Scientific Research Publishing

Social Networking, 2023, 12, 93-110
https://www.scirp.org/journal/sn
ISSN Online: 2169-3323
ISSN Print: 2169-3285

Local Trade Networks among Farmers and Traders

Abdul-Samad Abdul-Rahaman[1], Patience Pokuaa Gambrah[2*]

[1]Department of Mathematics and Statistics, Tamale Technical University, Tamale, Ghana
[2]Department of Mathematical Sciences, Kumasi Technical University, Kumasi, Ghana
Email: siraras97@gmail.com, *patience.pgambrah@kstu.edu.gh

How to cite this paper: Abdul-Rahaman, A.-S. and Gambrah, P.P. (2023) Local Trade Networks among Farmers and Traders. *Social Networking*, **12**, 93-110.
https://doi.org/10.4236/sn.2023.124006

Received: July 22, 2023
Accepted: September 3, 2023
Published: September 6, 2023

Abstract

Both farmers and traders benefit from trade networking, which is crucial for the local economy. Therefore, it is crucial to understand how these networks operate, and how they can be managed more effectively. Throughout this study, we examine the economic networks formed between farmers and traders through the trade of food products. These networks are analyzed from the perspective of their structure and the factors that influence their development. Using data from 18 farmers and 15 traders, we applied exponential random graph models. The results of our study showed that connectivity, Popularity Spread, activity spread, good transportation systems, and high yields all affected the development of networks. Therefore, farmers' productivity and high market demand can contribute to local food-crop trade. The network was not affected by reciprocity, open markets, proximity to locations, or trade experience of actors. Policy makers should consider these five factors when formulating policies for local food-crop trade. Additionally, local actors should be encouraged to use these factors to improve their network development. However, it is important to note that these factors alone cannot guarantee success. Policy makers and actors must also consider other factors such as legal frameworks, economic policies, and resource availability. Our approach can be used in future research to determine how traders and farmers can enhance productivity and profit in West Africa. This study addresses a research gap by examining factors influencing local food trade in a developing country.

Keywords

Local Trade, Social Network Analysis, Food Trade, Exponential Random Graph Models (ERGM), Food Security

1. Introduction

There has been gradual increase in farmers quitting farming [1], as farmers cannot maintain rapid economic growth with increased farm capital and labor costs. Thus, the government of Ghana implemented programs and policies (e.g., Planting for Food and Jobs Program [2] and fertilizer subsidy program [3]) to promote farmers' growth and productivity by strengthening selected crops, improving job creation, and enhancing profit. However, these programs focus on farmers while ignoring local traders who purchase harvested crops. Thus, the programs are unsuccessful in the long term. Most small and medium-size farmers in developing countries such as Ghana have weak capacity to stimulate independent trade [4] or access accurate information on innovation and new methods for farm upgrading and transformation [5]. Local and rural-urban resources and technological assets are distributed unequally [6].

To benefit from other locations' resource distribution, innovation efficiency, and development, diffusion of knowledge among farmers is vital [7] [8]. Therefore, continued growth in local trade and information sharing is necessary for locations' industrial and innovation development. Local trade occurs between locations in the same country—domestic trade by local people. Analyzing network patterns and factors influencing local trade and information network development is important because local trade contributes to food security significantly [9] and helps Ghana's sustainable economic growth. This could be a basis for other developing countries where current informal trade networks need to be recognized and improved to enhance food security [10].

However, most existing research focused on improvement in regional and international trade [11] [12] and numerous dyadic characteristics and actor attributes that influence tie creation among entities. In contrast, we assess factors affecting local food trade in Ghana. The aim is achieving the second United Nations Sustainable Development Goal of Zero Hunger [13]: achieve food security, end hunger, enhance nutrition, and stimulate sustainable agriculture.

In developing countries such as Ghana, inefficient distribution systems and neglect of the agricultural sector led to food demand exceeding its supply. Postharvest losses, low productivity, poor infrastructure, high transportation costs [14] and market systems, which are controlled privately without suitable official support systems [15], hinder Ghana's goal of self-sufficiency. Changing dietary patterns, predominantly urban population growth [16], and low productivity of householder farmers [17] have led to rapid increase in food imports. This situation can be addressed through trade with proper restrictions and policies to increase farmers' access to profitable markets. Most studies [17] [18] addressing these challenges focused only on farmers ignoring traders who purchase harvested products from farmers, causing a gap in the literature, which this study addresses. This is because, stimulating trade and information sharing can improve local- and national-level food security, thus enhancing economic growth.

Previous studies on farmers and traders in Ghana emphasized consumer

marketing or direct retail to maximize farmer/trader profits and consumer benefits. [19] studied business processes of cocoa traders, cocoa farmers, and Ghana Cocoa Board in the cocoa supply chain and underlying information technology systems. [20] examined tomato marketing in Ghana, focusing on linkages between farmers, traders, and retailers. [21] examined Ghana's cowpea markets to find out the costs and benefits of different market outlets as well as factors influencing farmers' decisions. [22] explored how women trader associations' activities in Ghana's rural market affect smallholder farmers' agriculture product marketing. [23] examined the discrepancies in perceived risk relating to vegetables in domestic urban markets among consumers, farmers, and traders, and tried to quantify subjective risk judgments on food safety hazards. [24] studied the formation of trust between farmers, traders, and producers of agricultural inputs and the role of working relations, customer friendships, and pre-existing networks in the process. [25] Analyzed potential challenges that may be encountered when taro is produced and utilized in Ghana's taro-producing areas by considering the perspectives of farmers, traders, and consumers.

Nonetheless, these studies ignored the factors that are critical to enhancing food security through the network of farmers and traders. They mostly considered one particular crop, specific area, or areas where the crop was marketed or planted; this could not comprehensively represent farmers and traders. Therefore, we comprehensively examine factors influencing the links between farmers and traders who trade in different crops, which could enhance productivity and ensure food security.

We follow [26] who studied a network of traders and farmers in villages sharing livestock markets. However, we focus on the network of farmers and food-crop traders. Following other studies claiming trade is a part of social networks/connectivity [27] [28], we concentrate on purchasing of food-crops in an informal process found among Ghana's traders and farmers. Since reliable data concerning local trade and information sharing in Ghana are difficult to obtain, we used social network techniques to examine the network's fundamental features and analyzed factors affecting its development using relational data.

We establish an exponential random graph model (ERGM; [29] [30]), select the best model, and test our hypotheses. Our proposed approach has the following advantages. First, compared with present statistical methods, ERGM incorporates endogenous and exogenous structural effects to systematically examine the factors affecting network formation. Second, compared with earlier longitudinal studies that analyzed networks' spatial configurations based on their cross-sectional flows, ERGM considers changes in current variables and linkages to examine development of the network's dynamic features. Applying statistical methods, the factors affecting development of the network for local trade and information sharing can be divided based on exogenous and endogenous structural effects [30].

Further, it tests whether local processes yield global network attributes [30].

Other studies used ERGMs to analyze issues disturbing a number of networks, like food network development [31], development of some processes [32], optimization of networks involving partner selection network, and many others. However, ERGMs have not been used to analyze the development of local trade networks in Ghana.

2. Materials and Methods

2.1. Data Acquisition

Our primary network data were obtained from farmers and traders in 3 locations in Ghana through questionnaire administration. Both non-probability and probability selection procedures were used to select the locations. First of all, a survey was conducted at the selected locations' local markets to gather data on the foodstuffs bought directly from farmers and the quantity of each crop being sold by farmers and traders. The survey was also used to assess the current prices of the foodstuffs in comparison to the prices farmers were receiving from traders, allowing for a more accurate understanding of the local market dynamics. After that random sampling was used to select traders for the study's interviews. By conducting interviews, we were able to gain a deeper understanding of the local market dynamics, as well as the process of buying from the farmer's location to the market center. After the interview with the traders, the farmers were consulted for their interviews. The farmers were asked about their experiences in the market, their strategies for selling their produce, and the obstacles they faced in the market system. This allowed us to gain an in-depth understanding of the dynamics of the local market. Random sampling was used to select traders who were then asked to connect us with farmers from whom they buy foodstuff. Since it takes a while to build social capital, traders and farmers who were connected for at least two years were considered. Most of the farmers were mentioned by different traders; therefore, 6 farmers from each location were considered. Some of them were intermediaries who also bought from other farmers; however, since they were farmers themselves and stayed in villages, we categorized them as farmers. Through questionnaire-based interviews, traders and farmers were asked about their social relations, structure of trading activities, and whether they get information concerning farming practices and improved innovative ideas from each other.

In all, 18 farmers and 15 traders were included in the study. We considered trade in foodstuff only because cash crop products have designated places and buyers who are readily available to buy. Thus, most cash crop markets are not a problem for farmers. The 18 farmers and 15 traders were selected through a process of random sampling, which is a technique used to select a representative group of people from a larger population. This method of random sampling makes sure that the sample group is made up of individuals who are statistically representative of the larger population, producing results that are accurate and trustworthy. This is due to the fact that it removes any selection biases, enabling

the researcher to ensure that the sample group truly reflects the demographic make-up of the larger population. Furthermore, since the sample group is not influenced by subjective factors, it also lowers the likelihood of inaccuracy. The random sampling procedure made sure the chosen farmers and dealers represented a representative sample of the local populace. This makes it easier to confirm that the study's findings are reliable and can be applied to a larger population. This is especially important in this case, as the results of the study will be used to inform policy decisions on the agricultural sector in the region.

2.2. Network Construction

This network involves farmers and traders collaborating for collective gain as regards routines, rules, practices, and supplies benefiting both to enhance trade within the locations; this also results in farmers' enhancing their productivity. The network "nodes" are both traders and farmers within locations where traders buy food products from farmers. The "ties" result from their collaboration to sell (farmers) and buy (traders) the products. Thus, individual farmers are related to traders linked through trade of the farmers' products.

The traders and farmers' relationships indicate their activities and wealth within the local trade network, personal abilities and inabilities, and relevance. This connection is determined by not only the single farmer but also attributes of the farmer's location. Thus, traders consider the characteristics of locations they wish to trade in before choosing the farmer. This challenges farmers to be more productive and recognize the need to participate in innovation and trade. Accordingly, we conceptualize that attributes of the farmer, trader, and their locations can explain their relation in a local trade network.

2.3. Descriptive Statistics

We calculated basic statistical information about the network (**Table 1**). The density coefficients (0.1259) indicate a well-connected network. This means that for any two nodes in the network, there is a high probability of a link between them. This indicates that the network is well-connected and efficient when it comes to trading. The mean of 4.0303 (standard deviation = 1.5509), meaning the network is well connected with no isolated nodes (**Figure 1**) which is also consistent with the network density. This highlights the effectiveness of the network, as connectivity among its nodes allows for a much smoother flow of information and resources. The network does not appear to be reciprocated (16 out of 133 links are mutual), nor are there any triangles (transitivity = 0.0060). There is an unbalanced connection between the nodes, where they send links to one another, but do not necessarily receive it back. Resources and information flow effectively through this network structure, but mutual benefit and trust may not be guaranteed. As a result, the network's strength can be seen by its high degree of connectivity, which was evidenced by no isolated nodes and a low reciprocity and transitivity.

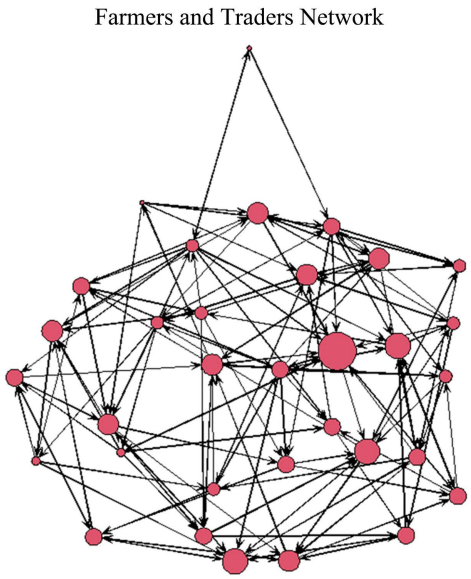


Figure 1. Network structure.

Table 1. Network statistics.

Variable	Estimation
No. of ties	133
Vertices	33
Density	0.1259
Mean	4.0303
Sd	1.5509
Degree centrality	0.1653
Betweenness centrality	0.0686
Closeness centrality	0.1559
Mutuality	16
Transitivity (triangles)	0.0060

2.4. Node Centrality

In a network, node centrality [33] indicates how important a node is. Nodes are rated based on how many connections they have to other nodes as well as how strong those connections are. By analyzing how the nodes are connected, we can gain a greater understanding of the network's structure, which provides insight into its dynamics. A node's centrality is a crucial factor for the ERGM since it influences both the sender and receiver statistically. In this way, understanding the centrality of nodes can provide valuable insight into how networks function. Based on the node centrality, farmers and traders can be informed about their role in the network based on the inflow and outflow of the links. It has the following components:

Inflow centrality:

$$\sum_{i=1}^{n} w_{ji}\,, \tag{1}$$

Outflow centrality:

$$\sum_{j=1}^{n} w_{ij}\,. \tag{2}$$

Node centrality can locate the most influential farmer or trader (**Figure 1**) as it indicates actors with high impact and control within the network.

2.5. Hypotheses Formulation

We now discuss different attributes and structural effects influencing local trade network. We formulate our hypotheses in line with various aspects of the attributes and structural effects to serve as a guideline for future studies.

Although network creation is influenced by dyad- and actor-specific features as those mentioned earlier, it involves larger social processes such as effects compelled by internal focal network processes [34]. There is a positive correlation between size of an initial trade network and formation of new trade linkages, where creation of these networks in a particular place depends on the partners' trade network [35].

Reciprocity is the most basic but vital propensity in relational collaboration [36]. The direction and number of an actor's link can influence the network structure. Popularity Spread demonstrates correspondence to the familiar "Matthew effect" [37] in social science where an already-popular actor becomes even more popular—"the rich get richer". For example, in an inter-organizational network, companies with many widespread cooperation links are likely to participate in impending coalitions, thus promoting their attractiveness and visibility as prospective partners. Similar links might be created by actors actively trying to find new network connections, known as Activity. Past studies revealed that dyad-specific features are significant elements prompting link creation and development. Based on existing research [29] [38], we consider the factors affecting network development (*i.e.*, endogenous and exogenous effects). Accordingly, we propose the following hypotheses:

Hypothesis 1: Foodstuff trade among farmers and traders is characterized by Activity Spread, Popularity Spread and multiple connectivity.

Hypothesis 2: Local food trade connections among farmers and traders will show reciprocity. Prior studies revealed that knowledge transfer effectiveness improves when a reciprocity factor influencing it exists and is affected by the rational economic reciprocal enterprise environment. This indicates that these networks tend to be impacted by some features of reciprocity. Similar to the African concept of Ubuntu [39]—referring to a life of hospitality, compassion, reciprocity, dignity, and mutuality that invokes the need to help others—the links provide the feeling of collectiveness and tend to influence reciprocity.

Hypothesis 3: Higher production by farming locations enhances network development. Productivity level is an essential factor within trade transfers [10].

Hypothesis 4: Good transportation systems in locations influence network development. The transportation of food to other locations is a major component of trade. Thus, good transport systems enhance the continual transfer of food to and from locations.

Hypothesis 5: Trade experiences of an actor (farmer/trader) promote local food trade. Prior studies (e.g., [40]) revealed that historical experience is vital in choosing trade partners. Thus, we investigate whether trade experience influences local food trade.

Hypothesis 6: A location's market openness effectively promotes local food trade. Market openness means a free market that all actors can access, unlike closed markets that are dominated by oligopolies or monopolies and have requirements/conditions preventing entry of actors. Market openness signifies the levels of both openness and competence of a location as regards trade within its locality. [11] identified a positive effect of market openness to international trade on developing countries' growth.

Hypothesis 7: Geographical proximity among locations impacts network development. Previous studies [41]; suggested that geographical proximity among entities greatly influences trade. Accordingly, we consider that local trade is related to geographical proximity, which in turn affects network formation (**Table 2**).

3. Results

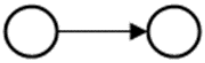
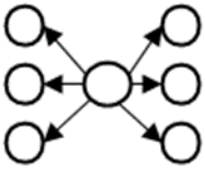
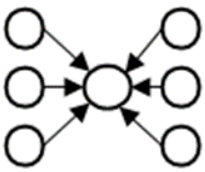
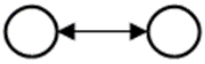
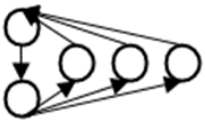
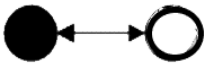
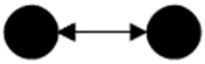
3.1. Statistical Dependence Assumptions and Framework

The ERGM takes the following form:

$$P_r\left(X_{ij}=x\right)=\frac{1}{k}\exp\left[\sum_A n_A z_A\left(x\right)\right] \tag{3}$$

Thus, X_{ij} represents the random variable having linkage with actors i and j (if there exists a tie between i and j, $X_{ij}=1$, otherwise $X_{ij}=0$). We use an adjacency matrix $n\times n$ (n represents the number of actors) to represents these tie formations, and it is denoted by X, while x represents the matrix within the network of recognized links. Since we deal with directed graphs, the ties (arcs) $X_{ij}\neq X_{ji}$. Moreover, A denotes the different types of network configurations. $z_A\left(x\right)$ represents covariates in the model, representing sets of network statistics of A, conjectured to influence the probability of forming the network and calculated on x. We substitute $z_A\left(x\right)$ with $z_A\left(x,P\right)$ in Equation (3) to modify it to additionally accommodate the P information's covariate as a dyad-specific feature. The n_A coefficients are parameters that are unknown but expected; they indicate the consequences of the network statistics incorporated into the model of the observed network. The above equation could likewise be written as the conditional log-odds (logit) of single links.

Table 2. Summary of estimation variables used in the study.

Parameter	Configuration	Social Process	Statnet Term	Hypothesis
Arc		Reference point for the tendency of linked tie formation	edges	
Activity Spread		Trend for degree variation in which trader 1 from location A is linked with multiple farmers from different locations (a trader is very popular among a lot of farmers in different locations)	gwodegree	Hypothesis 1
Popularity Spread Spread		Trend for degree variation in which farmer 1 in location A is mostly linked to multiple traders from different locations (*i.e.*, the farmer is very popular among many traders)	gwidegree	Hypothesis 1
Reciprocity		Tendency of farmer 1 from location A to invite trader 1 from location B to have trade ties, and vice versa	mutual	Hypothesis 2
Multiple Connectivity		Propensity for formation of multiple two-paths joining farmers and traders in an interconnecting network	gwdsp	Hypothesis 1
Node Attributes (Higher Producer, Transportation, Open Market, and Trade Experience)		Tendency of locations having unique qualities that traders are attracted to or make them comfortable to trade with farmers from those locations (Higher Producer, Good Transportation, Proximity to the Trader, Open Market, and Trade Experience)	nodecov and nodefactor	Hypothesis 3 (Higher Producer) Hypothesis 4 (Good Transportation) Hypothesis 5 (Trade Experience) Hypothesis 6 (Open Market)
Homophily (Proximity)		Tendency of farmers and traders from the same locations to be connected	nodematch	Hypothesis 7

$$\text{logit}\left[P\left(X_{ij}=1 \mid n, X_{ij}^{c}\right)\right]\sum_{A} n_A \delta z_A(x) \tag{4}$$

where X_{ij}^{c} represents the network that is not a singular variable X_{ij}, and δz_A denotes the extent to which z_A varies as X_{ij} changes from *0* to *1*. X_{ij}^{c} is used in the equation to denote how the ERGM clearly accepts interdependent observations by using X_{ij}^{c} as a mutual dependence of ties.

3.2. ERGM Fitting

After the ERGM was constructed, the Markov chain Monte Carlo maximum likelihood estimation (MCMC-MLE) technique was applied to estimate the parameters and variables. Then, goodness-of-fit was employed to test the model for the hypotheses [30]. Statnet software [29] was used to run our data for hypotheses testing.

We choose GW (Geometrically weighted) outdegree, GWGW (Geometrically weighted) indegree, and GWDSP as endogenous variables for the first hypothesis. GW outdegree and GW indegree indicate network Activity Spread and Popularity Spread, respectively [42]. The exogenous variables' values indicate the locations' tendency to have unique qualities that farmers/traders are attracted to or make them comfortable to trade with each other from those locations. These qualities are as follows:

1) Higher producer of a particular foodstuff;
2) Good transport system;
3) Proximity of the location to them;
4) Trade experience and;
5) Market openness.

To check potential detergency and examine model diagnostics, which is an issue of ERGM, we conducted an MCMC diagnostics test. The results are in **Figure 2** using the last iteration of the model. The subgraphs' right-hand side represents the histogram corresponding with the MCMC, whereas the left-hand

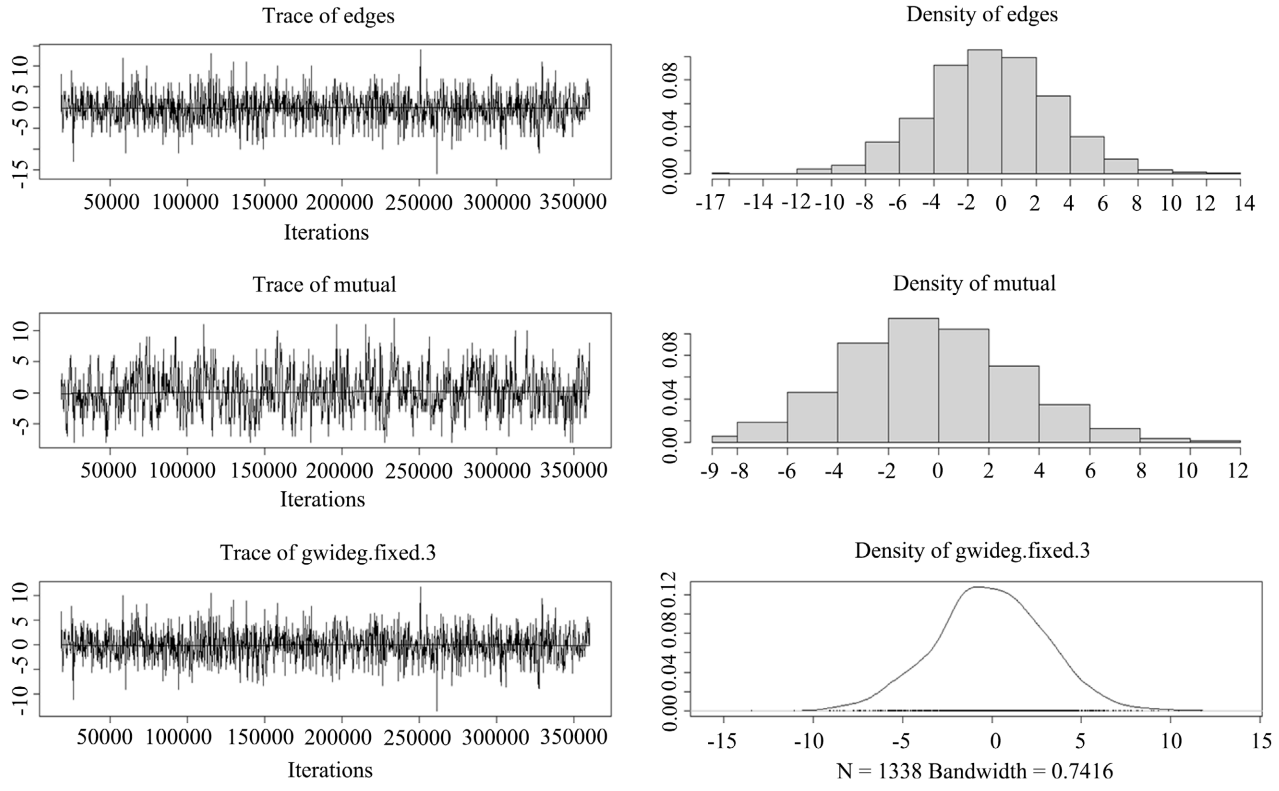


Figure 2. MCMC diagnostics test results.

side represents changes in each variable within the model's time series MCMC. Each variable has a random oscillation around 0, indicating model convergence. Thus, it is valid to use this model as it is shown to be stable.

3.3. ERGM Results

The model variables were divided into endogenous structural effects as well as exogenous relational effects. Table 3 presents the results.

3.4. Goodness-of-Fit

Goodness-of-fit was used to test the results' validity (Figure 3). It compared the stimulated and observed network based on the use of minimum geodesic distance, degree distribution, and model statistics. To interpret that the simulated

Table 3. Exponential random graph model result of the network.

Variable	Estimate	Pr (>|z|)	Significance
Edges	−14.46081	<1e−04	***
	Network structure		
Reciprocity	−0.00349	0.993145	
Activity Spread	14.26482	0.000862	***
Popularity Spread	10.99294	0.000185	***
Multiple Connectivity	−0.66289	<1e−04	***
	Node attributes		
Transportation	−0.15264	0.019341	*
Trade Experience	−0.19593	0.484899	
Open market	−0.58075	0.237908	
Higher yield	−0.80111	0.041213	*
Proximity	−0.08230	0.840292	

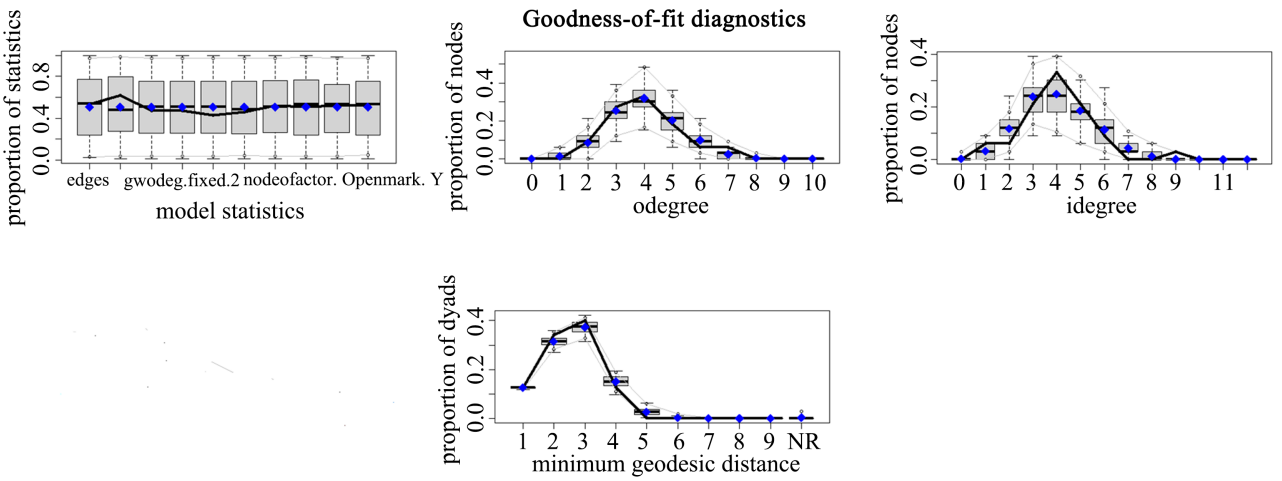


Figure 3. Goodness of fit.

network has captured the observed network's characteristics, the black lines must fall between the gray lines [43]. All graphs capture the network's characteristics very well.

3.5. Discussion of Results

Applying social network analysis, our work provided novel insights into the social networks involving farmers and traders. We found that while the edges are statistically significant ($p < 1e{-}04$), indicating that food trade among locations is comparatively high, the GWDSP is also statistically significant (<1e−04), indicating that connectivity has a great impact on network development. GW indegree and GW outdegree were also highly significant (less than 1%), indicating that both Popularity Spread and Activity Spread are strong, and their influence on network formation for food trade can be universal. This verifies Hypothesis 1, as farmers and traders with relatively high Popularity Spread and Activity Spread could have strong influence in such networks' formation, control more resources, and influence other farmers and traders.

Table 3 shows that reciprocity is not statistically significant (p value = 0.9931), that is, it is unimportant for network development. Thus, Hypothesis 2 is rejected, indicating that farmers and traders' network formation does not depend on reciprocity, although we expected that Ubuntu [39] could be applied to this situation. Ties they create in these networks are purely based on individual needs. As such, farmers are not obliged to sell to traders at disincentive prices that demotivate farmers [44]. Existence of reciprocity would have forced farmers to sell to particular traders even if the price was lower, leaving farmers with lower incentives to increase production or create market surplus.

The high production attribute of a location is statistically significant (p value = 0.0412), meaning that greater food production by the location can help network development. Thus, Hypothesis 3 is verified. This shows that traders move to locations where they can buy goods, and farmers linked with these traders are more likely to benefit from the net returns and quantity traded. This is in line with [45] who proved that villages with high yields attract traders, and demand from urban markets enhances crop expansion. This motivates farmers to be more productive and enhance crop yields.

Again, good transportation system is significant (p value = 0.0193), as it permits us to conclude that solidifying the transportation system in various locations is vital to promote network development. Thus, Hypothesis 4 is confirmed, in line with [46] who indicated that goods trade entails trade in services, among which transportation is vital.

Farmers' trade experiences within locations are not significant, reflecting an attribute with weak influence on formation of a network among farmers and traders. Therefore, Hypothesis 5 is rejected. This indicates that farmers' experience as regards trade and marketing of goods is not a determining factor for the formation of this type of network. However, some studies suggested that farmers' awareness of market demand, future prospects, warehouse facilities,

and certification benefits them [47].

Moreover, market openness is not significant, indicating that market openness in various locations is not an important driver of network development. Thus, Hypothesis 6 is rejected. This confirms the study of [48] who found that trade openness was not beneficial for the agricultural sector of Nepal, a developing country like Ghana. Thus, we confirm that trade openness does not matter for a developing country when traders and farmers engage in buying and selling. These results are also in line with [49] who argued that trade restrictions promote developing countries' growth, especially under certain conditions; this could be why network development does not depend on market openness. This result may also have appeared because this study was conducted at the local level where the central government sets rules for every location, while rules and restrictions change from country to country in international trade.

Finally, geographical proximity's impact on the network formation was not significant, indicating that it has no effect on network development. Thus, there is no homophily among farmers and traders within the same area. Therefore, we reject Hypothesis 7. This is contrary to [50], who suggested the proximity trajectory: Temporary geographical proximity creates cognitive and social proximity, which activates institutional and organizational proximity. However, in our case, traders do not consider how close a location is to the market before buying goods, in line with [26] who found that geographical barriers and distance do not determine farmers and traders' decision on where to trade.

4. Conclusions

A network of farmers and traders was constructed in 3 locations in Ghana, and ERGM was used to analyze its structural features. We examined factors influencing the relational dynamics, network structures, and node variables of network development.

Considering the open market as a factor for enhancing inter-location food trade, we did not observe a stable and sustained cooperation effect. Therefore, there was no significant impact of market openness within each location on network formation for inter location food trade as some scholars proposed [12]. The open market, however, could still play an important role in facilitating inter-location food trade, and further research in this area is warranted to identify the specific mechanisms driving the observed effects. Moreover, farmers and traders' trade experience had no impact on network formation. This implies that their social connections, not their professional experience, determined the formation of the network.

Again, since geographical proximity was not significant, its impact on local food trade is not obvious. This suggests that factors other than geographical proximity, such as higher production and transportation infrastructure availability, are more important in determining food trade patterns between locations. This highlights the need to invest in infrastructure to enable better access to markets and improve the economic environment. The implementation of poli-

cies aimed at reducing transportation costs and establishing a sustainable food system should also be considered.

Ultimately, farmers and traders traded food regularly in various locations, resulting in Activity Spread, Popularity Spread, and connectivity, but relations between them were not reciprocal. Although their ties were not equally reciprocated, trade between farmers and traders helped the spread of beneficial ideas and goods. This unreciprocated connection among farmers and traders leads to unequal power relationships, therefore traders tended to have more control over prices and terms. Due to this imbalance of power, traders were able to continue making profits while farmers received no share of the income they generated. It is therefore recommended that, local trade policies need to be made which may include controlling trade terms, establishing minimum prices for goods, and providing farmers with chances to strengthen their negotiating position. Farmers will be able to access the resources they need to grow food and make a living wage in this way. As a result, farmers could keep more of the profits from their work, which could reduce poverty and inequality. Farmers might also use their resources more sustainably and manage them better, which would help to save the environment. Farmers may then sell directly to customers, bringing down the price of food. As a result, costs may decrease, quality may advance, and a broader selection of food may be offered. We recommend the implementation of policies to encourage local trade. These policies should be strengthened, and there should be easier access to credit and technology as well. Additionally, while taking into account the larger economic and social backdrop, they should concentrate on the requirements of small-scale farmers and traders. All parties should profit from these actions as they work to promote a more just and long-lasting local food system. They should also make sure that farmers and traders have access to the resources they require for maximum profit and productivity. Finally, they should work to foster a climate of cooperation and trust among each other.

Both the global market and other local marketplaces in various nations can benefit from this study. This will enable them to comprehend the complexity of local trade between farmers and traders. By boosting the effectiveness and fairness of the market system, this might have a favorable effect on international agricultural commerce. Policymakers can create more effective strategies and policies to support sustainable commerce by knowing the local complexities. This can help local economics grow while also being advantageous to farmers and dealers.

One limitation of this study is our inability to directly monitor the interactions between traders and farmers in their dealings due to their geographic separation. Additionally, our strategy was restricted to the viewpoints of farmers and traders. Other stakeholders' opinions, such as those of policymakers, distributors, and consumers, which would have offered a different perspective on market dynamics, were not able to be included in our analysis. The research's scope was restricted to the local market and the sample size was quite small.

However, it is a positive move, and the findings of this study offer an insightful basis for additional investigation.

Acknowledgements

We are grateful to the farmers and traders for answering our questionnaires. Moreover, we would like to thank Editage (https://www.editage.com/) for English language editing.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Kazukauskas, A., Newman, C., Clancy, D. and Sauer, J. (2013) Disinvestment, Farm Size, and Gradual Farm Exit: The Impact of Subsidy Decoupling in a European Context. *American Journal of Agricultural Economics*, **95**, 1068-1087. https://doi.org/10.1093/ajae/aat048

[2] Ansah, I.G., Lambongang, M. and Donkoh, S.A. (2020) Ghana's Planting for Food and Jobs Programme: A Look at the Role of Capability in Farmers' Participation. *Journal of Human Development and Capabilities*, **21**, 161-182. https://doi.org/10.1080/19452829.2020.1745162

[3] FAO (Food and Agriculture Organization) (2015) Country Fact Sheet on Food and Agricultural Policy Trends—Ghana. FAO, Rome.

[4] Salami, A., Kamara, A.B. and Brixiova, Z. (2010) Smallholder Agriculture in East Africa: Trends, Constraints and Opportunities. African Development Bank, Tunis, 52 p.

[5] Kebebe, E. (2019) Bridging Technology Adoption Gaps in Livestock Sector in Ethiopia: A Innovation System Perspective. *Technology in Society*, **57**, 30-37. https://doi.org/10.1016/j.techsoc.2018.12.002

[6] Baffoe, G., Zhou, X., Moinuddin, M., Somanje, A.N., Kuriyama, A., Mohan, G., Saito, O. and Takeuchi, K. (2021) Urban-Rural Linkages: Effective Solutions for Achieving Sustainable Development in Ghana from an SDG Interlinkage Perspective. *Sustainability Science*, **16**, 1341-1362. https://doi.org/10.1007/s11625-021-00929-8

[7] DeLay, N.D., Thompson, N.M. and Mintert, J.R. (2022) Precision Agriculture Technology Adoption and Technical Efficiency. *Journal of Agricultural Economics* **73**, 195-219. https://doi.org/10.1111/1477-9552.12440

[8] Lokonon, B.O. and Mbaye, A.A. (2018) Climate Change and Adoption of Sustainable Land Management Practices in the Niger Basin of Benin. *Natural Resources Forum*, **42**, 42-53. https://doi.org/10.1111/1477-8947.12142

[9] Gautam, Y. and Andersen, P. (2017) Aid or Abyss? Food Assistance Programs (FAPs), Food Security and Livelihoods in Humla, Nepal. *Food Security*, **9**, 227-238. https://doi.org/10.1007/s12571-017-0655-5

[10] Yami, M., Meyer, F. and Hassan, R. (2020) The Impact of Production Shocks on Maize Markets in Ethiopia: Implications for Regional Trade and Food Security. *Agricultural and Food Economics*, **8**, Article No. 8. https://doi.org/10.1186/s40100-020-0153-5

[11] Romalis, J. (2007) Market Access, Openness and Growth. Working Paper 13048. National Bureau of Economic Research, Cambridge. https://doi.org/10.3386/w13048

[12] Yan, J. (2018) Do Mergers and Acquisitions Promote Trade? Evidence from China. *The Journal of International Trade & Economic Development*, **27**, 792-805. https://doi.org/10.1080/09638199.2018.1451553

[13] Gil, J.D.B., Reidsma, P., Giller, K., Todman, L., Whitmore, A. and van Ittersum, M. (2019) Sustainable Development Goal 2: Improved Targets and Indicators for Agriculture and Food Security. *Ambio*, **48**, 685-698. https://doi.org/10.1007/s13280-018-1101-4

[14] Arah, I.K., Kumah, E.K., Anku, E.K. and Amaglo, H. (2015) An Overview of Post-Harvest Losses in Tomato Production in Africa: Causes and Possible Prevention Strategies. *Journal of Biology, Agriculture and Healthcare*, **5**, 78-88.

[15] Behera, H.C., Kodirekkala, K.R. and Sinha, A.A. (2022) Small and Marginal Farmers' Participation in Potato Contract Farming in West Bengal, India. *Journal of Asian and African Studies*, **57**, 604-624. https://doi.org/10.1177/00219096211025074

[16] Bermudez, O.I. and Tucker, K.L. (2003) Trends in Dietary Patterns of Latin American Populations. *Cadernos de Saude Publica*, **19**, S87-S99. https://doi.org/10.1590/S0102-311X2003000700010

[17] Gambrah, P.P. and Yu, Q. (2022) Impact of Farmers' Social Relationships on Productivity: A Multiplex Network Analysis. *Journal of Complex Networks*, **10**, Article No. cnac046. https://doi.org/10.1093/comnet/cnac046

[18] Martey, E., Etwire, P.M., Wiredu, A.N. and Dogbe, W. (2014) Factors Influencing Willingness to Participate in Multi-Stakeholder Platform by Smallholder Farmers in Northern Ghana: Implication for Research and Development. *Agricultural and Food Economics*, **2**, Article No. 11. https://doi.org/10.1186/s40100-014-0011-4

[19] Ahoa, E., Kassahun, A. and Tekinerdogan, B. (2020) Business Processes and Information Systems in the Ghana Cocoa Supply Chain: A Survey Study. *NJAS*: *Wageningen Journal of Life Sciences*, **92**, 1-11. https://doi.org/10.1016/j.njas.2020.100323

[20] Robinson, E.J. and Kolavalli, S.L. (2010) The Case of Tomato in Ghana: Marketing. GSSP Working Paper 20, Ghana Strategy Support Program. International Food Program, Accra.

[21] Kotey, M.A., Adams, F., Nimoh, F., Mensah, J.O., Etuah, S. and Edwin, C. (2021) Choice of Marketing Outlets among Smallholder Cowpea Farmers in Ghana. *World Journal of Entrepreneurship, Management and Sustainable Development*, **17**, 441-456. https://doi.org/10.1108/WJEMSD-07-2020-0088

[22] Keelson, S.A. and Nanekum, I. (2021) The Role of Informal Commodity Traders' Association in the Marketing of Farm Products in Selected Rural Markets in Ghana. *Journal of Development and Agricultural Economics*, **13**, 314-324. https://doi.org/10.5897/JDAE2021.1277

[23] Lagerkvist, C.J., Hess, S., Okello, J., Hansson, H. and Karanja, N. (2013) Food Health Risk Perceptions among Consumers, Farmers, and Traders of Leafy Vegetables in Nairobi. *Food Policy*, **38**, 92-104. https://doi.org/10.1016/j.foodpol.2012.11.001

[24] Lyon, F. (2000) Trust, Networks and Norms: The Creation of Social Capital in Agricultural Economies in Ghana. *World Development*, **28**, 663-681. https://doi.org/10.1016/S0305-750X(99)00146-1

[25] Oduro, E., Donkor, E.F. and Ackah, E. (2021) Causes and Suggested Remedies to

Taro Endangerment in Four Regions of Ghana. *Bulletin of the National Research Centre*, **45**, Article No. 129. https://doi.org/10.1186/s42269-021-00587-x

[26] Ortiz-Pelaez, A., Ashenafi, G., Roger, F. and Waret-Szkuta, A. (2012) Can Geographical Factors Determine the Choices of Farmers in the Ethiopian Highlands to Trade in Livestock Markets? *PLOS ONE*, **7**, e30710. https://doi.org/10.1371/journal.pone.0030710

[27] Combes, P.P., Lafourcade, M. and Mayer, T. (2005) The Trade-Creating Effects of Business and Social Networks: Evidence from France. *Journal of International Economics*, **66**, 1-29. https://doi.org/10.1016/j.jinteco.2004.07.003

[28] Perz, S.G., Cabrera, L., Carvalho, L.A., Castillo, J., Chacacanta, R., Cossio, R.E., *et al.* (2012) Regional Integration and Local Change: Road Paving, Community Connectivity, and Social-Ecological Resilience in a Tri-National Frontier, Southwestern Amazonia. *Regional Environmental Change*, **12**, 35-53. https://doi.org/10.1007/s10113-011-0233-x

[29] Hunter, D.R., Goodreau, S.M. and Handcock, M.S. (2013) Ergm.userterms: A Template Package for Extending Statnet. *Journal of Statistical Software*, **52**, 1-25. https://doi.org/10.18637/jss.v052.i02

[30] Lusher, D., Koskinen, J, and Robins, G. (2016) Exponential Random Graph Models. Social Sciences Academic Press, New York.

[31] Nolin, D.A. (2010) Food-Sharing Networks in Lamalera, Indonesia: Reciprocity, Kinship, and Distance. *Human Nature*, **21**, 243-268. https://doi.org/10.1007/s12110-010-9091-3

[32] Koster, J.M. and Leckie, G. (2014) Food Sharing Networks in Lowland Nicaragua: An Application of the Social Relations Model to Count Data. *Social Networks*, **38**, 100-110. https://doi.org/10.1016/j.socnet.2014.02.002

[33] Lopes, M.P. (2012) "Good Vibrations": The Social Networks of Optimists and Alter-Optimists. *Social Networking*, **1**, 1-12. https://doi.org/10.4236/sn.2012.11001

[34] Lusher, D., Koskinen, J. and Robins, G. (2013) Exponential Random Graph Models for Social Networks: Theory, Methods, and Applications. Vol. 35, Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9780511894701

[35] Fertő, I., Bakucs, Z. and Fałkowski, J. (2021) Dairy Sector Trade Dynamics: Some Insights on the Evolution of Trade Linkages within the EU. *Journal of Agricultural Economics*, **72**, 698-711. https://doi.org/10.1111/1477-9552.12429

[36] Plummer, R. and FitzGibbon, J. (2006) People Matter: The Importance of Social Capital in the Co-Management of Natural Resources. *Natural Resources Forum*, **30**, 51-62. https://doi.org/10.1111/j.1477-8947.2006.00157.x

[37] Barabási, A.L. and Albert, R. (1999) Emergence of Scaling in Random Networks. *Science*, **286**, 509-512. https://doi.org/10.1126/science.286.5439.509

[38] Levy, M.A., and Mark N.L. (2018) Innovation, Cooperation, and the Structure of Three Regional Sustainable Agriculture Networks in California. *Regional Environmental Change*, **18**, 1235-1246. https://doi.org/10.1007/s10113-017-1258-6

[39] Mligo, E.S. (2021) The African Principle of Reciprocity: Examining the "Golden Rule" in Light of the Ubuntu Philosophy of Life. *STJ-Stellenbosch Theological Journal*, **7**, 1-20.

[40] Lane, J.M. (2020) Foreign-Trade Zones in the Southeastern United States: Do They Promote Economic Development or Lead to Spatial Inequality? *Southeastern Geographer*, **60**, 141-158. https://www.jstor.org/stable/26912606

[41] Robst, J., Polachek, S. and Chang, Y.C. (2007) Geographic Proximity, Trade, and

International Conflict/Cooperation. *Conflict Management and Peace Science*, **24**, 1-24. https://doi.org/10.1080/07388940600837680

[42] Hunter, D.R. and Handcock, M.S. (2006) Inference in Curved Exponential Family Models for Networks. *Journal of Computational and Graphical Statistics*, **15**, 565-583. https://doi.org/10.1198/106186006X133069

[43] Harris, J.K. (2014) An Introduction to Exponential Random Graph Modeling. Vol. 173, SAGE Publications, Thousand Oaks. https://doi.org/10.4135/9781452270135

[44] Subramanian, A., and Qaim, M. (2011) Interlocked Village Markets and Trader Idiosyncrasy in Rural India. *Journal of Agricultural Economics*, **62**, 690-709. https://doi.org/10.1111/j.1477-9552.2011.00309.x

[45] Gold, C.S., Karamura, E.B., Kiggundu, A., Bagamba, F. and Abera, A.M. (1999) Geographic Shifts in the Highland Cooking Banana (*Musa* spp., group AAA-EA) Production in Uganda. *International Journal of Sustainable Development & World Ecology*, **6**, 45-59. https://doi.org/10.1080/13504509.1999.9728471

[46] Egger, P.H., Francois, J. and Nelson, D.R. (2017) The Role of Goods-Trade Networks for Services-Trade Volume. *The World Economy*, **40**, 532-543. https://doi.org/10.1111/twec.12331

[47] Gandhi, V.P. and Zhou, Z. (2014) Food Demand and the Food Security Challenge with Rapid Economic Growth in the Emerging Economies of India and China. *Food Research International*, **63**, 108-124. https://doi.org/10.1016/j.foodres.2014.03.015

[48] Ghosh, B. (2021) Changing Scenario of Crop Diversification in Nepal: Delineating the Role of Trade Openness, Urbanization and Rural Infrastructure. *Journal of Tekirdag Agricultural Faculty*, **18**, 599-612. https://doi.org/10.33462/jotaf.746464

[49] Yanikkaya, H. (2003) Trade Openness and Economic Growth: A Cross-Country Empirical Investigation. *Journal of Development Economics*, **72**, 57-89. https://doi.org/10.1016/S0304-3878(03)00068-3

[50] Dubois, A. (2018) Nurturing Proximities in an Emerging Food Landscape. *Journal of Rural Studies*, **57**, 1-12. https://doi.org/10.1016/j.jrurstud.2017.10.005