Does ICT Promote the Private Provision of Local Public Goods?

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Abstract. In this paper, we found three conditions to clarify the social network structure for local people solving local problems with social network analysis. One is that a core group exists in the community; the second is that the inside of the core group is an exclusive network; and the third is that a person who has high value of Betweenness centrality is next to the core group. And we showed that using ICT increases the density of the social network in our case.

Keywords: social network, centrality, local public goods.

1 Introduction

Many regions in Japan use ICT to supply local public transportation, and many of these services are based on an administration initiative. However, some people are now proposing that these systems should be private, which would not make services available to new residents. Local residents are in a better position to know the local requirements. Promoting the practical use of dormant resources in a region is one of the best ways to find a quick solution to a local problem. With conventional network analysis techniques, communication cannot be studied at informal places or through relationships, other than through a relative.

There were two research objectives for this paper. The first objective was to clarify the social network structure for local people solving local problems. The second objective was to verify whether or not using ICT increases the density of a network. We used social network analysis to reach conclusions for our objectives.

To attain our research objectives, we used an example of public transportation reservation. In the section taken up in this paper, an inhabitant per se gains a subsidy and inside with much section which works on an administration is conducting the actual proof trial run for alternative transportation operation, etc.

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2 Previous Studies

A social network refers to relationship of members of a society, such as an individual and a company, as well as local and other governments. The technique for clarifying these structures is called social network analysis.

From this point, in Section 2.1, we show the indicators for analyzing the whole network structure. In Section 2.2, we show the indicators for analyzing the internal network structure. Further, in Section 2.3, we describe previous research on using ICT and the strength of the social network.

2.1 Structure of Whole Network

In the social network analysis, the indicators for getting to know the fundamental structure of the whole network are diameter, density, and cluster coefficient. The time concerning transfer of information is so short that a diameter is small. It is expressed whether the relationship of density between each summit is dense. Cluster means the status where a certain person's mates are mates. Cluster can be denoted by a triangle. Cluster coefficient can be defined as the number of cluster formation of the practice occupied to the number which can be cluster achieved. Conversely, Cluster coefficient is set to 0 if one cluster is not achieved, either. Albert and Barabasi (2002) show the Cluster coefficient of the real networks are between 0.1 and 0.7.

If diameter is small, high-density, and Cluster coefficients take the value near 1, it is an exclusive network. If the diameter is large, low-density, and Cluster coefficients take the value near 0, it is open network.

There are three strengths of an exclusive network. One is that is easy to have a common purpose. The second is that it is easy to engender a sense of reliability, since members are mutual acquaintances. The third is that reciprocity is effective. A member cannot betray others easily, since they are acquaintances. That is, building loyalty is easy. On the other hand, since membership is fixed, it is hard to get new information and resources.

In an open network, since there are people connected with others outside the network, the advantage over an exclusive network is that it is possible to acquire new information and resources. However, since people in open networks do not have direct relationships, reaching agreement across the whole network is difficult. If we assume that the network is one decision-making entity, it is hard to show a path that carries the exchange of an idea.

There is disagreement over whether or not an exclusive network is better than an open network. Coleman (1988), advocating the superiority of exclusive networks, stated that few children ever dropped out of exclusive communities. In contrast, Burt (2001) showed that the more dominant structure in an adult society is when members have connections with other communities.

2.2 Internal Structure of the Network

It is important to capture not only the whole structure of the network but the internal structure as well. Several groups may exist on the inside of a network, especially if it

is large. We call the indicator that divides a network into several groups a modularity. The group inside has dense relations if the value of the modularity is high. On the other hand, some groups can become alienated.

Newman (2004) was the first researcher to show modularity. Following that, various methods were proposed: Newman and Girvan (2004), Newman (2006), the CPM methods established by G. Palla et al. (2005), the local Newman methods shown by Clauset (2005), the L-shell methods proposed by Bagrow and Boltt (2005), and the procedure by Blondel et al. (2008), and so on.

There is also the sorting procedure that denotes the type of structure of the human relationships within the network. These indicators have been developed to clarify comparatively small network structures. One of these ideas is Centrality. Many indicators for measuring Centrality have been developed, for example, Degree centrality by Freeman (1979), Betweenness centrality by Brandes (2001), Closeness centrality by Sabidussi (1966), Eigenvector centrality by Bonacich (1987) and Page rank by L. Page et al. (1999).

These indicators are used in order to see the bull and bear of the relation that the person who becomes a reader exists in a network with everybody and a reader. If a certain specific person and other members have respectively powerful relation, a network is a structure of a top-down style. On the contrary, if two or more persons and everybody have relation like meshes of a net, a network has a horizontal structure. With a horizontal structure, a member tends to make mutual remark manifestation and suggestion.

Moreover, in order to measure network patency, we use Betweenness Centrality by Brandes (2001). Betweeness Centrality means whether there is any relation with the person of the inside and outside of a network through the person. As for the person who is influential in many fields, this value becomes high. If many high persons of Betweeness Centrality are contained in the network, calling in of information dispatch out of a network, and talented people and a resources will become possible.

Many techniques that analyze the whole network structure also examine validity using artificial data. Although the tools for analysis inside network structure have been applied to real data, validity changes with the candidate for analysis.

2.3 The Spontaneous Relationship between ICT and Local Residents

Whether or not ICT is stimulating spontaneous friendships among local residents awaits further research. According to the social trial runs by Hampton (2007) in the Boston suburbs, large differences were seen in the availability of electronic conference rooms and electronic bulletin board systems as well as the skills and life stage of individuals.

In this research, we supposed that participation in regional activity via ICT by the younger generation is being promoted. We also supposed that this usually results in changing the behavior of people who cannot easily participate in regional activities.

3 Analysis

We determined the research zone because of our research objectives. In section 3.1, we show the summary of this region. And we measured social networks using conventional techniques and by a social trial run that used ICT. Following section 3.2, we show the survey summary and the results.

3.1 Overview of the Subject Region

The region studied was Uji City, Makishima, in Kyoto, Japan. This city is near three larger cities. A "new town" undergoing a period of high economic growth is in Uji City, and the old and new residents are mixed in. Residents who were interested in city planning established a non-profit organization through which they plan and manage various local community activities.

In Japan, organizations with shared territorial bonding, like neighborhood associations, have traditionally organized local community activities. In Uji City, both the traditional neighborhood association and non-profit organizations complement each other when carrying out offering local community activities.

Public transportation stopped in three sections in Uji which will include Makishima area from April, 2013. For this reason, the travel difficulty person has arisen to each district. While in three areas, the inhabitant per se gained the subsidy and the Makishima area conducted the actual proof trial run for alternative transportation operation, etc. However, an actual proof trial run is not conducted in other two areas.

From our original survey in 2012, the use of cell phones and PCs in this district is shown below.

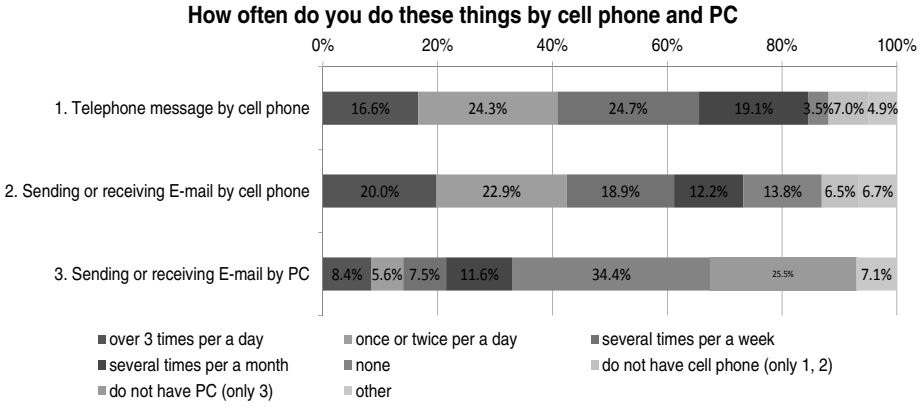

Fig. 1. Use of cell phones and the PCs in Makishima area

Our investigation showed that over 40% of the residents in Makishima are using cell phones for day-to-day telephone messages or e-mail. On the other hand, about 30% of the residents send e-mail by a PC (personal computer), even if this includes several times per person per month. From this, it can be determined that the cell phone is the ICT device used most often.

3.2 Social Network Analysis

The actual proof trial run of social network-analysis substitution transportation operation operated around the bus on demand, and the human performed the operation of the diagram installation. However, practical use of ICT became a future task from time and economic constraint. Then, ICT equipment with section inhabitants' high activity ratio will be chosen, and the procedure which can perform a clutch of demand will be developed jointly. We decided to conduct a social trial run using a smartphone as the ICT device based on the results of our investigation of the residents' trial outlined in the preceding paragraph. This is first time to test the system with inhabitants.

After receiving approval from the intramural Ethics Committee, we explained in advance how we intended to acquire personnel information to those cooperating with the trial run. We conducted the social trial run from November 11 to December 10, 2013.

Before the social trial run, we conducted a social network survey using conventional techniques with people who cooperated on 20 social trial runs from September 20 to October 5, 2013. The examination method used was the visit detention method. We designed a questionnaire using a name generator form. A name generator form differs from a normal questionnaire in several ways: first, the subject visualizes two or more people for a personal name relevant to questionnaire entries. Next, we ask

Table 1. Descriptive Statistics by name generator form

	Q1. Frequency by telephone				
	1st person	2nd person	3rd person	4th person	5th person
average	2.765	2.647	2.824	3.000	2.938
variance	1.239	0.934	1.087	0.588	1.309
N	17	17	17	17	17
	Q2. Frequency by SNS				
	1st person	2nd person	3rd person	4th person	5th person
average	3.000	2.500	3.286	3.429	3.333
variance	1.000	0.917	1.061	1.388	0.889
N	8	6	7	7	6
	Q3. Frequency of direct communication				
	1st person	2nd person	3rd person	4th person	5th person
average	2.650	2.500	2.684	2.944	2.706
variance	1.128	0.950	1.269	0.830	1.031
N	20	20	19	18	18

the relationship between the subject and those people. For this paper, the subject wrote down in the questionnaire five or fewer names of people whom he/she talks with about city planning. We asked them about those five people, including 1) the frequency that she/he talks by phone; 2) the frequency that she/he sends and receives e-mail; 3) the frequency that she/he talks through direct meetings, based on Likert's five-point scale. We also asked, using multiple choice, the place they were when they talked in a direct meeting. In addition, we asked the subjects to write down the name of the person whom she/he thinks is the leader for city planning activities. The ICT collection data used for this paper is obtained in this social trial run. The rate of collection was 100%.

Analysis of Social Network Structure by Name Generator Form. To grasp the fundamental structure of the whole network, we computed the diameter, cluster coefficients, and density. Most of the subjects are 60-70's, and they meet so often. Then, we analyze the data of the frequency of direct communications. The results are shown in Table 2. The whole network was not dense.

Table 2. Basic structure of the whole network

diameter	total number of clusters	average Cluster coefficient	density
5	87	0.117	0.063

To determine the inner structure of the network, we calculated modularity using the algorithm developed by Blondel et al. (2008). Our result: the modularity of the network in this research was set to 0.295. The number of groups was seven. In the central section of Fig. 2, we were able to find the group that most members belong to.

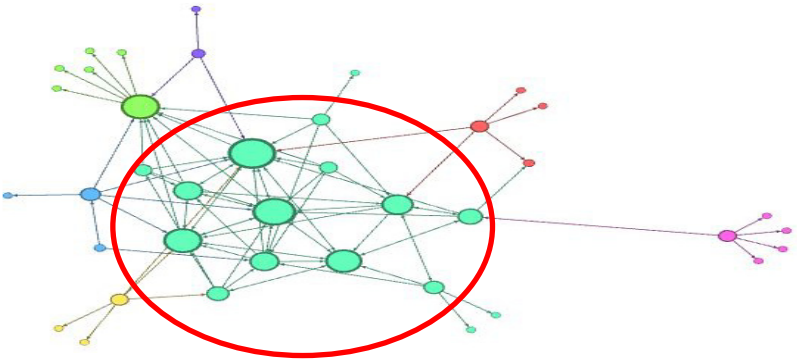

Fig. 2. Partition of the network by modularity

To understand the relationships inside the network, we used five indexes of centrality: 1) in degree centrality, 2) Betweenness centrality, 3) Eigenvector centrality, 4) Page rank, and 5) Closeness centrality. An assessment of these indicators is shown in Table 3.

Table 3. The results of each centrality assesement

Rank	In Degree Centrality		Betweenness Centrality		Eigenvector Centrality		Page Rank		Closeness Centrality	
	Value	name	value	name	value	name	value	name	value	name
1	13	T	95.0	Q	1.0	P	0.0895	P	2.818	F
2	11	P	71.4	E	0.93957	O	0.0879	T	2.75	G
3	9	Q	62.9	K	0.91685	T	0.0824	O	2.667	S
4	9	O	52.3	T	0.87113	K	0.0768	Q	2.571	D
5	8	K	42.7	M	0.83873	Q	0.0767	K	2.545	L
6	6	E	40.3	A	0.69547	M	0.0617	M	2.526	I
7	5	M	40.1	B	0.26340	B	0.0339	E	2.421	A
8	5	C	28.4	P	0.24437	E	0.0308	B	2.368	J
9	3	B	27.0	I	0.20171	I	0.0251	C	2.368	C
10	2	I	24.1	O	0.071688	C	0.0250	I	2.273	R
11	1	J	21.1	C	0.061688	A	0.0160	A	2.263	K
12	0	A	8.5	D	0.0468329	J	0.0146	D	2.211	B
13	0	D	3.3	J	0.0023015	D	0.0145	J	2.158	T
14	0	F	0.0	S	0.0	S	0.0102	N	2.158	P
15	0	G	0.0	R	0.0	R	0.0102	H	2.158	O
16	0	H	0.0	N	0.0	N	0.0102	R	2.105	M
17	0	L	0.0	H	0.0	H	0.0102	G	2.053	E
18	0	N	0.0	L	0.0	L	0.0102	S	2.05	H
19	0	R	0.0	F	0.0	F	0.0102	L	2.048	N
20	0	S	0.0	G	0.0	G	0.0102	F	1.0	Q

Compared with the results of asking the leader's name, the rank of each centrality of the leader usually was high, except 5) closeness centrality. Especially the person P who was supported overwhelming as the leader, ranked either first or second, were eigenvector centrality, page rank, and in degree centrality.

Fig. 3 shows the strength of their connections, when computed using Tarjan's algorithm (1972).

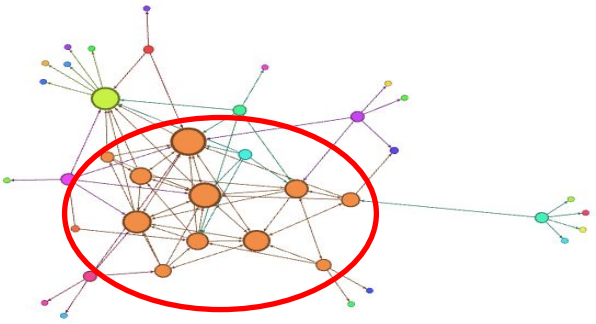

Fig. 3. Derivation of the core group

Although several members in Fig.2 were not included, most members had strong ties. In the network for this study, strong ties other than these were not detected. We defined this as the core group. The inside of the core group can be called an exclusive network.

When we observed a member of the core group using every index of centrality, they were located in a higher rank for all the indicators, except Closeness centrality. For degree centrality, eigenvector centrality, and page rank—indicators that evaluate relationships between members—the evaluator sees the entire network.

If we pay special attention to the directional movement of the arrows in the figure, when many arrows are aiming at a certain person, that person is said to be an authority. Conversely, someone who has many arrows going from them is said to be a hub. There was a person who was not only an authority but also a hub outside of the core group. After analyzing this network, we found several people with relationships to other groups that were next to the core groups.

After assessing the character of Betweenness centrality, which measures the degree of mediation with other networks or groups, we found that the core group could connect with other groups by having a relationship with the person whose Betweenness centrality has projected. That is, the whole network was an open network.

Analysis of Social Network Structure Using Social Experimental Data Based on ICT. The information was collected by ICT equipment using the smart phone. Table 4 shows the descriptive statistics of the transceiver registration of mail between social trial-run cooperators. During the survey time or an experimental period, since there is a person who did not transmit e-mail once, the number of samples used for the analysis is 13.

Table 4. Descriptive Statistics of e-mail sending/recieving with ICT

N	average	variance
13	2.362	0.364

It is verifying whether a utilization of ICT raising network density as for the second purpose of this paper. About the frequency data of the e-mail transmission and reception before a social trial-run inception, and the data obtained by ICT, the comparative analysis of the whole network structure is made to a beginning by the same technique as a preceding paragraph. In order to use the data between collection methods as a consistency target, ICT measuring data was changed into frequency data.

Table 5. Basic structure of whole network by SNS with name generator form and ICT

	diameter	total number of cluster	Average cluster coefficients	density
name generator form	3	6	0.145	0.005
data with ICT	3	186	0.707	0.276

From the table 5, the social trial run by ICT shows that the total number of clusters and the average cluster coefficients are increasing greatly. Moreover, density is also rising. These show that the exchange of mail between members increased and the share and the trade-off of the information on the whole network progressed by utilization of ICT in this network.

Subsequently, to know the structural change inside the network, each centeredness before and behind a social trial run is compared. The table 6 is a descriptive statistic of the data used for the analysis.

Table 6. Descriptive Statistics (N=13)

Centrality		average	standard deviation
Degree	Before	1.385	1.193
	After	8.154	5.829
Closeness centrality	Before	0.555	0.768
	After	1.211	0.874
Betweenness centrality	Before	0.000	0.000
	After	1.654	5.124
Page rank	Before	0.043	0.015
	After	0.042	0.011
Eigenvector centrality	Before	0.232	0.434
	After	0.519	0.088

We analyzed these centralities with the data by name generater form and ICT, using paired t-test. Table 7 shows the result.

Table 7. Results of paired t-test of each centrality with name generator form and ICT

	average	standard deviation	Confidence Interval		t-value	p-value
			lower	upper		
Degree	-6.769	6.274	-10.560	-2.978	-3.890	0.002
Closeness centrality	-0.655	1.064	-1.298	-0.012	-2.222	0.046
Betweenness centrality	-1.654	5.124	-4.750	1.442	-1.164	0.267
Page rank	0.001	0.019	-0.010	0.013	0.199	0.846
Eigenvector centrality	-0.287	0.475	-0.574	-0.000	-2.182	0.050

The slippage was observed in degree centeredness, proximity centeredness, and eigen-vector centeredness by 5% of the significance level from the result of the table 6. In this social trial run, since the e-mail and the telephone message to the person outside a network from the rule of a research-expenses use were forbidden, the

transmutation was not looked at by mediation centeredness. However, the transmutation was looked at by the frequency of mail in the network, and the bull and bear of relation. The result especially with degree centrality significant also with the 1% plane was obtained.

A transmutation of degree centeredness is seen in Fig. 4. The left figure expresses social trial-run before, and the right figure expresses the time of a social trial run.

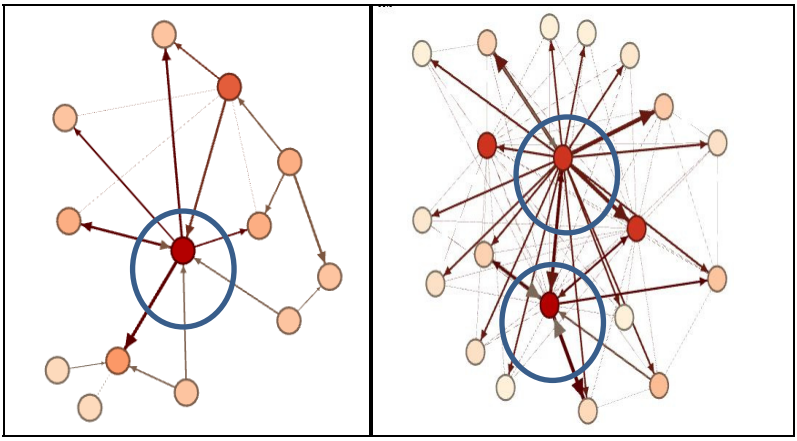

Fig. 4. Degree centrality before trial run and after

left side: before trial run right side: trial run

Although the authority and the hub were only one place surrounded with a circle with the left figure, authorities and hubs are increasing in number to two places surrounded with a circle with the right figure. Furthermore, two authorities with degree centeredness (a figure round mark of the density) comparable as an authority and a hub are added.

In this social trial run, all members' contact address was beforehand registered into the leased equipment, and a short-term course of the transceiver procedure of e-mail was taken to the simultaneous. This led to utilizing ICT as a liaison policy with the information dispatch and the reader towards all members, or a secretariat.

4 Considerations and Remarks

We tried to find the features—from the structure of the whole network and the structure inside the network—of a social network that becomes successful when local community activity is led by residents.

We revealed three conditions for the local problem-solving network by residents from analysis using a traditional name generator form: One condition is that a core group exists in the community; the second is that the inside of the core group is an exclusive network; and the third is that a person who has high value of Betweenness centrality is next to the core group.

The above-mentioned conditions 1 share a local task, and it is shown that an existence of the group which carries out desire of the settlement is important. Moreover, when performing the business solution procedure, the conditions 2 suggest the significance of each one having detailed relation so that division of roles according to an aptitude may be made. As the conditions 3 showed, it turned out that a required resources can be raised also from an outside towards business solution in the member connected also with the external network existing.

Thus, a group with union strong against a community used as a core exists in a share of a local task, and a realization of the measure towards business solution, and it is important for the group that an outside has a point of contact. The conventional shared-territorial-bonding structure is not necessarily filling them to the conditions 3, even if the conditions 1 and 2 are filling. Conversely, in a new structure, it is hard to fulfill the conditions 1.

Even if all the members are an old acquaintance's relations, it will be possible to raise the density of a communication using ICT. The aged are especially said to be hard to adapt themselves to ICT compared with a young man. However, from the result of this paper, gather at once, it is that simple usage is well-known to all the members, and the communization of the information became progressing also among the aged.

The data-gathering by ICT can record conscientiously the exchange which simultaneous distribution of the mail which he was not conscious of, and an individual forget by a name generator form. Further, it became possible to measure relationships other than a relative relationship by handing a smartphone to many subjects simultaneously. But since personal information can be dealt with easily, careful remarks are required. There were many people who do not use the smart phone usually among these social trial-run cooperators, and they held the utilization school in advance. Then, the direction which noticed carrying out a simultaneous transmission at a threshold and convenience was also watched by the member. By the participant questionnaire after the termination of a trial run, because the comment that the use increased and the usage of e-mail were found, there was actually remark that he would like to use more. On the other hand, there was also a person who does not send e-mail at all. Since stopping a trial-run participation without a previous notice on the way had not barred, time may have stopped.

The social trial run did not necessarily target the whole region. From now on, by extending the number of candidates for our survey region, we would like to analyze the relationships between the core group and the whole community and to examine how to promote contiguity of new members using Betweenness centrality.

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