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Keystone Sector Identification

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2000

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INTRODUCTION

This paper presents a method to identify *keystone sectors* in rural communities, where **sectors** are broadly defined to include individuals, groups, associations, institutions, as well as different types of businesses and industries. In an arch, the keystone is the one with the unique shape at the top of the arch that is critical for the arch's structural stability. In a rural community, the **keystone sector** is an agent/type that plays a unique role without which the community structure could be destroyed.

This research was financed by Tennessee Valley Authority (TVA) Rural studies. The Rural studies program mission areas include: describing and analyzing rural economy, enhancing entrepreneurial/business activity, and supporting innovative community change (see Appendix 1).

The term *keystone species* was coined by ecologists in reference to those fauna and flora that are critical in an ecosystem. The concept was introduced by ecologist Robert Paine in the late 1960's, and has been redefined over the decades to include keystone functional group (Kilkenny, 1996). The idea behind the study of keystone functional groups or species is to identify groups that play the most critical role in an ecosystem. As ecologists hypothesize about the existence of species or groups of organisms that determine the structure of an ecosystem, economists could hypothesize that there is one sector or various sectors that are critical in small economies.

By analogy, we economists seek to identify keystone sectors, where a 'sector' (or group of sectors) may correspond to a species or 'functional group'. The keystone sector is defined as the group of businesses which plays a unique and critical role in achieving the objectives of a small community (Kilkenny, 1996). Since different sectors may be key with respect to different objectives, a methodology that characterizes the interdependencies among sectors relative to each different objective is needed.

Approaches for identifying those sectors which might play a vital role in an economy together with the measures and interpretation of spatial economic structures have been in the economic literature for decades. What economists have been calling **critical or key sectors** are those sectors whose structure of backward and forward linkages create above average impacts on the rest of the economy (Sonis et al., 1998).

> Interdependencies among productive sectors indicate each sector's potential capacity to stimulate other sectors. Activities having the highest linkages are considering **key sectors** because by concentrating resources in them it should be possible to stimulate a more rapid growth of production, income and employment than with alternative allocations of resources (Cella, 1984).

> Any unit change in final demand of a particular sector will affect demand and supply of intermediate inputs. The demand stimulates other domestic sectors to satisfy its intermediate requirements (**backward linkage**). The supply also stimulates domestic production because it may induce use of its output as an input in new activities (**forward linkage**) (Cella, 1984).

The traditional approaches, introduced in the 1950's, to the study of critical sectors in economies are based on the analysis of input-output relationships. The weak point of the traditional key sector analyses is that only businesses sectors are analyzed. The analysis does not consider the roles of other entities in a community. The relationship between two industries in a given market could be due not only to the market conditions but also to the social relationship between the two businesspersons. For example, does the success of a business depend on the involvement of the business in the community?

Kilkenny, Nalbarte and Besser, 1998, studied 30 small communities of the Midwest, focusing on the interdependencies among business owners or managers, institutions, and local citizens. We tested and found statistical support for the "social investment" hypothesis: businesses whose owners or managers make more donations to their community and/or who serve as a volunteer or as an elected public servant, feel twice as successful as those who do not. The service, however, must be reciprocated by community support of the business. There is no evidence of differences across sectors or across towns by size. Neither the activity of the business nor the size of the town was found to be relevant. The findings are the same regardless of community sizes or different business activities.

We conclude from our work on "Reciprocated Community Support" that the usual market interactions and economic characteristics of business activity typically thought to be most relevant in explaining firm success were far less relevant than *non-market* interactions. This was a surprising finding, but not an unprecedented one. Kranton

(1996) argues that non-market reciprocal exchanges are a substitute for search and/or transaction costs. Non-market transactions can also help reduce damaging opportunistic behavior among strangers.

Economists concerned with the political economy of growth have also focused recently on the relationship between social capital and macroeconomic performance (Putnam, et al., 1993; Knack and Keefer, 1997). Almost all of these studies attempt to measure a dependence of macroeconomic performance (growth in regional or national gross product) on region-wide indicators of associational activity, trust, and civic cooperation. The hypothesis is that high-trust societies waste fewer resources protecting themselves from malfeasance; have cheaper, more credible and stable governments institutions; have more access to credit; and risk more on innovation-all of which lead to higher rates of national investment and national growth (Fukuyama, 1995; Knack and Keefer, 1997).

Economist also study the role of voluntary contributions to the public good (Sudgen, 1982) and (non-market) reciprocal exchange (Kranton, 1996) in raising economic welfare. Sudgen explains a *principle of reciprocity* by which agents pursue their self-interest through the provision of non-excludable public goods by making unrequited contributions at least as large as others do. Kranton explains why agents engage in reciprocal non-market relationships to economize on search or transaction costs and to avoid opportunistic behavior among strangers. Kranton also shows that the utility for reciprocal non-market exchange is higher the smaller the market, and, that personalized exchange is more likely when people expect to interact frequently. These claims, however, are purely theoretical. There is a dearth of empirical studies in the economics literature about the local growth implications of non-market relationships between firms and the communities in which the owners reside and do business.

In “Reciprocated Community Support and Small Town-Small Business Success” (Kilkenny, et al, 1998) we relied on one side’s opinions of how the other side feels: only one side of an interaction was interviewed. We learned that when hypotheses concern reciprocity, it may be better to sample both sides of the relations. Furthermore, if perceptions of both sides are collected, one could also test how well perceptions correspond with direct responses.

Since we do not have a primary data source on the reciprocated interactions between individuals, groups, associations, institutions, as well as different types of businesses and industries, we found a secondary data source to use in the development of the methodology. The goal is to identify *keystone sectors* that take into account all possible interdependencies that make up a community. The methodology should be useful for at least three things: one, to describe interdependencies within and among agents, institutions, sectors and communities. Two, to determine the degree of influence of an agent or groups in a community Three, to determine the sensitivity of the structure of the community to the excision of particular agents. The new method may identify sectors never identified before through the prevailing "critical sector" or "traditional targeting" approaches because we extend the analysis to non-market transactions and non-business entities.

This paper is organized as follows. Section 2 reviews network analysis and directed graphs. Section 3 presents an application of network analytical techniques on a set of secondary data. Finally, some insights and recommendations for further research are presented.

NETWORK ANALYSIS

I apply *network analysis* to the study of a secondary data on small community. The data were taken from Lauman, 1985. While network analysis has been widely used in transportation system research (Hanson and Huff, 1986, Koppelman and Pas, 1985, Wright, 1979) and anthropologic and sociologic research (e.g. Granovetter, 1973, Freeman, 1977), applications in the critical sector analysis have been less frequent. The few examples are some early applications by Campbell (1975), and some recent initiatives by Kauffman (1988), Roy (1994, 1995), and Sonis and Hewings (1997). Sociological applications of network analysis varies from individual studies, like interpersonal relations, friendship, leadership, etc, to global studies of communities, like élites studies, political behaviors, power.

Statisticians have contributed to the development of statistical techniques for network analysis (Fienberg et al, 1981, Fienberg et al., 1985, Wasserman and Pattison, 1996). Statistical models have been used by researchers to study social networks for almost 60 years. The goal of these models was (and remains) the quantitative examination of the stochastic properties of social relations between the actors of a particular network (Wasserman and Pattison, 1996).

The basic feature of network analysis, as distinct from the more usual data analytic framework common in the social sciences, is the use of *relational* information to study or test hypotheses. The collection of ties of a specific kind among a group is called a **relation.** For example, a relation could be the flow of money among actors, or trade links among countries, etc. Note that the mathematical definition of relation is what sociologists call tie. Consider now the *mathematical* definition of relation (Robinson and Foulds, 1980):

> Given two sets $\boldsymbol{S}$ and $\boldsymbol{T}$, each member of set $\boldsymbol{S}$ may be related to a number (perhaps zero) of members of set $\boldsymbol{T}$. The mathematical description of this situation is called a binary relation. If $\boldsymbol{x} \in \boldsymbol{S}$ and $\boldsymbol{y} \in \boldsymbol{T}$ then $(\boldsymbol{x}, \boldsymbol{y})$ is a member of this set when $\boldsymbol{x}$ is related to $\boldsymbol{y}$.

Social network data consist of one or more relations measured among a set of actors. The social network data are called **relational data**. Relational data, then, are the contacts, ties, and connections, between one agent and another. A relation could be: a) *directional or non-directional*, and b) *dichotomous or valued.*

> A **directional relation** implies that the tie between a pair of actors has an origin and a destination.
> A **non-directional relation** implies that the tie between a pair of actors has no direction (Wasserman and Faust, 1994).

For example, country A sells manufactured goods to country B. The direction of trade is from A to B, and this classifies it as an export activity of A. If the direction is not recorded, the trade could be misconstrued to be an export of B. In graph theory, a non-directional relation is represented by an **edge**. It is illustrated by a line connecting the interacting agents that has no arrowhead. A directional relation is represented by an **arc**, illustrated by a line with an arrowhead at the destination.

> A **dichotomous relation** between two actors indicates the presence or absence of a relation.

Meanwhile, a **valued relation** captures not only the existence of a relation but also the intensity or frequency of the relation (Wasserman and Faust, 1994). For example the dollar value of the exports from country A to country B could be recorded.

"Social network analysis may be viewed as a broadening or generalization of standard data analytic techniques and applied statistics, which usually focus on observational units and their characteristics. A social network analysis must consider data on ties among units" (Wasserman, and Faust, 1994). Often, relational data are collected by observing or interviewing individual actors about possible linkages among the actors in the set. In this case, the unit of observation is an actor, from whom we obtain information about their ties with other actors.

> A **Social Network** consists of a finite set of actors and the relation or relations defined on them.
>
> **Actors** are social entities, discrete individuals, corporate or collective social units. (Wasserman and Faust, 1994)

For example, actors could be a group of individuals in a particular community, a set of different communities, different agents in a community: businesses, government agencies, etc.

> The linkage established between a pair of actors is called **tie.** A tie is a property of the pair, therefore a tie can not be thought of pertaining simply to an individual actor.
>
> A **group** is the collection of all actors on which ties are to be measured. (Wasserman and Faust, 1994)

When the interest is focused on measuring the ties among actors (given that ties are properties of the pair, ties exist only between specific pairs of actors), the unit of observation is the *dyad*.

The **dyad** consists of a pair of actors and the possible ties between them (Wasserman and Faust, 1994). For example, two cities connected by a commuter's travel pattern between them form a dyad. The researcher could be interested in estimating the direction in which commuters are more likely to go, and the frequency of travel, etc.

Digraphs

Relational data are often represented by graphs. If ties have a direction (are *arcs*) the graphs are called **directed graphs (**digraphs) (Robinson and Foulds, 1980).

A **digraph** is a finite non-empty set N, whose elements $N = \{n_1, n_2 ..... n_g\}$ are called *nodes*, together with a set $A = \{a_1, a_2 ..... a_l\}$ of ordered pairs $a_k = (n_i, n_j)$, called *arcs*, where n_i and n_j are distinct members of N.

Two nodes, $n_i, n_j \in N$, in the digraph $D = (N, A)$ are adjacent if there exist either of the two arcs, $l_i = (n_i, n_j)$ or $l_j = (n_j, n_i) \in A$.

Given the digraph $D = (N, A)$, its **adjacency matrix** $A(D)$ is defined by $A(D) = (a_{ij})$, where $a_{ij} = 1$ if $(n_j, n_i) \in A$, 0 otherwise

Adjacency is the graph theoretical expression of the fact that two agents represented by nodes are directly related or connected with one another.

The number of arcs beginning at the node n_i is called the **outdegree** of the node n_i and is noted as $d_o(n_i)$.

The number of arcs ending at the node n_i is called the **indegree** of the node n_i and is noted as $d_i(n_i)$.

The row sums are the outdegrees of the nodes while the column sums are the indegrees of a node.

A digraph can be presented with graphics as well as in a matrix form. The graphic illustration of digraphs provides an easy visualization, if the number of actors is not too large, of how agents are related with each other. For example, we can see which agent (s) is (are) more connected and which are isolated. The direction of the arrows tells us who is the sender and who is the receiver (i.e. Appendix 2).

Graph data are presented in a matrix, called a **sociomatrix**. The rows of the sociomatrix represent the sending actors while the columns represent the receiving actors. The set of sending and receiving actors may be the same or different. Also, we will have as many sociomatrices as relations considered.

In the next section, I demonstrate the application of network analytical techniques to analyze a set of secondary data.

TOWERTOWN

The analysis is based on the study of one community, "Towertown". The two objectives of the analysis are, first to determine if are there any groups of individual agents whose patterns of interactions are sufficiently similar that they can be treated as a *type* of agent. Second, to describe the patterns of interactions among the different agents in the economy to identify their roles and to test for the input of their excision on the network. Is there a specific structure among agents, or do agents interact randomly with each other? Is there any agent or group of actors that play such an important role in the community that the community structure will be destroyed without it (them)? Although individual interactions are important, the study is also oriented toward the search for group structures within the community

The analysis is organized as follows: First is a description of the secondary data on the Towertown community. What actors were considered? What questions were asked, and, what information was collected? How were the data organized? Second, I present the multi-faceted analysis of Towertown data. The analysis has two levels: individual and community-wide. At the individual level, I try to determine what is (are) the agent(s) that play a vital role in the community. At the community level, I try to explain the density of the relations, and variety of possible structures.

The data

In the late 1970's, the sociologists Galaskiewicz and Marsden gathered information on the formal organizations in a midwestern U.S. community of 32,000 persons. The community was nicknamed, and referred to since, as Towertown. A total of 109 organizations were identified, and 73 were studied. These organizations included all manufacturing firms having more than 20 employees. Banks, laws firms, political organizations, associations, health institutions, educational institutions service clubs, labor unions, city offices and departments and churches. The executive officers of the 73 organizations were interviewed. They were presented with a list of the other 72 organizations in the community, and were asked the following questions:

1) To which organizations on this list would your organization be likely to pass an important information concerning community affairs?
2) To which organizations on this list does your organization rely upon for information regarding community affairs?
3) To which organizations on this list does your organization give substantial funds as payments for services rendered or goods received, loans, or donations?
4) From which organizations on this list does your organization get substantial funds as payments for services rendered or goods received, loans, or donations?

5) Which organizations on this list does your organization feel a special duty to stand behind in time of trouble: that is, to which organization would give support?

6) Which organizations on this list would be likely to come to your organization's support in time of trouble?

(Lauman, 1985)

From the responses to these questions, three dyadic relations were defined: information (1,2), money (3,4) and support (5,6). An organization was determined to be "in relation to" another organization if the former organization answered yes to the first question in a pair, or the latter organization answered yes to the second question in the pair. Note that if either actor in the dyad reported the existence of a tie, a tie was recorded.

For each relation a, *73 x 73*, adjacency matrix, X, was constructed with entries $x_{ij} = 1$ if the i^{th} actor has a relational tie with the j^{th} actor and $x_{ij} = 0$ if not. Also, $x_{ii} = 0$.

The analysis

The main goal is to determine possible interactions among agents (actors) which implies looking not only at individuals, but also at groups. The software used in all the calculations was UCINET IV. UCINET was produced at the University of California, Irvine (UCI). The standard version runs on any XT-compatible with at least 256k of RAM (Scott, 1991).

The following analyses were conducted:

1) Analyses of descriptive measures applied to the sociomatrices for each of the three relations, money, information and support.

2) Graph representation of the data.

3) Search for possible block-model structures.

4) Analysis of group interactions.

I will try to give an answer to some of the following questions: Is the network fully connected? Are all the ties mutual ties? Are there any isolated actors? How many components can we find in each relation? What happens if we remove some of the agents of the network? Are there any actors that play such an important role in the community that without them other actors become isolated? The answers to these questions will help identify which actors or agents may be unique and which are critical to the structure of the community.

I approach the description from a micro perspective (individual) and macro perspective (groups or community). For each one of the relations, I calculate general measures such as densities and component structures (defined below) that will give us a general idea of how interconnected the *community* is and which entities may be isolated.

Also, for each one of the relations I calculate measures for individual actors, like centrality, prestige, cut-points, etc. that will give us information on how well connected *individual* actors are. We will measure which actors are the most central, and which are the more prestigious ones. A **central actor** has more ties from it (higher outdegree measures) while a **prestigious actor** has more ties towards it (higher indegree measures). Those will be the actors that are more visible or recognized by the whole network. A network could have more than one actor that is well-known and well-connected, who could be considered either central or prestigious. Also, it could be the case that an actor is both central and prestigious.

Macro/Community wide structure

Density

The first step is to study the density and connectivity of the whole network. The **density** measure describes general level of linkage among the actors in the community. Summarize overall distributions of arcs in order to measure how far from *completion* the graph is. A **complete** graph is one in which all the actors are reciprocally adjacent to one another (all elements of the sociomatrix equal to one). The more actors that are connected to one another the more dense will the graph be.

The **density** of a digraph is defined as the number of arcs, expressed as a proportion of the maximum possible number of non-reflexive arcs.

$\boldsymbol{d_r} = \dfrac{\boldsymbol{a}}{\boldsymbol{g}(\boldsymbol{g}-1)}$ where $\boldsymbol{a}$ is the number of observed arcs and g is the number of agents.

The density depends upon the sum of the degrees of its nodes and the *inclusiveness* of the graph. **Inclusiveness** is defined as the number of nodes, which are included within the various connected parts of a graph. It is the total number of nodes minus the number of isolated nodes (Scott, 1991).

Since all the sociomatrices considered in the study have the same symmetric number of actors (73), the maximum possible number of non-reflexive arcs is 73x72= *5256*. The arcs present in the information matrix are *1264*, while the ones present in money and support are *512* and *814* respectively. Consequently, the density measures are 24%, 9.7% and 15.5% for information, money and support respectively. Of the three relations, the relation that appears to be more dense is information. Money appears to be the least dense.

One thing that can be concluded from the density measures is that not all the pairs of actors are mutually or reciprocally connected (their ties go in one direction but not in both). In the case of all mutually connected pairs the density values should be 100%. Furthermore, we also do not yet know which entities are connected at all. We do not know if some actors are isolated, while others are highly connected, or, if most actors merely have few ties.

Connectivity

Groups may be defined as consisting of agents which are *connected* in some way. An actor is **connected** when there is at least one arc that relates the actor with another actor, (Wasserman and Faust, 1994) and the tie need not be one-step. The actor could be reachable from another actor, or, the actor could make another actor reachable. The actor could be a **receiver** (the arc is toward the node), a **transmitter** (the arc is away from the node), or a **carrier** (there are at least two arcs, one toward and one away). An actor is **isolated** when there is no arc that relates the actor with any actor in the network. Some formal definitions (Wasserman and Faust, 1994) are:

An actor is **connected** either if it is a *carrier a proper source* or a *proper sink*

A node is a **carrier or ordinary** if both outdegree and indegree are different from zero, $d_i(n_i) > 0$ and $d_o(n_i) > 0$.

A node is a **proper source or transmitter** if its indegree is zero and its outdegree is non-zero, $d_i(n_i) = 0$ and $d_o(n_i) > 0$.

A node is a **proper sink or** receiver, if its outdegree is zero and its indegree is non-zero, $d_i(n_i) > 0$ and $d_o(n_i) = 0$.

A node is **isolated** if it's both a source and a sink, both indegree and outdegree are zero, $d_i(n_i) = 0$ and $d_o(n_i) = 0$.

To see the connectivity of groups of agents in the network we can check the existence of *components*.

A **component** is defined as the maximal connected sub-graph. All actors are linked to one another through paths.: all actors can reach one another through one or more paths, but they do not have connections outside the sub-graph. A **path** is a sequence of arcs where each node and each arc are distinct (Scott, 1991).

In a digraph we can find two kind of components: strong and weak components. **Strong component** is one in which the arcs that make up the paths are aligned in continuous chain without change of direction. **Weak components** are those that simply take into account the presence or absence of a connection (Scott, 1991).

Note that the algorithm used by UCINET in the analysis of component uses the weak definition of a component. The algorithm checks for the existence of relations no matter what is the direction of the arcs.

If a sociomatrix graph is dense, we expect to find a single component. If a sociomatrix graph is not dense, as all three of Towertown are (recall that the most dense is information, with a density of 24%), we expect to find multiple components. The existence of a single component with respect to information in Towertown would imply that all the 73 agents have at least one source or recipient of information within the community. In fact, this is what Towertown data display. All 73 entities have at least one source or sink of information, money, and support within Towertown. Thus, the analysis of connectivity does not show the existence of sub-groups. On the contrary, the network appears to be one single component. This is true with respect to all three relations considered. The Towertown community appears to be one big, interconnected group.

Micro/individual roles

Local Centrality and Prestige

Now that we know that there are no isolated actors, and, that the links among actors are not all mutual, we want to know which actors are the ones that play an important role in the community. Which are the actors that are distinguished either because they receive a lot from other actors, or, because they give a lot to other actors? We will try to determine how well-connected each entity is within Towertown, and how *prominent* each entity is.

Prominent actors are those that are extensively involved in relationships with other actors. This involvement makes them more visible to the community. The prominence could be due to either receiving and/or transmitting. The prominent actor is simply more involved than others are. The relevance of this is as follows. For example, if you were an outsider visiting Towertown, and you wanted to find out what others in Towertown know, the best entity to contact would be the entity with the most prominence with respect to information relations.

To determine which of the actors are prominent, we examine not only all the directed ties made by an actor (outdegree) and all the received ties (indegree) but also indirect ties (paths) as well. Two classes of prominence are considered: a) centrality and b) prestige (or, rank or popularity). Furthermore both classes are checked locally and globally. Of the four potential measures, I calculated: a) *local centrality* (i.e. outdegree) b) *local prestige* (i.e. indegree) c) *global centrality ("closeness")* and *global centrality* ("*betweenness*"). Note there was no algorithm for global prestige in the UCINET software.

An actor is **locally central** if it has a large number of connections with the other actors in its immediate environment. In effect the existence of some actors with greater local centrality defines the local environment. If all the nodes in the digraph (actors-rows/columns) are interchangeable, all the actors should be equally central

Local centrality measures are expressed as the number of actors to which an actor is connected. Local centrality ($C_d(n_i)$) are measured with the outdegrees of the nodes while **local prestige** ($P_d(n_i)$) are measured with the indegrees of a node. $C_d(n_i) = d_o(n_i)$ and

$P_d(n_i) = d_i(n_i)$. Since these measures are based on the degrees of the nodes the measure usually are called degree centrality and prestige (Wasserman and Faust, 1994).

An actor with a large outdegree should be recognized by others as a major source; actors with small in or out degrees are peripheral in the network, or not active in the relation process. Note that the Towertown data is dichotomous ,not valued, and it is possible that an agent with a single high-value tie plays an important role that we cannot perceive with this data.

Tables 1, 2 and 3 present the measures of local centrality and prestige with respect to the three relations studied. Note that none of the measures are standardized (UCINET uses the unstandardized version). If the number of agents varied from relation to relation we would want to standardize by normalizing with respect to the number of agents

The first four rows in each table show the summary statistics for all entities in Towertown. The mean of local centrality is the average outdegree measure across all 73 entities. For example, with respect to money ties (Table 1), on average, a Towertown entity *gives* money *to 7* other entities in Towertown. The mean of local prestige is the average indegreee measure across all 73 entities. For example, with respect to information ties (Table 2), on average, a Towertown entity *receives* information *from 17* entities in Towertown.

The 5th to 11th rows in each table show the local centrality and prestige measures of the top six most central and prestigious individual entities in Towertown. For example, with respect to money (Table 1), Towertown Newspaper is the most locally central, giving money to *33* other entities in Towertown. 1st Towertown Bank is the most locally prestigious, receiving money (presumably deposits or interest payments) from *49* entities in Towertown.

Table 1. Money: Local centrality and prestige

	CENTRALITY	PRESTIGE
Mean	7.01	7.01
Std. Dev.	6.35	8.97
Minimum	0	0
Maximum	33	49
1st TT Ban(11)	28	49
TT Saving bank (12)	17	38
Bank of TT (13)	23	26
TT Newspaper (39)	33	17
Family Services (69)	3	36
YMCA (71)	4	24

In Table 1 we can see that four of the top six agents are both locally central and prestigious. These agents are three of the four banks, and Towertown Newspaper. Family Services and YMCA, on the other hand, are only locally prestigious (high indegree but low outdegree, both outdegree are below the mean). If we consider that both are reliant on volunteers and donations, the findings make sense.

Table 2. Information: Local centrality and prestige

	CENTRALITY	PRESTIGE
Mean	17.29	17.29
Std. Dev.	11.21	11.22
Minimum	1	3
Maximum	63	62
TT Savings bank (12)	41	26
City Council (25)	32	43
City Manager’s off(26)	43	44
Newspaper (39)	42	44
WTWR Radio (40)	63	62
Family Service (69)	45	36

In the case of the information relation (Table 2), the top six agents also appear to be both locally central and prestigious. All the six agents receive and give information to a high number of agents in the community. The agent which appears to be the most locally central and prestigious is the Towertown Radio Station. The radio station is the maximum carrier for the community, it is the agent that receives and gives the most information.

Table 3. Support: Local centrality and prestige

	CENTRALITY	PRESTIGE
Mean	11.12	11.12
Std. Dev.	9.42	10.53
Minimum	0	0
Maximum	59	58
TT Savings bank (12)	37	14
TT small bs.Assoc.(20)	38	10
TT Comm.College (56)	59	58
State University (57)	20	42
Family Service (69)	12	52
Mental Health center	16	36

Table 3 shows the results with respect to the support relation. The Community College is the agent that receives and gives more support from the community. In times of trouble, the Community College is willing to give support to 59 entities while 58 entities are willing to give support to the Community College if it is needed. Towertown Saving Bank appears to be locally central, but not locally prestigious (has high outdegree but the indegree value is pretty close to the mean). This contrasts with the Towertown Savings Bank’s money relation. With respect to money, that bank has lower outdegrees than indegrees. And, the outdegree value is at least one standard deviation larger that the mean. Family Services and Mental Health Center are the case of agents that are distinguished for what they receive rather than what they give. They receive a lot, more than 2 standard deviations larger than the mean But they support an average number of other entities.

With the exceptions of Towertown Savings Bank and Family Services, the local centrality and prestige of the agents differs across relations. Different actors are prominent if we consider money flows than if we consider information or supports flows. But, Towertown Saving and Loan and Family Services entities are central and/or prestigious no matter which relation we consider.

Global centrality

An actor is **globally central** when it has a position of strategic significance in the overall structure of the network. It is central if it lies a short distance from many other actors. Globally central actors could be detected through *closeness* measures or *betweenness* measures. We can define that central actors are actors that have a minimum steps relating to all the others actors and central actors are those who are closer to the rest of the actors. But closeness is not the only factor that makes an actor globally central. The *betweenness* of an actor can also make it central. Interactions between two non-adjacent actors might depend on the other actors in the set of actors, especially those actors who lie in the path between the two. The actor between other actors has some control of the relations, thus can play a central role in the interactions of the set of actors.

Freeman's measure of **global centrality** is expressed in terms of the distances among the various actors. Two ways to measure global centrality are: closeness and betweenness.

Closeness ($C_c(n_i)$) measures are the inverse of distance measures. As a node grows farther apart in distance from other nodes, its centrality decreases. $C_c(n_i) = \left[\sum^{g} d(n_i, n_j)\right]^{-1}$ where $d(n_i, n_j)$ are the distance between nodes n_i and n_j.

Betweenness ($C_b(n_i)$) measures consider the probability that a communication or path from actor j to actor k, takes a particular route. The lines have equal weight and that communication will travel along the shortest route.

$$C_b = \sum_{j}^{g} \frac{g_{jk}(n_i)}{g_{jk}}$$ where $1/g_{jk}$ is the probability that a particular geodesic is chosen for the flow of information between actors, g_{jk} is the number of geodesic linking actors n_j and n_k and $g_{jk}(n_i)$ is the number of geodesic that go through n_i (Wasserman and Faust, 1994).

If actors A and B are connected only through actor C, C has a certain 'responsibility' to actors A and B. Counting all of the minimum paths which pass through C we have a measure of the *stress* which actor C must undergo during the activity of the network (Freeman, 1977).

All these measures of local and global centrality depend on the size of the network so if the idea is to compare this particular network to another one of a different size, the measures should be standardized. In degree centrality and closeness measures, the measures are standardized dividing by $g-1$, while in the betweeness measures the standardization factor is $(g-1)(g-2)$, where g is the number of agents..

The results for global centrality according to both closeness and betweenness with respect to money, information and support relations, are shown in tables 4 and 5 below.

Table 4. Global centrality: closeness and betweenness. Summary statistics.

	CLOSENESS			BETWEENESS		
	Money	Inform.	Supp.	Money	Inform	Supp.
Mean	52.34	59.06	53.42	88.51	57.68	78.73
St. dev.	6.74	7.13	8.38	244.87	131.43	238.37
Minimum	37.50	46.75	32.00	0	0.06	0
Maximum	78.26	88.89	82.76	1762.24	1013.23	1998.32

Table 4 shows the summary statistics for closeness and betweenness measures for the three relations. The three first columns are about closeness. The other three are about betweenness. The mean of betweenness is the average number of times an actor n_i is articulating, –in the shortest path-, the relationship between actors n_j and n_k. With respect to money flows, on average a Towertown entity serves as intermediary *89* times, this could be the case of entities acting as brokers.

Table 5. Global centrality: closeness and betweenness.

	CLOSENESS			BETWEENNESS		
	Money	Inform.	Supp.	Money	Inform	Supp.
1st TT Bank (11)	78.26			1762.24		
TT Savings (12)	71.29			686.38		
Bank of TT (13)	64.86			409.50		
Chamber of Commerce					221.83	
City Council (25)		72.73				
City Manager's office		75.79			307.84	
TT newspaper(39)	70.59	75.00		899.85	343.87	
WTWR RADIO (40)	66.67	88.89			1013.23	
TT Comm.College (56)			82.76		253.35	1998.32
State Univ. (57)			69.90			222.42
Family Services (69)		75.79	76.60			190.60

Table 5 shows the measures for the top eleven agents with respect to closeness and betweenness. The higher the value of closeness for a particular entity indicates the closer the entity is to other entities in the community. For example, 1st Towertown Bank needs a fewer money steps to reach other agents than the Bank of Towertown. 1st Towertown Bank is closer to the rest of the agents in Towertown than the Bank of Towertown; the closeness values are 78.26 and 64.86 respectively.

The higher the values of betweenness, the more potential an actor has to control relationships. Again, 1st Towertown Bank shows the highest betweenness measure, it appears to be in the strongest control position.

In the case of money and support flows, the entities that appear to be close also appear to be in-between actors. If we consider the flow of support, the Community College is an entity that has a lot of connections with the rest of the community, is an entity that appears highly in-between actors. The globally centrality of the Community

College is not only because it is closer to the rest of the agents than other actors, but also because it has a potentially major articulation role.

The money relation shows the banks, as well as the newspaper, as the 'main roads' to other entities. They act as intermediaries for other agents. The findings for flow of information relation support our intuition about how the interactions and flow of information should be. The entities with higher values of global centrality (both closeness and betweeness) are those having some informational power, like the media organizations: newspaper, radio and the city manager's office.

As with local centrality and prestige, which actors are globally central differs across relations.

In the above, we considered the highest measures. Now we consider the weakest. The actors with lower values of local and global centrality are the actors that are peripheral to the network. We can find actors that do not have many interactions with other actors. This is the case for unions, churches, and some of the government offices. Their counts of interactions are really below the average. In the case of the churches the situation is not uniform (measures not shown). Some churches are peripheral with respect to one relation (values of outdegree/indegree below the mean value) but are average entities with respect to another relation.

Two actors are notoriously peripheral in all the relations, the bankers' association and the county bar association. Bankers relate to many entities individually, and, to each other within their association. But as an association their relations with other entities are few. **Reflexive ties** are not considered (recall that $x_{ii} = 0$). A **reflexive tie** is the one that a particular agent has with itself, in this case $x_{ii} = 1$.

Now that we know about the centrality and prestige of agents, we have filled in the gaps that were left from our analysis of components. The findings of a single component did not provide any hints that any particular agent or set of agents in Towertown had unique patterns of relations. All entities appeared to be interconnected. The analyses of centrality and prestige, however, indicate that there are differences among entities. Some are better connected than others. But we still do not know whether their connections are critical to maintaining the structure of the community. The next section discusses the test for this aspect of "keystones".

Cut-points

Taking into account which actors are central or prestigious for each of the relations, a new analysis of components or connectivity groups can be made. Those actors that have been shown to be central are removed from the data. The results show that not only were some of those actors central, but also they are cut-points. Actors that are vital for the connectivity of the network are those without which some of the of actors will become isolated.

> A **cut-point** is the actor whose removal from the system would increase the number of components by dividing the graph into 2 or more separate subsets (components) between which there are no connections (Scott, 1991).

In the flow of money relation, removing 1st Towertown bank, Towertown Savings Bank, and/or Family Services, produced isolated actors. Removing the two banks and the family services breaks the single component into 5 components. The five components are: 1) County Medical Society, single component or isolated actor 2) Association of Churches #2, single component or isolated actor 3) Municipal Employees Union number one and Central Labor Union in one component, 4) Association of Churches number one and University Methodist Church in another component, and 5) all 64 others in the remaining component. Without the banks and family services, the two unions and two of the churches are isolated from the rest of the Towertown network. In particular, this means that the actors removed play an important role as pivotal articulation actors.

Considering the support relation, similar results are found: removing central actors with respect to the relation produces some separate groups that have no contact with the rest of the community. The removal of Towertown Savings and Loan, Towertown Community College and State University breaks the single component structure in three components. The three components are: 1) The four Unions in one component, 2) The democratic Committee and the County Housing Authority in another component and, 3) all the 64 others in the remaining component.

This is not the case for information. The removal of any actor changes nothing in the structure of the community. The single component structure in information relation is robust. There is no single agent that is critical for the integrity of the flow of information in Towertown.

Graphic illustration

The basic idea was to draw all possible connections among all entities in Towertown. But that idea was dropped, due to the large number of agents and the density of the relations. The complete digraphs of the three relations were prohibitively difficult to interpret. The digraphs are a bunch of lines all over the place and the objective of drawing to clarify the patterns, is not met.

For this reason, partial digraphs for each of the three relations were drawn (Appendix 2). Based on the information about the centrality of agents, the row data of the most central actors are illustrated. In the money digraph, the arcs from the banks to the rest of the agents were considered. In the information digraph, the arcs representing information from Towertown Savings and Loan, Newspaper, Radio Station, City Manager's Office, and Family Services to the rest of the actors, are illustrated. Finally, in the support digraph, the arcs from the Community College, the State University and Towertown Savings Bank are shown.

In each digraph the central, actors (and their flows) are differentiated by colors. The 'purple' actors are those *fully connected* with central actors, the 'purple' actors are those actors that receive something from *all* the central actors. The direction of the arrows shows which actor is the generator and which actor is the receiver.

In general, from these illustrations we can observe some of the results we found analytically. The information relation is the one with more connections, is the more dense one. The density is not only due to the fact that the information sociomatrix has more central actors than the other two relations, but also displays high connectivity of the central actors. Note that the same conclusion is reached by comparing the centrality results across relations. The fully connected actors vary across relations. One interesting result is that the fully connected actors in the case of support ties are mostly voluntary organizations.

Block modeling

This section concerns a macro view based on the micro analysis of individuals. We want to know whether the Towertown entities can be grouped (‘blocked”) into types. If so, we can study the network structure with respect to types of, rather than individual, actors. Blockmodeling is a technique for structural analysis that uses network analysis (Holland and Leinhardt, 1979). The technique was introduced by White, Boorman and Breiger (1976) for the descriptive algebraic analysis of social roles. The blocking procedure consists of partitioning of the population into a set of ‘equivalent’ subgroups or blocks.

A blockmodel consists of two things:

> a) a partition of actors in the network into discrete subsets called partitions
> b) for each pair of positions a statement of the presence or absence of a tie within or between the positions on each of the relations.

Groups

CONCOR

UCINET’s CONCOR (CONvergence of iterated CORrelations) analysis used to define blocks is based on the existence of *structural equivalence* between actors. **Structural equivalence** requires identical ties to and from identical other actors. If actor 1 is related with 3 and 4, and 2 is related with 3 and 4 in the same way, then 1 and 2 are structurally equivalent. 1 and 2 have the same position in the network.

> Actors $\boldsymbol{i}$ and $\boldsymbol{j}$ are **structurally equivalent** if, for all actors, $\boldsymbol{k} = 1,2....\boldsymbol{g}\ (\boldsymbol{k} \neq \boldsymbol{i}, \boldsymbol{j})$, and all the relations $\boldsymbol{r} = 1,2,.....\boldsymbol{R}$, actor $\boldsymbol{i}$ has a tie to $\boldsymbol{k}$, if and only if $\boldsymbol{j}$ also has a tie to $\boldsymbol{k}$, and $\boldsymbol{i}$ has a tie from $\boldsymbol{k}$, if and only if $\boldsymbol{j}$ also has a tie from $\boldsymbol{k}$ (Wasserman and Faust, 1994).

The CONCOR procedure takes as input one sociomatrix, or the set of all $\boldsymbol{R}$ sociomatrices. The first step is to calculate the correlations between all pairs of cases in the matrices measuring this by the similarity of the values, which are contained in the row entries. The result of this first step is a square case-by-case correlation matrix. The second step involves the use of clustering procedure to group the cases into structural equivalent sets according with similarities (Scott, 1991). CONCOR splits the group into 2 subgroups having all plus correlation within, and the minus correlation between. Then the rows and the columns are permuted. Structural equivalent individuals are blocked together along the rows (columns) of the permuted matrix.

The criterion of structural equivalence is being widely used among sociologists, but for economic analysis the assumption seems to be quite strong. It seems unlikely that every single agent in an economy interacts in the same way with all other agents in a group (and the other way around). If agents are perfect substitutes for each other, their ties could be mutually exclusive.

Even though the structural equivalence assumption seems too strong to be useful, the blockmodeling procedure was used to see if there is any distinct behavior among organizations, or if there is any particular set of "species" to whom the actors belong. The procedure was performed not only for each of the three relations separately but also for the three relations considered together. No clear 'intuitively sensible' block structure was found.

The result, show a different block structure for each relation. Few groups formed display a very clear role division of species. There was no clear distinction of businesses, or voluntary organizations, from government offices, etc. The blocks formed using CONCOR were mixtures of all kinds of entities. When the three relations were studied together, the blocks formed were also a mixture of all kinds.

Even though the blocks found do not give much information with respect to a 'species behavior' some of the results were interesting. Some groups were formed of similar agents. For example, three of the four banks were grouped together. The distinct behavior of the bank not included in the block (Towertown Savings and Loan) was noted before when centrality and prestige were studied. We do not know exactly if this distinct behavior is due to the fact that Towertown Savings and Loan is a different kind of bank, or is because it behaves differently for other reasons. The other entities, which were also blocked only with entities of their kind included political party committees, and the unions.

The CONCOR group structure considering the three relations together, is shown in Appendix 3.

Statistical cluster analysis

Given that the CONCOR procedure of block modeling did not give a satisfactory set of groups, I tried statistical cluster analysis. I was looking for groups of agents that could be considered “species” in the sense the ecologist use the term, i.e. that are similar in characteristics due to genetic determinants. For example, businesses have legal characteristics that differentiate them from voluntary organizations.

The method used to cluster was WARD, a method that minimizes the variance within the groups and maximizes the variance between groups. Before applying the cluster procedure, some transformation of the data was needed. Since the original data consist of a set of three adjacency matrices, I transformed the data to three distance matrices. The distances are the geodesics.

The **distance** from $\boldsymbol{n_i}$ to $\boldsymbol{n_j}$ is the length of the *geodesic* from $\boldsymbol{n_i}$ to $\boldsymbol{n_j}$.

The **geodesic** in a graph is the length of the shortest path between two nodes.

Note that although the arc distance from $\boldsymbol{n_i}$ to $\boldsymbol{n_j}$ is not necessary the same that the distance from $\boldsymbol{n_j}$ to $\boldsymbol{n_i}$, the procedure used in UCINET symmetrizes the matrices. The symmetrical data does nor represent directions of the ties.

The results obtained for the three relations do not show any structure that can be considered logical with respect to species with common characteristics. For Money, four groups result: a big group with almost all the agents, and three “groups” that are individual agents: YMCA, Mental Health Center and Towertown Youth Services Bureau. In the case of the support relation, similarly useless groups are formed. For the information relation, every agent belongs to one big cluster. This was the same result that was found in the analysis of components.

Exogenous Criteria

According to the CONCOR and cluster procedures no satisfying block structure could be found that grouped entities with similar characteristics as well as ties. One exception was that most the banks formed a group. This is reasonable, since among private businesses, only banks both give (lend) and receive (accept deposits) from many entities in a community.

We proceeded to define groups according to *external information* about the nature of the entities: commercial or not commercial, private, or public. The possible combinations of those characteristics suggest three possible groups (Table 6). The public/commercial group does not exist in a pure market economy.

Table 6. Classification of entities

	Commercial	Not commercial
Private	Businesses	Voluntary Org.
Public	-------------	Government

The three possible groups from the above classification are businesses, voluntary organizations and government. From all previous analyses, since the banking agents display different network behavior from the rest of the private businesses, this suggested further dividing the business into: banks and other businesses. The final four groups formed were 1) banks, 2) business, 3) voluntary organization and 4) government.

Any flow of money is reciprocated by a sale of a good, or provision of a service, or even a “good feeling” from a charitable act. To the previous three relations, I added one more, “service”. Service is the transpose of the money relation. This is the same convention that records foreign aid as an import of the donor country in the current account of the donor’s Balance of Payments statistics. The transpose shows the relation “gives something to” from the row actor to the column actor.

Once the four blocks groups were defined, the next step was the assignment of ties. *Kilkenny’s block* procedure (see below) was applied for each of the four relations.

Ties

After the blocks are formed, the next step is the assignment of ties (0 or 1) to each submatrix (interaction between groups). There are three criteria, among others, used to assign ties: a) *Zeroblock* b) *Oneblock* and c) α *density criterion*. Which one to use depends on the researcher’s objective (Wasserman and Faust, 1994).

Zeroblock Criterion. States that the ties between two groups for a given relation is 0 only if there are no ties from actors in the row group to actors in column group on the specified relation, otherwise the block is oneblock:

$b_{klr} = 0$ if $x_{ijr} = 0$, for all $i \in B_k$, $j \in B_l$

= 1 otherwise

Oneblock Criterion All possible ties from actors in the row group to actors in the column group need to be present in order to define a oneblock, otherwise is a zero block:

$b_{klr} = 1$ if $x_{ijr} = 1$, for all $i \in B_k$, $j \in B_l$

= 0 otherwise

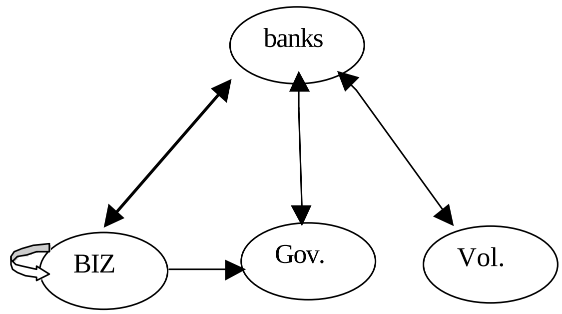
a density Criterion. Is a criterion that could be considered somehow in between the two previous criteria. The procedure define a density a, such that if the observed block density, Δ_{klr}, is greater or equal than a then the block is coded as one, and zero otherwise. The value of a depends on the density of the relations. One possibility could be the overall density computed across all relations.

In general it is assumed that the use of the assignment procedures depends on the density of the network. The oneblock procedure might be most appropriate when the relations are dense rather than sparse. However, oneblocks and zeroblocks seem to be quite rare. We expect that oneblock's might contain 0's and zeroblocks might contain 1's. To deal with those situations the a criterion was created**.** The application of any of the three criteria could introduce bias since it is directly related with the researcher objectives. The zeroblock procedure may be applied in the cases that *all* the agents are perfect substitutes of one another. The oneblock procedure may be applied in the case *all* the agents are complements to one another.

The zeroblock, oneblock and a density criterions were applied for the money relation. The resultant matrices for the zeroblock and oneblock procedures were a matrix of ones and a matrix of zero respectively. In the a density criterion, the result a matrix is 'in-between' of the two previous procedures applied.

MONEY $\boldsymbol{a}$ density

	Banks	BIZ	V.org	Gov
Banks	0	1	1	1
BIZ	1	1	1	1
V.org	1	0	0	0
Gov.	1	0	0	0



Kilkenny's block procedure is another method to assign ties that is in-between zeroblock and oneblock procedure. The procedure is more appropriate in the case of agents who are potentially complements and/or substitutes in economic relations. The zeroblock criterion simply formalizes that the type of interactions we are analyzing may be somewhat exclusive and that entities may be substitutes. For example, small businesses in a small community may not have more than one banker. Thus, every business may be tied to only one bank. Kilkenny's version makes clear that as long as every business has a tie with at least one bank in the community, that all the business are connected to banks in the community. If one business does not have a tie with a local bank, then this would not be true.

The procedure is formalized as follows:

Let $\mathrm{T} = \{1,.....,73\}$ be the number of original Towertown entities, and $\boldsymbol{G} = \{1,.,4\}$ be the number of groups formed. The agents (individual nodes) in Towertown are denoted as $\boldsymbol{i}, \boldsymbol{j}$ while the agents in the grouped-towertown are denoted as $\boldsymbol{a}, \boldsymbol{b}$. So $\boldsymbol{i}, \boldsymbol{j} = 1,......,73$ and $\boldsymbol{a}, \boldsymbol{b} = 1,..,4$.

Let $\boldsymbol{R}$ be the set of relation adjacency matrices, where $\boldsymbol{R}_{ij}$ is the set of adjacency matrices related with original Towertown entities $\boldsymbol{R}^{\boldsymbol{T}} = \{\boldsymbol{I}^{\boldsymbol{T}}, \boldsymbol{M}^{\boldsymbol{T}}, \boldsymbol{S}^{\boldsymbol{T}}, \boldsymbol{V}^{\boldsymbol{T}}\}$ and $\boldsymbol{R}$ is the set of adjacency matrices related with the grouped data, $\boldsymbol{R}^{\boldsymbol{G}} = \{\boldsymbol{I}^{\boldsymbol{G}}, \boldsymbol{M}^{\boldsymbol{G}}, \boldsymbol{S}^{\boldsymbol{G}}, \boldsymbol{V}^{\boldsymbol{G}}\}$.

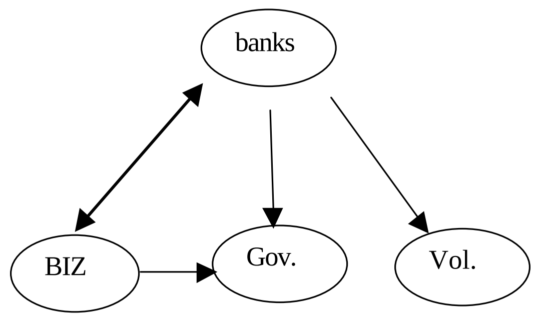
The following rule was imposed:

$$\boldsymbol{R}^{G}_{ab} = 1 \text{ iff } \forall \ \boldsymbol{i} \in \boldsymbol{a} \ \exists \ \boldsymbol{j} \in \boldsymbol{b} \text{ s.t. } \boldsymbol{R}^{T}_{ij} = 1$$

The results are the following sociomatrices and digraphs:

MONEY

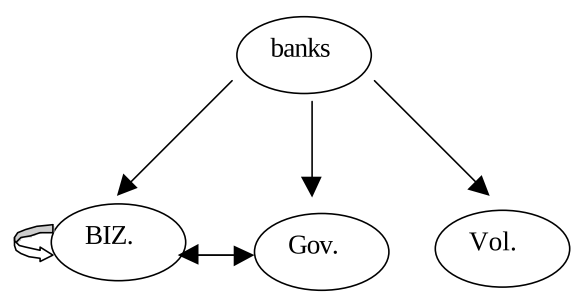
	Banks	BIZ	V.org	Gov
Banks	0	1	1	1
BIZ	1	0	0	1
V.org	0	0	0	0
Gov.	0	0	0	0



These digraphs show that the banks and business have reciprocated money transactions as lenders, borrowers, depositors, and creditors. Businesses (including banks) all give money to government agencies, i.e. taxes. Banks give money to voluntary organizations, i.e. donations. Business are connected to Voluntary organizations through banks, the banks play in this case the role of articulating agent.

SERVICE

	Banks	BIZ	V.org	Gov
Banks	0	1	1	1
BIZ	0	1	0	1
V.org	0	0	0	0
Gov.	0	1	0	0

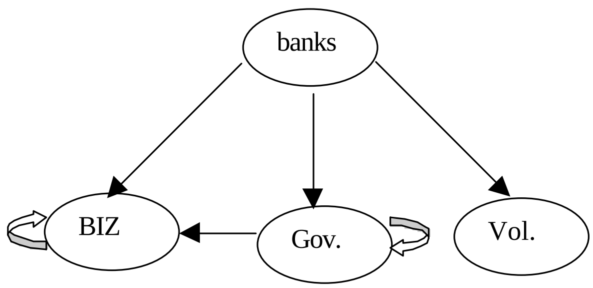


The digraph of service shows that is not the mere reversal of the ties with respect to the money relation. In contrast with money, we observe that the reciprocity between business and banks is lost. Banks give service to businesses but businesses do not give service to banks. Because of that, the path from businesses to voluntary organizations, through banks, is broken. In the flow of services we observe that businesses give service to the government agencies and to themselves (I-O matrix).

Note that banks are (again) the proper source or transmitter in the system.

INFORMATION

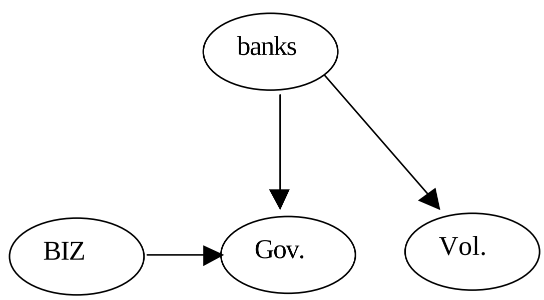
	Banks	BIZ	V.org	Gov
Banks	0	1	1	1
BIZ	0	1	0	0
V.org	0	0	0	0
Gov.	0	1	0	1



The pattern observed in information is similar to the one observed in the service relation (above). The big differences are the absence of reciprocity between businesses and government, and the presence of relations within government entities. A flow of information between different government agencies is a reasonable pattern to be observed.

SUPPORT

	Banks	BIZ	V.org	Gov
Banks	0	0	1	1
BIZ	0	0	0	1
V.org	0	0	0	0
Gov.	0	0	0	0



The results show that the banks are the most connected group of agents.

Blocked system integrity

If banks are removed there is no path from any group to voluntary organizations; voluntary organizations are dis-connected from the system. Thus banks play the role of cut-point that we saw above; the banks are the articulating actors. Banks are critical for maintaining the structure of the system.

Three of the four relations have a two-component structure, where banks (as a group) are present in both components. Banks are the common element. This means banks provide connectivity to the community. The removal of banks leads to two disconnected sets. In the case of the fourth relation, 'support', there are three components. The ones who play the articulating roles are banks and government.

The importance of banks can be easily seen from the digraphs showed above. But it also can be shown analytically. We can remove the group of actors one by one and study, for each of the cases, the two-step and three-step paths between the remaining groups. If the removal of a group changes the n-steps paths, then the one removed played a key role.

> For any digraph D with adjacency matrix $A(D)$, each entry a_{ij}^{p} of $A(D)^{p}$ equals the number of path of length p from node $\boldsymbol{i}$ to $\boldsymbol{j}$ in D, for any positive integer p (Robinson and Foulds, 1980).

The procedure was applied for each of the four relations. The results show that the removal of an agent changes an n-path: in the cases of money and service, the removal of banks and/or businesses produces a change in the interactions between the remaining entities. For information, the removal of government is the one that produces changes. Support is not affected by removing any entity; the interactions between the remaining entities are unaffected.

CONCLUSIONS

The idea of this paper was to develop a methodology to describe and analyze rural communities. In particular, we sought a methodology that would be useful in the determination of possible keystone sectors of any community.

Network analysis appears to be helpful in the achievement of these objectives; the description of rural communities and the determination of possible “keystone” sectors. The use of an existing methodology that has been used in other disciplines seems to give good results. The analysis provides new insight into how the community is organized: it tells us which are the actors that are prominent because of centrality or because of prestige, and which are the actors that control the flow of relations due to the articulating roles they play.

From the analysis, we learned that when individual agents are considered, which agent is key depends on the relation. Nevertheless, we found two agents (Towertown Savings and Loan, and Family Services) that appear to play important roles in the community, according to all three relations. The relevance of most other actors differs across the relations of money, information, and support.

The entities that appear to be important display local centrality, local prestige, global centrality; or, have a major role as an articulating entity. From the analysis of individuals, we found that the most important actors are representative of the 4 groups that were formed later on the basis of exogenous criteria. The eleven most visible actors are the banks, the media organizations: Newspaper and Radio; the educational organizations: Community College and State University; some of the government offices: Council Manager’s Office and City Council; and the Family Services entity. The most prestigious and central actors seem to be a pretty good summary of the powerful entities in a community.

An interpretable agent/type structure was not detected with the techniques available in UCINET or with statistical cluster algorithm. One possible explanation for this is that the blockmodeling procedure is based only on the possibility of the agents to play substitutes roles. We found that some agents might be perfect substitutes but some agents might be not only substitutes but also complements. For example, with respect to a money tie, businesses should (hypothetically) be substitutes for each other in their interactions (deposits and loan payments) with banks, but the opposite is not necessarily true. The banks need deposits but it does not matter which mix of business provides those deposits. But for a business with needs for loans too large for any one bank to finance, the mixing of banks is critical. Suppose that business *A* needs a big loan that exceeds the limit that any individual bank is allow to give. In this case business *A* will need the action of more than one bank to have the loan. In this case, banks are complementary actors.

The network analysis of Towertown highlighted the importance of banks. The banking sector appears to be key according to various graph-theoretic measures of connectivity at the economy (community) wide level. Previous studies in the critical sector tradition, based on input-output (exclusively between businesses) relationships, have not been able to uncover the critical role of the banking sector because input-output data concerns only current account transactions. Although the analysis shows that banks play a critical role, the analysis also suggests that there is variation among banks in their network patterns at the local level. All banks do not behave in the same way.

In further research, we will investigate how banking behavior varies across banks with different characteristics in different communities. To that intent, a survey of banks by location is in progress. The survey is designed for a sample drawn from the population of 185 bank offices located in southwest Iowa. The survey will give us elements to describe the relationship of the banks with their own and surrounding communities.

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APPENDIX 1:

Towertown Organizations

1-Farm Bureau
2-Farm Equip. Co.
3-Clothing Mfg. Co.
4-Farm Supply Co.
5-Mechanical Co.
6-Electric Equip. Co.
7-Metal Products Co.
8-Music Equip. Co.

9-Chamber of Commerce
10-Banker's Association

11-1st Towertown Bank
12-Towertown Savings and Loan
13-Bank of Towertown
14-2nd Towertown Bank

15-Brinkman Law Firm
16- Cater Law Firm
17-Lenhart Law Firm

18-County Bar Association
19-Towertown Board of Realtors
20- Towertown small Bs. Association
21-Municipal Employees Union 1
22-Municiapal Employees Union 2
23-Teacher's Union
24-Central Labor Union

25-City Council
26-City Manager's Office
27-County Board
28-Fire Department
29-Human Relations Commission
30-Mayor's Office
31-Police Department
32-Sanitary District
33-Streets and Sanitation
34- Park District
35- Zoning Board
36-Democratic Committee
37 Republican Committee
38-League of Women Voters

39-The Towertown Newspaper
40-WTWR Radio Station

41-Towertown Public Hospital Board
42-Towertown Public Hospital
43-County Medical Society
44-County Board of Mental Health
45-County Board of Health
46-County Health Service Center

47-State Highway Authority
48-Kiwanis Club 1

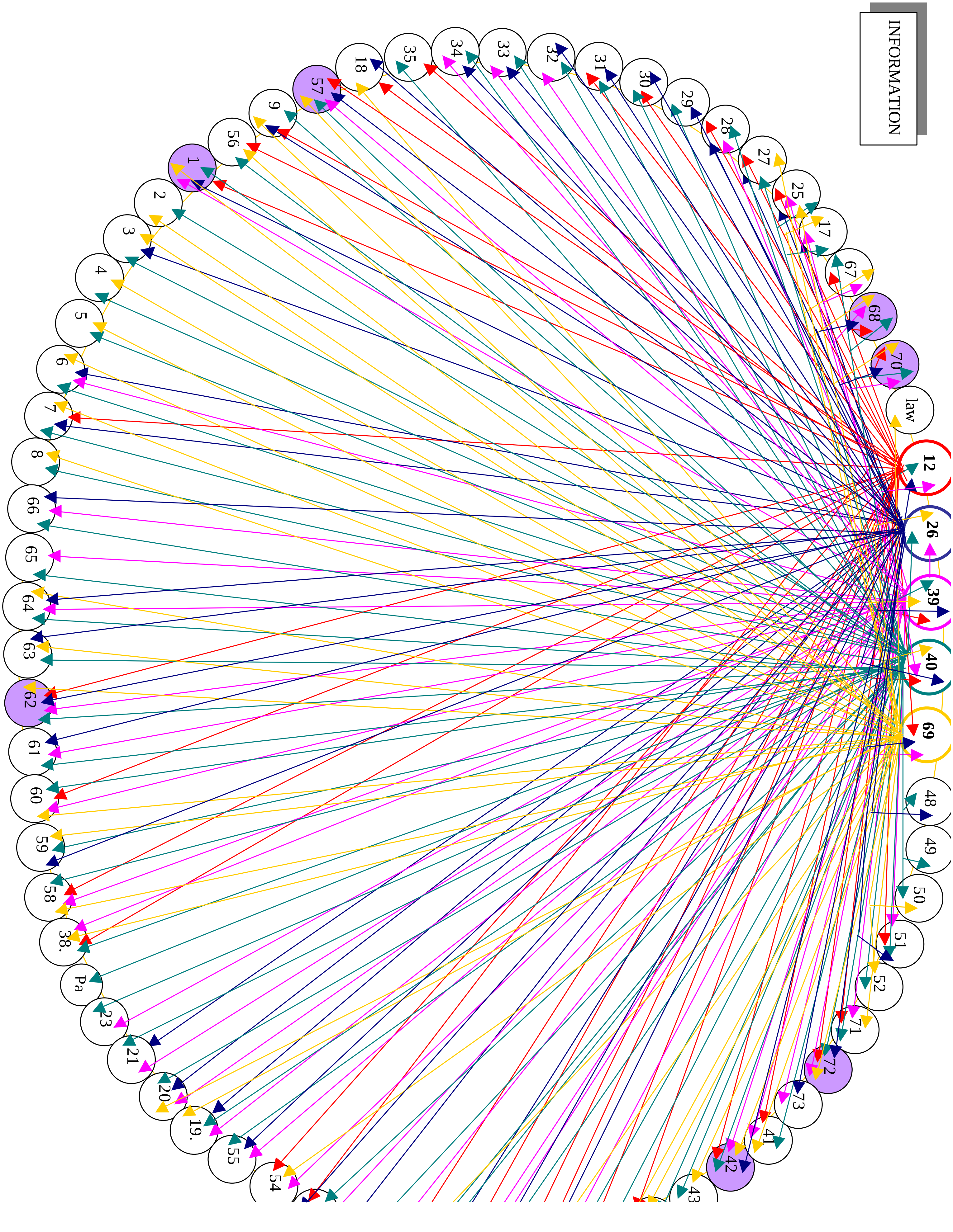
49-Kiwanis Club 2
50-Rotary Club
51-Lions Club
52-United Fund

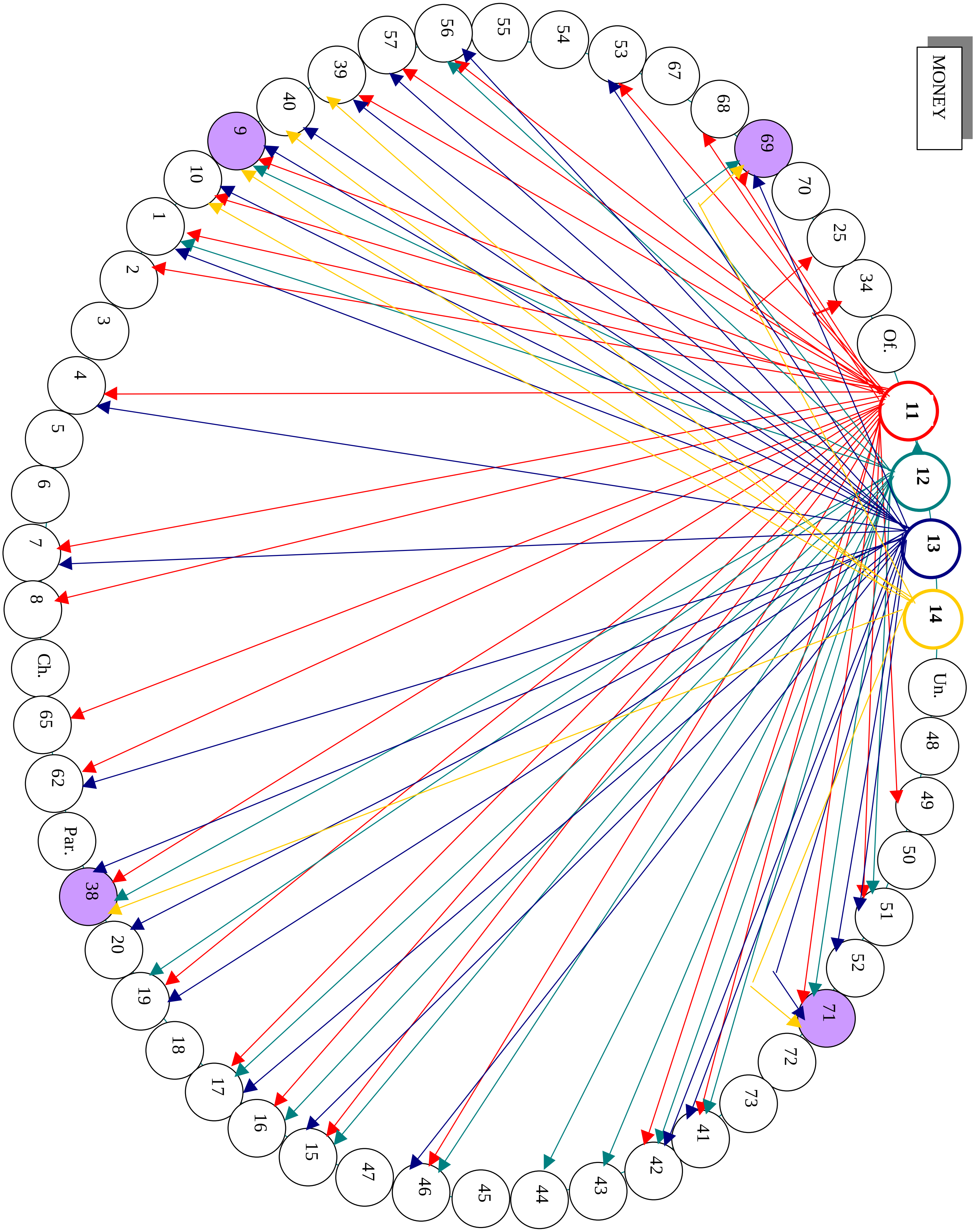
53-School Board
54-Towertown High School
55-Towertown Parent-Teacher Association
56-Towertown Community College
57-State University

58-Association of Churches 1
59-Association of Churches 2
60-St. Hilary's Catholic Church
61-1st Baptist Church
62-1st Church of the Light
63-1st Congregational Church
64- 1st Methodist Church
65- Unity Lutheran
66- University Methodist Church

67- State Department of Public Aid
68-County Housing Authority
69-Family Services
70-State Employment Services
71-YMCA
72-Mental Health Center
73- Towertown Youth Services Bureau

APPENDIX 2: Digraphs

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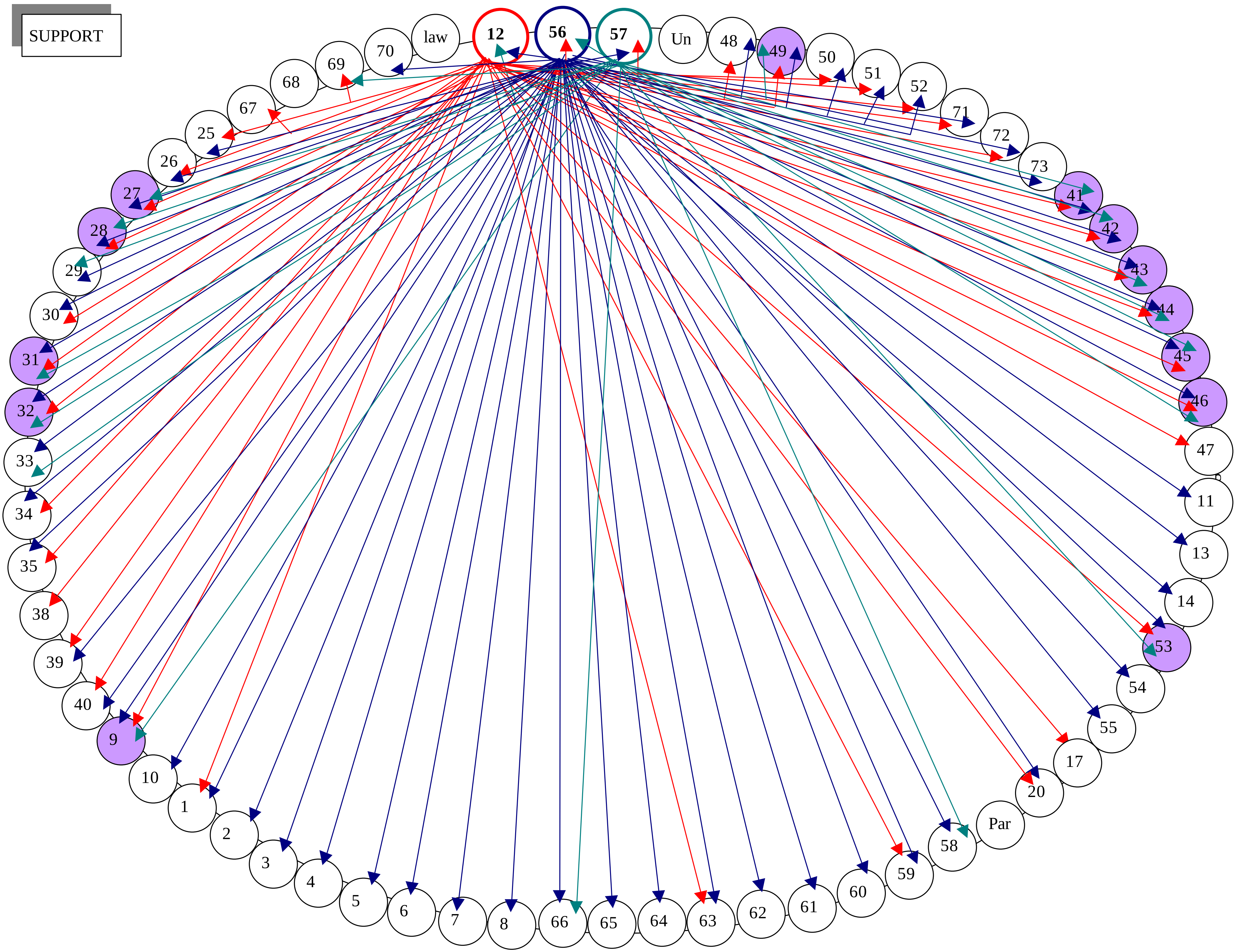

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APPENDIX 3: CONCOR results

Block1: Farm Bureau, St. Hilary's Catholic Church, University Methodist Church, Association of Churches 1, 1st Congregational Church and 1st Methodist Church

Block 2: County Medical Society, County Board of Mental Health, TT Public Hospital Board, County Housing Authority, TT Public Hospital, State Employment Services, State Department of Public Aid, Mental Health Center and County Board of health.

Block 3: TT Community College, State University, TT Savings and loan and TT High School

Block 4: YMCA, Brinkman Law Firm, United Found, County Health Service Center, Family Services

Block 5: 1ST Church of the Light, League of Women Voters, 1st Baptist Church, School Board, TT Small Business association, Banker's association and Chamber of Commerce

Block 6: Kiwanis Club 1, Kiwanis Club 2, Rotary Club, Lions Club, Park District and TT Parent Teacher Association

Block 7: WTWR Radio Station, Association of Churches 2, Cater Law Firm, City Manager's Office, TT Newspaper, City Council and County Bar Association

Block 8: Human Relations Commission, Fire Department, Police Department, Sanitary District, Mayor's Office, County Board and Zoning Board

Block 9: Farm Equip Co., Clothing Mfg. Co, Farm Supply Co, Mechanical Co, Electric Equip Co, Metal Products Co and Music Equip Co

Block 10: Unity Lutheran

Block 11: 1ST TT Bank, Bank of TT and 2ND TT Bank

Block 12: Streets and Sanitation, State Highway Authority, TT Board of Realtors and Lenhart Law Firm

Block 13: Democratic and Republican Committee

Block 14: Municipal Employees Union 1 and Teachers' Union

Block 15: Municipal Employees Union 2 and Central Labor Union