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UNRAVELLING WEST AFRICAN LIVESTOCK TRADER NETWORKS

DECEMBER 2024, NO. 48

OECD
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Dr. Valerie C. Valerio (University of Florida)

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UF Sahel Research Group
Center for African Studies
UNIVERSITY of FLORIDA

WEST AFRICAN PAPERS

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Abstract:
Natural resources, urbanisation, and population distribution create disparities in production and demand that drive a vast network of intraregional live animal trade in West Africa. It has long been argued that social capital is essential for long-distance transactions in a region where trade agreements are not fully executed and many barriers to trade exist. This paper examines the social and spatial structure of the trader networks that underpin regional trade. Using co-location social network analysis and 2013 to 2017 regional survey data from the Permanent Inter-State Committee for Drought Control in the Sahel (CILSS), it provides valuable insights into the interplay between economic factors and geographic constraints. The results reveal a fragmented and decentralised social network with border- and infrastructure-driven geographical fragmentation. They also suggest that the network relies on brokers who connect groups of traders with differentiated trade characteristics. The findings reinforce that, in the face of a regionally fragmented environment with many barriers, long-distance commodity flows rely on the social capital of traders.

Keywords: Livestock trade, social network analysis, regional integration, West Africa

JEL Codes: F1, F14, F4, Q1, Q17, Q18, R12

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Valerie C. Valerio holds a Ph.D. in Agricultural and Biological Engineering from the University of Florida. Her current research focuses on using data and simulation models to understand and improve agricultural and livestock value chains in Sub-Saharan Africa.

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Note to readers:
This note is published as part of the partnership between OECD/SWAC and the Sahel Research Group of the University of Florida. The collaboration aims to: 1) Reinforce ties between research and policies for sustainable development that can help better anticipate changes within the Sahel and West Africa region; and 2) Promote West African expertise by reinforcing links with African researchers and research centres through the Sahel Research Group network.

THE SAHEL AND WEST AFRICA CLUB

The Sahel and West Africa Club (SWAC) is an international platform whose Secretariat is hosted by the Organisation for Economic Co-operation and Development (OECD). OECD/SWAC produces and maps data, provides informed analyses and facilitates strategic dialogue, to help better anticipate transformations in the region and their territorial impacts. Through its retrospective and prospective approach, it promotes more contextualised policies as levers for regional integration, sustainable development and stability. Its areas of work include food systems, urbanisation, climate and security.

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ACRONYMS

CILSS	Permanent Inter-State Committee for Drought Control in the Sahel
ECOWAS	Economic Community of West African States
GCC	Giant connected component
SNA	Social network analysis

EXECUTIVE SUMMARY

Trade is an essential contributor to regional integration in West Africa. Amongst the many traded food commodities between ECOWAS countries, livestock is by far the most important. Because it involves long-distance transactions amongst people and places across the region, live animal trade is a major driver of regional integration. In a perfectly integrated environment, traders and their products would be able to easily flow across borders, under constraints imposed by supply and demand differentials and the infrastructure system. At the other end of the spectrum, in a regionally fragmented environment with many barriers to the exchange of goods, traders would need to leverage their social capital to overcome high costs and conduct their business successfully.

This paper contributes to a growing body of evidence that seeks to formally study informal West African cross-border trade. While African trade networks have historically received limited attention in formal quantitative studies, there has recently been an increase in the application of network analysis tools to the region. However the majority of studies that concern live animal trade modelled the market system as animal movements connecting countries, regions and cities and have not featured the economic actors involved in these transactions. This paper addresses this gap by examining the regional network of live animal traders in West Africa.

To understand how regional integration shapes the livestock trader network, the paper examines the structure of trader activities. This is achieved by applying formal co-location network analysis to informal trade data using survey data collected by the Inter-State Committee for Drought Control in the Sahel (CILSS) between 2013 to 2017, containing over 32 000 traders, 69 000 shipments and 550 000 livestock heads. The live animal movements span markets in Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali, Niger, Nigeria, Senegal, and Togo. First, the paper uses centrality metrics to evaluate the structure of the trader network and trader roles. In the context of trader networks, social capital is the advantage that a trader's social connections give them, and results from a combination of embeddedness and brokerage. Then, the paper evaluates community patterns of trade.

The study finds that the cross-border trade network relies on local trust-based connections and on the ability of broker traders to connect their local market to the wider regional market. Most actors in the network are connected to few other traders and conduct business in a single country. The presence of broker traders and groups of traders who operate in similar and limited geographic locations reflect the pressure that non-tariff barriers exert on regional trade in West Africa. They reinstate that in an environment marked by high costs and informal institutions, social capital between actors involved in the livestock supply chain is key.

INTRODUCTION

In West Africa, natural resources, urbanisation, and population patterns give rise to spatial differentials in animal production and demand for animal products. These differentials fuel intraregional live animal trade activities that span thousands of kilometres and operate across country borders. Despite its importance for the economy, food security and livelihoods of millions of people in the region, the social, temporal and spatial structure of trade remains understudied.

It has been argued that strong social ties are essential for long-distance trade to function under the high-cost environment in West Africa (Howard and Shain, 2005). Empirical findings support this claim. Agricultural trade is organised around a few key hubs, such as Bouaké (Côte d'Ivoire), Kumasi (Ghana) and Bobo-Dioulasso (Burkina Faso) that are more likely to trade with smaller, peripheral markets (Valerio et al., 2020). These large markets are interconnected, forming regional networks specialised on various commodities such as rice, onion, or livestock. These networks have been found to rely on brokers, or actors who bridge gaps between otherwise disconnected parts of the network (Walther, 2015). It is plausible that they have evolved to this configuration as an adaptation to a high-cost environment where, in the absence of strong formal institutions and governance, business relies on social connections (Fafchamps, 2003).

This study examines the trader network structure that is most adapted to carrying out regional live animal trade in West Africa. This is achieved by building on the concept of regional integration, the institutional and functional process of increased relationships between people, places and regions (Walther, 2018). In a regionally integrated area with few or no barriers to the free flow of goods and people, traders would presumably need not rely on brokers to conduct business. If traders were able to freely cross international borders, they would operate under the constraints imposed only by the infrastructure system and the influence of border differentials on the direction of trade.

On the contrary, a non-regionally integrated environment would impose strong constraints on the ability of traders to ship goods across borders. In such a scenario, traders would find advantage in conducting business through socially embedded actors that can serve as brokers by connecting them to the wider market. As a consequence, trader communities linked to each other through brokers would form around key markets. Without those brokers, the network would fragment into smaller trading groups. This configuration of regional trade is a likely scenario in West Africa, where actual progress towards regional integration has remained limited despite numerous formal partnerships signed between countries (Bach, 2015).

The paper uses a formal approach to networks called Social Network Analysis (SNA) to answer a series of fundamental questions for the future of livestock trade in West Africa: What is the structure of the regional trader network? Do traders have differentiated functional roles in the network? What trader roles exist and how do they relate to social capital? How does the state of regional integration spatially shape trader activities? By examining trade patterns through the lens of regional integration, the paper seeks to generate empirical evidence to inform the promotion of trade integration in West Africa.

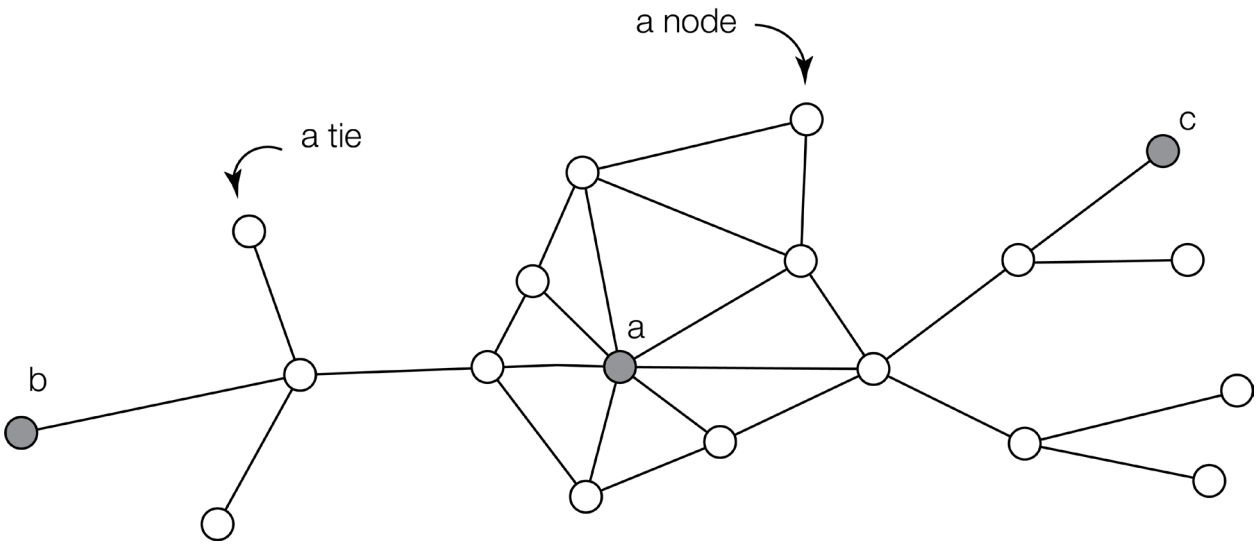
METHODOLOGY

The formal study of West African trade networks has received increased attention in the past decade (Walther, 2014; Walther, 2015; Kuépié, Tenikue, and Walther, 2016; Brønd, 2018; OECD/SWAC, 2019b; Walther, Tenikue and Trémolières, 2019). Live animal mobility networks have been qualitatively and quantitatively spatialised (Motta et al., 2017). For example, the Permanent Inter-State Committee for Drought Control in the Sahel (CILSS) has published multiple livestock export maps and tables (CILSS, 2017), while Jahel et al. (2020) used a landscape connectivity approach to identify the potential paths followed when animals move between Mauritania and Senegal. This paper builds on this body of literature to develop a network approach to livestock trade in the region. It expands previous studies by explicitly considering the volume of flows, the role of economic actors in supply chains and the specificities of certain commodities at the regional level.

Instead of relying on official mobility certificates or official trade statistics, which oftentimes underestimate the actual volume of products traded in the region (Benjamin, Golub and Mbaye, 2015; Bensassi, Mitaritonna and Jarreau, 2017), this paper sourced live animal trade data collected by the CILSS. In partnership with regional trade organisations, CILSS collected agricultural trade data between 2013 and 2017 in selected trade corridors (markets and border crossings) between Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali, Niger, Nigeria, Senegal, and Togo. More recent data has been affected by the Covid-19 crisis and is difficult to compare with the data already available from 2013 to 2017. The markets mentioned in this paper are defined as geographical locations that were either surveyed (data collection points) or reported as origins or destinations (loading or unloading points) of animal shipments. This allows to track the direction and magnitude of intraregional agricultural trade across the region instead of covering one or few countries (Apolloni et al., 2018; Chaters et al., 2019; Apolloni et al., 2018; Apolloni et al., 2023).

In previous studies using social network analysis, locations are typically represented as nodes and shipments between locations as ties connecting those nodes, as in the simple network presented in Figure 1, where some locations (a) are much more connected than others (b or c). Yet, with the exception of Walther (2015) and OECD/SWAC (2019b), few studies have featured the economic actors involved in these transactions. This study attempts to study both the geographic location of each node of the livestock network and the identity of the traders involved in these activities. In other words, the study includes not only the physical infrastructure used to trade livestock in the region but also the people involved in these economic activities. This allows to examine which markets are frequented by which traders and whether traders tend to do business in the same location. Each market and trader were assigned a unique identification number. Markets were identified with their names and geographic locations, while traders were assigned identifiers by using vehicle licence plate numbers as a proxy variable. A trader country was assigned based on their licence plates (Box 1).

Figure 1.
Simple network composed of 20 nodes and 25 ties



In the networks, nodes represent traders, and ties between nodes indicate co-location. Throughout this paper, a tie between two traders indicates that they traded live animals in the same market on the same calendar day. The trader networks are visualised with an algorithm that places central actors towards the centre and peripheral actors on the outlines, and pairs of traders with stronger ties closer to each other in comparison to more weakly connected ones.

The networks are unweighted, which means that ties do not have a quantitative value associated with them, such as the number times two traders met at the same market on the same day for example. The networks are also undirected, meaning that ties do not have a direction, for example from a seller to a buyer, as in Figure 1. The resulting sociograms can then be used for qualitative diagnostic of the network structure. This paper is particularly interested in detecting whether the networks include numerous brokers, who bridge different segments of the market, and whether traders involved in selling or buying livestock tend to form tightly knit groups, called 'communities' in the network jargon. Such communities can stretch over several markets and countries and, for this reason, are difficult to detect using traditional surveys. Network analysis allows to visualise the existence of trade communities based on the fact that business interactions within the communities will be much denser than interactions across communities. After visualising the network, a more rigorous cluster analysis is conducted with a community detection algorithm to classify nodes into densely or strongly connected sub-groups.

Some of the quantitative metrics and methods used in this paper are not well-defined for networks with disconnected or isolated nodes or groups of nodes. This is the case of community detection, which requires that each node be connected to at least one other node of the network. To overcome this challenge, a giant connected component (GCC) network is built. The GCC is the subset of a network with the largest group of traders that are connected to each other by at least one tie, and by definition it excludes isolated traders.

The descriptive part of the paper provides a descriptive summary of the network in which its size (number of movements, markets, traders) and average trading activity of each actor are commented. The centrality of the overall network and of individual traders is assessed using several centralisation and centrality metrics:

- **Degree.** Degree centrality is the number of connections of each actor, or the number of calendar days in which the trader coincided in the same market with another trader. A network with high degree centrality indicates that there are traders who coincided at markets with many others. Degree centralisation indicated whether a network is centralised around one single node.

- **Betweenness.** Betweenness centrality is the number of shortest paths between all pairs of traders that pass through each trader. High betweenness centrality suggests that there are nodes who function as brokers, bridging otherwise disconnected groups of traders. Betweenness centralisation is the degree to which a network is polarised by brokers.

- **Closeness.** Closeness centrality is the reciprocal sum of the average distance from each node to all other nodes such that a node with higher score is present in more of the shortest paths. High closeness centralisation is a sign that the network has are highly influential actors. A trader with high closeness centrality could be highly influential as they could serve as an efficient communication channel between groups of traders, or individual traders. Closeness centralisation is the degree to which a network is composed of nodes that are close to each other.

- **Eigenvector.** Eigenvector centrality is the transitive influence of nodes in the network; a node with high eigenvector centrality is linked to important nodes, or nodes with high degree centrality. Eigenvector centralisation refers to the tendency of a network to be polarised by well-connected nodes connected to well-connected others.

Degree and betweenness centrality are of particular interest to determine the level of social capital of individual traders (Walther, 2014; Walther, 2015). Degree centrality, or the number of other actors each trader is connected to, characterises their embeddedness. Betweenness centrality determines whether traders function as brokers and connect groups of actors who might otherwise not be linked. These actors are therefore able to access and transmit information between groups in an efficient manner (Burt, 2007). Consequently, many of the shortest paths between all pairs of traders pass through them (or they have high betweenness centrality) and they can reach other traders with fewer intermediaries (they have high closeness centrality). In a regionally integrated environment, trade movements would be primarily shaped by supply and demand differentials. If international borders and trade barriers represent a large burden for traders, they would operate in a geographically fragmented but somewhat established manner. In this case, traders would form communities with differentiated characteristics. Brokers would then fill structural holes between otherwise disconnected communities.

The study also investigates whether traders operate in densely connected communities – and if so, which are the largest groups that contribute to promote regional integration and how other spatial and economic factors gave rise to those groups. The paper then examines patterns of economic activity by using a community detection algorithm that classifies traders to maximise intra-group ties. This algorithm divides the trader into sub-groups by comparing the actual number of connections within groups with the expected number of connections if traders connected randomly (or the network modularity, Q). To gain insight into the factors that shape these groups, the largest communities are profiled based on their primary markets of economic activity, trade frequency, size, type of animal and trader country. Finally, the role that influential traders have in the different trade communities is examined.

Box 1.
Data processing details

The data was processed using R statistical software 4.2.3 (R Core Team, 2021). It consisted in the remaining entries after excluding entries corresponding to the years 2009 to 2012, entries for markets missing 100% of the trader id values, as it would not have been possible to assign any co-location ties based on these markets, entries for markets missing over 30% of the trader id values, as missingness affects the reconstructed network, entries that had no trader identification number and entries for traders that did not coincide with any other trader on any calendar day, as they would not have had any ties in the network.

The initial dataset had 121 191 movements recorded (2009 to 2017). Of these, 78 238 movements occurred between 2013 and 2017 (6.5 % of which were missing a trader identification number). Data collected in 8 markets had no trader identification information (Fourou, Gumke Gari, Illela, Kadiana, Kangaba, Mokko, Siekorole and Yanfolila), comprising 737 entries. For an additional 11 markets (Birni N'Konni, Daloa, Guenin, Guidan Kane, Kouremale, Loulouni, Maiadua, Maigatari, Narena, Ouenra and Torodi; 1 194 entries) trader identification information was missing for 30 % of records or more. Of the remaining entries, 3 553 had no trader identification information. After a last step of filtering out traders with no ties in the network (2 919 entries), 69 835 movements remained.

Before pre-processing, trade ids were missing for approximately 7 % of entries and 7 % of heads. (3.9 to 9.9 % range by year; Table 1). The reported metrics include overall and average (per trader and per market) number of livestock movements, markets, traders, unique trading (calendar) dates, trade rate and frequency, livestock heads and countries. The input dataset included 69 835 movements made by 32 808 traders amongst 32 markets in 6 countries.

Table 1.
Summary of data missing trader id (vehicle number) by year and overall, for the original dataset

YEAR	NUMBER OF MOVEMENTS	PERCENT OF MOVEMENTS (%)	NUMBER OF HEADS	PERCENT OF HEADS (%)
2013	1 160	8.5	97 896	9.9
2014	799	4.4	119 021	6.8
2015	1 070	5.8	82 620	5.6
2016	642	4.1	49 539	3.9
2017	1 414	11.4	96 100	9.1
All years	5 085	6.5	445 176	6.8

Due to known changes in data collection throughout the years, spatiotemporal data collection patterns were examined. The survey frequency was quantified as the number of unique calendar dates in which at least one record existed per collection market, by year. Collection markets were not excluded based on this information because most of the data corresponded to markets that were surveyed in all five years and the exclusion criteria would filter them out.

A one-day, co-location window was used to construct the network. Though a larger window could have been used, it is not typical for markets in the region to have storage capacity, and each additional day that a herd spends near or at the market could be detrimental to the herd's status. In addition, it proved a reasonable window to use after confirming that most markets only recorded movements once or twice a week, which implies that for the network to change significantly, a window of more than one week would have to be used.

The co-location networks were visualised for each year using the DrL layout that facilitates visualisation of large, real-world networks (Martin et al., 2008). The DrL layout uses a multi-level force-directed algorithm that produces coarsened graph representations of the original graph with collapsed nodes and ties. All visualisations and analyses were done using the igraph R package (Csárdi and Nepusz, 2006).

A SPARSE, DECENTRALISED, AND CLUSTERED TRADER NETWORK

The regional trader network in West Africa is sparsely connected and geographically clustered. The subset of data included 69 835 movements (89.3 % of the records in the initial dataset) made by 32 808 traders amongst 32 markets in 6 countries. An average of 38 animal shipments occurred each calendar day. The typical trader was not very active: on average, each trader was involved in 2.1 movements at 1.2 markets in 1.1 countries and traded 173 animals. Markets were active every 3 days, and 1 197 traders visited each market each year between 2013 to 2017 (Table 2).

Table 2.
Descriptive summary of the trader network between 2013 and 2017

METRIC	OVERALL	AVERAGE PER TRADER	AVERAGE PER MARKET
Animal movements	69 835	2.1	2 182
Markets	32	1.2	1
Traders	32 808	1.0	1 197
Unique trading dates	1 702	2.0	390
Trades per day	38.00	0.03	0.34
Days between trades	0.03	35.30	3.00
Livestock heads	566 980	173	177 181
Countries	6	1.1	1

Note: The trader summary metrics exclude actors who could not be identified. Average quantities were calculated between the minimum and maximum date of trader activities

The overall co-location network is composed of a giant component, to which most traders are connected. This dense cluster is surrounded by many groups of isolated traders located towards the periphery of the sociogram (Figure 2). While some variations can be observed in the overall structure of the network from 2013 to 2017, the structure is composed of 3 to 4 trader communities, or sub-groups of traders (Figure 3). While brokers are not easily spotted with visual diagnostics, there appear to be trader communities, or groups of traders who are more densely connected to each other than to the rest of the network.

Figure 2.
Overall trader co-location networks, 2013 to 2017

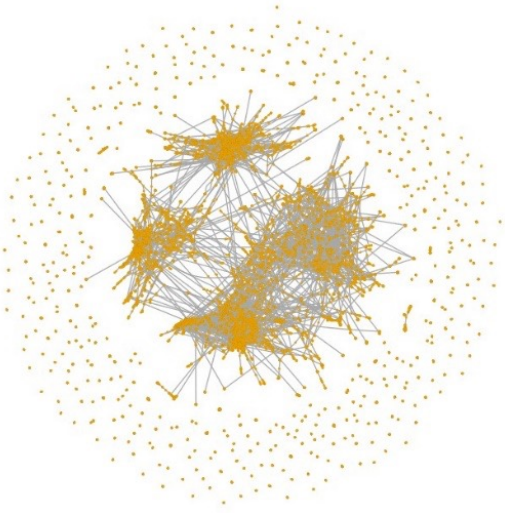
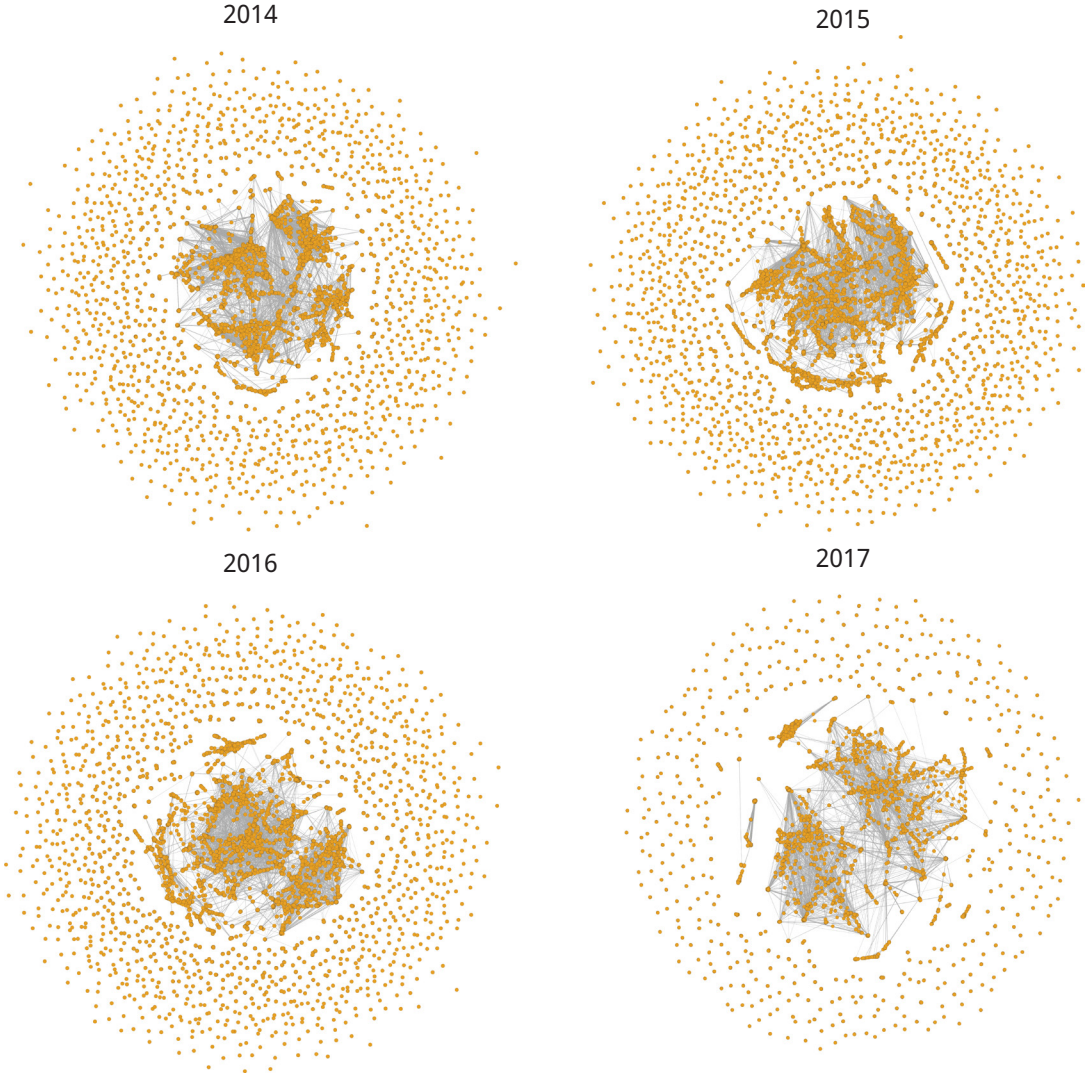


Figure 3.
Yearly trader co-location networks, 2014 to 2017



Traders operate mostly within borders and in proximity to a few others. A typical trader frequented a single market in a single country. On average, every trader was connected to 16 other traders over the five years. Low tie densities confirm that traders conduct economic activities coinciding with only a small number of other traders. When compared to a network where all traders are connected to each other, less than 0.05 % ties exist, which is not surprising considering the size of the region and the high number of traders involved (Table 3). While degree, betweenness, and closeness centralisation are low, the extremely high value for eigenvector centrality indicates that markets tend to be dominated by a few influential traders who are capable of buying or selling a very large number of animals.

Table 3.
Overall and yearly trader network properties for the trader network, 2013 to 2017

METRIC	OVERALL	2013	2014	2015	2016	2017
Number of traders	32 808	7 314	9 951	10 557	9 958	6 741
Number of ties	265 549	36 255	76 136	58 145	49 504	49 804
Average number of ties per trader	16.2	9.9	15.3	11.0	9.9	14.8
Density (%)	0.05	0.14	0.15	0.10	0.10	0.20
Degree centralisation (%)	4.1	3.5	4.7	3.8	2.7	2.5
Betweenness centralisation (%)	5.8	6.2	5.3	7.4	5.8	6.3
Closeness centralisation (%)	20.6	14.8	19.7	12.9	15.4	14.9
Eigenvector centralisation (%)	99.3	98.8	98.1	98.9	98.7	97.7
Average path length (ties)	5.0	5.2	5.3	5.9	6.0	5.6

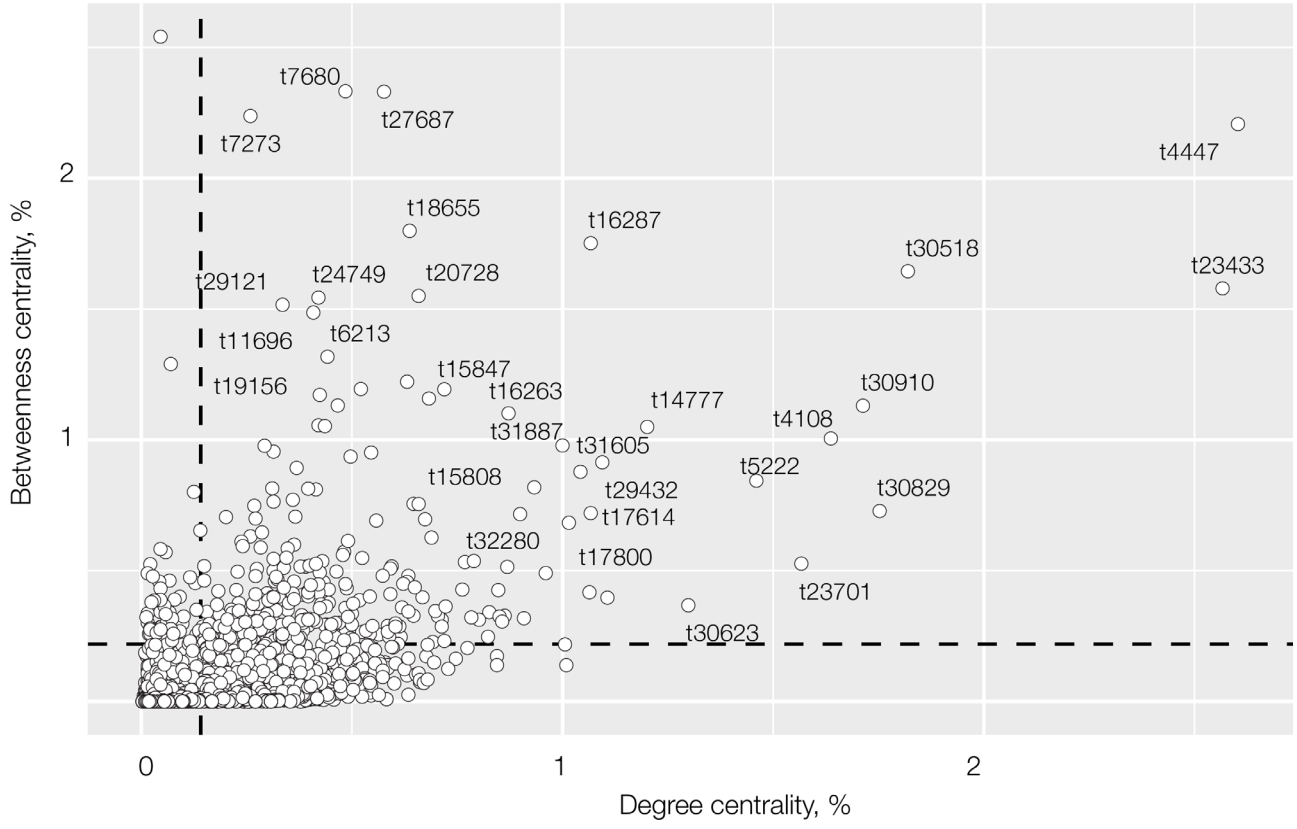
Note: Betweenness and closeness centralisation are not well defined for disconnected networks. Therefore, they are calculated for the giant connected component (GCC) only.

A SMALL NUMBER OF HIGHLY INFLUENTIAL TRADERS WITH DIFFERENTIATED ROLES

Network analysis allows to precisely measure how each West African trader benefits from his/her structural position within the network. This "social capital" results from the combination of two types of centralities: degree centrality, which characterise their embeddedness into the network, and betweenness centrality, which characterises brokerage. Traders who have numerous business partners have high degree centrality. Those who play the role of brokers between several markets have high betweenness centrality. By combining degree and betweenness centrality scores on Figure 4, one can identify several profiles of traders. Traders who have high degree and betweenness centrality scores have the highest levels of social capital (upper right corner). These fortunate traders with high social capital have numerous business partners locally and engage with potentially more distant traders in other markets regionally. This is of course very hard to achieve, which explains why there are so few of them. For example, trader t4447 is very centrally embedded in Benin and ships from Burkina Faso towards the Nigerian market (Figure 4). Those who are connected to many other traders without playing the role of brokers are major hubs (lower right corners).

Those who have only a few ties but connect different communities are "pure" brokers (upper left corner). For example, trader t29121 is a broker from Mali who is not highly embedded but is structurally important in bridging the Senegalese market to the rest of the network, hence their high betweenness centrality score. These intermediaries are essential for regional livestock trade because private traders dominate this economic activity in West Africa (De Haan, Quarles Van Ufford and Zaal, 1999). Individual intermediaries coordinate market transactions, often increasing the probability of success but also affecting sellers' margins (Baltenweck, Okike and Williams, 2004). Intermediaries' many functions include providing market information, identifying and connecting buyers and sellers and organising the assembly and transport of animals for export. Finally, traders with the lowest social capital are those with low degree and betweenness scores (lower left corner). They represent the majority of traders in the region, in line with the results of previous studies (Walther, 2015; OECD/SWAC, 2019b).

Figure 4.
Degree and betweenness centrality of traders in the network, 2013 to 2017



Note: Betweenness centrality measures the percentage of shortest paths between traders that pass through each actor. Degree centrality quantifies embeddedness, or the number of ties with other traders. Note: we use the mathematical limit of two standard deviations from the mean to split the actors into four quadrants (dotted line).

GEOGRAPHICALLY FRAGMENTED TRADER COMMUNITIES

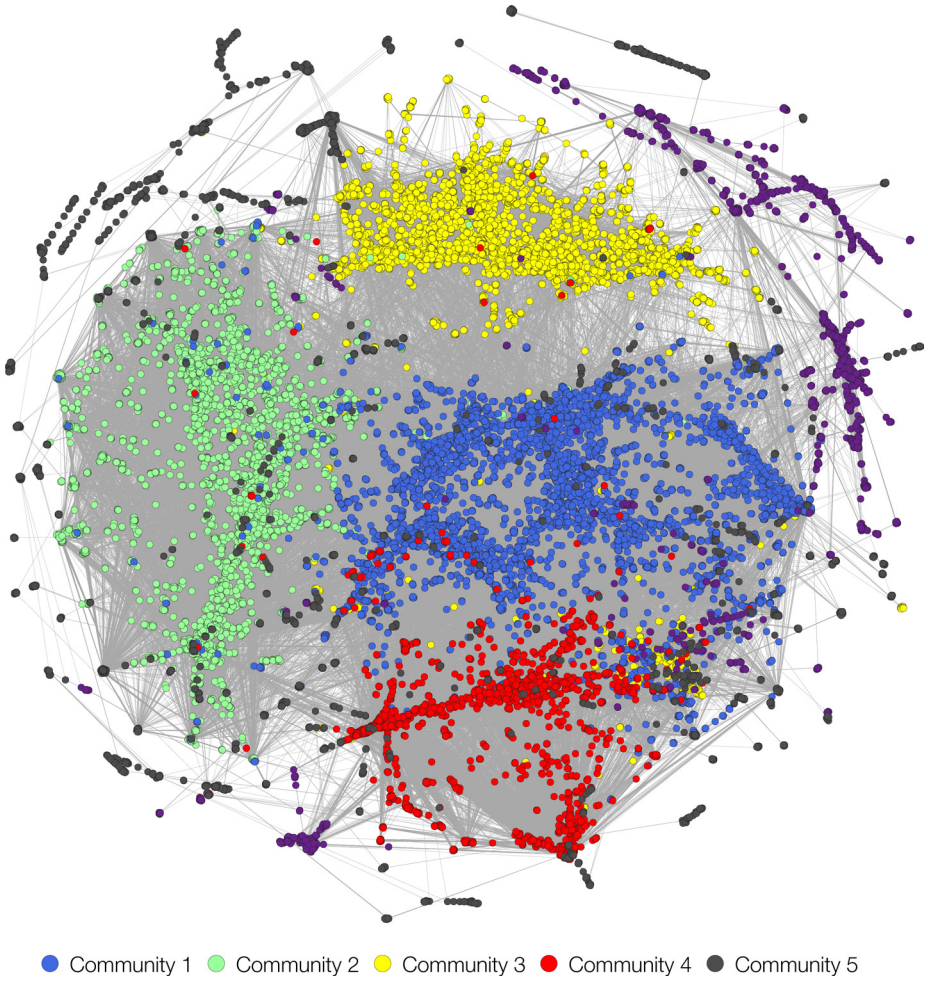
The co-location network is composed of several communities, whose members share more ties amongst themselves than with other groups. The 5 largest trader communities included 24 168 members, or nearly 85 % of all traders, and 217 284 ties, or 84 % of all trade connections recorded in the region from 2013 to 2017 (Table 4).

Table 4.
Size of the 5 largest trader communities, 2013 to 2017

TRADER COMMUNITY	SIZE (TRADERS)	PERCENTAGE OF TRADERS (%)	NUMBER OF CONNECTIONS (TIES)	PERCENTAGE OF TIES (%)
1	7 028	25	50 807	20
2	5 623	20	63 986	25
3	4 918	18	26 751	10
4	4 256	15	51 193	20
5	2 343	8	11 951	5
Top 5	24 168	87	217 284	84
All	27 895	100	265 549	100

In the sociograms, each community appears as nodes of the same colour situated near each other (Figure 5). The largest community in size, with more than 7 000 traders represented in blue, is also the most central one. It is surrounded by two large trade communities (2=green, 3=yellow) of 5 000 and 5 600 traders. Members of community #4, in red, are more decentralised and can be found in proximity to other communities. Community #5, in purple, occupies the peripheries of the network, suggesting that it is less cohesive than the others.

Figure 5.
Largest five trader communities in the network, 2013 to 2017



Note: The sociogram shows the five largest trader communities in the configuration with the maximum modularity coefficient (Q = 78 %).

Traders are generally organised around hub markets near border crossings (Nadiagou, Dan Barto) or urban areas (Ouagadougou, Bouaké, Fada N'Gourma) (Valerio et al., 2020). Accordingly, their primary markets lie in regional trade corridors. The first two groups are mostly Burkinabe traders transporting cattle and sheep sourced in Burkina Faso and Mali but serving different consumption markets. Community 1 ships from Zegoua (Mali) to Abidjan (Côte d'Ivoire) in the Bamako-Abidjan corridor (blue nodes in Figure 6). Community 2 operates between Senegal and Mali along the Dakar-Bamako corridor. These findings confirm spatial characteristics of trade reported in other studies: community 1 primarily serves the urban populations in Bouaké and Abidjan where buyers have reported preferring to source animals from Burkinabe suppliers (Holtzman, Kozyn and Seydou, 2015).

Figure 6.
Most important markets for each trader community, 2013 to 2017

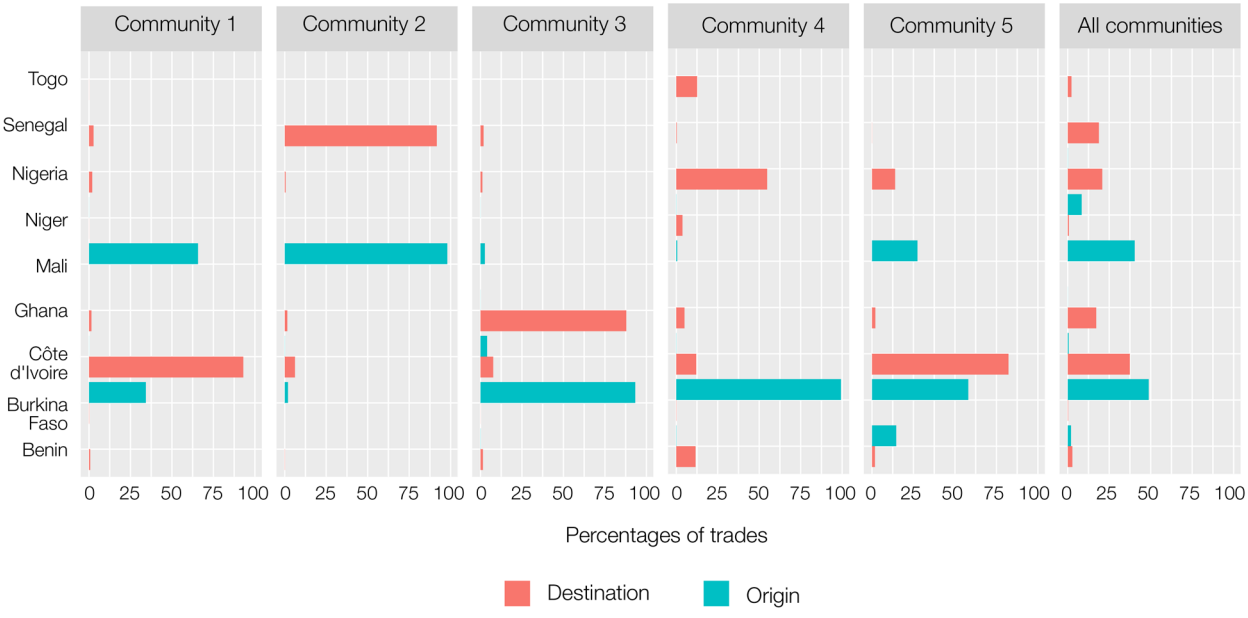
Note: The modularity coefficient Q = 78 % for the 2013 to 2017 network, 74, 79, 78, and 80 and 83 % for the yearly networks.

The third community's main market (Kumasi, Ghana) is in an important urban area along the corridor from central Burkina Faso to Accra (Figure 7). Though animals originate in Burkina Faso, traders from Burkina, Mali and Benin make those movements. It is probable that some of the livestock are sourced in Mali.

Community 4 operates in three key markets in Burkina Faso: Fada N'Gourma, Nadiagou and Pouytenga. This group ships cattle, sheep and goats in similar proportions, and almost all traders are from Mali. Most animals in this group are destined to Nigeria, the largest economy in the continent and a major hub of animal food consumption. Lastly, the fifth community ships almost exclusively sheep from Niger, Mali and Burkina Faso to Côte d'Ivoire and Nigeria. Accordingly, most traders were from Mali and Burkina Faso.

Community 5 is unexpected because all but 11 traders only visited either Bouaké or Gogounou. A closer inspection of the data revealed that this community comprises two distinct parts. One group of traders that operates between Burkina Faso and Côte d'Ivoire (through Bouaké), while the other ships from Benin to Nigeria (through Gogounou). This separation is also visible in the sociogram as two clouds of purple nodes away from each other (Figure 5). Both sub-groups had visits to Burkinabe markets in common, which explains why they form a single community even when the key markets are not geographically near each other.

Figure 7.
Trades by origin and destination market for the top five trader communities



While the number of trades per trader is relatively constant, communities differ in their volumes traded and livestock types (Table 5). There is no visible correlation between the number of heads traded and the overall size of trade communities: the largest community (#1) trades roughly the same number of animals as community 4, which is twice smaller. Sheep are the most commonly type of livestock traded in most communities. Cattle is dominant in community 3 and goats are well represented in community 4.

Table 5.
Geographic and trade characteristics of each trade community, 2013 to 2017

CTY	MAIN MARKET(S)	TRADES PER TRADER	HEADS PER TRADE	LIVESTOCK TYPE (%)		
				CATTLE	SHEEP	GOAT
1	Abidjan and Zegoua	2.3	97	27	72	1
2	Diboli and Kayes	2.3	61	39	61	0
3	Kumasi	1.7	36	76	23	1
4	Fada N'Gourma, Nadiagou and Pouytenga	2.7	102	32	38	30
5	Bouaké and Gogounou	2.0	147	13	87	0
All	All	2.2	84	32	60	8

Brokers' trading behaviour differed from their community peers. When compared to others in their group, brokers were, on average, more active in the most connected markets of the regional network. While a typical actor traded less than four times, brokers frequented the key markets significantly more (Table 6). Brokers are particularly represented in such markets as Fada N'Gourma, Gogounou and Kumasi, three important market centres that serve as relays for the regional movements of livestock between the Sahel and the Gulf of Guinea.

Table 6.
Average market visits by trader role and community, 2013 to 2017

CTY	MARKET	AVERAGE VISITS, BROKER	AVERAGE VISITS, NON-BROKER	RATIO OF VISITS, BROKER VS ON-BROKER
1	**Abidjan**	17.2	2.2	8
1	**Zegoua**	13.2	3.3	4
2	**Diboli**	15.8	1.9	8
2	**Kayes**	11.6	1.8	7
3	**Kumasi**	16.4	1.6	10
4	**Fada N'Gourma**	38.7	2.1	19
4	**Nadiagou**	14.7	2.8	5
4	**Pouytenga**	10.1	2.7	4
5	**Bouaké**	12.8	2.0	6
5	**Gogounou**	22.7	1.6	14

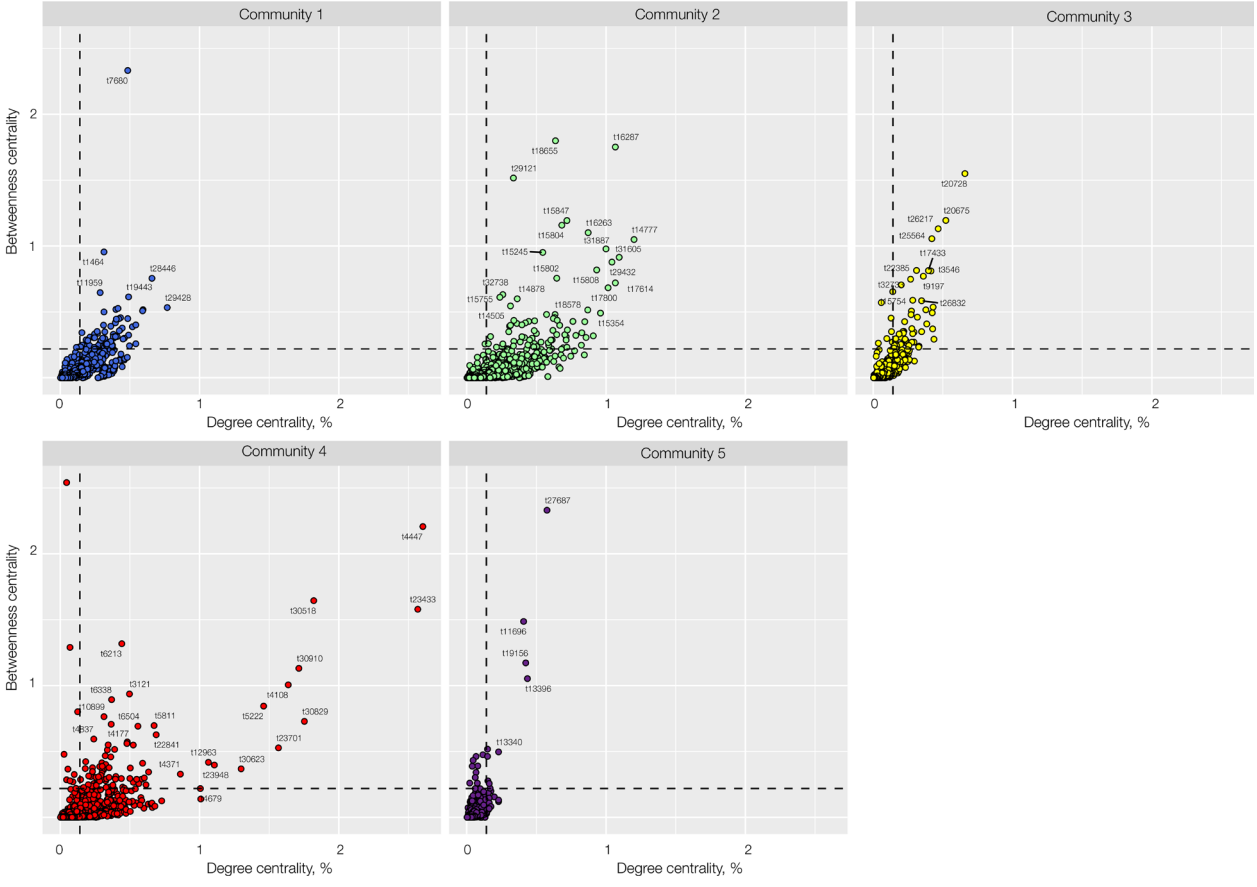
Note: Actors with betweenness centralities significantly higher than the rest (over 2 standard deviations from the mean betweenness) were considered brokers.

INTER- AND INTRA-COMMUNITY BROKERS

This section investigates if central traders also have specialised roles in their respective communities. Previous studies found that the most successful traders in West Africa tend to balance brokerage and embeddedness by maintaining a large number of business connections within their community and developing ties to more distant social networks (Walther, 2015). Similar results are observed in the livestock trade network if the social capital of each trader resulting from the combination of degree and betweenness centrality is represented on the same graph by community, as in Figure 8. In all trade communities, the distribution of social capital tends to follow a diagonal line, with very few actors having high social capital (or both degree centrality and embeddedness).

High embeddedness pays when sourcing high-quality beef in assembly markets like Pouytenga and Fada N'Gourma (Burkina Faso), as in community 4. In these markets, animals from multiple origins are exported primarily through Benin (likely Parakou) to Nigeria but also to coastal markets in Togo and Benin. In this group, the structural position of the trader is related to trading frequency and spatiality. Traders with high social capital (like t4447) were very active, trading frequently and operating in multiple trade corridors. Highly embedded trades, on the other hand, also traded fairly frequently, but shipped animals along a single corridor. Brokers traded more sporadically yet visited markets in multiple trade corridors, which explains why they have few links but high betweenness.

Figure 8.
Trader embeddedness and brokerage by community, 2013 to 2017



Note: We use the mathematical limit of two standard deviations from the mean to split the actors into four quadrants (dotted line).

PERSPECTIVES

This study examines the structure of the livestock trader network in West Africa, revealing a sparse and geographically clustered system where most traders operate within localised circuits and are connected to a small number of others. Despite spanning multiple countries, the network relies on a small number of influential actors who facilitate inter-regional trade by connecting otherwise isolated trader communities to major markets. Similar characteristics have also been reported for other commodities (Walther, 2015). This trader organisation reflects the challenges and opportunities that lack of regional integration represent for traders.

The findings suggest that trader activities are influenced by non-tariff barriers, which prevent the development of a fully integrated economic market. In an environment where formal institutions are lacking and costs are high, such as West Africa, social connections and structural position confer traders with a performance advantage. Highly embedded actors exploit the trust of their local trading partners by establishing long-term business relationships. Brokers, on the other hand, benefit from bridging their immediate peers with distant groups, often across borders.

Our understanding of African agricultural traders can be significantly enhanced with formal network analysis. Previous studies have focused on geographic locations and their connections without covering the economic actors involved, the live animal sector, or informal trade. This paper addresses these gaps by using informal livestock trade data that includes multiple countries and a wide range of trade actors, thereby providing a more complete picture of trader social networks.

Adopting a network approach to study West African trade patterns can offer valuable insight for policymakers. Network methods allow for a quantitative evaluation of the roles, organisation, and performance of economic actors. These approaches are also well adapted to capture informal activities, such as livestock trade, for which official or regional data are often missing. As intra-regional trade continues to evolve and adapt, recognising the roles of key brokers and the interconnectedness of trader communities will be vital for policymakers aiming to foster regional integration and economic development. Future research should particularly consider temporal dynamics of trade. Livestock trade volumes fluctuate in response to drought, violent conflict, population growth and urbanisation, government policies (such as currency changes), economic prosperity or recession, meat imports and other non-tariff barriers to trade. Therefore, a temporal understanding of economic networks is warranted to ensure that the trade system can continue supporting the livelihoods of millions across West Africa.

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WEST AFRICAN PAPERS

UNRAVELLING WEST AFRICAN LIVESTOCK TRADER NETWORKS

Natural resources, urbanisation, and population distribution create disparities in production and demand that drive a vast network of intraregional live animal trade in West Africa. It has long been argued that social capital is essential for long-distance transactions in a region where trade agreements are not fully executed and many barriers to trade exist. This paper examines the social and spatial structure of the trader networks that underpin regional trade. Using co-location social network analysis and 2013 to 2017 regional survey data from the Permanent Inter-State Committee for Drought Control in the Sahel (CILSS), it provides valuable insights into the interplay between economic factors and geographic constraints. The results reveal a fragmented and decentralised social network with border- and infrastructure-driven geographical fragmentation. They also suggest that the network relies on brokers who connect groups of traders with differentiated trade characteristics. The findings reinforce that, in the face of a regionally fragmented environment with many barriers, long-distance commodity flows rely on the social capital of traders.