reviews are regarded by readers as believable (Ganley & Lampe, 2009). Online fora have been created extensively within communities of individuals having a shared interest, from very specialized niche interests, such as historic steam railways to much larger general interest communities, characterised by mass collaboration, A notable example of the later is the Chinese forum Baidu (eg www.baidu.com) whereby very large numbers of individuals contribute their knowledge voluntarily to the community and which is accessible to everyone.

Online contribution behaviours

The question which this paper addresses is why some online fora succeed while others fail. For every online forum such as Baidu which succeeds, there are many more which fail to become sustainable. Sustainable success in this context is defined as a forum which achieves a long-term surplus of new members recruited over existing members who defect. Successful fora require a constant input of information from members, implying some form of sacrifice of time and effort by contributors. Without continuing contributions, visitors would be less likely to visit a forum, and with fewer visitors, contributors of information may be less motivated to post comments, believing that their comments will not have significant impact if the audience is small .

Explanations for why people contribute to online fora have been derived from economic, sociological and biological perspectives. One significant contribution derives from game theory, which has been refined with models of direct and indirect reciprocity to incorporate an individual's expected return from their contribution (Axelrod & Hamilton, 1981; Sugden, 1984; Dufwenberg et al., 2001; Groson, 2007; Imhof et al., 2007; Taylor & Nowak; 2007; Nowak et al., 2010; Nowak & Highfield, 2011). Theories of altruism have sought to explain why an individual takes care directly of others' welfare at one's own cost (Becker,1974; Frohlich, 1974), although critics have sought to impute expected returns for altruistic activities, with the exception of genetic kinship theories (Wright, 1922; Hamilton, 1964; Dawkins, 1976; Smith et al., 1987; Alger, 2010). However, these theories have not taken sufficient account of the scale of social networks relative to their population in influencing growth rates of a forum. Rewarding or punishing individuals according to a game theoretic approach can be inefficient for promoting cooperative behaviours because of incomplete information and memory about cooperative and non- cooperative individuals (Oliver, 1980; Marwell et al., 1988).

3 Critical mass

To overcome problems of incomplete information which are a weakness of game theoretic approaches, this study uses a methodology based on critical mass theory, incorporating measures of production function and network structure (Marwell et al., 1988; Wascko et al., 2009; Westland, 2010).

Critical mass theory (Oliver et al., 1985) explains how a small number of selected individuals can have a powerful, positive impact on the mass collective production. Similar to threshold models (Granovetter, 1978), it focuses on the number or proportion of self-interested contributors for whom net benefit exceeds net cost . In biology, this transformation is analysed through the contagion model (Dodds & Watts, 2004). In social life, one simple example is “fashion”, where several selected stars can evoke uniform massive behaviours.

Critical mass theory is the most compelling argument of Olson’s (1965) logic of collective action (Oliver and Marwell, 2001). Olson (1965) points out that rational individuals will not behave cooperatively in order to achieve their common or general interest, without incentive or punishment mechanisms that reward selected co-operators or punish non-co-operators. Oliver et al., (1988) argue that punishment and encouragement are not the solution to collective action problems, because paying “incentives” or “punishing” are themselves a sort of “collective action”. Therefore, rewarding or punishing that is embedded in a complete information system is merely producing a second collective action problem. Although Oliver (1980) recognises that reward or punishment can be efficient for cooperation behaviours, these mechanisms are unrealistic in electronic social network circumstances because of incomplete information and memory about cooperative and non- cooperative individuals. Critical mass theory encompasses incomplete information issues, and focuses closely on production function and network structure.

The original critical mass model developed by Marwell et al. (1988) can be employed to illustrate individuals’ decisions about contributing to public goods as follows:

$$G = p(\sum r)I - r,$$

where G represents an individual’s net gain from contribution. It interprets the relationship between an individual and the group in general, thus, it omits the interactions between individuals but highlights the general exchange pattern; $p(\sum r)$ refers to the production function of the total contribution by all parties to public goods, which specifies the relationship between inputs of total resource contribution and outputs of levels of public goods. Furthermore, the production function in this model is a u-concave[1] or accelerating function, which ensures the increasing marginal returns. In online discussion, for instance, one response to a seed message tells 10% of the truth, the second one contributes to 20%, the third one goes to 50%, and the fourth up to 90%. In other words, accelerating production function encourages individuals to make sequential contributions that are embedded in previous outputs, because additional contributions could accelerate victory to certainty. However, the central challenge is to start collective actions because rational individuals will contribute in the late stage in order to enjoy higher payoffs; I is an individual's interest level in the public good; And r means an individual's contribution resource. That is, when $p(\sum r)>r/I$, .i.e. the total payoff from all contributions to public goods exceeds the individual's r/I ratio, an individual will make a positive contribution decision. In other words, the value of a given public good is subjected to available resources and the willingness to pay: the higher the interest level, the more possible that individual contributes; the richer the resources available, the bigger the outputs.

It can be concluded that there are two important assumptions in the critical mass model: the accelerating production function that highlights the feasibility problem, and the group heterogeneity that allows either highly interested or resourceful individuals to pay the early starting up cost of collective actions. The idea of critical mass is related to exactly these kind of contributors. In this sense, the critical mass members attract numerous others to contribute sequentially.

However, Oliver and Marwell's (1988) model does not discuss the detailed mathematical and numerical analysis of the ratio of selected individuals and their effects on the general population. This could be one reason why theories of critical mass are often surrounded by disagreements. Westland (2010) further defines a formal metric for critical mass in electronic social networks while following the percolation logic[2]. This determines the critical mass probability required for an electronic community to be self-sustaining, i.e. $p \geq pc=1/(z-1)$, where. p is the probability that an individual member of the network will form an acquaintance link to another member; pc is the critical probability at which a phase change occurs and a "giant" cluster appears, z the maximum number of links that any member may create, Westland (2010, p7)". When $p \geq pc$, the value of social networks is dependent on Log(ňs (p)),

[1] Contrast to u-concave or accelerating production function, u-convext or decelerating production function that traditionally studied in economical models fostered initial actions, which leads to strategic action and free-ride problem (Oliver and Marwell, 2001). For a given public good, the benefit to individual A exceeds largely A's cost, thus it worth A to contribute this public good. Individual B knows A will whatever contribute, B could pay little or nothing but enjoy this public good in the future.

[2] The study of probabilistic models that exhibit a 'phrase transition' (Westland, 2010, p7)

Log(ňs (p)), the logarithm of average number of each member's special interest clusters containing s members. S, the size of the social network, can be the indicator of the level of interesting of the online community.

It is noted that Westland (2010) provides a sophisticated, pure mathematical model that investigates the social network structural effect. Further empirical studies are necessary. To simplify, in this study we integrate Westland's logarithmical concept into Oliver and Marwell's (1988) model: Gc= P((∑r) Log(ňsc (p)))– Sc*Rc, where Gc represents the gain of the critical mass group; Sc is the size of the critical mass group; Rc refers to the average contribution cost of the critical mass member; (∑r) is the value of social network; and Log(ňsc (p)) represents the logarithm of the average number of interest (per critical mass member) containing Sc critical mass members. Logarithmical measure is more robust than simple summarization of number of interest. It is presumed that human perception logarithmically transforms intensities for obtaining a wider perceptive range that crosses multiple order of magnitude. This idea is mostly reflected through examples such as human perception of light, sound and other sensory information (Westland, 2010).

It appears that critical mass theory describes a transmission model that leads to stable and dynamic collective collaboration, which is different to theories of altruism, commitment or reciprocity that discusses the voluntary cooperation. As a result, we propose that altruism, commitment and reciprocity behaviours are antecedents of voluntary contribution. When the proportion of contributors achieves the threshold point , mass collective behaviours become a trend or a belief that is shared among individuals, which finally ensure the evolution of collaboration.

This study investigates whether a critical mass exists for online fora by examining five key indicators for each forum: i) the benefit of critical mass members by contributing to the online forum, [Gc]; ii) the maximum number of connections that a participant can create, [z]; iii) the level of critical mass members' interests, [ňsc (p)] ; iv) the total cost of critical mass members, [ScRc]; and 5) the production function of the total resource of online forum, [P(∑r)]. The methodology involves comparing whether Gc≥ P((∑r)Log(ňsc (p)))– Sc*Rc.

Method

This study seeks to examine our integrative understandings about critical mass theories in the context of online fora by comparing whether Gc≥ P((∑r)Log(ňsc (p)))– Sc*Rc.

The propositions are being explored with an analysis of statistics for 200 online knowledge exchange fora. For the studied fora, "bulletin board" technologies are used, which provide historical statistics of usage. As discussed before, online fora are dynamic with continual addition and attrition of members. In order to make our studies realisable, we employed "generations" to describe the development of online fora and counted the "generations" by month. In the studies of Wasko et al. (2009), data were collected using two means of posted messages during two months in order to describe the layout of participation activities of members. In the studies of Westland (2010), a picture was taken to show the structure of a social networking. In our studies, we focused on the first generation as our studying period to understand the "pre-phrase change behaviour" in online discussion fora. The first generation is defined when the number of members is at least or bigger than 3. When the number of members is small than 3, the network effect is too small to be negligent (Westland,2010).

To examine our model, five key indicators were recorded about each forum: i) the benefit of critical mass members by contributing to online forum, Gc; ii) the maximum number of connections that a participant can create, z; iii) the level of critical mass members' interests, ňsc (p) ; iv) the total cost of critical mass members, ScRc; And 5) the production function of the total resource of online forum, P(∑r).

Firstly, Gc is obtained through the total knowledge of an online forum that can be represented by the total number of answered seed messages. A seed message is considered potentially useful information when it is discussed among members. The discussed message is often value-added knowledge since discussers could contribute their further understandings to the seed message. Therefore, we consider the total number of discussed seed messages which are accessible to each member to represent the value of an online forum. This is consistent with the view of the characteristics of online knowledge as digital public goods (Wasko et al., 2009).

Secondly, Z reflects the capacity of an online forum to allow members to connect to each other during a generation. Z is between 0 and N(N-1)/2 if edges between members are pair wised adjacent. In theory, one generation away from an original member can generate maximum 1+z members. Another generation away, there are $1+z(1+z-1)=1+z^2$ members. For the ath generation, there will be $1+z^2+$(z-

$1)^2+\ldots.+(z-1)^\wedge(a-1)$ members. However, in reality, members are connected to limited others because of the existence of barriers to connectivity, such as limited memory of mail box-returned messages or limited recognising capacity-Spam messages and so on. In fact, Albert-Laszlo et al. (2002) have found out that for the scale-free networks, assume that z is continuous, and thus the probability P(zi) can be interpreted as a continuous rate of change of zi, and p(zi), follows the Power Law: P(z)~z^-y, with y between 2 and 3. It is defined that F(x)~ ∑z>=x P(z), and that F(x)~z^-y-1. That is, Ln y = Ln F(x)=-(y-1)Ln z, where X=Ln x, and Y=Ln y. The slop of Ln F(x) is therefore (LnF(x))'= –y+1. With this, we can calculate z. Therefore, -y is independent with the initial number of members. The smaller the y the bigger the Z. Here, we assume y =2 because the biggest z is expected in our studies. In fact Albert and Baraba (2002) Newman (2003) had found out y for internet based complex network is 2,5.

We propose that each addition of a member represents an accepted invitation, and vice versa. This assumption is consistent with "greedy" techniques (Newman, 2004; Clauset et al., 2004; Du et al., 2007; Fortunato, 2009). Suppose that there are n clusters, each containing one vertex. The edges are therefore added so that m clusters can be connected (m<n). That is, there are n-1 clusters if one edge is added. Furthermore, the edge is chosen to ensure a maximum increase of members of community with respect to the previous step (the community is understood as the emerged clusters). For a given time series O(t), the variation of the numbers of members ΔQ can be observed. When ΔQ is negative or zero, there is no more edge to guarantee the growing of the community. Similarly, in our study, we observed generations O(t) ~{O(ti)| ΔQi>0, i=0,1,…m }.

Z is an essential factor, through which we can identify the critical mass members .i.e. (the total number of members)/(z-1).Having identified the number of the critical mass members, we can measure the interest level of topic shown by critical mass members, ňsc (p). In the general case, critical mass members are top posters. We thereafter count the total number of messages created by critical mass members during the generations. Researchers such as Odlyzko and Tilly (2005) and Westland (2010) argued that the size s of a special group could be a measure of the interest level of such group, we proposed therefore that the size of audience of messages created by critical mass members is the indicator of the interest level of these messages. In addition, we propose that the interest level of a message can reflect the interest level of the poster since a member publishes a message for seeking it's echo.

With regard to the total cost of critical mass members, ScRc, we counted the total number of messages published by critical mass members. According to Oliver and Marwell (1988), the cost of contribution is the resource of the contributor. In the context of online discussions, published messages are knowledge which reflect intellectual resources owned by publishers.

Finally, P(∑r) is the total number of posts in addition to the total number of replied posts. The production function in the critical mass model (Oliver and Marwell, 1988) is an acceleration function, which ensures an increasing return on input recourses. Published messages, the resources of an online forum, not only benefit members but also visitors.

The following table illustrates how we collected data using the five key indicators discussed above:

Gc	The sum of the number of posts by view
Z	P(z)~z^-y
ňsc (p)	The sum of the messages created by critical mass member(s) and their numbers by view
ScRc	The number of messages created by critical mass member(s)
P(∑r)	The total number of messages by reply

Results

This study is in the early stages of data analysis. However, of the 200 typical fora that have been analysed, a preliminary sample of typical cases indicates a bucketful prediction rate of about 80 per cent. The preliminary analysis indicates that the distribution of connections among members in a typical social network is characterised by the power law. That is, a small number of members have a lot of connections while most members have relatively few connections. Figure 1 shows the distribution of connections by members.   Figure 2 shows clusters of fora users, indicating groups of relatively high and low connected users. Table 1 indicates the results which are consistence with our model.

The considerable task of undertaking data from 200 fora is continuing and results should be available to present at the conference.

Figure 1 Distribution of connections

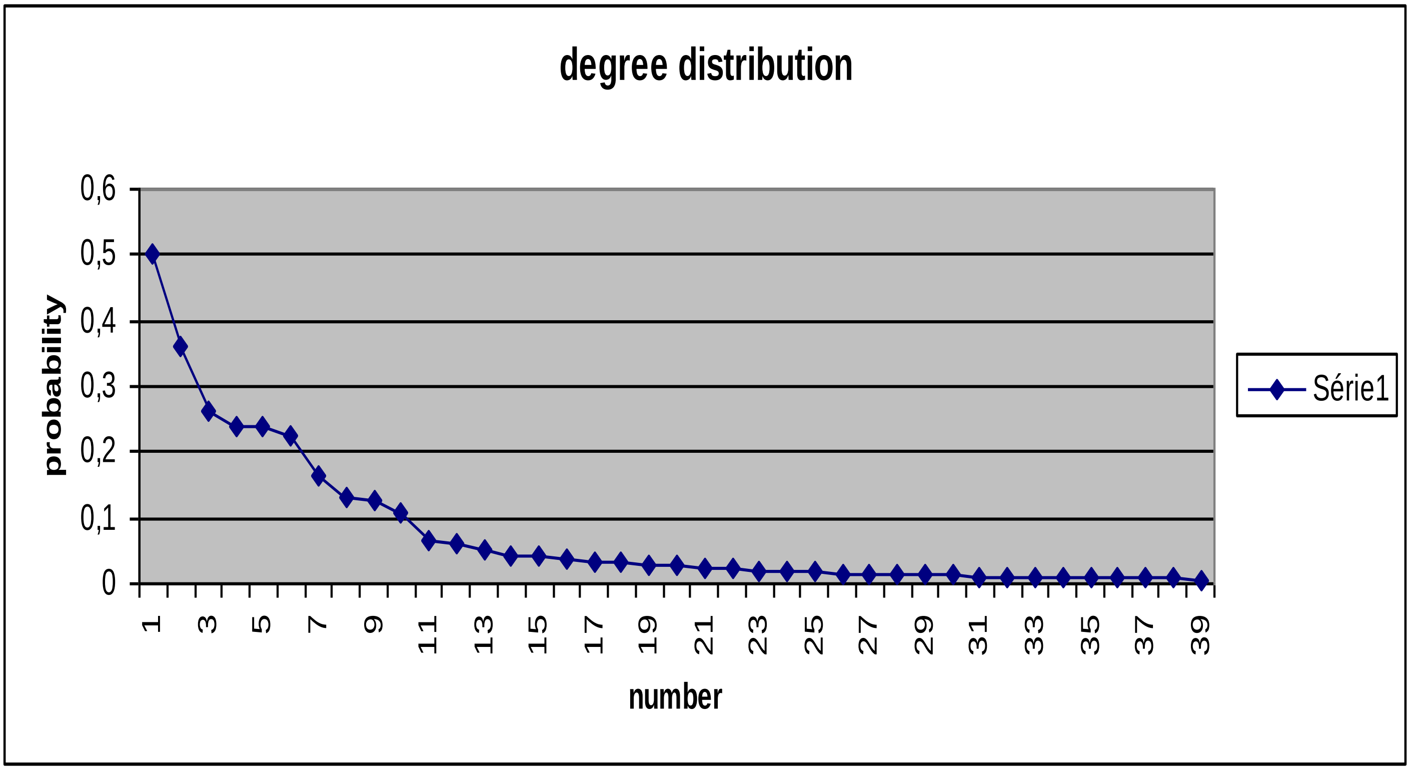

Figure 2 An example of online fora dogexpert

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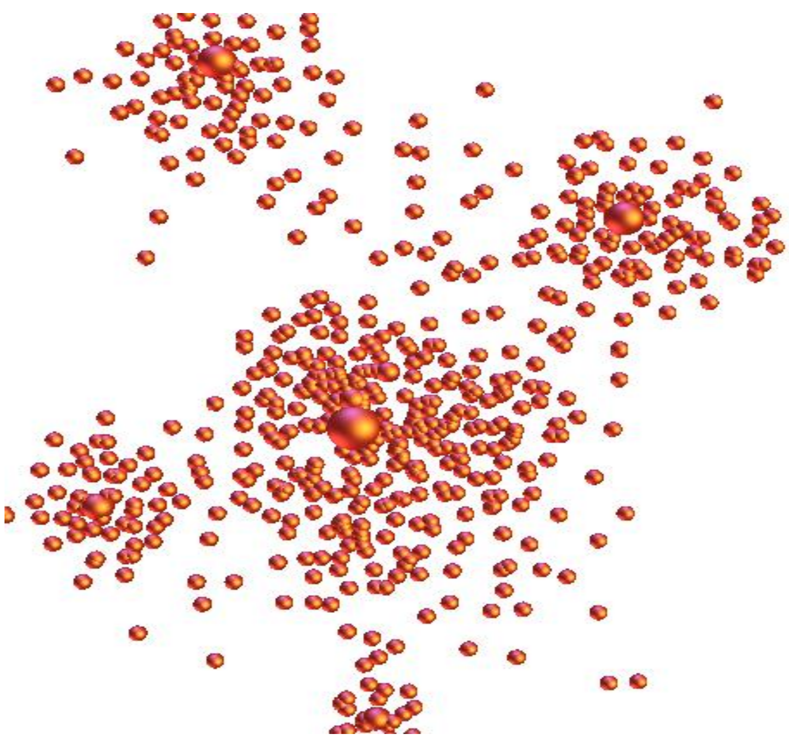

Table 1 An example of online fora dogexpert- suit

Pc=	Maxim z =	Critical mass member =	Log(ňsc (p))=	P(∑r)=	Sc*Rc=	Gc=	Gc≥ P((∑r) Log(ňsc (p)))– Sc*Rc:
,0233	44	5	5,395488895	415874	248593	2555628	Yes

Conclusion

In an era of social Network Media, the number of fora through which individuals can obtain or contribute information has increased. Many online fora have failed to attract significant numbers of users from their target population, and many disappear completely. Others go on to achieve sustainable success, based on a large number of contributors relative to users of information, and a rate of attrition that is offset by continuing strong recruitment.

This paper has proposed that incorporating critical mass into explanatory models of success will overcome limitations of linearity and improve explanatory performance. Preeliminary analysis of a subset of a sample of 200 online fora has suggested that the proposed model, based on theories of crotical mass, may successfully predict critical ;points at which an online forum becomes sustainable. A contribution to knowledge in this research will be to identify the factors influencing such “tipping points”.

References

Barabasi, A.L., Jeong, H., Néda, Z., Ravasz, E., Schubert,A. and Vicsek, T. 2002. “Evolution of the social network of scientific collaborations.” Physica A: Statistical Mechanics and its Applications. 15 August, 311(3/4), pp. 590–614.

Alger, Ingela. 2010. “ Public Goods Games, Altruism, and Evolution.” Journal of Public Economic Theory. July, 12:4, pp.789-813.

Axelrod, R. and W.D. Hamilton. 1981. “ The Evolution of Cooperation.” Science. 211, pp.1390-1396.

Becker,Gary S. 1974. " A Theory of Social Interactions." Journal of Political Economy. 82:6, pp. 1063-1093.

Dawkins, Richard. 1976. “ The Selfish Gene”. Oxford University Press.

Dufwenberg, M., U. Gneezy, W. Güth, and E. Van Damme. 2001. “ Direct vs Indirect Reciprocity: An Experiment.” Homo Oecon. 18, pp.19-30.

Frohlich, Norman. 1974. “Self-Interest or Altruism, What Difference?.” The Journal of Conflict Resolution. March, 18:1, pp.55-73.

Groson, Rachel T.A. 2007. “ Theories of Commitment, Altruism and Reciprocity: Evidence From Linear Public Goods Games.” Economic Inquiry. April, 45:2, pp.199-216.

Hamilton, W.D., 1964. “ The Genetical Evolution of Social Behaviour.” Journal of Theoretical Biology. July, 7:1, pp. 1-16.

Imhof, Lorens A. Drew Fudenberg and Martin A. Nowak. 2007. “ Tit-for-tat or Win-stay, Lose-shift?.” Journal of Theoretical Biology. 247, pp. 574-580.

Marwell, Gerald, Pamela E. Oliver and Ralph Prahl. 1988. “ Social Networks and Collective Actions: A Theory of the Critical Mass. III.” American Journal of Society. November, 94:3, pp.502-534.

Oliver, Pamela E. 1980. “ Rewards and Punishments as Selective Incentives for Collective Action: Theoretical Investigations.” American Journal of Sociology. 85, pp.1356-1375.

Oliver, Pamela E. and Gerald Marwell. 2001. “ Whatever Happened to Critical Mass Theory? A Retrospective and Assessment.” Sociological Theory. November, 19:3, pp. 292-311.

Oliver, Pamela, Gerald Marwell and Ruy Teixeira. 1985. “ A Theory of the Critical Mass. I. Interdependence, Group Heterogeneity, and the Production of Collective Action.” American Journal of Society. November, 91:3, pp.522-556.

Nowak, Martin A., Corina E. Tarnita and Tibor Antal. 2010. “ Evolutionary Dynamics in Structured Populations.” Philosophical Transaction of The Royal Society B. 365, pp. 19-30.

Nowak, Martin and Roger Highfield. 2011. Super Cooperators- Evolution, Altruism and Human Behaviour or Why We Need Each Other to Succeed. New York, NY: Free Press.

Sugden, Robert, 1984. "Reciprocity: The Supply of Public Goods through Voluntary Contributions." Economic Journal, Royal Economic Society. December, 94:376, pp. 772-87.

Smith, Martin S., Bradley J. Kish and Charles B. Crawford. 1987. "Inheritance of Wealth as Human Kin Investment." Ethology and Sociobiology . 8:3, pp.171–82. doi:10.1016/0162-3095(87)90042-2.

Taylor, Christine and Martin A. Nowak. 2007. " Transforming the Dilemma." Evolution. October, 61:10, pp.2281-2292.

Wasko, Molly McLure, Robin Teigland and Samer Faraj. 2009. " The Provision of Online Public Goods: Examining Social Structure in an Electronic Network of Practice." Decision Support Systems. 47, pp. 254-265.

Westland, J.Christopher. 2010." Critical Mass and Willingness to Pay for Social Networks." Electronic Commerce Research and Applications. 9, pp. 6-19.

Wright, Sewall. 1922. " Coefficients of Inbreeding and Relationships." The American Naturalist. 56, pp. 330-338.

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