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Social Network Structure Among Seoul National University Students

서울대학교 학생들의 소셜 네트워크 구조 분석

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경제학부 경제학 전공

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이 논문을 경제학석사 학위논문으로 제출함.

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Abstract

Social Network Structure Among Seoul National University Students

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This paper examines a model of favor exchange in networks and explores the implications of cultural differences on the model. The model predicts that social quilts are robust and therefore the clustering coefficients of these resulting networks will be low. This paper predicts, however, that cultural traits can affect the structure of the network in ways not predicted by the model. A survey of students of Seoul National University is conducted, and the networks resulting from the data are analyzed. The networks that consist of both friendship and favor relationships tend to have high clustering coefficients, while the networks consisting only of favor relationships show relatively low clustering coefficients.

Keywords: Networks, Favor Exchange, South Korea, Clustering

Student Number: 2010-23993

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I. Introduction

Across all cultures, humans cooperate with each other through both informal and formal means of enforcement. Formal measures of enforcement of cooperation include contracts and laws. Informal methods of enforcing cooperation come from culture, which dictates social norms and can arise from religious customs and schools of thought. When economic transactions are costly or risky, the formal measures help to ensure that people cooperate. However, a need for the informal methods of cooperation occurs when setting up formal contracts or lobbying for laws is too costly, for instance, in the everyday favors that people do for one another.

However, various cultures have different expectations of, reasons for, and ways of enforcing cooperation. For example, in an individualistic society, one may feel obligated to help a friend in the hopes that one day that friend will return the favor. On the other hand, a member of a more collectivist society may wish to perform a favor for a friend in order to protect his image as a member of the group and to maintain group harmony. Because of this, the dynamics of these real-life transactions may vary across cultures.

Most of the economics literature involving cooperative games assumes that the agents act opportunistically, due to the inability to differentiate whether the other agents will behave opportunistically as well (Ghoshal and Moran, 1996). Chen, et al. (2002) criticize the opportunistic view and argue that opportunism varies depending on how agents are conditioned by culture, examining the individualism-collectivism paradigm and its effects on ingroup and outgroup transactions.

Jackson, Rodriguez-Barraquer, and Tan (2012) introduce a model of favor exchange that seeks to provide a specific definition of social capital. Their definition of social capital that comes from the model captures "notions of ostracism and social expectations of individual behaviors" (Jackson, et al., 2012, p. 1860). However, the model fails to truly capture these social expectations because it assumes the agents act opportunistically. For instance, if the agent sees that performing a favor for an agent he or she is connected to will not be profitable, he will simply sever the link. He or she does not take into account any notions of friendship or cultural expectations. Coleman (1988), however, emphasizes the need for a merging of economic principles of rationality with the effects of social organizations. He maintains that social capital consists of a combination of both economic and social relationships.

Understanding how and why networks form is important because network structure has an impact on the flow of information and contagion. Raub and Weesie (1990) and Ali and Miller (2009) show the effects of network structure on the amount of time it takes for information to spread through a network. They show that completely connected networks reduce the time needed for contagion to occur. In order to properly understand how and why contagion occurs, one must also examine the factors that lead to different network structures.

This paper examines the effects of social expectations on network structures by examining the patterns of social network structures among Seoul National University students. First, the model will be presented in Section 2. In section 3, the survey, data collection methods, and the subjects will be explained In section 4, the results of the empirical study will be discussed, and the paper will conclude in Section 5.

II. The Model

A. Networks of Favor Exchange

Jackson, Rodriguez-Barraquer, and Tan (2012) provided a model of favor exchange in which agents are connected in a social network and play a favor exchange game. The fixed and finite set of agents, denoted by $N=\{1,\ldots,n\}$, are connected in a network described by an undirected graph, denoted by g. The set of all links in the network is denoted by g^N, and let $G=\{g \mid g \subset g^N\}$ be the set of all possible networks. The notation ij will be used to indicate the link $\{i,j\}$, so that $ij \subset g$ indicates that i and j are linked in the network g. Also, $g-ij$ will be written to indicate the network that remains after the link ij is removed from g. For an integer k, $0 \le k \le n(n-1)/2$, denote G_k as the set of all networks that contain exactly k links, so that $G_k=\{g \in G : |g|=k\}$. The neighbors of agent i, which excludes self-links, is denoted by $N_i(g)=\{j \mid ij \in g\}$. The degree of agent i in the network g, denoted by $d_i(g)=|N_i(g)|$, is the number of agent i's neighbors.

In this game, time proceeds in discrete periods and is indexed by $t \in (0,\ldots)$. For any two connected agents i and j, let $p>0$ denote the probability that in any given period, i will need a favor from j or j will need a favor from i. It is assumed that across all agents, at most one favor will be needed in any time period. Providing a favor costs an agent $c>0$ and receiving a favor yields an agent an amount $v>c$. It is ex ante Pareto efficient for agents to engage in favor exchange over time. Agents discount their payoffs over time by a discount factor $0 < \delta < 1$. The model examines the case in which the expected value of favor exchange over time between two agents in isolation is not profitable, i.e., where $c > \frac{\delta p(v-c)}{1-\delta}$.

In this case, when he or she is called upon to do a favor an agent will see that the cost to perform the favor is higher than the future value of potential favor exchange, so favor exchange will not occur. The society is described by (N, p, v, c, δ).

B. The Favor Exchange Game

Jackson, et al. (2012) describe the favor exchange game as follows. The game begins with an initial network, g_0, in place. Period t begins with the network from the previous period, g_{t-1}, in place. First, agents announce the links they want to retain. This is done simultaneously. The individual's chosen set of neighbors is denoted by $L_i \subset N_i(g_{t-1})$ and the resulting network is $g_t' = \{ij | j \in L_i \text{ and } i \in L_j\}$. The need for a favor arises with probability $2pk_t$, where k_t is the number of links in g_t'. The favor, if needed, can apply to any link in the network with equal likelihood and go in either direction. The agent called upon to do the favor will be denoted by i_t and the agent who needs the favor will be denoted by j_t, where $i_t j_t \in g_t'$. Agent i_t chooses to perform the favor or not. If he or she does, i_t will incur the cost c and agent j_t will receive the benefit v. If he or she does not perform the favor, the link between the two agents is severed and the ending network is denoted by $g_t = g_t' - ij$. Otherwise, it is g_t'.

The agents choose with whom they want to be linked and also whether or not to perform favors when called upon. Once a favor is denied, the link cannot be formed again. This model also does not consider the formation of new links, but only the severance of links. The model assumes complete information, so all agents are aware of all moves in the game at every node.

Agent i that is in a network g that is expected to last forever will have an expected utility of $u_i(g) = \frac{d_i(g)p(v-c)}{1-\delta}$. Therefore, any network g can be sustained as a pure strategy equilibrium if $c < d_i(g)\frac{\delta p(v-c)}{1-\delta}$ for every agent i. Sustaining this network relies on a type of grim trigger strategy, in which all agents delete all their links if any agent fails to provide a favor.

C. Renegotiation-Proof Networks

Jackson, et al. (2012) define *renegotiation-proof networks* to be networks that can be sustained via pure strategy renegotiation-proof equilibria. The set of pure strategy renegotiation-proof equilibria are defined inductively.

To characterize renegotiation-proof networks, some intuitive sufficient conditions that give insight into the networks' structures must be given.

Jackson, et al. (2012) describe m as a whole number defined by

$$m\frac{\delta p(v-c)}{1-\delta} > c > (m-1)\frac{\delta p(v-c)}{1-\delta}. \tag{1}$$

The parameter m captures how many links an agent has to risk losing in order to have an incentive to provide a favor. In the analysis of the model, the definitions are relative to m and so it is fixed and defined by equation (1).

Networks in which each agent has either at least m links or zero links are sustainable as subgame perfect equilibria, and the set of those networks is denoted by $G(m)=\{g \mid \forall i, d_i(g) \geq m$ or $d_i(g)=0\}$. A network g is said to be m-*critical* if $g \in G(m)$ and for any i and $ij \in g, \nexists g' \subset g-ij$ such that $d_i(g') > d_i(g)-m$ and $g' \in G(m)$. Any nonempty network $g \in G(m)$ contains a nonempty critical network and any critical network is renegotiation-proof.

D. Robustness

A network is robust if the damage from failing to provide a favor is localized, rather than globalized. That is, robustness looks at how far the loss of links caused by failure to provide a favor spreads. Jackson, et al. (2012) observe that if (1) holds for $m \geq 2$, if g is a renegotiation-proof network, and if $ij \in g$, then $g-ij$ is not a renegotiation-proof network. The implication of this is that if a link is deleted from a renegotiation-proof network, then the network will degrade further. Robustness against social contagion minimizes how far the loss of links spreads beyond the original deviator in the network.

A network g is *robust against social contagion* if it is renegotiation-proof and sustained as part of a pure strategy subgame perfect equilibrium with $g_0 = g$ such that in any subgame continuation from any renegotiation-proof $g' \subset g$, and for any i and $ij \in g'$, if i does not perform the favor for j and then $g'' \subset g' - ij$ is reached with positive probability and played in perpetuity, if $h\ell \in g'$ but $h\ell \not\in g''$ then $h \in N_i(g') \cup \{i\}$ and $\ell \in N_i(g') \cup i$. That is, the only links that are deleted because of an agent's failure to provide a favor in a renegotiation-proof (sub)network only involve the agent deleting the link and his or her neighbors.

To describe which networks are robust against social contagion, we first must define some terms, keeping in mind that $m > 1$.

An m*-clique* is a complete network with $m+1$ nodes. Every node in an m-clique has exactly m links. A network g is called an m-quilt if g is a union of m-cliques and there is no cycle involving more than $m+1$ nodes. These are also known as social quilts.

THEOREM 1 (Jackson, et al, 2012): *A network is robust against social contagion if and only if it is a social quilt.*

The proof of this theorem can be found in Jackson, et al. (2012).

III. Overview of the Survey

A. The Subjects

The theory behind favor networks described in Section II predicts a robust network will consist of several small cliques. This empirical study examines students of Seoul National University. When students are admitted to the university, they are randomly assigned to a homeroom (a rough translation of the Korean word *gwabang*) in their school. These rooms serve as places where students gather and relax between classes. The students, who may come from different majors in the same school, can meet in these rooms often to eat meals together and socialize. Like many other social groups in South Korea, they participate in and host events both inside and outside of school. For example, besides taking classes together, students in the homerooms will go on retreats (known as MT, or “membership training”), hold parties, and take part in school festivals together.

Eight homerooms were analyzed, with a total of 142 students surveyed. The homerooms were selected from the School of Social Sciences, the School of Agricultural Sciences, and the School of Humanities. Since only a few students gather at one time in the homerooms, multiple visits were paid in order to collect more data. The students present in the homeroom were given a copy of the survey, were read the instructions, and then given a small piece of candy as a token of appreciation after finishing. The individuals were told to not consult with one another while filling out the survey.

B. The Survey

The survey consisted of 11 questions and asked individuals about their connections with regards to various sorts of relationships. The questions asked about the following relationships: with whom he or she is closest too or talks with the most, who he or she meets in his or her spare time, who he or she would lend class materials to or from whom he or she would borrow them, who he or she would lend money to or borrow money from if needed, who he or she asks for advice or gives advice to, who attends any clubs or organizations with him or her, who the subject would invite to a club or organization he or she belongs to, and who would invite the subject to a club or organization her or she is involved in. The survey was written in Korean, and an English translation can be found in the appendix.

The questions can be divided into two types: *friendships* and *favors*. The networks that are analyzed are the *favor* networks, which are derived from the questions that ask about favor relationships, and the *all* networks, which are derived from all of the questions. The types of questions are specified in parentheses next to the questions in the translation of the survey found in the appendix.

The subjects wrote the full names of the individuals and were informed that their responses as well as their own names would be encoded to protect their privacy. The networks formed consisted of undirected links. A link was formed between agents i and j if either i answered agent j's name or agent j wrote agent i's name. In other words, a link was formed if at least one of the subjects acknowledged a relationship with the other. The names of those who were named in the responses but did not take the survey were deleted from the data set. This was to ensure that the networks that were analyzed were subnetworks of the true networks.

As with any empirical study involving surveys, there are some sources of measurement error. First, not all students attending each homeroom could be surveyed. Second, issues involved with conducting surveys also apply. For example, the subjects may have felt tired when writing the names or they may have forgotten to write some of their connections. There was a cap of only five names per question, but there were very few cases in which the cap was reached.

IV. Results

A. Clustering Coefficient

This analysis mainly looks at the clustering coefficient as an indicator of group structure. The formula for the clustering coefficient is given by the following. For any graph g, the individual clustering coefficient is

$$Cl(g) = \frac{\sum_i \# \{jk \in g \mid k \neq j, j \in N_i(g), k \in N_i(g)\}}{\sum_i \# \{jk \mid k \neq j, j \in N_i(g), k \in N_i(g)\}},$$

which can then be rewritten as

$$Cl(g) = \frac{\sum_{i;j \neq i;k \neq j;k \neq i} g_{ij} g_{ik} g_{jk}}{\sum_{i;j \neq i;k \neq j;k \neq i} g_{ij} g_{ik}}.$$

The clustering coefficient measures the probability that, given links ij and ik, the link jk is also in the network. It takes values between 0 and 1, where 1 means the network is a complete network, and 0 means that for any pair of agents that are connected, there is no other agent that is mutually connected to both of them.

B. All Networks

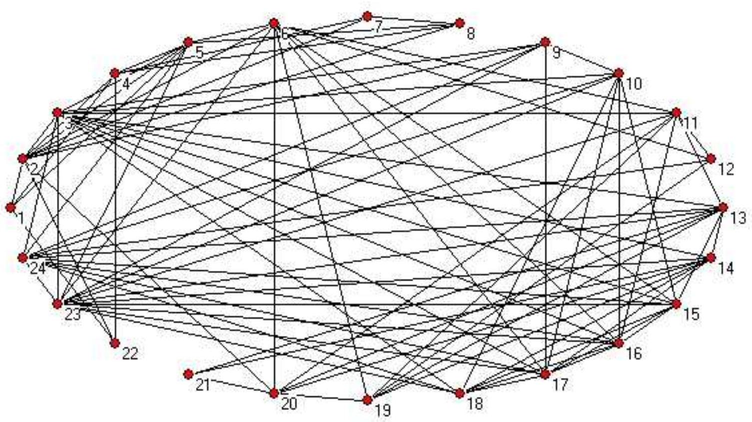
Table 1 below shows the metrics for the *all* networks.

Table 1: Network Metrics- All

Homeroom	n	Diameter	Average Geodesic Distance	Clustering Coefficient
A	24	3	1.84	0.568
B	24	3	1.78	0.418
C	23	5	2.16	0.279
D	17	4	1.83	0.364
E	14	3	1.62	0.490
F	14	4	1.79	0.549
G	13	4	1.76	0.604
H	13	6	2.65	0.541

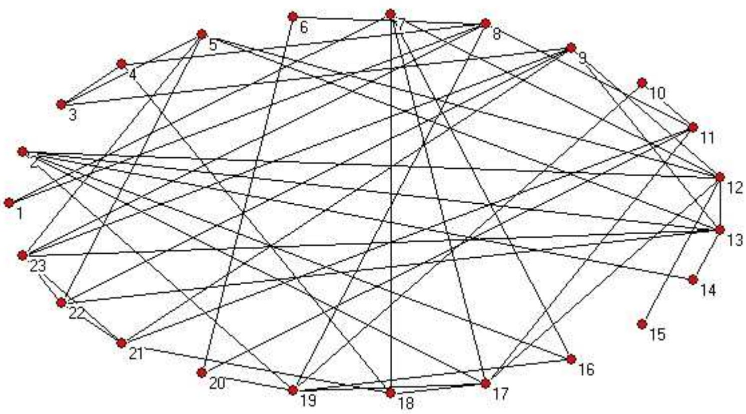
Each network that arose from the data contained only one connected component. In other words, no agents were isolated. An example network, the network for homeroom A, is shown in Figure 1.

Figure 1: Network with Relatively High Clustering- Homeroom A



In six out of eight networks, clustering was relatively high, hovering at around 0.4 or more. The average degree for Homeroom C, shown in Figure 2 below, was 4.34, which was lower than the other homerooms of similar size (Homerooms A and B with average degrees of 7.5 and 6.67, respectively). This fact, along with a high diameter relative to network size and a relatively low clustering coefficient, implies that the agents form cliques within this network. However, overall, the average of the clustering coefficients of the networks is 0.477. This is more than double the clustering of 0.222 that was reported in Jackson, et al. (2012).

Figure 2: Network with Relatively Low Clustering- Homeroom C



The high diameters relative to network size, particularly for Homerooms F, G, and especially H, seem counterintuitive given their relatively high clustering coefficients. Surely, as the network converges to a complete network, the diameter must decrease. However, one must take into account the average geodesic distances, defined as the average shortest path length between any two nodes. As shown in Table 1, each of the diameters is at least two times greater than the corresponding average geodesic path lengths, which suggests that the high diameters are caused by outliers in the network.

C. Favor Networks

Table 2 gives the metrics for the *favor* networks.

Table 2: Network Metrics- Favor

Homeroom	n	Diameter	Average Geodesic Distance	Clustering Coefficient
A	24	4	2.17	0.553
B	24	4	1.91	0.322
C	23	5	2.49	0.233
D	17	4	2.14	0.217
E	14	4	1.94	0.363
F	14	4	2.06	0.384
G	13	3	1.63	0.528
H	13	6	2.77	0.490

In the *favor* networks, we see that the clustering coefficients have all fallen. While clustering remains relatively high in a few networks, many of them show clustering that is closer to the results of Jackson, et al. (2012). In fact, the average of the clustering coefficients for the *favor* networks has decreased to 0.388. This lower clustering implies that agents perform favors in groups that are smaller than their overall friendship networks. In other words, the subjects surveyed will share friendships with a large amount of people, but they will not perform favors for everyone.

An interesting factor to note is that network A, which is a homeroom from the School of Agricultural Sciences, has relatively higher clustering than those found in the other networks from the School of Social Sciences and the School of Humanities. This result is consistent with those from the results of the studies on co-authorship by Newman (2003) and Goyal, et al. (2001), which are summarized in Jackson (2008). A likely reason for this is because students of the natural sciences take many of the same basic classes regardless of major, compared with humanities and social science students who take classes separately. Also, research in scientific fields usually involves many people, rather than the individual work found in social science or humanities fields.

V. Conclusion

The relatively high clustering coefficients have some interesting implications for the networks that were analyzed. According to the model, the networks with high clustering are not social quilts, and therefore are not robust against social contagion. Intuitively, this makes sense. Highly clustered networks create pressure for an individual to conform to his or her group. Given that this is a complete information game, if an agent were to deviate and not perform a favor, all agents would become aware of this and may inflict punishments. In the real world, this complete information may come in the form of gossip. In relatively collectivist societies such as those found in East Asia, an agent may be more hesitant to refuse to perform a favor, and so the network would not deteriorate as much as in that of an individualist society.

However, the results of the survey show that the network does indeed break down, manifested in the lower clustering coefficients. Nonetheless, the networks that still display relatively high clustering demonstrate that there are some social and cultural factors influencing them. With an increase in the influence of Western culture in South Korea, the younger generation is becoming more individualistic than the older generation. Expanding the survey to include questions related to culture that ask about the personalities of the subjects may provide more insight into why these network structures form.

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Appendix: English Translation of the Survey

Below is an English translation of the survey used for this paper. The original survey was written in Korean. The words "friendship" and "favor" have been added next to each question below to indicate which type of relationship is being asked about.

Hello. My name is Brian, and I am a graduate student in the Department of Economics. I am conducting a survey about social network structure among Seoul National University students for my Master's thesis. The purpose of this study is to examine the various relationships between students. Since this survey will be used to build social networks, please use your full name as well as the full names of the people named in your responses. All names will be encoded in order to ensure your privacy when analyzing and presenting the results, and the results of this survey will only be used in this study. Thank you for your time.

1. Basic Information

-Name:

-Gender: M/F

-Age:

-Year: Freshman / Sophomore / Junior / Senior

-Homeroom:

-Area where you attended high school: Seoul / Gyeongi / Gangwon/ Chungcheong / Honam / Yeongnam / Jeju / Other

2. Please answer the following questions. Please limit your responses to at most 5 people per question. Please do not discuss this survey with others until after this survey has been completed. If there are any questions, please raise your hand and sit quietly.

1) Who are you closest to or who do you talk to the most in your homeroom? (friendship)

2) Who in your homeroom do you contact first to meet you in your free time or on weekends? (friendship)

3) Who in your homeroom contacts you first to meet in their spare time or on weekends? (friendship)

4) If you needed to borrow materials for class, to whom in your homeroom would you feel comfortable asking? (favor)

5) If they asked, to whom in your homeroom would you feel comfortable lending materials for class? (favor)

6) To whom in your homeroom would you feel comfortable asking to lend you 50,000 won in an emergency? (favor)

7) Who in your homeroom would feel comfortable asking you to lend them 50,000 won in an emergency? (favor)

8) To whom in your homeroom do you ask for advice? (favor)

9) Who in your homeroom asks you for advice? (favor)

The following questions are about clubs and organizations.

10) Please write the name(s) of any clubs or organizations you belong to.

10-1) If you belong to a club or organization, who from your homeroom also participates in your club or organization? (friendship)

10-2) If you belong to a club or organization, who from your homeroom would you like to join your club or organization? (friendship)

11) Among the people in your homeroom who are part of a club or organization, who would invite you to join their club or organization? (friendship)

3. Finally, we need to confirm that the answers provided in this survey were written by you and you alone, and that you agree to allow your answers to be used in this research. Please write and sign your name below. Thank you very much for helping me in my research.

Date: Name: (Signature)

국문초록

Social Network Structure Among Seoul National University Students

서울대학교 학생들의 소셜 네트워크 구조 분석

본 연구는 네트워크의 구성원들 사이에서 발생하는 호의 교환에 관한 모형을 바탕으로 문화적 차이가 모형에 미칠 수 있는 영향에 대하여 고찰한다. 기존 모형이 예측하는 바에 따르면 사회적 퀼트(quilt)는 단단하므로 그것들로부터 형성되는 네트워크의 경우 낮은 군집화 계수(clustering coefficient)를 보인다. 그러나 본 연구는 문화적 특성이 기존 모형이 예측하지 못하는 방식으로 네트워크 구조에 영향을 미칠 수도 있음을 밝혀낸다. 이를 위하여 서울대학교 학생들을 대상으로 설문조사를 실시하였으며, 조사 결과를 바탕으로 얻어진 네트워크를 분석대상으로 삼았다. 분석 결과 친목 관계 및 호의 관계로 이루어진 네트워크의 경우 높은 군집화 계수를 보인 반면, 호의 관계만으로 이루어진 네트워크의 경우 상대적으로 낮은 군집화 계수를 보였다.

주요어 : 네트워크, 호의 교환, 서울대학교, 군집화

학　번 : 2010-23993