Network Analysis of Farmer Groups

A Training Manual for Extension Educators*

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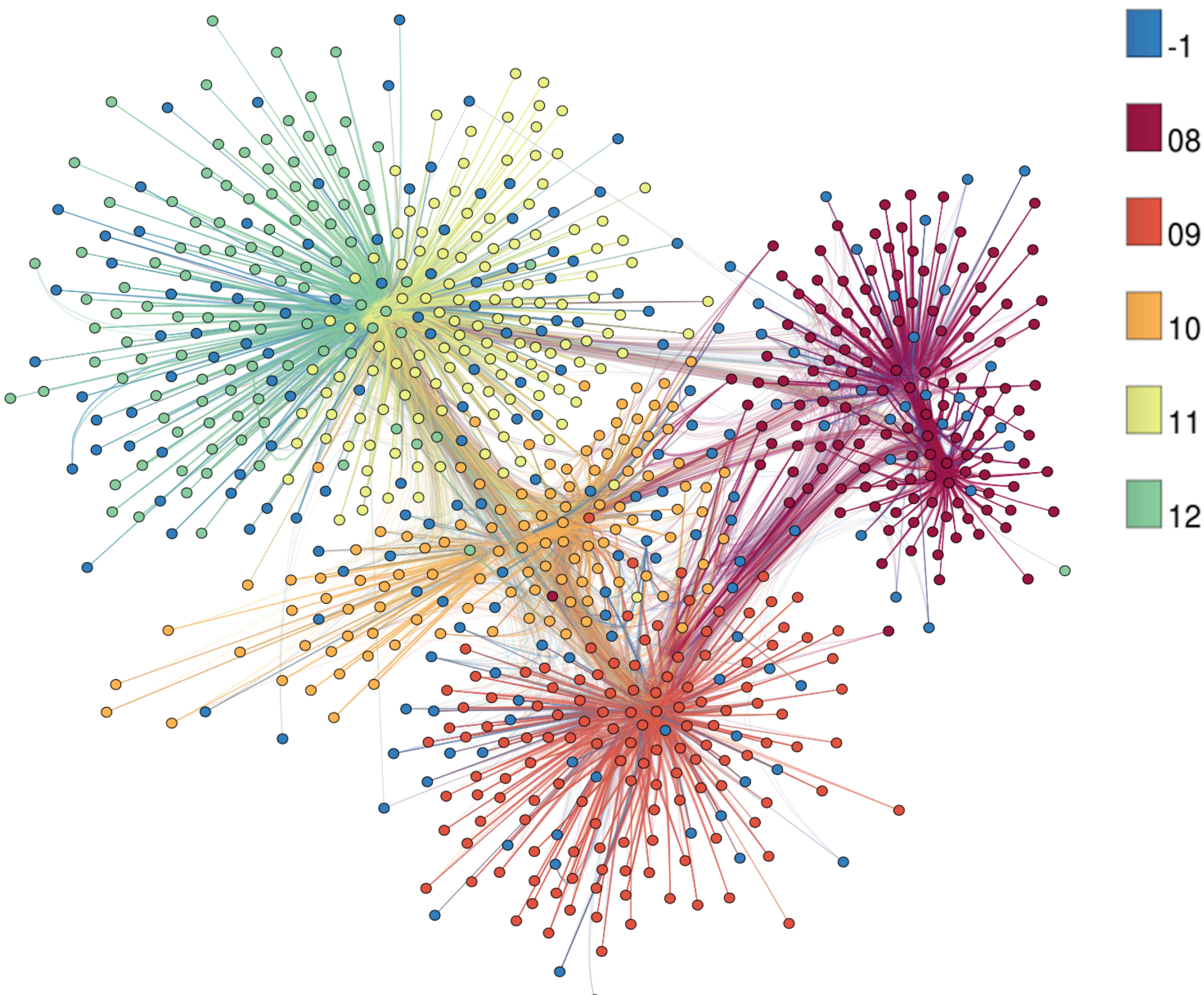

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by

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Network Analysis of Farmer Groups

Introduction

This document presents the content of a curriculum prepared for extension educators and others who are interested in conducting a network analysis of farmer groups. While the emphasis here is on minority farmer groups, the principles discussed are universal. After outlining how to conduct a network analysis and describing basic network concepts we use primary data collected by the authors under a three-state Capacity Building Grant (CBG) led by Tennessee State University (TSU) to illustrate how this type of analysis can be used in a real-world setting.

1. An overview of Network Analysis

The idea that individuals are connected with one another – i.e., that they each have networks – introduces powerful new ways of analyzing and understanding their incentives, situations and behaviors. For example, in the past researchers may have looked at the determinants of farm profits by relating net farm income to factors such as farmer experience, skills, assets and location. *Network analysis*, or more specifically an analysis of the network within which each individual is embedded, introduces an important new element in that it also considers farmers' multidimensional relationships with other farmers.[1] Knowledge of a farmer's position in his or her local network may yield important additional insights into farmers' economic wellbeing or variables such as sales or profits.

Understanding these basic underlying network relationships among their farmer stakeholders can also be critical for Extension educators who seek to disseminate new science-based educational materials. A network analysis can identify opinion leaders and otherwise centrally-located individuals within a network who can more effectively transmit the new knowledge to other network members than less central actors.

At its essence, a network consists of the individual participating members (the nodes) and how they are connected (the links). In our case we are primarily interested in groups of farmers who have something in common so that the boundaries of their networks are well established. For example, the farmers may live in the same region, or they may be members of a cooperative, a certain ethnic group, or follow joint production practices such as organic agriculture. In the case of farmers, the analysis can be made more interesting and the insights generated more useful if we also consider that farmers have to be connected to input suppliers, as well as to marketing agents if they are to get their products to consumers. This extends the network analysis beyond farmers to market agents.

A recent paper by Borgatti et al. (2009) succinctly summarizes why and how networks matter in the social sciences, and also explains how a network's structure or organization matters. A first useful description of a network is the extent to which it is centralized or

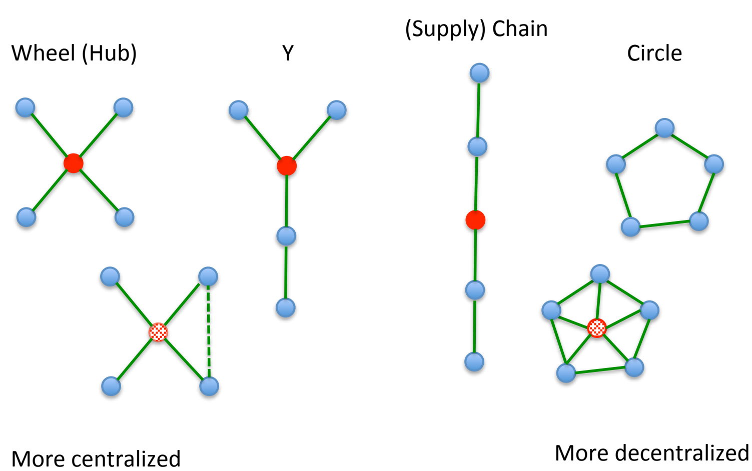
[1] Instead of viewing each observation on an actor as a row, the actor is placed into a matrix of interrelationships.

decentralized (Figure 1). For example, in the case of a wheel-shaped network, there may be one very important and central (in the network sense) farmer who is connected to all of the other farmers. And these other farmers are connected to one another, as they would be in the case of a circle, which represents a decentralized network.

For example, the wheel structure is familiar from the hub-and-spoke system that airlines use. In this case the central hub is quite powerful in that it can control information flows, and decide who gets to know what. It is only by connecting through this hub that the different members are linked or connected. On the other hand, in the circle each farmer is connected to two other farmers so that they all have more even standing with one another. One can also imagine a situation where the wheel and the circle are combined. For example, this may be a cooperative in which farmer-members meet regularly and exchange information. While there is still a central hub farmer or leader of the cooperative in this scenario, that individual does not have as much importance as in the wheel structure because the other farmers are also connected to one another.

Figure 1 also shows that between the extremes of a wheel and a circle structure there are at least two other interesting configurations. The first is a Y-shaped structure. This could represent a farmer (at the bottom) who sells to a wholesaler, who in turn sells to a distributer (the red circle) who sells to two different stores or farmers markets. These latter two retailers may compete with one another for the food sold by the distributor. In the case of a chain we have a similar arrangement except for the fact that there is only one end user, store or consumer, so that competition may be reduced. This would be an example of a vertically integrated supply chain, without any horizontal connections. Real-world network analysis is so rich and powerful because one usually encounters any number of combinations of the configurations shown in Figure 1. For example, combining all 4 basic forms shown yields a so-called *kite* network structure which is not shown here.

Figure 1: Classifying Basic Network Structures



Source: Goetz (2016), adapted from Borgatti et al. (2009)

2. Collecting Data for a Network Analysis (operationalizing)

In an earlier NIFA-funded project we worked with a group (network) of Hmong farmers, a Chesapeake Bay farmers' alliance, of organic farmers organized into a cooperative, and female farmers (see Goetz et al. 2006; Brasier et al. 2007). As noted, to conduct a meaningful network analysis, the group that is being studied in terms of its network needs to be defined as clearly as possible. Graham (2015) reviews recent work on identifying and modeling networks. In the case of the Hmong farmers it was straightforward to conduct a census and determine group membership. These individuals had a common language and culture as well as agricultural production practices in their backgrounds and generally higher levels of trust among themselves than with outsiders. They could easily be identified by the specialty crops they grew, as well as the common markets they served, sometimes in competition with one another.

The farmers in the Chesapeake Bay area for the most part grew commodity crops, also in competition with one another, but they were all united by the common goal of preserving land and agriculture in the bay region by ensuring farm profitability. This group was formally organized into a cooperative and even funded its own research arm. The organic farmers group cooperated together in synchronizing production schedules to deliver fresh produce to high-end restaurants in DC. The last example, a network of female farm operators in Pennsylvania had a connection with one another through their gender. These individuals felt they could find more support and advice from within the group than from other entities. Other states similarly have official organizations of women farmers. In each of these examples, delineating the network and its boundaries was very straightforward.

To operationalize this first step of data collection a list of potential network members needs to be generated. Often Extension educators already have such lists if they work with individuals or farmer stakeholders who come to meetings or receive educational materials, etc. If the group is not well defined, however, it is possible to use snowball sampling to complete the list. In this case, a member is asked about others who should be added to list of members.

2.1. Identifying Network Members

A first step in carrying out a network analysis is identifying a group of farmers and others who should be included. This is a critical step because it determines who is included in the analysis and what resources are needed to survey network members. In the case of the TSU-led Capacity Building Project we identified three distinct groups who were located in the same areas or had the same ethnic backgrounds.

For the remainder of this manual we refer to our farmer groups as residing in States 1, 2 and 3 without identifying the actual state so as to preserve survey respondents' anonymity.

State 1. Producers surveyed in this network were selected via a combination of criteria. The State University's cooperation extension program has a master list of producers in its small farms program who are served on a regular basis. The small farms program provides technical assistance to its clientele, via farm visits, telephone calls, emails, workshops conferences and mentorship. Thus, most of the individuals selected for the survey were producers who participated in a myriad of extensions events and outreach programs that were hosted by the State University. The producers selected were primarily landowners or leaseholders who were engaged in commercial small scale agricultural production. Selected participants grow and market plant and animal products for human consumption. Blacks, Whites, Asian Indians and Hispanics are all served by the State University and are all included in the network survey. Any group that was not represented in the survey was not omitted intentionally. Large-scale producers were for the most part excluded from this survey. Even though the State University is open to providing technical assistance to large producers, considerable time is spent expanding opportunities for limited, small and minority producers in the state. Producers from all counties in the state were represented in the network survey. They operate their business in both urban and rural communities. One additional selection criterion was to identify producers who had the potential to market fresh agricultural produce and value-added products in large neighboring metropolitan areas with diverse populations.

State 2. Farmers included in this state's network were selected based on the agro-ecological zone of the state. In fact, the areas chosen are known for growing high-value crops and are in constant quest of diversifying agricultural enterprises and expanding produce sales into the Northeast metro market corridor. These farmers were reached by phone using a database of commercial small farmers and ranchers maintained by the University. In addition, some farmers were contacted at the small farm conferences and meetings organized by the University. Hence, farmers selected were a mix of landowners and lease holders growing a variety of products ranging from high-value vegetables (i.e., hot peppers, eggplants, okra, amaranth, garden eggs, etc.) to cut flowers, mushrooms, lamb, and goat. Farmers in the network were a mix of African Americans, Caucasians, Asians, males, females, singles, and married. Any other groups not represented in the survey were omitted unintentionally. Given the nature of the farmer database used, it is obvious that only commercial small-scale socially disadvantaged farmers were included in the network analysis. In this State there are two subgroups within the overall network.

State 3. The network covered five counties in the state three of which are adjacent to metro areas. Each county provided a list of pre-identified producers. These farmers were retrieved from lists maintained by county Extension educators and they are ethnically diverse, consisting primarily of Laotians, Whites and Blacks. The pre-identified list included small vegetable farmers and excluded large commodity producers. It also excludes those that reside in the same household and work on the same farm. Additionally, those with the same last name were excluded. The farmers were given space on the survey instrument to add other farmers not in the list. Any duplicate names were dropped. This survey of producers generated information including characteristics of the operators such as education, age and gender as well as their operations such as sales, years farming, experience operating in network and future plan to continue or discontinue farming. All counties in this state had adequate number of farmers that provided useful network information. There are five sub-groups in this state, clustered within counties.

2.2. Developing the Survey Instrument

Once this list of farmer-respondents is compiled, the next step is to develop and administer a survey that will allow one to conduct the network analysis. If the population to be surveyed is not too large, the simplest way to do this is to show survey respondents a table or matrix that lists farmers across the top as well as down the rows. If the list is very long, farmers could be asked to just write down (across columns, with one per farmer) with whom they have a network relationship. Farmers are then asked about their relationships, if any, with the other farmers in the network. It is also a good idea to give them space that would allow them to add other individuals who are not listed.

Sample Survey Instrument for Collecting Data on Farmers; one for each State
Basic Question: On the following list, please place a checkmark next to the name of any farmer you would seek out for marketing (or production) advice, or share equipment, etc.

	Production Advice	Marketing Advice	Sharing of Resources
Farmer A			
Farmer B			
Farmer C			
Farmer D			
Etc.			

Now each respondent (that is, Farmers A, B, C, etc.) can be asked to place a check mark or an X into the box corresponding to other farmers with whom he or she has different kinds of relationships. Respondents do not need to do anything with their own boxes (down along the diagonal of the table). As noted, a different way of doing this is to provide a list of names of farmers to the respondents, with enough space next to the name for respondents to enter the number corresponding to the other farmer with whom a relationship exists.

The specific question related to the nature of the relationship is key. A very simple question would be: Do you know this farmer: yes or no. A more elaborate question may be: How often do you see, or interact with, this farmer: daily, weekly, monthly? The more frequent the interaction, or interdependency, the more intense the relationship.

A different and more refined way of posing the question is to ask: Among these farmers, which one would you go to, to get information about a production problem? Who do you go to for a marketing problem? Who do you ask for advice on how to apply for credit, or file taxes? The purpose of the study and what one is trying to learn about the network is key to deciding what kind of question to ask. This information, properly collected and analyzed, will reveal who the most central and important individuals are within the network (e.g., the influencers or information brokers).

With the survey the educator or researcher may also be interested in other farmer characteristics, such as income, sales, production practices, years of experience, assets, and opinions or attitudes. Often this information can be related in meaningful and important ways to the results of the network analysis. For example, one hypothesis may be that farmers who occupy more central positions within a network also have higher incomes, sales or access to resources, etc.

To summarize, results of a network analysis can serve two distinct purposes. The first is simply to describe the network using various network statistics, which we discuss below. The second is to relate each individual's network measure to his or her socioeconomic characteristics to assess if they are correlated. Lastly, it is also interesting to compare the overall or aggregate network statistics of different groups with one another. This is illustrated by an example below.

2.3. Administering the Survey

Very high participation rates in the survey are essential (>90% if possible), if the network is to be properly described. The higher the participation rate the greater will be the quality of the data and therefore the reliability of the results of subsequent analysis.

In order to survey farmers it is often best to administer the questionnaire at a meeting, etc. Describe procedure and what works best for different groups (Wetherill, 2013). He discusses cultural factors that can lead to differences in relationships with minority farmers and emphasizes the importance of attending social events and then utilizing word of mouth to spread word of Extension programs from one minority farmer to the rest of their community.

The first task was to familiarize participants with the guidelines for participating in the survey and the goal of the project. In one state, this was achieved by reading written statements given at the top of the survey instrument. The entire survey questions were also read to the participants one by one prior to beginning the survey. This provided opportunity for clarification of the survey questions. Respondents were asked to complete the survey prior to turning it in. They were also screened to avoid duplication. For example, brothers living in the same household and working on the same farm were eliminated. We also verified that participants were indeed from the county being surveyed, and not another county. We made sure the participants were small fruit and vegetable producers. A translator was used in one county where the respondents had very poor or no knowledge of English. The survey was administered at county extension facilities with local extension agents in attendance.

In the first state, farmers were selected from a database that is managed by the Small Farms Program within Cooperative Extension at the land grant university. The survey was mailed to farmers using this database. Farmers were added to the survey list by extension educators via farms visits and at extension events such as field days, workshop and annual small farms conferences. This was followed up by a visit to the farmer for the purpose of conducting and completing the survey. In a few cases, the survey was administered via one on one post event meeting at an extension forum such as a workshop or the annual small farm conferences. A total of three personnel assisted in administering the survey related to the project. All three personnel were paid or were directly affiliated with the CBG farmer's network project. Once the survey was completed, the responses were secured in the office of the campus project director, and electronic copies of these documents were sent to the lead institution.

In the second state, a list of farmers was obtained from the cooperative extension program data base at the land grant university. The survey was mailed to farmers using the data base. A follow up was made with farmers who did not return the completed survey. Phone calls, farm visits and/or farmers' interactions during workshops and small farms annual conferences were used.

In the third state, a list of farmers was obtained from the Cooperative Extension Office of the land grant university. The survey was conducted face-to-face with small fruit and vegetable producers in five counties. The selection of the specific producers was in line with the goal of the project. The venue for the survey in all cases was the county extension office. Three of the five counties surveyed were located adjacent to metro areas where retailers, whole sellers and farmers markets are located. County extension educators were instrumental in organizing the meetings and assisting in conducting the survey.

2.4. Entering the Data

Once the data collection was completed, data were entered into software for subsequent analysis. An exception to this is if the data have been collected online, via software such as Qualtrix or SurveyMonkey. It does not matter whether the data are available in matrix format or as a list (using the sparse method). No matter what the data collection format, getting the data into a form in which they can be analyzed is relatively straightforward.

3. Analyzing the Network Survey Data

Listed below are some of the best sources that we have found for analyzing the network survey data. Each has strengths and weaknesses but will generally work for your own Network Analysis.

UCINET: If you are interested in conducting network analysis of your own data, a free 90-day software program called UCINET is available. After the initial trial period the software can be purchased from the website. This software was developed with the NetDraw network visualization tool. It aids researchers in showing the connections between nodes and can be used to create tables for data demonstration.

UCINET has tools that can help users with their work and analysis. In addition, there are numerous helplines and individuals available for contact from UCINET: https://sites.google.com/site/ucinetsoftware/home

Other sources that are useful for conducting a Social Network Analysis are listed below with brief descriptions.

For a free source with a good overview of Social Network Analysis, visit:
http://www.faculty.ucr.edu/~hanneman/nettext/

This source shows different Social Network Analysis Software Programs:
http://www.gmw.rug.nl/~huisman/sna/software.html

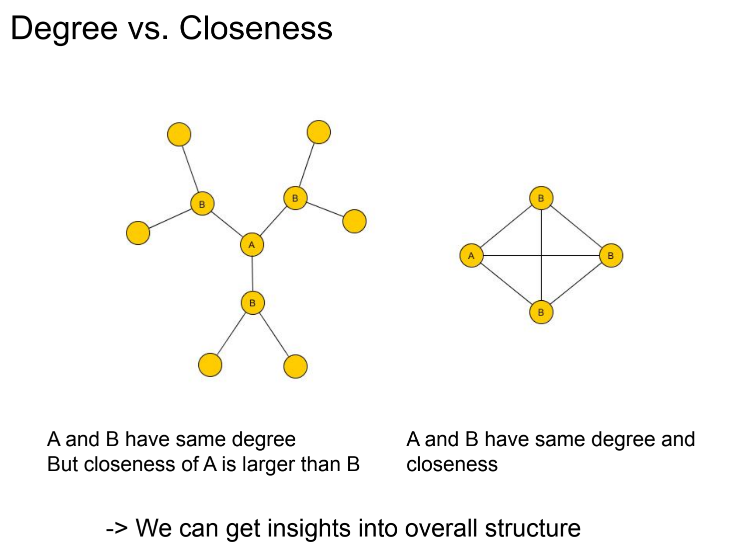
This final link has a comprehensive review of Social Network Analysis and its related software. http://en.wikipedia.org/wiki/Social_network_analysis_software

While a number of statistics can be calculated for a network, a few are key. In one way or another, they capture how central (or important) an individual is within a network. These are individual-level statistics. In addition, we can consider how well the overall network is connected, for example, in comparison to another network.

Some network terms to be familiar with to understand the graphs are listed below. These terms can then be used to explain the results to the participants, once the participants have been taught what they each mean.

- Degrees-In: The number of connections directed to the node; this is a measure of how many people connect to the person, or how popular the individual is. The higher the number, the more popular or prestigious.
- Degrees-Out: The number of connections that the node has to others; this measures how sociable or out-going an individual is. A farmer may list many others to whom he or she feels connected without the others necessarily reciprocating. A farmer with high out degrees, that is, who is followed by many other farmers (e.g., on Twitter or Facebook) would be a good person to ask to disseminate new knowledge or important updates.
- Closeness-In: Inverse of total shortest path length directed to the node, propagation time of information from others to the node. This measures how quickly an individual receives a message from another person within the network; here speed refers to the number of other nodes through which the information must travel, not necessarily the time required to travel. Someone with low in-closeness has to rely on many other individuals to pass information on to him or her.
- Closeness-Out: Inverse of total shortest path length that the node directs to others, propagation time of information from the node to others. An individual with high out closeness can rapidly (involving few other nodes or intermediaries) spread out new information, without it having to pass through other individuals, that is, relying on others to pass on the information.
- Betweenness: This is the frequency (or number of links) of the node that sits on the shortest path between two other nodes; it is also a measure of ability to control information flows in the network. This is a measure of the number of other nodes between which the individual is inserted. In other words, between how many other relationships is this individual positioned? The larger the number, the more the number of flows between which the individual is placed.

Each of these measures is nuanced and differs in subtle ways in terms of how it reflects or represents an individual's position within the network. The following graphic highlights the difference between the degree and closeness centrality measures. This in turn allows us to develop insights into the overall structure of the network.



4. Interpreting the Results

PART 1: Using network data only

The table below shows the data sample from our study. Specifically, there were 23 farmers in the network of the first State, followed by 46 and 127 respectively in the other two States where the survey was conducted. In the first state, 19 of the 23 nodes had at least one connection (entire), whether it was in terms of production or marketing advice, or sharing resources. Actually, sharing resources was more common and occurred at a higher rate in this State, at 82.6% or 19 out of 23 possible connections, than in the other two, where it was 43.5% and 44.9%, respectively. On the other hand, sharing marketing advice was comparable across these three networks, at 56.5% (or 13/23), 52.2% and 48.8%, respectively.

State	Connection type	Total nodes	Connect-ed nodes	Degree	Close-ness-in	Close-ness-out	Betweenness
1	Entire	23	19	2.65	0.1999	0.2014	5.83
	Prod. advice		18	1.57	0.1307	0.1319	5.57
	Market. advice		13	1.13	0.0647	0.0640	2.52
	Sharing res.		19	2.52	0.1880	0.1868	5.39
2	Entire	46	29	0.76	0.0238	0.0242	1.02
	Prod. advice		24	0.67	0.0211	0.0211	0.93
	Market. advice		24	0.67	0.0211	0.0211	0.93
	Sharing res.		20	0.30	0.0076	0.0079	0.09
3	Entire	127	86	1.02	0.0128	0.0130	4.02
	Prod. advice		72	0.70	0.0074	0.0076	1.35
	Market. advice		62	0.53	0.0049	0.0049	0.42
	Sharing res.		57	0.59	0.0069	0.0070	1.80

The table also reveals that the network of farmers in State 1 is the most densely connected, as indicated by the average 2.65 degrees that link the entire network, followed by sharing resources (2.52) and production and marketing advice, respectively. Note that the "entire" network measure just combines the other three, and that is larger than any one of the three individual measures. The difference is especially pronounced in State 3 (1.02 compared with 0.70 as the next-highest). Note also that while sharing of resources has the highest degree of the individual measures in State 1, it has by far the lowest in State 2 (0.30 compared to 0.76). In State 2 the two types of advice also show the same average degrees, of 0.67, suggesting that exactly two-thirds of all farmers are somehow linked in sharing production or marketing advice.

In general the closeness measures (in and out) track the patterns in the degrees as well as the Betweenness measures, in terms of their relative sizes, within each of the three networks (States). This confirms that these measures are all to some extent interrelated. At the same time it is notable that in and out closeness measures for the "entire" measure are bigger in State 2 compared to State 3, even though the degrees are higher in State 3 than in

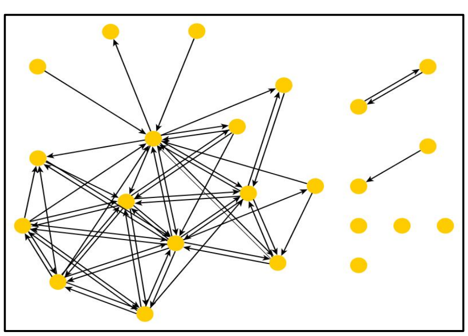
2. Thus, the average density of connections (degrees) is higher in State 3 than 2, but the closeness scores are lower. Again, this shows the subtle differences in the workings of these networks, and how effectively they may operate or move information, for example. The betweenness score shows the same pattern as the degrees, with the highest value recorded (for the entire network) in State 1 followed by States 3 and 2. However, in the case of State 1 it is noteworthy that the betweenness score for obtaining production advice (5.57) is greater that than for sharing resources (5.39) even though the average degrees for the latter (2.52) is considerably higher than that for production advice (1.57). This suggests that individuals in State 1 are more likely to be inserted (or lie) between the connections of other nodes in terms of production advice, even though the average density of connections is lower than is the case for sharing resources. The same can be observed in State 3, for these two particular network measures.

Graphs (examining only the network statistics)

Comparing the entire networks with one another graphically confirms visually what is already evident from the table above. The Appendix shows graphs for each of the nine networks contained in the different states (1 in State 1, 2 in State 2 and 6 in State 3).

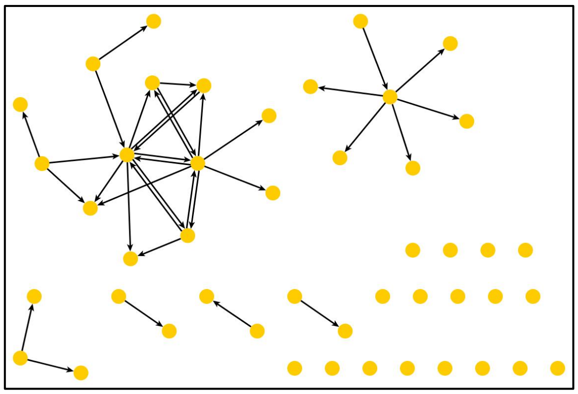
Also included are detailed summary statistics for each group. Following immediately below are the overall graphs for just one State, extracted here as an example for more detailed discussion.

State 1
In this State only four farmers are not connected with anyone else (this is also calculated as the difference between the total number of nodes in the network (23) and those who are connected (19). Overall this network still has the highest average degrees, which indicate that each farmer is on average connected with 2.65 other farmers. This (entire) network also has the highest closeness (in or out) and betweenness scores, all of which are evident from the relatively tight connection patterns in the graphic. Particularly noteworthy here is that many of the connections are reciprocal, i.e., the arrows are drawn in both directions between the nodes.



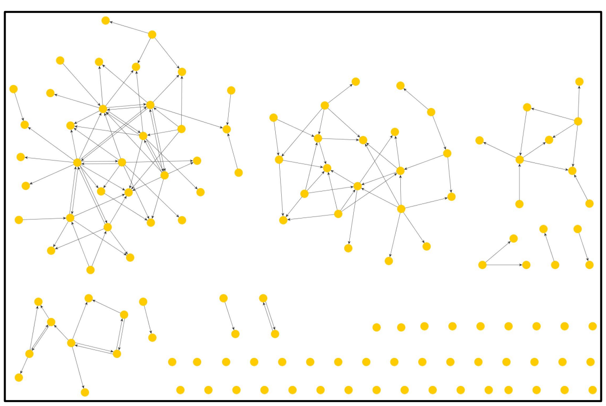
State 2

Note in this case that a relatively large share of farmers are not connected (46-29=17, or 37.0% of nodes) so that this network has the lowest average degrees and betweenness scores. Interestingly, however, it does *not* have the lowest in- or out-closeness scores despite this fact; that distinction is held by the network in State 3. Also of note is the Star-shaped sub-network in this figure, in which five of the arrows point away from the central node (hub) and only a single one points towards it.



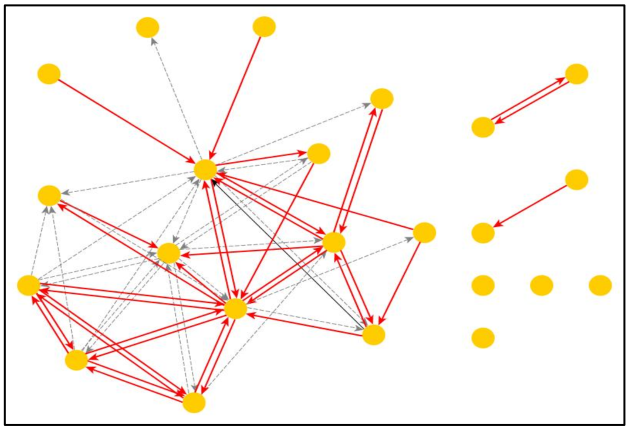
State 3

In this network there are clearly also many nodes (farmers) that are not connected with others (32.2%), but even so there are sufficient connections among the other farmers to still give this State the second highest average degrees. As noted, however, it also has the lowest closeness scores, perhaps largely because most nodes are only connected in one direction rather than in both, as is the case in State 1.

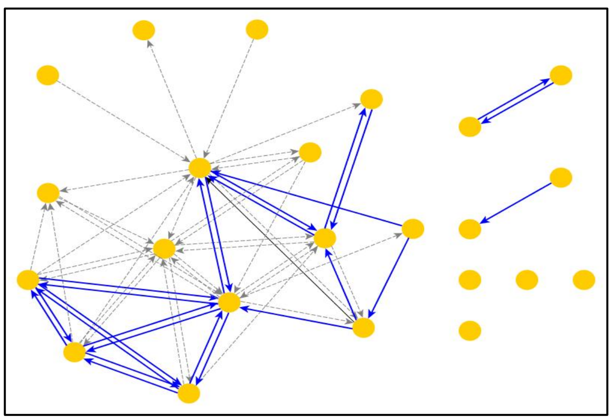


Comparing the results across the different types of networks within a State (in this case State 1) also confirms what is already evident in the table above. The degrees are highest for sharing resources, followed by production advice and marketing advice. In other words, the knowledge network surrounding production is more dense than that for marketing information, and there may be important opportunities for extension educators to intensify or deepen the latter type of network.

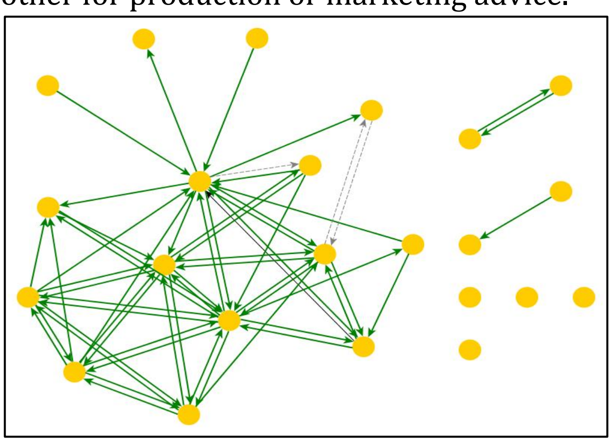
Production Advice



Marketing Advice: note the similarity with and difference from the production advice net-work.



Sharing Resources: this is the most densely connected of the networks, suggesting that more farmers share resources among one another in this particular state than ask each other for production or marketing advice.



PART II of the analysis: Combining network with socioeconomic data.

How Farmers' Positions in the Network Relate to Their Demographics, and vice versa

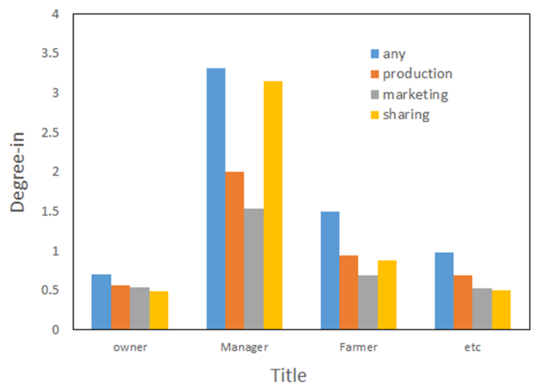
As part of this project we also collected data on farmers socioeconomic status, including factors such as job title, age, gender, when they started to farm, computer use, amount of sales, etc. In this section we discuss some of the salient findings that relate these variables to farmers' positions in the network.

First of all we plot the in-degrees for each job title, which is owner (N=37), manager (N=13), farmer (N=16) or other (N=46, not specified) in the bar graph below. We note that there are only 13 managers in this sample, or 11% of the total number of respondents. Especially noteworthy is that these individuals also have the highest in- and out-degrees among all the job titles provided, and they also have the highest closeness scores. This fact in turn indicates (even without mapping the network) that the network follows a tree-ish (or star-shaped) structure, whereby the managers are located in the central area of information flows, which is what would be expected. This means not only that these managers have social influence within the networks, but also that they have the greatest ability to disseminate information to other network members (Lubell et al. 2014).

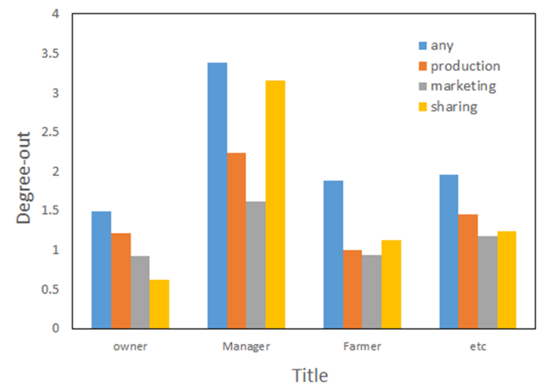
The highest degrees are observed for resource sharing, which also occurs with or from managers. Altogether, this indicates that managers have the ability to exert a certain degree of control over the information flows within these networks. Alternatively, they would be the go-to sources for disseminating new information, if the goal was to get the information out as quickly and efficiently as possible. The managers are *central* both in terms of giving and receiving advice and, as such, can be seen as information brokers. Across the types of information shared, production dominates (has higher centrality) than marketing, although the differences in most cases are small.

The differences across the bars are even higher in the case of closeness scores, and again managers have the highest scores. As noted earlier, an individual with a high closeness core has a position in the network that allows him or her to very quickly receive information (for in-closeness) or disseminate information directly to others without going through intermediaries (out-closeness). To the extent that managers are paid (unlike farmers or owners) to know about production and marketing processes, this result is to be expected. For equipment sharing, on the other hand, the explanation is perhaps less obvious or intuitive.

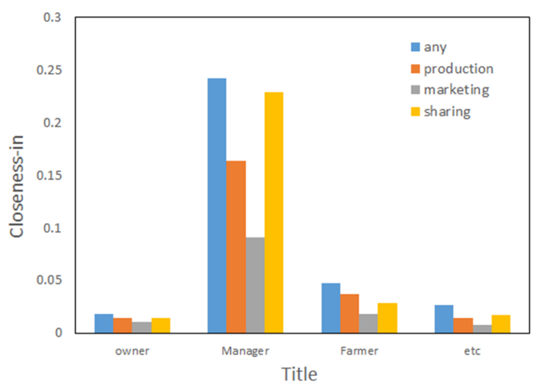
Title — degree in



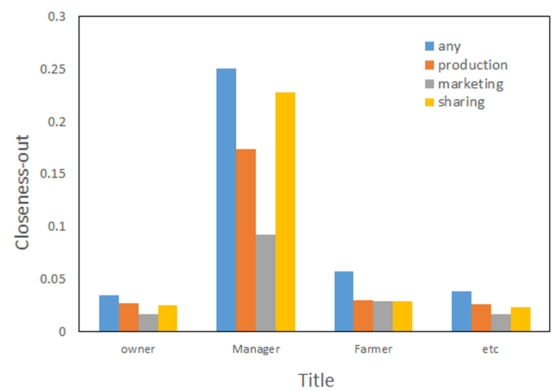
Title — degree out



Title — closeness in

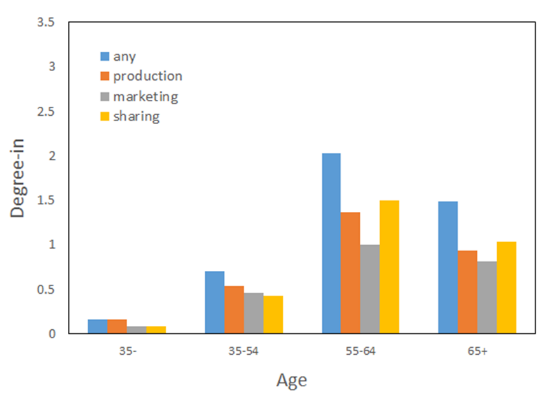


Title — closeness out

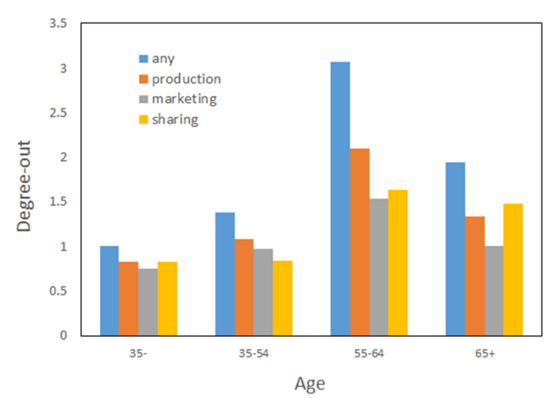


Another notable demographic variable is age. Here those who are in the 55-64 year old age cohort have the most in and out degrees, where the latter are even higher than the former. This suggests both of these individuals receive the most inquiries in terms of others seeking advice, and they also are more likely to seek advice of others. At least for the former (in degrees), this suggests that other farmers in the network come to these individuals for advice, that is, others likely seek them out because of their greater experience farming.

Age— degree in

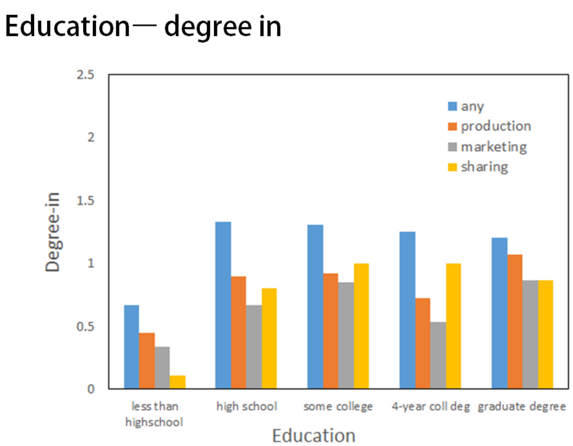


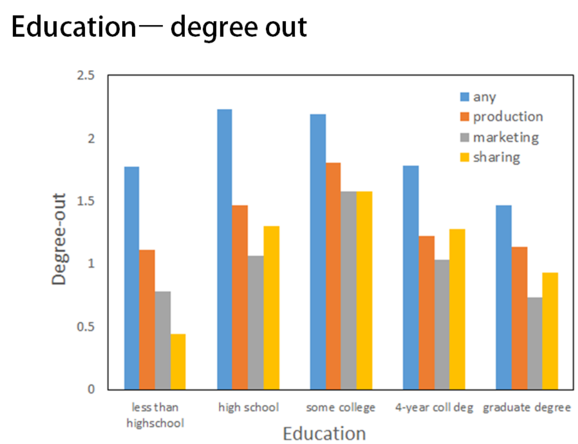
Age— degree out



It is noted that these degrees are normalized, in the sense that they are averaged for each of the age cohorts. In other words, the average 55-64 year old has an average in-degree of 1.5 for production advice and an out-degree of about 2.25. It is also noted that some individuals who were not part of the network were asked for advice. This explains why the out-degrees are greater than the in-degrees. Again, among the in-degrees, the largest numbers are found for sharing of equipment, and in general more production than marketing advice is traded among these farmers. It is plausible that farmers are getting their marketing advice elsewhere, such as on the internet or from Extension educators, although the differences are not that pronounced.

The educational attainment measure is also interesting in that farmers with less than a high school education have much smaller in-degrees, while their out-degrees are more comparable to those of the more highly educated network members. In other words, they are much less likely to be asked for any of the types of advice, or even to share resources. At the same time, those without a high school diploma are about as likely to seek advice (but not share resources) from others as those with graduate degrees. Again this result seems plausible and gives the analyst some degree of confidence in the survey results.





In terms of gender differences, in degrees for all four measures are comparable between males and females, and the same is true for out degrees with one exception: for females the degrees (0.65) are smaller than for males (1.25) in the case of marketing advice, whereas they are more comparable for production advice (around 1.35 for either group). This suggests females are less likely to give or be asked for marketing advice than production advice. But at the same time, males are slightly less likely than females to share equipment (about 1.5 compared to 1.2). On the sharing-in side, males and females have about the same degrees, on the other hand (about 0.8 each).

For gross farm sales, the out-degrees are greater than the in-degrees, with the possible exception of those selling $100,000 and more. Especially noteworthy are the high out degrees (information given) for those selling between $3,000 and $99,999 worth of products.

Further analysis shows that farmers who are located in central areas of the network have several characteristics in common. They tend to be managers of medium-size farms (gross farm sales $3,000 – $10,000), and they began to operate farms only in 2001-2005 when they were 40-50 years old. Now they are 55-64 years old. This fact could suggest that operating of the farm might be a second job. The usage of computers and the Internet does not significantly relate to the local network but it does to the global network as shown in the Degree vs. Closeness figure.

The degree centrality does not show significant differences between farmers who do and do not have computer and Internet access. This means that the farmers have a similar number of connections to other farmers, and similar local network structures. However, the farmers who have computer and Internet access also have a higher closeness centrality. This higher closeness centrality indicates the farmers are located in more central areas of the network and that the information from/to this group spreads out quickly to other farmers in the network even though the number of directly connected farmers is similar in terms of degree centrality.

In terms of how computers are used, Skype by farm dominates in in-degrees across all four network types, i.e., any, production, marketing and sharing. This suggests that Skype is used, even among these farmers who are located relatively close together in space, to secure information or shared equipment. On the out-degrees side the patterns are much more even, with searching for information, email and social network media slightly dominating Skype usage for production advice, and all uses (including selling and buying inputs) dominating Skype usage in the case of marketing advice.

Another interesting stratification is in terms of how many years the respondent has been in the network surveyed (with 63 being less than 5 years, 6 between 6 and 10 years, and 17 being over 10 years). Those who have been in the network the longest also (by far) have the highest in-degrees and (to a lesser extent) the highest out-degrees. This confirms that as individuals have the opportunity to get to know one another more closely, with familiarity arising as time passes, they also pass around more information among themselves. The same is not observed for sharing equipment with others; here the average degrees are similar (around 1.5) regardless of years in the network. For sharing-in, on the other hand, the average degrees are about twice as high for those in the network ten years or longer.

How the Network Position Affects Farmers' Sales

We next analyze how involvement in the network affects individual farmers' sales. Five centrality measures representing proximity/distance of the actors in terms of information access, control of information flow as well as the number of connections are used. The centrality measures used are: betweenness centrality, close-in centrality, close-out centrality, degree-inn centrality, and degree-out centrality. In this case all farmers are considered together, as one group, and do not distinguish between farmers from the three different States. The overall results confirm a significantly positive relationship of sales volume with involvement in network.

A significant concern here is inferring cause and effect between network position and the outcome variable. For example, sales could be high because of a farmer's high centrality within the network but the opposite is equally plausible. While it is beyond the scope of this manual to discuss this issue, researchers have started to deal with the statistical aspects of this problem (e.g., Boehmke et al. (2016)). Interested readers should consult this paper.

Betweenness centrality
The results show a significantly positive relationship between betweenness centrality and farm sales. Betweenness centrality is an indicator of ability to control information flow in the network. A positive regression coefficient in the relationship between betweenness centrality and sales suggests that sales volume increases as the farmer's power to control information flow increases. The results reveal that a one-point increase in betweenness centrality is associated with a 3.3% increase in sales volume.

Degree-in and degree-out centrality
A significantly positive coefficient of degree-in and degree-out centrality on farm sales was found. A positive 0.188 coefficient of degree-in centrality suggests that the expected sales increase with the number of farmers who know the farmer in question—a 19% increase in expected sales is associated with a one unit increase in degree-in centrality. Similarly, a positive 0.246 coefficient of degree-out centrality suggests a sales increase as a farmer knows more other farmers—a 25% increase in expected sales is associated with a one unit increase in degree-out centrality.

4.2. Presenting the results to the participants

Once the analysis has been completed the question arises whether or not to share the results with the population surveyed, and how. To make the most use of the results (and the effort that went into collecting, entering, and analyzing the data), they should ideally be shared with the respondents. The reason for this is that there is evidence that groups working towards a common goal (and assuming that is the case here as well) work more effectively after they have been presented with the results. Often individuals get new ideas about whom to work with or contact for information once they have seen the network graphic.

Thus, in addition to benefiting the extension educator who can gain deeper insights into the nature of the relationships among his or her farmer stakeholders, the individual farmers may also benefit from seeing themselves, and others, within the larger network. Of course, care and discretion are needed when sharing the results, to avoid embarrassing any one of the survey subjects. Thus, educators need to decide on a case by case basis on the level of trust within the group and what it is that is appropriate to share.

5. Summary

Social Network Analysis is a powerful tool to use when working in communities trying to expand and disseminate knowledge. It may be a particularly useful tool working with minority farmers who have different cultures and norms than do other farmers who may have a longer history of working with Extension Agents. By using Social Network Analysis, it is possible to reach many of the farmers from communities who might otherwise not work with Extension on different projects.

This Manual has shown how to collect data, organize and input data, how to interpret the results, and sharing the findings. From this, and the resources listed, a comprehensive introduction into Social Network Analysis has been provided, when to use it, how to use it, and the good that can come from its use.

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Technical Appendix

Network centrality

Centrality of node *i*	degree	closeness
in-	$\sum_{j}^{N} w_{ji}$	$\frac{J_i/(N-1)}{\sum_j^N d_{ji}/J_i}$
out-	$\sum_{j}^{N} w_{ij}$	$\frac{J_i/(N-1)}{\sum_j^N d_{ij}/J_i}$

Where, N = total number of nodes in a network

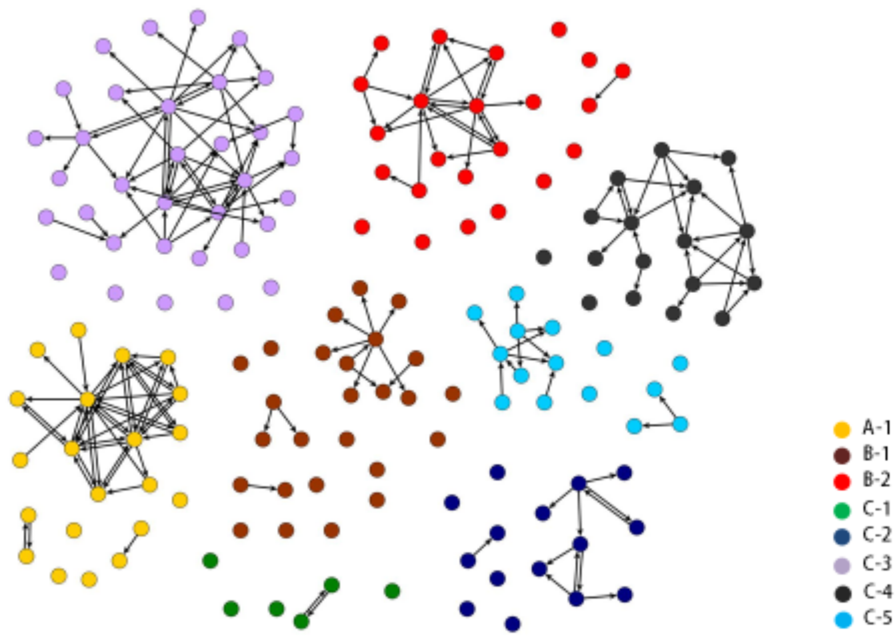
w_{ij} = 1 when node i and j are connected, else 0

J_i = number of reachable nodes from (or to) node i

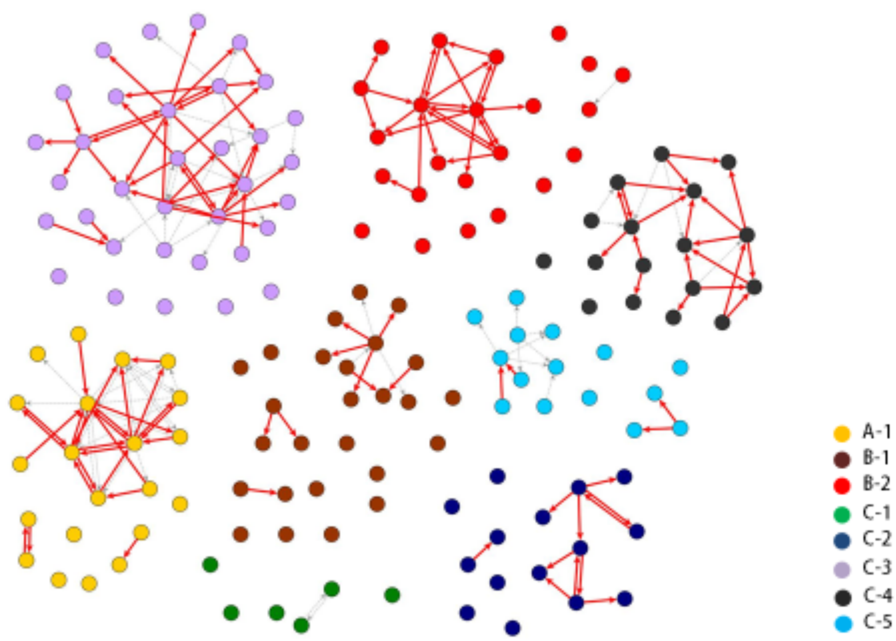
d_{ij} = shortest path length (number of edges) from node i to j

Appendix

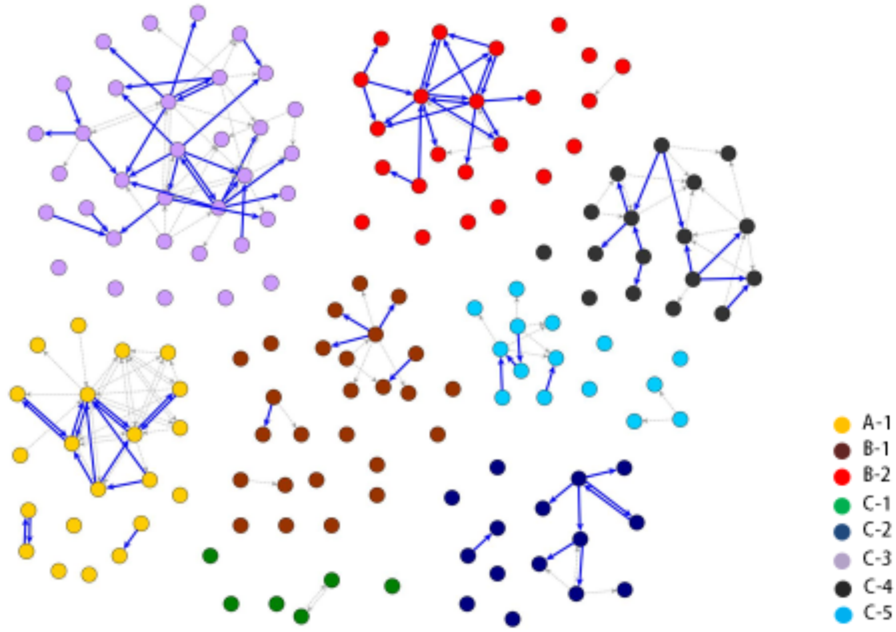
Entire



Production Advice



Marketing Advice



Sharing Resources