Analysing the social network of technology and information transfer for maize sheller service providers in Zimbabwe

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Preface

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Table of Contents

Analysing the social network of technology and information transfer for maize sheller service providers in Zimbabwe.....	1
Analysing the social network of technology and information transfer for maize sheller service providers in Zimbabwe.....	i
Preface	ii
Table of Contents.....	iii
List of Tables	iv
List of Figures	iv
List Acronyms.....	v
Abstract.....	vi
1. Introduction	1
1.1 Background information	1
1.4 Objectives.....	3
1.5 Research questions	3
1.6 Hypotheses	4
2. Materials and Methods.....	5
2.1 Characterization of the study area	5
2.2 Data Collection	6
2.3 Data Analysis.....	7
3. Results.....	9
3.1 Characteristics for maize sheller customers and non-adopters	9
3.2 Customer's reasons for choosing service providers	9
3.3 Demand creation approaches used by service providers to obtain shelling customers	10
3.4 Social networks	11
3.6 Network metrics	13
3.7 Network densities for districts.....	15
4. Discussion.....	17
5. Conclusion.....	20
6. References	21
Appendix A – Tables.....	24
Appendix B –Figures.....	26

Figure B2: Reasons for using manual shelling by non-adopters in Makonde district.....	26
Figure B3: Visualization of the social network for service provider 1 in Domboshava	27
Figure B5: Visualization of the social network for service provider 4 in Domboshava.....	28
Figure B6: Visualization of the social network of service providers for maize shelling in Domboshava	29
FigureB7: Visualization of the social network for service provider 1 in Makonde district	29
Figure B8: Visualization of the social network for service provider 2 in Makonde	30
Figure B9: Visualization of the social network for service provider 3 in Makonde district	30
Figure B10: Visualization of the social network for service provider 4 in Makonde district	31
Appendix C – Thesis Questionnaire	Error! Bookmark not defined.

List of Tables

Table 1: Characteristics of maize sheller customers and non-customers	9
Table 2: Business performances and network metrics of service providers between districts	14
Table 3: Correlation of business performances and centrality measures for service providers	14
Table 4: ANOVA results for relations on business performances and network metrics for service providers	15

List of Figures

Figure 1: Map of Zimbabwe with study sites (Domboshava is under Mashonaland east province and Makonde is under Mashonaland west province as indicated in the map).....	6
Figure 2: Methodological framework of the research design.	7
Figure 3: Customers' reasons in order of importance (Imp) for selecting service providers (SP) in Domboshava and Makonde districts.	10
Figure 4: Demand creation approaches used by service providers in finding customers.	11
Figure 7: Visualization of the social network of service providers for maize shelling in Makonde.....	13
Figure 8:Total earnings in relation to network degree and sheller capacity(t)	15
Figure 9: Box plots for Network Density of service providers between districts.	16
Figure B10: Visualization of the social network for service provider 5 in Makonde district	31
Figure B11: Visualization of the social network for service providers 6 in Makonde district	32
Figure B12: Visualization of the social network for service provider 7 in Makonde district	32
Figure B13: Visualization of the social network for service provider 8 in Makonde district	32
Figure B14: Visualization of the social network for service provider 9 in Makonde district	33
Figure B15: Visualization of the social network for service provider 10 in Makonde district	33
Figure B16: Visualization of the social network of service providers for maize shelling in Makonde district	34

List Acronyms

Agritex	Agricultural technical and extension services
ANOVA	Analysis of Variance
CIMMYT	International Maize and Wheat Improvement Center
FACASI	Farm Mechanization and Conservation Agriculture for Sustainable Intensification
GDP	Gross Domestic Product
GMB	Grain Marketing Board
NGOs	Non-Governmental Organizations
SNA	Social Network Analysis
SPSS	Statistical Package for the Social Sciences
SP	Service Provider
SSA	Sub Saharan Africa
TDES	Total Dietary Energy Supply

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Abstract

Smallholder farmers and their households in Zimbabwe depend on maize as a staple food and source of income. Despite the high demand for maize production, there is little service provision particularly shelling on post-harvest technologies. Therefore, service providers for maize shelling are suggested to have a strong social network with customers and other service providers for demand creation. The aim of the project was to understand the business approaches of the service providers and their performances, using SNA to track the use of shellers for service provision and the associated information network in Domboshava and Makonde districts, Zimbabwe. SNA through interviews were used to assess the demand for shelling through customer and non-customer characteristics, to identify demand creation approaches and to analyze how the communication network differs between service providers. There was a variation in total earnings on average Makonde service providers with more earnings than in Domboshava. Service providers obtained the customers based on trust from the community. Total earnings increased with increasing number of customers ($p < 0.001$), higher degree centrality and shelling capacity for both districts. Network density was higher in Domboshava than in Makonde district indicating more frequent contacts in Domboshava. Despite the earnings, most of the service providers operated below full capacity due to the low maize production caused by drought and the late availability of shelling services to the farmers. The service providers that achieved higher turnovers, tended to have shelling machines with higher capacities compared to those operating with small shelling capacities. Service providers started their business in 2016 season and little promotion had been made amongst farmers for shellers' awareness campaign. There is more urgent need for promotion and business development and upgrading of shelling capacities to boost business performance. Identification of central actors such as the agricultural extension officers is vital in the social network for dissemination of information for high uptake of services.

Key words: income, service providers, shelling, social network analysis.

1. Introduction

1.1 Background information

Many smallholder farmers in Sub Saharan Africa(SSA) depend on maize as a staple food and source of income (Tefera, 2012), yet the traditional, labor intensive manual cultivation and processing methods can hinder attaining high productivity in subsistence farming households. In Zimbabwe, smallholder farmers grow maize for subsistence under rain-fed conditions. Maize production plays a significant role for the people, as 80% of the population is directly involved in its production (Tefera, 2012). It is the most important food crop in the country because it is the staple crop for the majority of the population. Maize production accounted for 43% of total dietary energy supply (TDES) between 2003 and 2004 (Chiukira and Juru, 2012). Aside from being eaten as green mealies, it can also be processed into maize meal or used to make different kinds of by products such as *maputi*, *samp* and grit which is used in making snacks and can be used for livestock feed as well (Chiukira and Juru, 2012). Despite the high demand for maize production in Zimbabwe, scarcity of agricultural labor is the main constraint that forces farmers to adopt mechanization and any agricultural practices that can save labor (Jaleta et al., 2014). The labor deficit hampers timely execution of crop cultivation practices and prevents farmers from uniform management (e.g. weeding, tilling) of larger areas and from processing large quantities of products. Agricultural technology development such as mechanization improved labor efficiency, improved timeliness of operations, improved input efficiency and enabling more sustainable production systems since mid-1800s to the present (Sims and Kienzle, 2016). Many African country governments have justified their intervention in promoting mechanization as a way of reducing drudgery associated with farming (Diao et al., 2016). This has a large potential for impact on women and children, as they carry out most agricultural operations, including maize shelling, which is often highly labor intensive.

The production of maize goes through several processes, including harvesting, drying, shelling, winnowing, processing, bagging, storage, transportation and finally consumption (Abass et al., 2014). Maize shelling involves detaching of the maize grain from its cobs (Nkakini et al., 2007). It is a required post-harvest process in maize production since the maize kernels are tightly attached to the cobs. However, hand shelling which is a traditional method by smallholder farmers in Zimbabwe is time consuming and labor intensive. The output of hand shelling is generally low. To put this to a greater extend, it takes approximately 16 labor days to shell maize for approximately 1tonne (Fandohan et al., 2006). When the moisture content is above 25%, shelling is difficult and requires much energy, and kernels may be damaged. Maize shelling becomes easier when the moisture content ranges between 13% and 14% (Nkakini et al., 2007). A variety of mechanical equipment are being introduced both in rural and urban parts of Africa to make shelling of maize faster, easier and more efficient.

Since women take part in a majority of the domestic responsibilities, the introduction of new technologies may possibly also reduce drudgery and improve productivity. According to FAO, as for the need for mechanization in the agricultural sector, the response to poverty reduction is increased, profitable growth and employment generation (Sims and Kienzle, 2016). It has been documented that women with more access to resources reinvest their time and money in their children's education, nutrition and health care

(Anaglo et al., 2014). However, they are limited by poor access to resources and other income generating opportunities (Anaglo et al., 2014). Introducing technologies that reduce the labor burden can allow them to focus on improving agricultural production, income generating activities, child care, and/or time to rest (Quisumbing and Pandolfelli, 2010).

In Zimbabwe, a variety of mechanical interventions have been developed in rural and urban areas to enable quicker, easier and more efficient shelling. It has been discussed that mechanization can lessen labor shortages where physical labor is highly relied on (Sims & Kienzle, 2016). In several districts, maize sheller service providers were provided with mechanized shellers and received equipment and business training with the Farm Mechanization and Conservation Agriculture for Sustainable Intensification (FACASI) project led by the International Maize and Wheat Improvement Center (CIMMYT). The service provision would be imperative to farmers in reducing the drudgery of related work allowing farmers to carry out additional operations. It would also improve the efficiencies in post-harvest operations and decrease crop loss as well as speed up marketing processes allowing faster cash inflows to the farm business (Magnan et al., 2013). However, it is important to understand the variability in the performance of these entrepreneurs and their ability to reach farmers. Some are performing well while the others are struggling with their businesses. In terms of overall social benefit and the sustainability of the service provision business model, success can also be defined in terms of frequency of service provided, geographical spread of customers, and diversity of customers (including marginalized community sectors). For their enterprises to be successful, it is suggested that having a strong social network with customers and other service providers can be vital for demand creation. The dissemination of information and the successive implementation of technology depend highly on social relationships since social ties within and beyond community boundaries are important for individuals and the group to get useful information from exterior agencies (Cadger et al., 2016). New innovations and markets will entail that farmers have entrance to better information. In contrast, an information barrier exists between the service providers and their prospective recipients (Raman Nair, 2006; Trauger et al., 2008). To understand information flows and technology transfer in service provision analytical tools such as SNA can be employed.

SNA is an approach used to study interactions and the sharing of resources among actors which can be applied to understand information flows and technology transfer (Haythornthwaite, 1996). Social networks are composed of actors who are tied to one another through social relations. Studies conducted in Ghana have shown that informal networks play a vital role in agriculture and these networks improve flexibility and allow new innovations (Cadger et al., 2016). Moreover, SNA is a useful tool for identifying patterns of dissemination for knowledge and technology in agricultural production. Apart from understanding network structure and distribution of knowledge within the society, it is also important to know the power of formally established, knowledge sharing sources within an agricultural information setting and the implications with regards to information transfer to a larger agricultural setup (Cadger et al., 2016). When examining social networks, it is important to analyze characteristics of individual players and how they relate with others within the overall network (Prell et al., 2009). The exchange of information can be through individuals, organizations or partners who may be linked together. Haythornthwaite (1996), has shown that the strength of ties between actors is determined by the number and type of relationships between actors.

Actors with strong ties can influence one another, and they can improve mutual learning and sharing of knowledge and information. Communities do not comprise of one single group of stakeholders but are characterized by complex patterns of subgroups with different opinions and interests (Crona and Bodin, 2006). It has been argued that SNA can be an effective approach to understand how innovation occurs in agricultural systems and can highlight the important roles of gender in such networks (Cadger et al., 2016). Through understanding social network, stakeholder groups become conscious of their different requirements, needs and goals. Furthermore, when stakeholders are fully part of development processes, they more easily accept or support the implementation of innovations or technologies (Hermans et al., 2017). Hence the diffusion of information and the consequent adoption of innovation depend greatly on social relationships.

The purpose of this study was to analyse the social network of technology and information transfer for maize sheller service providers in Zimbabwe. Through the ongoing project of FACASI conducted by CIMMYT, there are maize sheller service providers in Makonde and Domboshava districts in Zimbabwe. The study aimed to evaluate the importance of social networks for business competitiveness. SNA could play a significant role in understanding technology and information transfer for maize sheller service providers in Zimbabwe. Through this study we will provide feedback to the service providers on how best they can improve their social network to many customers and become more competitive hence more profitable.

1.4 Objectives

The main objective of this study was to understand the characteristics and communication networks of successful and struggling maize sheller service providers. The paper assessed the demand for shelling through customer characteristics, the mostly used demand creation approaches and how the communication network differs between service providers.

The specific objectives of the study were:

1. To identify the demand for shelling services through customer and non-customer characteristics.
2. To assess the demand creation approaches that are mostly used to build service provision in maize shelling business
3. To understand the structure of communication networks between service providers and the customers.

1.5 Research questions

1. What are the characteristics of maize sheller adopting and non-adopting farmers?
2. What are the most demand creation approaches to build service provision in the maize shelling business?
3. How does the structure of communication network differ between successful and struggling service providers in different districts?

1.6Hypotheses

1. Sheller customers have higher education, large farm size, more maize, are located close to service providers and with small household size.
2. Mostly used approaches include FACASI business meetings, linking with other service providers, talking to agricultural extension officers and neighbors, visibility in the community and use of business cards.
3. Service providers that are highly centralized, in a high-density network and with more relationships with other actors are more profitable.

2. Materials and Methods

2.1 Characterization of the study area

Zimbabwe is a landlocked country in southern Africa with a population of about 13million people (PLAN, 2014). Agriculture contributes about 15% to the GDP and provides more than half of the country's total employment (Mberegog and Sanga-Ngoie, 2014). The country is divided into five agro-ecological regions with regards to rainfall regime, vegetation and soil quality. The average rainfall ranges from 40mm in the farthest south to above 2000mm in some parts of the Eastern Highlands (Mberegog and Sanga-Ngoie, 2014). The research was conducted in two districts namely: Makonde and Domboshava.

Makonde district is situated (16° 53' S and 30° 09' E and 17°21' S) in Mashonaland West Province of Zimbabwe. The district lies in Natural region 11A that is characterized by rainfall of 750mm to 1000mm/year (Dowog and Kativu, 2013). Soils range from light sands to loamy sandy soils. The total population of the province is 1,501,656 with 747,475 males and 754,181 females (PLAN, 2014).The district has a dry, cool season from May to September where there is little rainfall. The rain season starts from mid-November up to end of March. Agricultural land is individually owned. There is enough land and new fields are still being opened for cultivation. Mining is an important employment and the main mineral mined is copper.Crop and livestock are predominant farming activities. Major livestock include cattle, goats and pigs. The main crops are maize (*Zea mays* L.), tobacco (*Nicotianatabacum* L.), cotton (*Gossypiumhirsutum* L.) and ground nuts (*Arachishypogaea* L.). Minor crops grown include Bambara groundnuts (*Vigna subterranean* L.), sunflower (*Helianthus annus* L.) and pumpkins (*Cucurbita maxima* L.) that are grown mainly as intercrops.

Domboshava is a village in the province of Mashonaland East, Zimbabwe. It is located in an area of granite hills about 27 km north of Harare (Ingwani, 2015).Domboshava falls under natural region 11A with an average annual rainfall of 750-1000mm/year (Jeranyama et al., 2007). Population of the whole province accounts for 1,344,000 with 651,781 males and 693,174 females (PLAN, 2014).Soils are predominantly sandy loam and sandy clay loams derived from granite, classified as typical Kandiustalf(Jeranyama et al., 2007). Domboshava is a communal area where land is in custody of headmen. The farming system in this area is mainly crop and livestock farming. Main livestock reared include cattle, goats and chicken. Predominant crops include maize (*Zea mays* L.), ground nuts (*Arachishypogaea*L.) and pumpkins (*Cucurbita maxima*L.) that are grown as intercrops. Domboshava is the centre of the capital's market garden activities with horticultural crops including tomatoes (*Solanumlycopersicum*), onions (*Allium cepa*), potatoes (*Solunumtuberosum*) and other all year-round horticultural crops.

Figure 1: Map of Zimbabwe with study sites (Domboshava is under Mashonaland east province and Makonde is under Mashonaland west province as indicated in the map)

2.2 Data Collection

Data was collected using the method “name generator technique” (Cadger et al., 2016). During the name generator interviews, demographic data was collected such as respondent age, household population size, sex, and education level. The name generator technique brought out a list of ties from individuals and the relationship between them as well as identifying whether relationships were formal or informal among them (Lin, 1999). This approach helped to gather information on how often the respondents communicated with each other. During data collection, we also requested the customer’s contacts and the information on how far they were situated from the service providers. Non-customers were selected in consultation from local leaders who provided names of all households. Depending on the number of respondents we wanted per local leader, interviews were done after every fifth household. Social network data was gathered by structured questionnaires completed through face-to face interviews which comprised all service providers, FACASI staff, agricultural extension officers, customers and non-customers. We used a snowballing method to identify customers nominated by service providers. This is a method that provides an economical and efficient way of finding participants that may be difficult to

contact or locate within a short space of time (Faugier and Sargeant, 1997). The total sample size was 210 respondents which were contacted from beginning of April to beginning of May 2017.

Figure 2: Methodological framework of the research design.

2.3 Data Analysis

Prior to the analysis, the data collected from the respondents were cleaned and coded. Descriptive statistical analysis for service providers was done. One-way ANOVA test was done to find the significance level of the characteristics of customers of maize shelling and non-customers. The alpha level for the testing for statistical significance was set at 0.05. Descriptive statistics for service provider selection by those offered services were done. The demand creation approaches and the mostly used methods used by service providers were further analyzed using descriptive statistical methods. Comparison of means on business performances and network metrics among service providers were done using t-test analysis. Analysis of Variance (ANOVA) was done to measure relations on business performance, network metrics and relations among network metrics for service providers. All the data analyses were done using statistical R studio, R version 3.4.0 and Genstat. Graphs were created in Microsoft Excel. To identify social networks, centrality measures were analyzed in UCINET (Borgatti et al., 2018). The chosen analyses were the following:

- Density: measures the proportion of possible ties in a network that are present. A network density is commonly used to measure the degree to which actors in a network are connected to other actors (Wasserman and Faust, 1994). The analysis indicates if actors are highly centralized, they are more diverse, able to pass and receive more information than low centralized actors.
- Betweenness centrality: measures the number of times an actor rests on a short path linking two other members not directly connected (Prell et al., 2009).
- Degree centrality: measures how many other actors are directly connected to others.

- Closeness: measures the shortest path between an actor and every actor in the network (Haythornthwaite, 1996).

The service provider with the lowest sum of distances is the most central in the network. Correlations were calculated to find the relationship between variables and linear regression to get significances were done.

3. Results

3.1 Characteristics for maize sheller customers and non-adopters

Table 1 shows the characteristics of farmers that made use of shelling services and those who did not adopt the services in Domboshava and Makonde district.

Table 1: Characteristics of maize sheller customers and non-customers

	Domboshava				Makonde					
	Customers(Aver)	STD	Non Customers(Aver)	STD	p-value	Customers(Aver)	STD	Non Customers(Aver)	STD	p-value
Number	26		26			70		64		
Education Level			0.61	0.58	0.11			0.55	0.71	0.37
None	4%		4%			3%		9%		
Primary	34%		23%			34%		20%		
Secondary	62%		73%			63%		69%		
High secondary	0%		0%			0%		0%		
Diploma/Higher	0%		0%			0%		2%		
Household Size	5.3	2.36	5.1	1.87	0.69	7.4	4.28	7.2	3.56	0.89
Distance (km)	0.5	0.89	0.4	0.75	0.63	1.4	1.58	1.2	1.43	0.98
Area (ha)	2	1.69	0.6	0.64	0.01*	7.4	8.07	6.8	4.79	0.99
Last year maize (ha)	1	0.85	0.6	0.36	0.02*	2.2	1.43	2.1	1.31	0.98
Maize production(t)	2.5	2.98	1	0.71	0.02*	4.3	2.99	4.2	4.01	0.99
This year maize (ha)	1	0.77	0.6	0.37	0.02*	3.5	1.87	3.2	1.96	0.88
Crop sales (\$)	584	961.62	187	198.45	0.04*	1295	1502.76	977	1347.7	0.84
Livestock sales (\$)	272	670.43	143	305.65	0.38	265	591.47	164	281.66	0.79
Agriculture income (\$)	450	933.42	162	321.65	0.41	86	270.03	147	490.99	0.89
Other income (\$)	215	1614.18	108	82.76	0.41	185	520.96	147	377.42	0.95
Off-farm income (\$)	696	933.42	34	321.65	0.04*	520	1683.96	201	727.76	0.62
Savings (\$)	38	624.49	44	197.84	0.84	117	491.79	10	37.53	0.43
Household debts (\$)	0	105.06	34	100.22	0.11	650	1066.44	847	1278.3	0.97

Asterisk bolded indicate a significant difference between customers and non-customers. Significant level set at p-value 0.05.

Characteristics of customers and non-customers of maize sheller services in Makonde and Domboshava districts (Table 1) showed that customers in Domboshava had larger farm area than non-customers, similar to crop sales and maize production. Customers had more area for maize production for both seasons and off-farm income than non-customers in Domboshava. Other variable had no significant differences in Domboshava. In Makonde all variables had no significant difference between customers and non-customers.

3.2 Customer's reasons for choosing service providers

Customers were asked to rank the most 3 important reasons for choosing a particular service provider to offer them services (Figure 3). In both districts, customers selected particular service providers based on trust in the service provider. Customers in Domboshava also chose the service providers because they were the only available in the area as the most important reason. Customers acknowledged that the services and prices offered by service providers were good particularly in Makonde district. In both

districts, recommendations from friends, FACASI staff and Agritex officers were regarded as minor reasons to choose service providers.

Figure 3: Customers' reasons in order of importance (Imp) for selecting service providers (SP) in Domboshava and Makonde districts.

3.3 Demand creation approaches used by service providers to obtain shelling customers

Service providers in both districts were interviewed on methods they use to find customers for maize shelling (Figure 4). In Makonde district the service providers attracted most customers by demonstrating how the sheller operates. As a new technology in the area customers could have accepted the efficiency of the machines and became willing to take the services. In both districts service providers obtained more customers after seeing the sheller operating as well as through word of mouth. To a lesser extent, awareness about shellers by the Agritex officers also influenced the service providers' business. Service providers in Domboshava never mentioned that they linked with other service providers and FACASI meeting in the business. The mostly used demand creation approaches in Makonde district included demonstrating how the shellers work, visibility in the community and through word of mouth by neighbors. Service providers in Domboshava confirmed that business cards and visibility in the community were mostly used to business.

Figure 4: Demand creation approaches used by service providers in finding customers.

Stars represent the mostly used demand creation approaches.

3.4 Social networks

Figure 5 summarizes the social network of the Domboshava service providers for the growing season of 2016. There were four service providers operating in the district with 97 ties for the whole ego network. There are few actors and customers in the network. The relationships between service providers, customers and other respondents are based on formal and informal contacts. Frequencies of communication among actors were either weekly, monthly or few times a year. The highest performing service provider offered services to 12 customers while the lowest service provider gave services to two customers. The highest performing service provider had the biggest shelling capacity of 25 tons per day and he is also an Agritex officer in the district. The lowest performing service provider had a small shelling capacity of 3 tons per day. Only one service provider communicated with local leaders in the district for agriculture information. Out of four service providers, one was a female service provider who offered services to 8 customers with a small shelling capacity. A total of 26 customers received maize shelling services from Domboshava service provider.¹

¹ SP represents service provider, Cust - customer, FAC - FACASI staff, Ext - Agricultural extension officer, Friend - SP friend, Leader - local leader, Ext SP - external service provider

Figure 5: Visualization of the social network of service providers for maize shelling in Domboshava

The social network of Makonde service providers (Figure 6) show that there were 10 service providers operating in the district. Makonde district is a higher performing agricultural area compared to Domboshava. Hence it is more productive and more farmers are producing maize. There are more actors and customers in the network. The relationship between service providers, customers and other respondents are based on formal and informal contacts. Frequencies of communication among actors were either daily, weekly, monthly or few times a year. The highest performing service provider had 18 customers operating with the highest shelling capacity of 25 tons per day. The second largest performing service providers were youths operating with a medium shelling capacity of 12 tons per day. Nevertheless, the majority of service providers operated the business with small shellers with a capacity of 6 tons per day. On average most of them received total revenues of less than \$200 from maize shelling business. The least performing service provider offered services to two customers. The total network had 203 ties. Overall, 70 customers received maize shelling services by service providers in the district.²

²Ext SP represent External service provider, SP – Service provider, Cust - customer, FAC - FACASI, Ext - Agricultural extension officer, Leader - local leader, Dealer - sheller dealer, friend - SP friend,

Figure 5: Visualization of the social network of service providers for maize shelling in Makonde

3.6 Network metrics

A comparison of business performances and centrality measures of service providers was done (Table 3). On average the costs of shellers were higher in Domboshava than those in Makonde district but there were no significant differences ($p>0.05$) between the costs. There were no significant differences on the average number of customers offered shelling services. Makonde service providers had higher average total earnings but there were no significant differences. On average the total amount shelled per service provider in Makonde district was higher than in Domboshava, however there were no significant differences. There were no significant differences on the sheller capacities between districts. The average total ties of service providers were slightly different and had no significant differences. Betweenness centrality and closeness centrality were significantly larger in Makonde ($p<0.05$). However, degree centrality had no significant differences between districts. The sample sizes in both districts were relatively small and that could be the reason of no significant differences.

Table 2: Business performances and network metrics of service providers between districts

	Domboshava		Makonde		
	Mean	Std. Dev	Mean	Std. Dev	Sig.
Sheller cost(\$)	555	963	348	623	0.32
Customers No.	6.3	4.6	6.6	6.1	0.46
Earnings(\$)	166	168	304	322	0.22
Tons Shelled(t)	12.3	13.9	25	28.1	0.21
Sheller cap(t)	9.3	10.6	8.2	6.3	0.41
Total ties	21.5	11.7	20.3	10.7	0.40
Degree	12.8	4.6	13.7	5.8	0.39
Betweenness	102	42	553	306	0.007*
Closeness	76	5	204	79	0.004*

Asterisk bolded indicate significance level between districts. Significant level set at p-value 0.05.

Table 3: Correlation of business performances and centrality measures for service providers

The white cells indicate no significant correlation ($P > 0.05$), red in negative and blue is positive correlation ($P < 0.05$).

Results show that there was no significant difference ($p > 0.05$) between districts on total earnings of service providers. However, it was noted that the mean earnings for Domboshava were lower than Makonde district. Total earnings increased with increasing number of customers ($p < 0.001$) and higher degree centrality ($p < 0.01$), and these relations the same for both districts (non-significant interactions with the factor District, $p > 0.05$). The service provider with the highest total income recorded \$949 and was from Makonde district. The service provider with the least total income recorded \$55 in Makonde district as well. The highest earner had 18 customers whilst the least earner had two customers (Appendix A3).

The sheller capacity was positively related to total earnings ($p < 0.001$). Service providers with high shelling capacities earned more income than those with low shelling capacities. This relation was stronger for service providers in Makonde than in Domboshava, as indicated by the significant interaction ($p < 0.05$). The districts were significantly different in network density (Figure 7).

Figure 6: Total earnings in relation to network degree and sheller capacity(t)

Table 4: ANOVA results for relations on business performances and network metrics for service providers

Response variable: total earnings	p-value
District	0.25
Degree centrality	0.002*
District and Degree	0.72
Number of customers	0.0005*
District and number of customers	0.45
Sheller capacity(t)	0.0009*
District and sheller capacity	0.05*

Asterisk bolded indicate significance level at p-value 0.05. Combinations of factors show the interaction effect while single factors show the main effects.

3.7 Network densities for districts

Regarding the network densities, Domboshava had higher network density than Makonde district. This means that on average, Domboshava service providers had more information contacts connected with compared to Makonde service providers. However, it is shown that in Makonde there is more variation network is more than in Domboshava.

Figure 7: Box plots for Network Density of service providers between districts.

4. Discussion

This section discusses the findings on the characteristics of customers for maize shelling and non-customers, the demand creation approaches used by service providers in boosting business and the social networks for service providers. Sheller services adoption differed between districts with more customer adopters in Makonde district than in Domboshava. The business performance for service providers were based on trust from their clients. The mostly used demand creation approaches by service providers were mainly through seeing shellers operating in the community and performing demonstrations on how the machines operate. When comparing the densities of network between two districts, Domboshava had had higher network density than in Makonde. This implied that on average service regardless of their number had more frequent contacts enhancing denser network. However, the sample size of the research was too small which thus could not be a true representative of results.

In Domboshava there were significant differences ($p < 0.05$) in crop sales, number of hectares grown and maize production between customers and non-customers. The differences may perhaps be because customers in both districts customers had more land than non-customers hence could have grown more crops for sale. This could encourage them to use maize shellers than non-customers. Farm size could have a positive effect in adopting maize shelling services to reduce labor bottlenecks. Studies have shown that farmers with more land are likely to encounter labor shortages and are cited as possible reasons for their willingness to take up services (Kassie et al., 2011). Research has further shown that farm size is an indication of the level of economic resources available to smallholder farmers and chances to accept improved technologies increases as this resource base increase (Polson and Spencer, 1991). The capability of farmers to use services could be influenced by numerous household and socioeconomic characteristics such as capital, land, other assets and livelihood options (Benin et al., 2013).

There were no significant differences in the education level of customers and non-customers in both districts. Thus the hypothesis was not confirmed. The use of shelling services was not influenced by the education level of farmers. Previous research confirmed that education increases the technical efficiency of a person and promotes better information from various sources about the uptake of new services (Panin and Brümmer, 2000). In addition, research has shown that early adopters of new services are more educated compared to late adopters who are hesitant to take up new services (Abass et al., 2014; Adrian et al., 2005; Mwebaze and Mugisha, 2011). Despite other factors which had significant differences between customers and non-customers there is need for awareness of maize shelling services so that many can benefit from it.

Service providers used several demand creation approaches which influenced their businesses. In both districts service providers obtained more customers through seeing the shellers operating which corresponded with the hypothesis. Social network as noted by Quisumbing and Pandolfelli (2010) is very important as farmers learn and examine from others in the neighborhood about the suitability and efficiency of new agricultural production methods. Customers made neighbors aware of shellers, hence they became interested to get shelling services. This is in line with previous research that farmers with higher levels of social capital and with neighbors who adopt the technology gather more information and accept the services much quicker (Isham, 2002). Farmers are important agents of farming services because

if they assess the characteristics of the service they usually pass information to other farmers (Adesina and Baidu-Forson, 1995).

Demonstrations on how the shellers operate were performed particularly in Makonde district. There were positive effects on the shelling capacity which influenced shelling volumes and total earnings by service providers between districts. Those operating with bigger shellers performed better and earned more income compared to those with small shelling capacities. Nevertheless, most service providers operated far below their maximum. It should be noted that since most shellers were available later in the season when most farmers had already shelled the maize, shelling business was relatively low. Awareness rising by agricultural extension officers on the availability of shellers in the area influenced the business performance of service providers to a lesser extent. Previous research conducted in Niger and Burkina Faso to evaluate the uptake of triple bag storage of cowpeas was positively influenced by an extension programme thus proving the effectiveness of extension on technology diffusion (Moussa et al., 2009). Government departments have to create synergies with non-governmental organizations (NGOs), local communities and donors in enforcing programs that support smallholder farmers' adoption of agricultural services which can promote agricultural production (Nkonya, 2004; Rosegrant et al., 2002; Masasi, 2015). Small shelling capacity shellers were less durable which compromised their performances. There is a need to upgrade these shellers if service providers are intending to remain in business.

In Makonde district customers particularly chose a certain service provider based on trust. This correlated with previous research that aspiring service providers should be open to technology, with a good reputation to farmers surrounding him (Sims and Kienzle, 2015). Stakeholders develop reputations of trustworthiness that may become essential information for other players in the network as trusting rapport build inside a network (Tsai and Ghoshal, 1998). In Domboshava the most important reason for choosing service providers was because they were the only available in the area. Domboshava is a peri urban area where horticultural production is the main activity rather than maize production. In this regard, there are few service maize providers as people mainly resort to hand shelling. It may perhaps also be because farmers were still unconvinced about mechanical shelling therefore service providers and agriculture extension officers could meet farmers to explain the benefits of mechanical shelling. Studies have shown that any innovation process in the agricultural sector includes learning and most learning is through extension (Collier and Dercon, 2014; Masasi and Ng'ombe, 2019). Jenny (2010), argued that assessing the impact of extension services generally depends on measuring the correlation between interventions and farmers' knowledge, productivity and the adoption rate thus making it complex to measure the impact of agricultural extension programs.

In both districts customers selected particular service providers because they felt that they were offered good services. For service providers to maintain good reputation with farmers, specific quality requirements have to be met and must build up the skills required to make the business financially sustainable (Adebayo et al., 2010; Sims and Kienzle, 2015). For service providers to deliver quality services to customers they should be part of the network, with access to knowledge and training and should be aware of their potential clients (Sims and Kienzle, 2015). It would also be beneficial to customers if service providers give extra services such as bagging and sealing of bags so that the maize would be ready for storage. This encourages good relations between service providers and their clients.

The social network in both districts showed that better performing service providers were more connected with customers and other actors than lower- performing service providers. Literally, there are significant correlations between total earnings and the centrality of the service providers in the information network in particular to degree centrality. It was also shown that higher performing service providers had higher degree centrality than lower performing service providers (Table A2 and A3 in Appendix A). It could be argued that the aggressiveness of the higher-performing service providers towards business impacted their performance and their position in the social network. The social network of other higher performing service providers included sheller dealers, local leaders and agricultural extension officers showing the diversity of information access. Studies have shown that those with diverse relations may be in a better situation to face vulnerability as diversity in a social network may open access of new information and increase adoption of technology (Cadger et al., 2016). The network density was higher in Domboshava than Makonde district. This showed that on average service providers in Domboshava had more frequent contacts with other actors in the network regardless of their number. This may possibly because one the service providers was an agricultural extension officer who had had more information contacts through extension services. The influence of an actor within social network depends on one's position and may have implications on how the information flows (Burt, 2004). In addition, a female service provider had more frequent contacts with other actors through social gatherings such as church and could have increased the average network density for service providers.

There were significant differences between districts in terms of earnings and the number of customers. This might be because some higher-performing service providers only targeted few customers with more maize thus resulting in more profit. Some higher performing service providers confirmed that they travelled out of their locality where shellers were not available to offer services. This showed the competitiveness of service providers in boosting their business. Service providers could also increase their network over time through awareness on social gatherings such as churches, field days and political gatherings for the services to be acknowledged by many people. Research conducted in Kenya have shown that farmers have acquired most of their information pertaining technology from schools and churches (Davis et al., 2004). Regardless of whether information was coming from service providers or other stakeholders including local leaders, there was a balance of both informal and formal sources of information within the networks. Studies have indicated that the strength of ties linked with local leaders and other clients' relations may actually drive some tie balance (Granovetter, 1973; Hansen, 1999). Participants are able to apply influences over others in the network if they are occupying certain central positions in the social network and may have access to useful information which can benefit them (Burt, 2004). Degenne and Forsé (1999), indicated that the number of ties a participant holds with regards to degree centrality has been shown to have positive effect on that participant's influence.

5. Conclusion

This paper evaluated the social network of service providers in their business performance. As an analytical tool, social network analysis increased the understanding of variability in the business performance for service providers in 2016 shelling season with significant correlations on many variables. Higher performing service providers were in Makonde district compared to Domboshava with the majority operating with medium sheller capacities. The major findings showed that social network in particular to degree centrality was highly correlated to total earnings and the sheller capacity (which determined tons shelled). This enhanced the profitability of higher performing service providers as this influenced the number of customers. This also influenced their position in the social network. The major factor which contributed to successful business performance was the capacity of shellers. Nevertheless, most service providers operated below full capacity since the shellers were available to farmers late in the season while most farmers had already shelled their maize. Service providers enhanced their business competitiveness through demonstrations on sheller performances, awareness from neighbors and also basing on trust from the customers. Even though little awareness was conducted by FACASI staff and the extension officers this season they could be influential in strengthening networks for business competitiveness of service providers. Therefore, identification of central players in the network such as the agricultural extension officers is imperative to out scale the uptake of shelling services. Network density was varied with Domboshava having higher density than Makonde district. For increased uptake of services denser networks may have a relative advantage for the passing of information. This will both benefit the service providers in boosting the business as well as farmers reducing labor drudgery and save on time. Maize shelling services are quite important to farmers; hence service providers should target farmers with maize quantities which suit their capacities to fully utilize the shellers. Future recommendations would be assessing the average yield of maize in a particular area and assess if farmers are in need of shellers and advice service providers to buy shellers which suit the average maize volumes in a particular area.

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Appendix A – Tables

Table A1: Demographic characteristics of service providers in Domboshava and Makonde districts (n=14).

Characteristics	Domboshva Frequency	Percent	Makonde Frequency	Percent
Service Provider	4		10	
Service Providers Sex				
Male	3	75	10	100
Female	1	25	0	0
Service Provider Age				
26-40yrs	1	25	3	30
41-60yrs	1	25	6	60
>60yrs	2	50	1	10
Service Provider Education				
Primary	1	25	0	0
Secondary	1	25	8	80
Diploma+	2	50	2	20
Shelling Income				
<\$50	1	25	0	0
\$50-\$100	1	25	4	40
\$101-\$200	1	25	2	20
>\$200	1	25	4	40

Table A2: Business performances and network centrality measures for Domboshava service providers.

SP	Custom ers	Earnin gs (\$)	Tones Shelled	Sheller Type	Sheller Capacity (t/day)	Days at full Capa city	Degr ee	Between ness	Closen ess	Densit y
1	12	405	32.5	Grownnet big	25	1.3	18	134.9	72	0.137
2	8	158	10.45	Double Cob	6	1.7	15	136.7	78	0.143
3	3	57	3	Single Cob	3	1	10	50.2	82	0.200
4	2	42	3.3	Single Cob	3	1.1	8	86.7	73	0.357

Table A3: Business performances and network centrality measures of service providers in Makonde district.

SP	Customers	Earnings (\$)	Tones shelled	Sheller Type	Capacity(t/day)	Days to Full Capacity	Degree	Betweenness	Closeness	Density
1	18	949	83.8	Big Grownnet	25	3.3	22	378.7	241	0.087
2	9	690	57.5	Small Grownnet	12	4.8	14	279.7	56.5	0.143
3	17	577	44.55	Double Cob	6	7.4	26	1321.	230	0.031
4	5	316	26.4	Double Cob	6	4.4	13	586.2	211	0.231
5	4	150	13.5	Double Cob	6	2.3	11	464.0	250	0.109
6	4	112	10	Double Cob	6	1.7	10	351.2	252	0.156
7	3	72	3.5	Double Cob	6	0.4	11	564.0	249	0.091
8	2	60	5	Single Cob	3	1.7	13	770.2	245	0.077
9	2	60	1	Double Cob	6	0.2	9	478.1	252	0.111
10	2	55	4.7	Double Cob	6	0.8	8	337.7	57	0.179

Appendix B –Figures

FigureB1: Reasons for using manual shellingby non-adopters in Domboshava

Figure B2: Reasons for using manual shelling by non-adopters in Makonde district

Figure B3: Visualization of the social network for service provider 1 in Domboshava

Figure B4: Visualization of the social network for service provider 2 in Domboshava

Figure B5: Visualization of the social network for service provider 4 in Domboshava

Figure B6: Visualization of the social network of service providers for maize shelling in Domboshava

FigureB7: Visualization of the social network for service provider 1 in Makonde district

Figure B8: Visualization of the social network for service provider 2 in Makonde

Figure B9: Visualization of the social network for service provider 3 in Makonde district

Figure B10: Visualization of the social network for service provider 4 in Makonde district

Figure B8: Visualization of the social network for service provider 5 in Makonde district

Figure B9: Visualization of the social network for service providers 6 in Makonde district

Figure B10: Visualization of the social network for service provider 7 in Makonde district

Figure B11: Visualization of the social network for service provider 8 in Makonde district

Figure B12: Visualization of the social network for service provider 9 in Makonde district

Figure B13: Visualization of the social network for service provider 10 in Makonde district

Figure B14: Visualization of the social network of service providers for maize shelling in Makonde district