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Macrostructure and microstructure: Evidence from overlapping village networks in The Gambia

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Abstract

Using a unique dataset collected in 60 Gambian villages, I study six social and economic networks: (i) land exchange, (ii) labor exchange, (iii) tool and fertilizer exchange, (iv) credit exchange, (v) matrimonial relationships and (vi) kinship relationships. A variety of measures gleaned from the Social Network Analysis (SNA) literature are used to study how features of the networks at different levels of disaggregation are related to various aspects of economic development. In particular, I focus on the role of ethnic fragmentation and income inequality. Analyzing the network macrostructure I find that village-level income inequality plays a role in increasing interactions, while a measure of ethnic fragmentation is only related to land exchange. At a more disaggregated level, household's centrality seems to be determined by traditional roles and other characteristics, including ethnicity and, to a lesser extent, relative income in the village. At the dyadic level, traditional roles, family ties and differences in endowments are better predictors of link formation than income and ethnicity.

Keywords: West Africa, Social Networks, Ethnic Fragmentation, Income Inequality.

JEL codes: C31, D04, 012, Z13.

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"In The Gambia, virtually everything is lendable and at times will be lent. This includes nearly all factors of agricultural production: land, labor, livestock, seed, fertilizer, pesticides, and farm tools. Craft tools, vehicles, and household goods are also lent" Shipton (1990).

1 Introduction

In his pathbreaking article about the *embeddedness* of economic interactions, Granovetter (1985) pointed to a great divide in the economics literature of the time. On the one hand, the *undersocialized* view of neoclassical models, in which agents are treated as atomized entities where social structure plays no role. On the other, the *oversocialized* view of new institutional economics, in which institutionalized social structures dominate human actions. The real world must then lie somewhere between the two extremes, with rapidly changing social structures defined by apparently unstable interactions and multiple links among agents, thereby creating dynamic and overlapping mesostructures.

During the past two decades, the economics literature has advanced in terms of filling this gap, particularly with the development of game theory, behavioral economics, information economics and, especially, through the study of social and economic networks. Social Network Analysis (SNA) has been an important component of sociological research for more than a century, but economists have only recently started to incorporate it into their toolkit.[1] While the concept of social capital proposed by Putnam (1995) called attention to SNA, it was the modeling efforts of Jackson and Wolinsky (1996) and Bala and Goyal (2000) that created the bases for the incorporation of networks in economic analysis. Since then, a growing body of theoretical literature has been developed, accompanied by an increasing number of empirical studies that address issues as diverse as job search, criminal activities and the use of the internet.[2]

The present study aims to contribute to the recent empirical literature on the study of social networks in rural economies. It is part of a broader research project related to very detailed data about social and economic interactions collected in 60 Gambian villages, in the context of the impact evaluation of a national level Community-Driven Development Program (CDDP). This database is used to study how the characteristics of networks at different levels of disaggregation are related to various aspects of economic development. In particular, I focus in the role of ethnic fragmentation and income inequality.[3] The empirical analysis that I present is meant to provide a detailed description of the networks and the variables associated with their characteristics and results should not be interpreted in causal terms.

[1] In Granovetter (2005) there is a broadranging summary of the sociological point of view concerning the influence of social networks on economic activity.

[2] For a complete review of the history and recent progresses of SNA in economics, see Jackson (2009).

[3] It is beyond the scope of the present study to explain the importance of these two factors for economic development. Ethnic fragmentation has been highlighted as an important impediment for development in Africa by Easterly and Levine (1997) and a series of follow-up papers, thought the results are questioned by Arcand, Guillaumont, and Jeanneney (2000). A summary of the topic is provided by Alesina and Ferrara (2005). Income inequality is considered to be positively associated with economic growth in early stages of development in the Kuznets tradition but negatively related to political stability (Alesina and Perotti (1996)), social capital (Knack and Keefer (1997)) and other indicators of social welfare. A review is provided by Kanbur (2000).

The main results at the village-level show that income inequality and poverty indicators are important determinants of the macrostructure of networks, but that a measure of ethnic fragmentation is rarely significant. The analysis at the household level (mesostructure) reveals that relative income in the village is only associated with participation in a few networks, while traditional roles, together with other households characteristics, are important determinants of centrality. Households that belong to ethnic minorities are less likely to participate in the exchange of labor and credit, but more prone to be land borrowers. When the unit of analysis attains the link-level (microstructure), the most basic unit of a network, traditional roles are still fundamental to explain link creation between two households, along with differences in endowments and family ties. Differences in income *per se* only affect link formation in the credit network, while belonging to the same ethnic group only increases the probability of creating a labor link.

The paper is organized as follows: Section 2 briefly summarizes the relevant literature on social networks in rural societies. Section 3 explains in detail the process of data collection and presents descriptive statistics on villages and households. In section 4 I summarize previous studies that help to understand the cultural anthropology of the networks. In section 5 the measures to describe networks at different levels are presented, followed by econometric analysis of their determinants. The final section discusses the main results and concludes.

2 Literature review: empirical analysis of networks in Development Economics

Though the crucial role played by social networks in the economic systems of rural societies has long been recognized,[4] formal empirical evidence is fairly recent.[5]

A natural function of networks is the diffusion of information. As such, understanding them is essential for promoting technological innovations in agriculture, as shown by Foster and Rosenzweig (1995) in the context of India's Green Revolution. Significant recent contributions are provided by Conley and Udry (2010) for the adoption of pineapple crops in Ghana, and Bandiera and Rasul (2006) for sunflower in Mozambique. Network mechanisms for the transmission of information are also relevant when it comes to the introduction of public policies, particularly in the area of health, as shown by Miguel and Kremer (2003) in the context of a deworming drug information program in Kenyan schools. Behrman, Kohler, and Watkins (2003) for their part, consider perceptions of the risk of becoming infected with HIV in data from rural Kenya and Malawi.

[4]In his famous description of the production system of the Trobriand islanders, Malinowski says "*it enmeshes the whole community into a network of reciprocal obligations and dues, one constant flow of gift and counter-gift*" (Malinowski (1921), p.8)

[5]A fertile area of empirical analysis in developing countries relates to various forms of social capital (an excellent summary is provided by Durlauf and Fafchamps (2004)). Social capital and social networks are closely related concepts, the former being a broader (and sometimes loosely defined) concept that includes the latter. The present literature review is focused on studies that directly relate to social networks.

Goods and services, and not just information, are exchanged on social networks. Particularly relevant for rural economies where access to formal credit markets is limited are mutual insurance arrangements that help households to deal with adverse shocks. These usually take the form of an informal exchange of gifts, favors and zero-interest loans that take place in groups of households linked by kinship, geographical proximity or some kind of homophily.[6] The importance of networks for risk-sharing in rural economies has been noticed at least since Rosenzweig (1988) work about insurance within the family in India. Using a sample of households from four villages in rural Philippines, Fafchamps and Lund (2003) find that risk-sharing does not exist at the village level, but, instead, mutual help is received within networks of friends and relatives. Fafchamps and Gubert (2007) expand the analysis of these data to the prediction of links between households, concluding that geographical distance and differences in income and age are the main determinants. Using very detailed data for all the households in one village in rural Tanzania, De Weerdt and Dercon (2006) find that risk-sharing of health shocks at the village level is likely to exist in food consumption, but for non-food consumption the insurance takes place in smaller networks. Using the same data, De Weerdt (2004) analyzes link formation, confirming the role of kinship, geographical distance and homophily. Comola (2008) expands the same study to include the indirect benefits stemming from link creation.

Risk-sharing is far from being the only economic activity in which networks play a role in rural societies. Given the importance of traditional structures, market imperfections and limited access to information and new technologies, one would expect that most economic exchange would be embedded within networks of interactions that are very far from the anonymous-atomistic agent models of standard theory. This is the case of labor-sharing arrangements, as studied by Krishnan and Sciubba (2009) in 15 villages in Ethiopia. They show that differences in the symmetry of labor networks depend on the quality of participants and that the architecture of these networks is relevant in terms of economic performance. Few studies have jointly analyzed the different networks that overlap in rural economies. To my knowledge, the first empirical attempt to deal with the issue is Udry and Conley (2004). They use data stemming from 4 villages in Ghana to relate four different exchanges: information, credit, land and labor, finding evidence of the relevance of networks in these activities.

The present study contributes to expanding the literature in various ways. First, the characteristics of the data allow us to compare various networks in both formal and informal transactions (land, labor, inputs and credit), controlling for dyadic family ties and other characteristics. Second, given the availability of information for a large number of villages and a complete census of links in each village, I can analyze simultaneously the networks at different levels: village (macrostructure), household (mesostructure) and link (microstructure). Third, I take advantage of these data to explore how key aspects of economic development can be empirically studied from a network perspective, with a particular focus on ethnic diversity and income inequality.

[6]These arrangements sometimes take place in more established organizations that form networks governed by a set of (usually unwritten) rules (Bhattamishra and Barrett, 2010), like ROSCAS (Besley, Coate, and Loury, 1994 and Anderson and Baland, 2002) and funeral groups (Dercon, De Weerdt, Bold, and Pankhurst (2006)).

The literature on networks and ethnic diversity has produced results that are by no means clear-cut. Some studies argue that different ethnicities mistrust each other and are less likely to create links: "*lower trust between diverse ethnic groups makes it difficult to form the social networks (social capital) that promote growth by disseminating advanced technology and economically useful knowledge.*" (Easterly (2001), p.689). Thought there are many case studies that relate ethnic fragmentation to warfare and segregation, the empirical literature on social networks is far from being consistent in confirming this idea. Grimard (1997) finds that Ivorian households tend to partially risk-share within the same ethnic group. Analyzing the membership in various community based organizations (CBOs), Arcand and Fafchamps (2008) find that households of the same ethnicity are more likely to belong to the same group in Burkina Faso and Senegal, thought a caveat is that ethnicity may just be a proxy for other characteristics not measured captured by their data. Hoddinott, Dercon, and Krishnan (2005) point out that households belonging to ethnic minorities do not have smaller mutual assistance networks when describing the same data from rural Ethiopia used by Krishnan and Sciubba (2009). Analyzing trade credit in market towns of Benin, Malawi and Madagascar, Fafchamps (2003) finds no evidence that ethnicity is an important predictor for trust in business, when other network characteristics are controlled for.

The debate concerning income inequality follows similar lines. Differences in income can generate lack of trust between groups that can lead to polarization, marginalization and suboptimal socioeconomic interactions. On the other hand, income heterogeneity can generate opportunities for interactions that are not possible in egalitarian societies. For example, assuming that risk aversion decreases with income, richer households are in a better position to insure poorer brethren. Consistent with this idea, Fafchamps and Gubert (2007) find that differences in wealth (which are highly correlated with income in their data) are important determinants of the existence of a risk-sharing link between households. Using a different database, Comola (2008) confirms the result that rich households are willing to create links with less wealthy ones. Nevertheless, Santos and Barrett (2006) find that the poorest herders among Boran pastoralists in southern Ethiopia are excluded from insurance networks. Udry and Conley (2004) also find that individuals who differ in their wealth are not likely to exchange credit and gifts. They find the same result for the labor network, but in the case of the land and information networks income inequality increases the probability of a link. In terms of CBOs membership, Arcand and Fafchamps (2008) find evidence of assortative matching by wealth.

3 Data collection and description

3.1 Data collection strategy

The methodology adopted for the present study differs from that of traditional household surveys in which a random sample of households is collected in each village. The goal is to collect data for the full range of nodes participating in different networks within the village, as well as the external links of these nodes. Given the costs associated with implementing LSMS-type surveys for all households in a village, structured group interviews geared to collect quantitative information were implemented instead. Therefore, village censuses were carried out through gatherings co-organized with the village chief (*Alkalo*) and district-level officers. In such village meetings it is possible to obtain relatively coarse quantitative information -with a particular focus on socio-economic interactions- for almost all households in each village. This type of approach is common in ethnographic research and is related to the *rapid rural appraisal* methodology that has been successfully used in the past for quantitative analysis in different disciplines (Chambers (1994)).

The data collection consisted of the following strategy: Two enumerators spent 1 to 2 days days in each village. The first step was a meeting with the village chief or his representative, to explain the purpose of the visit and to offer a traditional symbolic gift to the village (kola nuts). The Alkalo was consulted about general village information and his authorization to use the taxation roster, where all compound heads are registered, was secured in order to create a list of households. With the Alkalo's assistance, household heads were invited to gather in the village's meeting point (*bantaba*). As the heads were arriving at the *bantaba*, enumerators formed groups of 5 to 8 people and administered simultaneously the questionnaire to all members of this group. Though questions were closed-ended, some interaction among participants was allowed, to clarify data that were incomplete or doubtful. The process was repeated until all households had been interviewed. Sometimes it was necessary to move to some specific compounds to individually administer the questionnaire because of households head being sick and (in a few cases) because some individuals refused to be interviewed in the *bantaba*. Simultaneously in some villages Focus Groups were conducted for three groups of villagers, men, women and youth, with the goal to better understand the structure of each community.

The structured group survey gathered two categories of information. The first section was a standard (and very lean) household questionnaire designed to collect a vector of household characteristics including: economic and demographic indicators, household head characteristics, extent of ties with traditional village authorities, membership in various village-level groups, household migrants, and sources of external information. In order to see how such data differ from that gathered in standard surveys, Figure 1 compares the distribution of income in 15 villages where, some months earlier, a random sample of households were interviewed using LSMS techniques in the context of the baseline analysis of the Gambia CDDP impact evaluation, with very detailed questions about different sources of income for the month preceding the survey. Both distributions share the same support, but group data are more concentrated at the mean and have a notably high level of kurtosis. It is possible to see that in the left-hand portion of the densities, where poorer households are located, the distributions are very similar, but richer respondents seem to provide downward-biased information in the context of group survey. The comparison should be taken with caution however, because the LSMS-type survey was conducted right after the rainy season. Annualized income, particularly for the rich, can be overestimated in such data when is collected during this period.

The second section of the survey instrument was specifically designed to understand the networks in the village. Given that a list of all households in the village before the gatherings was systematically established, it was possible to assign a unique identifier to each household head beforehand.[7] The names of all the villagers (that were matched with the unique identifier) with whom members of the household had had interactions in six networks, using the following questions:

[7]If during the interviews some individuals were recognized as household heads by the community but not present in the list, the new household was added and assigned a new identifier number to it.

- *LAND=Of the land you cultivated last year: did you lend out or borrow in land from other villagers? If yes, what is the amount of land?*

- *LABOUR=Did you, or any members of your household, work for other households during the last year (2008-9)? If yes, how many days?*

- *INPUT=Did you lend out to or borrow in any means of production (such as tools or fertilizer) from other households in the last year (2008-9)?*

- *CREDIT=Did you lend out to or borrow in money from other household in last year (2008-9)?*

- *MARRIAGE=Have any of your household members married members of other households?*

- *KINSHIP=With which households do your family members have kinship relationships?*

In what follows, I will refer to the first four as *economic networks* and the last two as *family networks*. For each of these networks, also was asked the existence of connexions external to the village.

3.2 Sample and household data description

The survey was conducted between February and May of 2009. 60 Gambian villages, mainly in rural areas (just 4 villages are in semi-urban areas), were randomly selected. In order to achieve a modicum of representativity at the national level, for each of the 6 Local Government Areas (LGAs) eligible for the CDDP program (out of the 8 in to which Gambian territory is divided), wards were randomly selected, a smaller geographical division that tends to be homogeneous in geographical but heterogeneous in socio-cultural terms. Finally, 3 to 8 villages were randomly drawn within each ward.

In order to minimize selection problems it was attempted to interview all households in the village, yielding a median household coverage rate of 94% (when the number of surveyed households is compared with those on the taxation list). We targeted the household head for interview purposes, but, in cases where he or she was absent or not able to answer, it was allowed someone else to answer, either another household member or a close relative. This was the case for 28% of the sample. Finally, 3,320 persons were interviewed.

In Tables 1 and 2 I present descriptive statistics for the data collected using the first survey instrument, the general questionnaire. In the first of these tables I present village-level statistics (60 observations) while in the second I present the household-level data, for a sample reduced to the units that I will use in the empirical analysis (2,810 observations when incomplete data are removed).

The data on village population available in the 2003 Gambian Census (used to construct the sampling frame) turned out to be significantly out of date and, in some cases, very inaccurate. This explains that even just villages with populations between 300 and 1,000 inhabitants were targeted, in practice the smallest village has 202 inhabitants and the largest 1,402. The average population of the surveyed villages is 586 inhabitants. Population density, at least when the denominator is the inhabited area, is high, with an average of 6,900 inhabitants per square kilometer. In contrast, agricultural land was usually very abundant. The average amount of agricultural land per active worker was around two hectares, when land usage rights for the year of the survey were considered, with a great deal of variation given that the average standard deviation at the village level was 4.6 hectares.

Average household size, on the basis of the household data, is 12.6 members (see Table 2), and slightly lower (11.6) when the mean of village medians is considered, reported in Table 1. While some households appear exceedingly large, respondents were very clear in terms of their definition of a household. The presence of households with more than 50 members (approximately 1% of the sample) is explained both by the polygamous nature of Gambian rural society and the existence of *marabout* households where the household is constituted by a mass of disciples and other followers. 45% of households declare to be polygamous and there was at least one marabout in half of the villages in the sample. As is to be expected in West Africa, a very small number of household heads are females (7%), generally represented by widows and mainly concentrated in the semi-urban areas on the outskirts of Banjul (the national capital). These villages also accounted for the few non-Muslims in the sample (4%).

The sample is representative of the ethnic diversity in The Gambia. 41% of the respondents are Mandinka, 26% Fula, 8% Wollof, 7% Jola and 4% Serer, with the rest either belonging to local ethnic minorities or being non-Gambian (these represent 4% of the sample).[8] While some villages are very homogeneous in terms of ethnic composition, others are very diverse. 22% of tour respondents come from a minority ethnic group in their village, thought in some villages the predominant group accounts for no more than 30% of respondents. I build an Ethnic Diversity Index as $EDI = (1 - \sum_{e=1}^{N} s_e^2)$, where s_e is the share of each ethnic group in the village. The EDI ranges from zero (complete homogeneity) to 0.84, with a mean of 0.3.

The economic conditions in the villages in the sample correspond, by and large, to those of traditional rural societies. There is almost no access to electricity, with an average village-level access rate of 3%. 88% of households have no access to an improved source of water, while 38% lack access to a private toilet. 38% of household dwellings are built with grass. 82% of the respondents declared having no formal education, although a substantial fraction of the villagers received some kind of koranic education and usually master basic Arabic language skills. The main economic activity is related to agriculture (66% of households have this as their main activity) or fisheries (6%). Nevertheless, a Herfindahl index of sectoral heterogeneity shows a significant degree of diversity, driven mainly by the presence of inhabitants working outside the village (25%). Monetary income is very low. The average (self-declared) annual income per capita is 3,565 Gambian Dalasis, which corresponds to approximately 90 Euros (using the exchange rate of 2009), and just around 12% of this income stems from agricultural activities. The distribution of income is, moreover, not necessarily egalitarian in all villages. Though the average Gini coefficient is 0.34, it reaches 0.5 in some villages. The higher level of inequality reported

[8]Compared with the data for rural areas of the 2003 Census for The Gambia, the sample overrepresents Mandinkas (33%) and underrepresents Wollof (15%).

in some villages seems to be driven by remittances and off-farm jobs. Around half of the respondents declare having current or former household members who work outside the village, including 12% who receive remittances from overseas migrants outside Africa.

4 Cultural anthropology of the networks

The basic unit of study will be the household, the definition of which is not straightforward. Villagers in rural Gambia are usually organized into *compounds*, a concept which corresponds to members of the same family, usually related by blood or marriage, living in a group of huts surrounded by a grass fence. Most of the time a compound can be identified as a household, meaning that the members eat together, organize daily activities in common and have a head who takes most important decisions. Nevertheless, it is sometimes the case that some members of a compound declare themselves to be an independent household, with their own head. The independence of a household within a compound is related to two local concepts: the *dabadas* or farm production units and the *sinkiros*, cooking and consumption units (Webb (1989)). People in the same *dabada* tend to belong to the same *sinkiro*, and more than one of these units can be found inside compounds, particularly when it comes to the largest of these. The intra-compound distinction was, in most cases, clear to the *alkalo* and all other village inhabitants. Just 16% of the household heads in the sample are not the head of the compounds where they live.

The choice of a household as the unit of analysis is not without cost. As noted by Udry (1996) and Goldstein and Udry (2008), among others, the assumption of within-household Pareto efficiency is far from reality in West African rural societies. The relationships that uncovered with the data collection strategy might therefore be interpreted in terms of the networks centered on the household head and might not necessarily reflect the complete network of the household. In the context of The Gambia, Carney and Watts (1990) and von Braun and Webb (1989) have shown that the decision-making process inside compounds and households is complex, particularly considering that individual resource allocation is sometimes divided between common farm land, known in the Mandinka language as *maruo*, and private plots or *kamanyango*, where members of the household, such as some of the wives or the young people, can manage a crop under their exclusive control. It was asked how much of the respondent's land is *kamanyango* (or any similar concept of private plot in the local dialect). 25% of the compound heads that practice agriculture declared to have at least a portion of land cultivated as *kamanyango*.[9]

Carney and Watts (1990) describe the clear division of labour in Mandinka society, which is largely similar in villages dominated by other ethnic groups. Men cultivate cash-crop plots, mainly groundnuts, but recently also fruit trees, in conjunction with some staple food such as millet, maize and sorghum. Women grow rice and take care of the village garden (if there is one).[10] In semi-urban areas there are almost no agricultural

[9] Just 6% of the respondants declared to have more than a quarter of the land as *kamanyango*. Of those declaring no *kamanyango*, a portion was not familiar with the concept and it was not possible to explain its meaning.

[10] This division of labour is very ingrained. Several efforts of the British colonial authorities and post-independence programs have failed to incorporate men in rice production, a very important factor when

plots and inhabitants usually have titles for the land they use. This is in contrast with rural areas, where there is usually no land scarcity (at least in terms of quantity, but not necessarily in terms of quality) but the unwritten rights over its usage are determined by the descendants of the village's founders, generally the Alkalo and his direct relatives. In some cases, the *kabilo* (clan) heads, who might not be related to the founder's lineage but represent the descendants of other early settlers, are entitled to permanent usage rights.[11] All other villagers must borrow plots on either a seasonal or an annual basis from them, in agreements that can also last for several years (Chavas, Petrie, and Roth (2005)). Sometimes other individuals own small plots of land outright that can be lent or rented. The transactions in the $LAND$ network will therefore principally be given by a moneyless assignment of plots, though they can sometimes imply a remunerated rental contract.

While land is not scarce, labor is, particularly before and during the rainy season. The solutions to a household shortage of workers constitute the core of the interactions in the $LABOUR$ network. The available alternatives are described by Swindell (1978): the use of *kafos*, an organized workforce of villagers who participate in the provision of public goods but who can also be hired for a fixed wage by a household; the hiring of particular villager or outsider at a given "market" wage; inviting other villagers or outsiders to help with household tasks in exchange for various kinds of goods, labor or even a marriage arrangement; the use of *strange farmers* that provide part-time labor in exchange for the right of use of part of the family plot for his own benefit.

The links in the $INPUT$ network are defined as exchanges of means of production that imply a monetary or opportunity cost for the lender, such as tools, cattle, fertilizer, seeds and the like. While cattle are usually lent for milk, manure and transport during the whole year, agricultural tools and inputs are particularly important in the period before the rainy season. This seasonality is also explained by the investment decisions of the villagers. While some invest in means of productions after the crop season, others do not, either because of a bad year for cash crops or due to substitution effects driven by consumption of non-productive goods. The exchange can also be driven by risk-sharing behavior with households investing in differentiated means of production.

Information concerning the $CREDIT$ network must be taken with caution. While there exists lively money lending and borrowing amongst villagers, it is not easy to secure these data. During the field tests prior to the survey we were initially reluctant to ask information about money exchange, thinking that it might be perceived as being disrespectful. On the contrary, it was found that villagers were in general willing to respond to questions related to credit. The clue was given by one of the local enumerators: *"In Islam there is no interest rate. If you lend money it means that you are helping at the moment when the other really needs it, so you are doubly blessed. While usually lenders will not reveal the information, grateful borrowers will."* On the other hand, this idea can be in contradiction with the local concept of *juloo* (rope): "*It can refer to a small-scale trader, or to credit or debt. Every Mandinko knows the meanings are related. Traders*

it comes to understanding the country's dependence on imported food.

[11]As remarked by Webb (1989), the rights over land are related to the old social structure, with the former highest castes having the most productive plots. Apart from its historical consequences, mainly in terms of the division into freeborn and former slaves, the caste system is not relevant in rural Gambia nowadays, and interviewees were generally not willing to talk about their ancestors' caste.

are also lenders, and their loans, while sometimes useful like a rope ladder, also tie down a farmer like a rope around the neck" (Shipton (1990)). Apart from the direct borrowing of money from another household in the village, there is also the possibility of obtaining credit from external sources, both informal and formal (mainly rural development banks or microcredit agencies), or from some village-level rotating saving and credit associations (ROSCAs), locally know as *osusus*.[12] Other forms of organized saving, such as the *village bank* where women save incomes from their gardens or skill center are also available.

With respect to the family networks, in the small villages in which the surveys were conducted kinship relationships are very common and are usually dominated by the lineage of the village founders and the oldest settlers. Intermarriage within families is common and there is also a very active inter-village exchange of brides. In polygamous rural Gambia, it is often the case that the first marriage is arranged between the elders of the respective families, while the other wives are requested by the husband according to his capacity to sustain a bigger family.

5 Empirical analysis of the social and economic networks

5.1 Network measurement

I will consider a household as a node i in each of the m networks g^m. I restrict each network g^m to consist of a set of nodes belonging to $N = 1, ..., n$ where n is the number of households inside each village. Figures 2 to 6 present graphical representations of some of the networks in the data, where the arrows represent the existence of a directed link between nodes and the nodes in the upper left section do not have any links in this particular network.

Theoretical predictions of link formation are difficult to come by. Applying the concept of *pairwise stability* proposed by Jackson and Wolinsky (1996) usually results in multiple equilibria and unclear predictions. In this paper I will limit to the empirical estimation of the observed links, registered as an indicator variable which it is assumed to be generated by:

$$\ell^m_{ijv} = 1 \text{ if } B[d_i^{+j}(g^m)] - C[d_i^{+j}(g^m)] > 0,\ \ell^m_{ijv} = 0 \text{ otherwise,}$$

where $B[d_i^{+j}(g^m)]$ is the benefit of increasing i's degree in network g^m by creating a link with j and $C[d_i^{+j}(g^m)]$ is the associated cost. The benefits are (not exclusively) given by the access to the resources involved in each network (for borrowers) and to well-connected people via link creation with households that play important roles in the village. The costs are associated with losses in resources (for lenders), with the opportunity cost of creating a different link, and are also a function of the differences between i and j along a number of dimensions, including household size, ethnic group, kinship lineage and educational attainment. When analyzing the data at the link level, I will

[12] In the CDDP baseline survey, 58% of the rural villages declared to have at least one *osusu* association.

refer to *microstructure*.

A basic metric of the embeddedness of a node i in a network g^m is its *degree*, $d_i(g^m)$, measured as the number of links involving this particular node. In the case of the data, a distinction must be made depending on the directionality of the link. If the link goes from i to j, then it be counted in the measure of the *out-degree*. Formally:

$$\text{Out-degree: } d_i^{out}(g^m) = \sum_j \ell_{ij}.$$

In the economic networks, the out-degree of i is related to its position as a lender. In the case of $MARRIAGE$ out-degree is associated with being a *sender*. When the link goes in the other direction, from j to i, it will be counted as part of the *in-degree* of i:

$$\text{In-degree: } d_i^{in}(g^m) = \sum_j \ell_{ji}.$$

For economic networks the in-degree is a characteristic of i as borrower. In the $MARRIAGE$ network this corresponds to being a *receiver*. In the case of $KINSHIP$, the data are undirected, so that in-degree and out-degree are the same.

Table 3 show the matrix of simple correlations of in- and out-degree for the different networks. While most of the correlations are positive and significant at the 5% level, indicating that households have similar degree in all networks, this is not always the case. In $LAND$, borrowers and lenders are negatively correlated in degree, indicating that land-for-land transactions are not common, and the household is either a pure lender or a pure borrower. Though sometimes statistically significant, the degree in $MARRIAGE$, both as sender and receiver, appears to be uncorrelated with the otehr networks, with the obvious exception of $KINSHIP$. The degree in the latter is correlated with all other networks, except land lenders.

In order to be able to compare across networks, degree centrality is usually expressed as a proportion of the total possible links in each particular network:

$$\text{Degree centrality: } C_d^m(i) = \frac{d_i(g^m)}{n-1}.$$

When I study the data at the node (household) level, aggregating over its links, it will be considering *mesostructure*.

In the first two columns of Table 4 I present basic statistics for the distribution of in- and out-degree centrality in different networks. The average degree tends to be between 1% and 2% of total possible links, except for $KINSHIP$ with 10%, but the data are very heterogeneous, indicating important differences in the centrality of households.

Though the networks are defined in terms of within-village interactions, the links of each household with nodes outside the village were also registered. Columns 3 and 4 of Table 4 present the distribution of a variable that is equal to one if the household has at least one external link, and zero otherwise. *External-in* are links created to bring something to the village, with *external-out* representing the opposite direction. External actors are very important for the marriage network, but in economic networks less than

10% of the surveyed households have at least one link outside the village (exept for credit borrowers). This fact provides support for the idea that the most important interactions in the networks take place inside villages.

Given its definition, the analysis of network architecture or aggregate characteristics is at village-level. I will refer to this as *macrostructure*. A common measure used in SNA at this level is the density of the network, the sum of the degree of all egos in the network g^m over total possible links:

$$\text{Density: } D(g^m) = \frac{\sum_{i=1}^{n} d_i(g^m)}{(n-1)n}.$$

The density can be considered as the probability of forming a link in a purely random network of average degree $d_i(g^m)$. The second panel of Table 4 presents descriptive statistics for the macrostructure. In the first column the number of links in each network is reported and in the second column its density. Densities are between 2% and 5% for most networks, with the exception of $KINSHIP$ which has an average density of 14%, confirming the fact that in several villages the inhabitants tend to be close relatives.

An important regularity observed in the SNA literature is that an ego's links, instead of being distributed evenly, tend to be concentrated in local neighborhoods, creating clusters of egos well connected among themselves but not with the rest of the network ("my friends tend to be friends amongst themselves"). A standard measure used to study this feature is the clustering coefficient, $Cl_i(g^m)$, which represents the probability that j and k are linked given that i has a link with both:

$$\text{Clustering coefficient: } Cl_i(g^m) = \frac{\sum_{j\neq i;k\neq j;k\neq i} \ell_{ij}\ell_{ik}\ell_{jk}}{\sum_{j\neq i;k\neq j;k\neq i} \ell_{ij}\ell_{ik}}.$$

The clustering coefficient for a given network g^m can be calculated as a weighted average of $Cl_i(g^m)$:

$$Cl(g^m) = \sum_i Cl_i(g^m) w_i,$$

where w_i is a weight given by $d_i(g^m)$ (i's undirected degree). A simple way to assess the presence of clusters in a network is to compare the average clustering coefficient with the density. In Table 4 it is possible to see that the networks differ in terms of their level of clustering: for $KINSHIP$ and $INPUT$ the average $Cl(g^m)$ is higher than $D(g^m)$, while the opposite is true for $LAND$ (these differences are significant at the 99% level). The low level of clustering in $LAND$ is related to the hierarchical ownership of land described in the last section, which impedes transitivity in its exchange. In fact, it is very common to observe the emergence of *stars* in the $LAND$ network (where $Cl_i(g^m) = 0$), with the Alkalo or another descendent of the founders being the hub (see Figure 2). For $LABOR$, $CREDIT$ and $MARRIAGE$ there is no clear evidence of clustering.[13] Nevertheless, it is important to consider that this average comparison hides some important diffences for particular networks. For example, Figure 3 represents a labor network with $D(g^m)$ being

[13]The p-value for the one tailed test of the null hypothesis of mean $Cl(g^m) > D(g^m)$ is 0.968 for $LABOR$, 0.972 for $CREDIT$ and 0.934 for $MARRIAGE$. The p-values for the two tailed test of the equality of means are 0.062, 0.054 and 0.13 respectively.

more than one standard deviation above the mean density, but with zero $Cl(g^m)$. Figure 4 represents the diametrically opposite situation, with $Cl(g^m)$ almost 10 times bigger than $D(g^m)$.

A useful concept from SNA is the *component*, a subnetwork of the network g^m such that its nodes are connected amongst themselves but disconnected from the rest. The network in Figure 4 has nine components (when isolated nodes are not considered). In a random network, a standard prediction is that as the probability of forming a link increases, a *giant component* that connect most of the elements in the network will emerge. As shown in the original work of Erdős and Rènyi (1960), in a Poisson random network where the probability of forming a link is greater than $\frac{1}{n}$, a giant component emerges, and when the probability increases to $\frac{log(n)}{n}$, all the elements in the network are connected. When the formation of networks is strategic or links represent family ties, the links can be distributed in very different ways. For example, in the case of the network in Figure 4, $D(g^m)$ is around the $\frac{1}{n}$ threshold, but there are many components, some of which being relatively big, instead of just one giant component. This is similar to the case of the network represented in Figure 5, with $D(g^m)$ well above the first threshold, but still with 4 components, two of them being very big. With respect to the second threshold, in most of the networks where $D(g^m) > \frac{log(n)}{n}$ all nodes are connected in the giant component (with the exception of few isolated egos). Nevertheless, this is not the case for $KINSHIP$, where 45 networks have density over the threshold, but 21 of them have more than one component (see Figure 6 as an example).

To study this feature of the data, an *index of compactness* will be used defined as:[14]

$$\text{Index of compactness: } Cmp(g^m) = \sum_{c=1}^{C} s_c^2,$$

where s_c is the share of nodes in each component over the total number of nodes. When the network is a collection of several small component $Cmp(g^m) \in [0, 0.1]$. If links are concentrated in few big components $Cmp(g^m) \in [0.1, 0.5]$. When most of the nodes are in the giant component $Cmp(g^m) \in [0.5, 1]$. The statistics in Table 4 indicate that $KINSHIP$ is, on average, more compact than other networks, as opposed to $CREDIT$ which displays the smallest average index of compactness. Nonetheless, this index has a great deal of variance in all networks, and the differences are rarely statistically significant.

5.2 Macrostructure: network architecture

I now turn to the analysis of the village characteristics associated with network architecture. The approach will be to take each network g_v^m as the unit of analysis, with $m = \{LAND, LABOUR, INPUTS, CREDIT, KINSHIP, MARRIAGE\}$ and v corresponds to each of the 60 villages for which there is information, yielding a total of 360 observations. The empirical specification will be as follows:

$$y_{mv} = G\left(\alpha_{ward} + \alpha_m + \alpha_{ethnic} + \alpha_{activity} + X_v\beta\right) \quad (1)$$

where y_{mv} is one of the three village-level network characteristics described below: density, clustering and compactness, $G(.)$ is the logistic function, and X_v the vector of

[14] In sociology this index has been used under the name of *component size heterogeneity.*

relevant village characteristics. I will be particularly interested in the Ethnic Diversity Index (EDI) and the Gini coefficient of inequality in self-reported income. A set of dummies to control for unobservables is also included: taking advantage of the stratified nature of the sampling scheme, ward-specific effects (α_{ward}) that control for several geographical characteristics, such as distance to the capital and other important population centers or climate. Also network-specific effects are considered (α_m), as well as dummies corresponding to the predominant ethnic group in the village (α_{ethnic}) and its main economic activity ($\alpha_{activity}$).

Since network measures are proportions, a quasi-MLE procedure is implemented to estimate equation (1), implementing the fractional logit procedure proposed by Papke and Wooldridge (1996).[15] Table 5 presents the results when the estimation is over the pooled set of networks, as well as when dividing the sample into *economic networks* ($LAND$, $LABOUR$, $INPUTS$ and $CREDIT$) and *family networks* ($KINSHIP$ and $MARRIAGE$). In Table 6 the results are presentd for each network separately, using a more parsimonious model (given the limited number of degrees of freedom) to estimate the parameters β^m associated to X_v in each network. I report the goodness of fit measure proposed by Cameron and Windmeijer (1997), based on deviance.

Density and compactnesses are always decreasing in village population, while this characteristic is not significant for clustering, with a few exceptions such as $LABOR$, which is more clustered in bigger populations. Average household size displays a significantly positive association with network density (again an unsurprising result, since larger households will have more members who can potentially interact with other households in the village). This variable is also associated with significantly more clustered networks, a result that seems to be driven by the $INPUT$ network, and with more compact networks in the case of $LABOR$. Population density is negatively correlated with clustering and positively correlated with compactness in some networks, but has no effect on density.

Income inequality, as measured by the Gini coefficient constructed from self-declared household monetary income *per capita*, appears as an important factor in increasing both $D(g^m)$ and $Cmp(g^m)$ and decreasing $Cl(g^m)$. In the case of the first two measures, the effect seems to be related to the input and credit networks, while for the latter the driving force is the family network. This finding is in line with the hypothesis of income inequality being a factor which increases exchanges in networks, as a result of some complementarities between richer and poorer households. I will come back to this point later. Most of the other indices capturing economic diversity, such as the standard deviation of household size and land *per capita*, are never statistically different from zero and are not reported, with the exception of diversity in economic activity, which is associated with significantly lower levels of density and clustering.

The various indicators of poverty are associated with higher densities and compactness, but this is not the case for monetary income *per capita*, which is never a significant explanatory variable. In the case of $D(g^m)$ the results are mainly associated with labor and credit exchanges, while $Cmp(g^m)$ is higher in poorer villages for all economic networks except for $LAND$. The regressions in Table 6 show that the poverty indicators are

[15]The main results hold if the equation is estimated using OLS with fixed effects. These results are available upon request.

positively associated with clustering for $LABOR$, $CREDIT$ and $KINSHIP$, while the association is negative in the case of $MARRIAGE$.

While the EDI is usually not significant in the aggregated models presented in Table 5, in the individual network regressions it is possible to see that ethnic diversity is associated with higher density and compactness in the land network, while it is associated with more clustering in family networks. As such, no evidence of negative effects of ethnic fragmentation is found on the economic activities of the village using the macrostructure measures of networks.

A final result concerns the importance of interactions outside the network, measured by the percentage of households with external links in each village-network. In Table 6 the coefficients associated with the percentage of households with external links as senders (external-out) and receivers (external-in) are reported. While the coefficients are not always statistically significant, the results indicate that villages with more external senders have higher density and compactness, with the opposite being true for villages with more external receivers.

5.3 Mesostructure: household centrality

In this section the household-level variables associated with degree centrality are studied. Once again we estimate a fractional logit, since the dependent variable, be it the in-degree (borrowers/receivers) or the out-degree (lenders/senders) centrality, is expressed as a proportion over total potential links in the network. The model to be estimated is given by:

$$C_d^m(iv) = G\left(\alpha_v^m + \alpha_{ethnic}^m + \alpha_{acty}^m + X_{iv}\beta^m\right) \tag{2}$$

where dummies to account for unobservables at the village level (α_v) are included, as well as the household head's ethnic group (α_{ethnic}) and economic activity (α_{acty}). The vector of household-level characteristics, X_{iv}, will be divided, for clarity in the exposition, in three groups: X_{iv}^{hh}, a vector of socio-economic household characteristics; X_{iv}^{role}, a vector of characteristics related to the role of the household head in the village; and X_{ivm}^{ext}, that indicates whether the household has an external link in network m.

In Table 7 presents the results for the X_{iv}^{hh} vector of regressors. Household size plays an important role in how active a node is in networks, and has a positive effect on degree for most of the networks. Older household heads tend to be borrowers of labor. For the economic networks, evidence that decisions are taken at the household level is found, with the exception of land exchange, because compound heads are not significantly different in degree compared with others. Household heads with some level of formal education are less likely to be borrowers of land and inputs. When agriculture constitutes an important component of income, households tend to borrow land and lend labor. While the amount of land over which the household has rights is only significant in the land lender equation, a particularly interesting result emerges with respect to land quality. Though this variable is measured with error (it is self-declared), it can be seen that households that declare having high quality land are more central as land lenders, but also as labor borrowers, credit lenders and in the exchange of inputs. I interpret this as evidence that having better land is related to the time the household has been settled in the village (a variable not available in the data), though it could also be related to other possible aspects of social status.

To analyze the participation of ethnic minorities in networks, I divide the sample into a first group whose household heads belong to minorities that represent less than 30% of the population of the village, a second group of households who belong to a minority that represents between 30 and 50% of the village population, and the rest. There are 461 households in the first group and 88 in the second. As shown by the results reported in Table 7, ethnic minorities are active borrowers of land. In the case of *small minorities* (household s whose ethnicity represents less than 30% of the village population) degree as labor and credir lenders is also smaller, and they are less embedded in the family networks. These results suggest that minorities are not disciminated against in terms of getting land from the village founders' descendants, but can face a modicum of exclusion in other networks.

In terms of monetary income, I divide households into quartiles. The relative position of the household in the village's income distribution is related to centrality for input and credit networks, in line with the results for macrostructure presented in section 5.2. For $INPUT$, households in the intermediate quartiles are more active in exchange than those in the first quartile (the reference group). In terms of $CREDIT$, households from the richest quartile are, unsurprisingly, more likely to be lenders.

The fact that differences in income plays a relatively limited role in a household's centrality may be related to the fact that traditional structures and roles are more important than monetary income. In Table 8 shows that the role played by the household head in the village (X_{iv}^{role}) is indeed fundamental. The village chief or *Alkalo* always has a higher degree, with the exception of labor and marriage networks. In rural areas, the *Alkalo* is the oldest descendant of the village founders and is usually both the most respected figure and the one who takes the main decisions at the village level, usually in consultation with the Council of Elders. The members of this council are active as input and credit lenders, and its head as a land lender. The Alkalo's relatives only have a higher degree as land lenders (not surprisingly since on average 30% of the households are blood-related with the chief, with this figure sometimes reaching 90%), and the Alkalo's assistants a higher degree as labor and input lenders. The Village Development Council (VDC), which is the most decentralized part of the Gambian national system of development coordination, links a village with officers at the ward and LGA levels. The members of the VDC are representatives from each *kabilo*, each CBO and other co-opted members. VDC members are very embedded in terms of kinship relations and tend to be central in all economic networks.

Being a religious leader is also important. While all villages have at least one Imam that leads prayers, only half have a *Marabout*, a respected Koranic teacher who is sometimes imbued with mystical powers and who maintains some syncretic pre-Islamic traditions such as making amulets for good luck. Both are active as credit lenders and the Imam as a labor borrower (one of the main public activities in the villages is the construction and maintenance of the Mosque). Also it was asked whether respondents had treated other villagers using traditional medicine methods, since the *traditional healer* is a very respected person, a fact reflected by his higher degree as a borrower of labor, input and credit. The traditional musician and story-teller, the *Griot*, is also central in terms of being a land and credit lender.

Table 9 the importance of networks external to the village is explored. A dummy variable which is equal to 1 if a household has a external link in each network is included, either to bring (external-in) or to send (external-out) something/someone (X^{ext}_{ivm}). Household's degree appears to be negatively correlated with the existence of external links within each network (e.g., households receiving inputs from outside are less likely to both borrow and lend inputs inside the village).

5.4 Microstructure: links in the network

To study the variables related to the existence of a link between two households, I will follow the literature on dyadic regressions by posing the following empirical specification:

$$\ell^m_{ijv} = \alpha^m_v + (X_{iv} - X_{jv})\beta^m_{dif} + (X_{iv} + X_{jv})\beta^m_{sum} + w_{ijv}\beta^m_{dyad} + \epsilon^m_{ijv} \quad (3)$$

where the vector X_{iv} is made up of household socio-economic characteristics (X^{hh}_{iv}), their roles in the village (X^{role}_{iv}) and the existence of external links in each network (X^{ext}_{ivm}). The directed formation of links is studied, which implies that $\ell^m_{ijv} \neq \ell^m_{jiv}$. More precisely, $\ell^m_{ijv} = 1$ if i is the lender and j the borrower. In most networks it is very rare to observe individuals being both borrower and lender in within the same dyad, with the exception of the $INPUT$ network. To take this fact in consideration, I split $INPUT$ into *pure borrowers-lenders* on the one hand and *sharers* on the other. The latter lend and borrow inputs at the same time ($INPUTSHARER$). To preserve symmetry on the right-hand-side, I follow Fafchamps and Gubert (2007) by specifying three types of regressors: the coefficient β_{dif} is associated with the difference in attributes between i and j; β_{sum} is associated with the sum of the attributes of the members of the dyad; and β_{dyad} the parameter associated to the variable w_{ijv} that corresponds to common characteristics of i and j. The disturbance terms ϵ^m_{ijv} are allowed to be correlated across observations involving the same individual using the two-dimensional clustering methodology described in Cameron, Gelbach, and Miller (2011).

Table 10 displays the results for X^{hh}_{iv}. A pair of household heads with a direct kinship relationship (consanguinity) are more likely to form a link in all networks. When the kinship stems from one of the wives, the likelihood of forming a link also increases, except for the $LAND$ and $INPUTSHARER$ networks. As expected, when the sum of the sizes of both households is bigger, they are more prone to establish a link in all networks (a result that resembles the *gravity equation* for trade between two countries). If they differ in size, the probability of lending $LAND$ and $LABOR$ decreases. Conversely, the probability of lending increases for the $INPUT$ and $CREDIT$ networks. Older household heads tend to be borrowers of workers and lenders of inputs, but do not display homophily in terms of forming links with household heads of similar age. When the sum of the percentages of income stemming from agriculture is bigger, the households are more likely to exchange labor. Heterogeneity between households in this variable reduces the likelihood of lending land and increases the likelihood of lending of $CREDIT$.

Once one controls for various characteristics, belonging to the same ethnic group is *not* an important predictor of links, with the exception of $LABOR$ and the mutual exchange of inputs. This is in line with earlier results. I will expand on this finding in the concluding section.

The sum and differences in declared income *per capita* are generally not significant correlated to link creation, with the notable exception that richer households are more likely to lend money, the only real monetary transaction that is common amongst villagers. Nevertheless, wealth may be better captured by other endowments of the households. For instance, when the sum of land over which the households in the dyad have rights of use increases, the probability of establishing a relationship is higher in all the networks apart from $CREDIT$. When differences in land are considered, this only occurs for $LAND$, while for $LABOR$ the effect is the opposite: the household which is relatively less well-endowed in land tends to follow its *comparative advantage* and send workers to its counterpart. Homophily is also observed in terms of the quality of dwellings: when both households have a grass hut the exchange is more likely in labor and inputs. In terms of differences, households living in grass huts are more likely to lend labor to households that have huts constructed with more advanced materials (poorer households lend labor). Formal education can also be a measure of wealth. The sum of education attainment within the dyad does not increase the likelihood match, but considering the differences, the more educated household will bes more likely to be a land lender.

As shown in the results for mesostructure, traditional structures are significant predictors of a household's position within the various networks. The dyadic effects of village roles are presented in Table 11. When the role in question can only be filled by a single villager (Alkalo, VDC head and Elders Council head), only β_{dif} is considered since only the difference in roles matters. When the role can be shared by other villagers β_{sum} it is also include to see whether individuals with the same role will be more likely to form a link. The Alkalo is a lender of both land and credit, while the VDC and Elders Council heads are only lenders of credit. Other VDC members are also more likely to have a match, except for $INPUT$. While the Alkalo's relatives do not create additional links amongst themselves, they are more likely to lend land to the rest of the village (usually the descendants of the first settlers are those who have rights over land). As for the religious leaders, the *Marabout* and the Imam are lenders in $LAND$ and $CREDIT$, with Imams also having a higher probability of receiving workers. *Griots* also tend to be lenders of land and credit.

Despite a few exceptions, external links are of limited explanatory power at the dyadic level. For $LAND$ and $INPUT$, where both parties have an external link (either as a borrower or as a lenders) it is less likely that they will have a link inside the village. But if one household in the dyad is an external lender, it is more likely that it will also lend internally.

Overall, it appears that link formation is related to kinship relationship, the roles that households play in the village, and differences in endowments. Differences in ethnicity and income *per se* seem to be of limited importance.

6 Conclusions

In this paper, I have investigated the structure of six social and economic networks at different levels of disaggregation in a database collected in rural Gambia, with a sample of 60 villages, 2,810 households and 101,940 (potential) links. I use these particularly rich data to explore whether network analysis can shed light on various aspects of the economic development of this rural society, with a particular focus on income distribution and ethnic fragmentation.

Comparing across villages, it is found that income inequality and poverty indicators are related to network architecture. In particular, it is found that more unequal villages have economic networks that are denser and more compact, and thus with more interactions. This is particularly the case for the exchange of goods and money (input and credit networks), a result confirmed in the analysis of the factors associated with a household's centrality. At the link level, differences in income *per se* only explain a match in the credit network. This results might appear to contradict previous findings, usually at more aggregated levels of analysis, that have shown that higher Gini coefficients are associated with lower levels of social capital and social interactions (e.g. Knack and Keefer (1997)). In the small Gambian communities that studied here, things are different: inequality creates opportunities for exchange, which are driven (as shown in the analysis of the microstructure) by differences in endowments. Since differences amongst households are often a function of the traditional structure of the village (related to the roles of the household heads and other members of each household and with shades of the abandoned caste system), it may be the case that these differences do not create distrust and are taken into account as unavoidable aspects of village life. One could interpret this as preliminary evidence for an inverted U-shaped effect of income inequality on the level of social and economic interactions.

In terms of the effects of ethnic fragmentation, I find little conclusive evidence at the macrostructure level, except for an increase in the density and compactness of the land network. At the household level, I find that households belonging to ethnic minorities participate in very particular ways in networks, with a higher degree as land borrowers and a lower degree for labor and credit exchange. As for microstructure, most of the predictions concerning link creation related to ethnicity seem to be captured by the family ties variables, though homophily in ethnicity is still relevant in terms of explaining labor links. One potential explanation for these results is that minority ethnic groups migrate to villages with an excess supply of land, which is then given to them by the early settlers who possess the property rights. On the other hand, the newcomers are still marginalized from other networks. These results also have to be understood in the context of rural Gambia, where the ethnic composition of villages is often heterogeneous, but where, despite the traditions preserved by each ethnicity, there is a shared religion and common culture.

Future research on this particularly rich dataset will be geared towards understanding the interactions among the various networks and the causal mechanisms that lie behind link formation, thereby hopefully leading to a deeper understanding of the determinants of network formation and its effects on economic development in poor West African villages.

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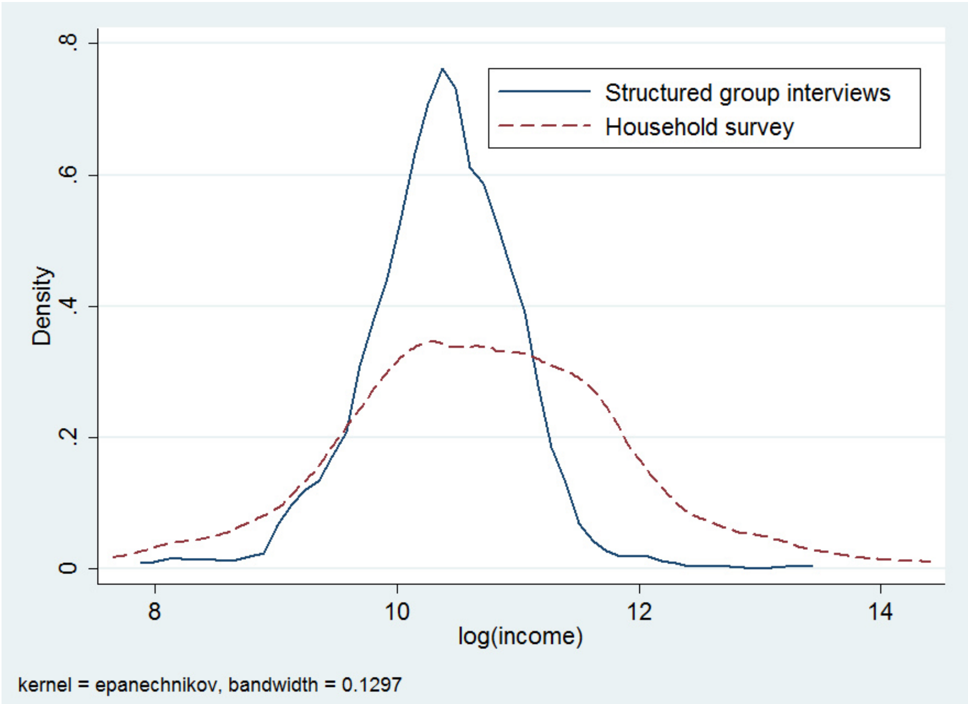
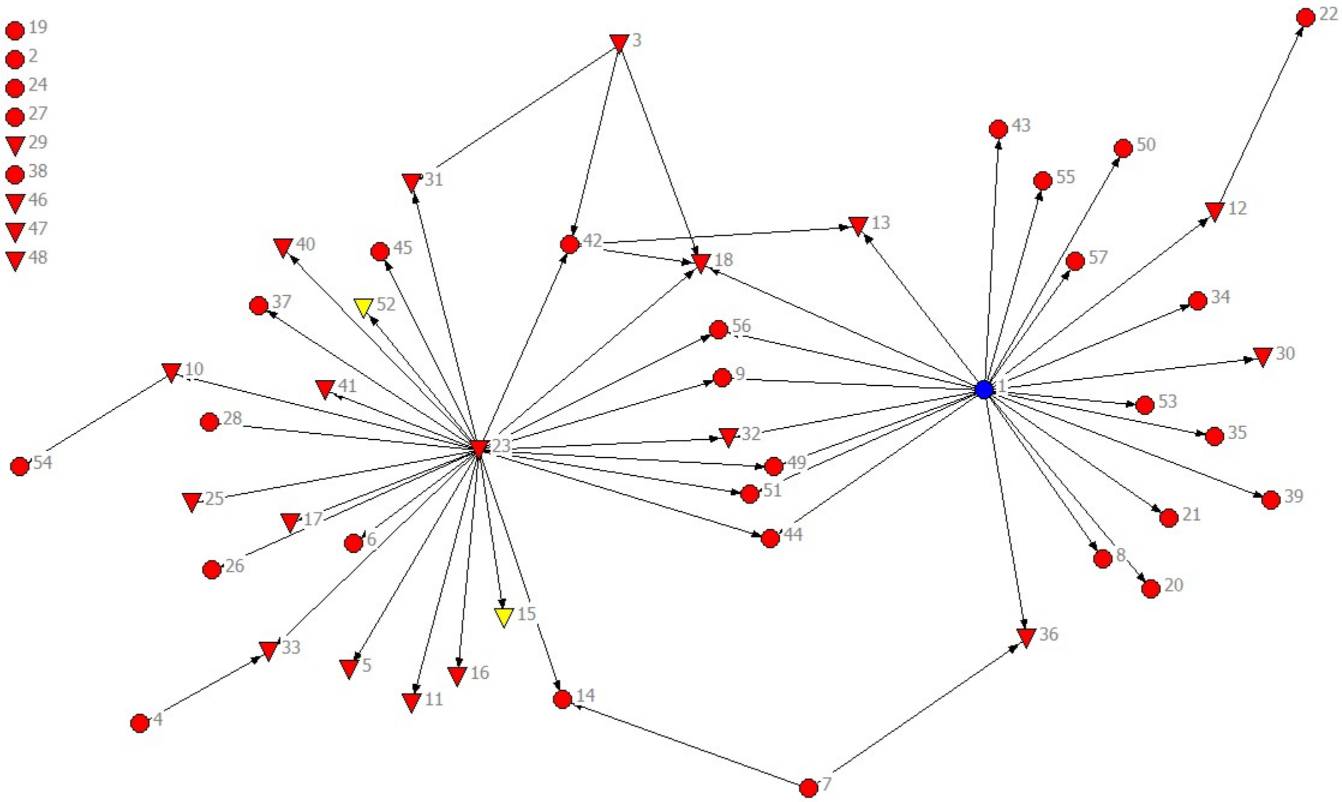
Figure 1: INCOME DISTRIBUTION WITH DIFFERENT SURVEY INSTRUMENTS



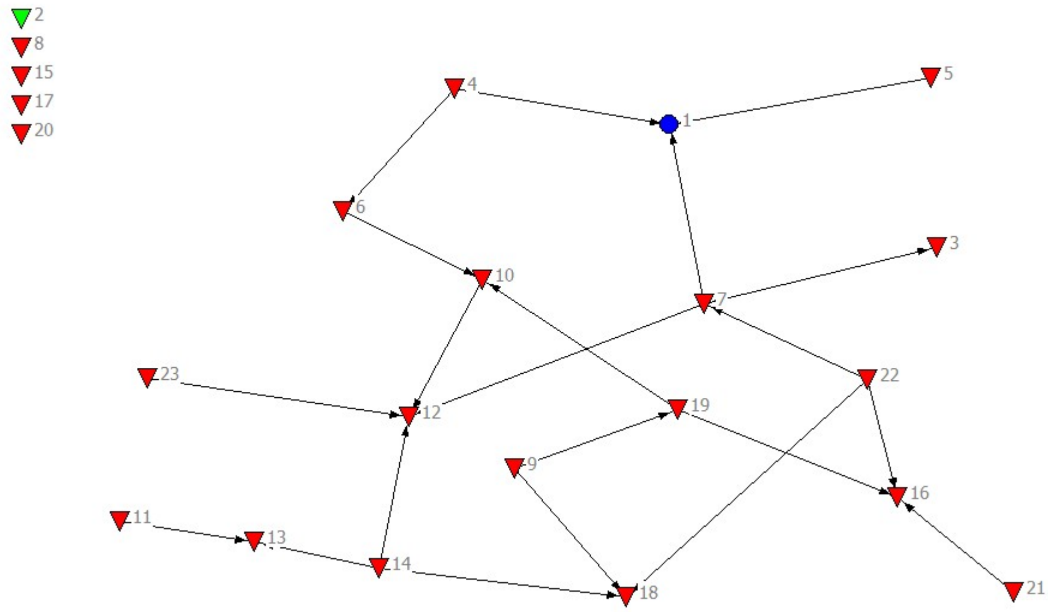
Note: Kernel density estimates for the distribution of income with data for 15 villages in which both surveys were conducted. The household survey drew a random sample of villages and collected disaggregated data on monthly income The distribution displayed here uses 230 observations. The methodology that lies behind the structured group interview data is described in the paper. The sample corresponds to all household heads and the distribution was constructed using 773 observations.

Figure 2: LAND NETWORK IN BARAJALLY SUBA VILLAGE



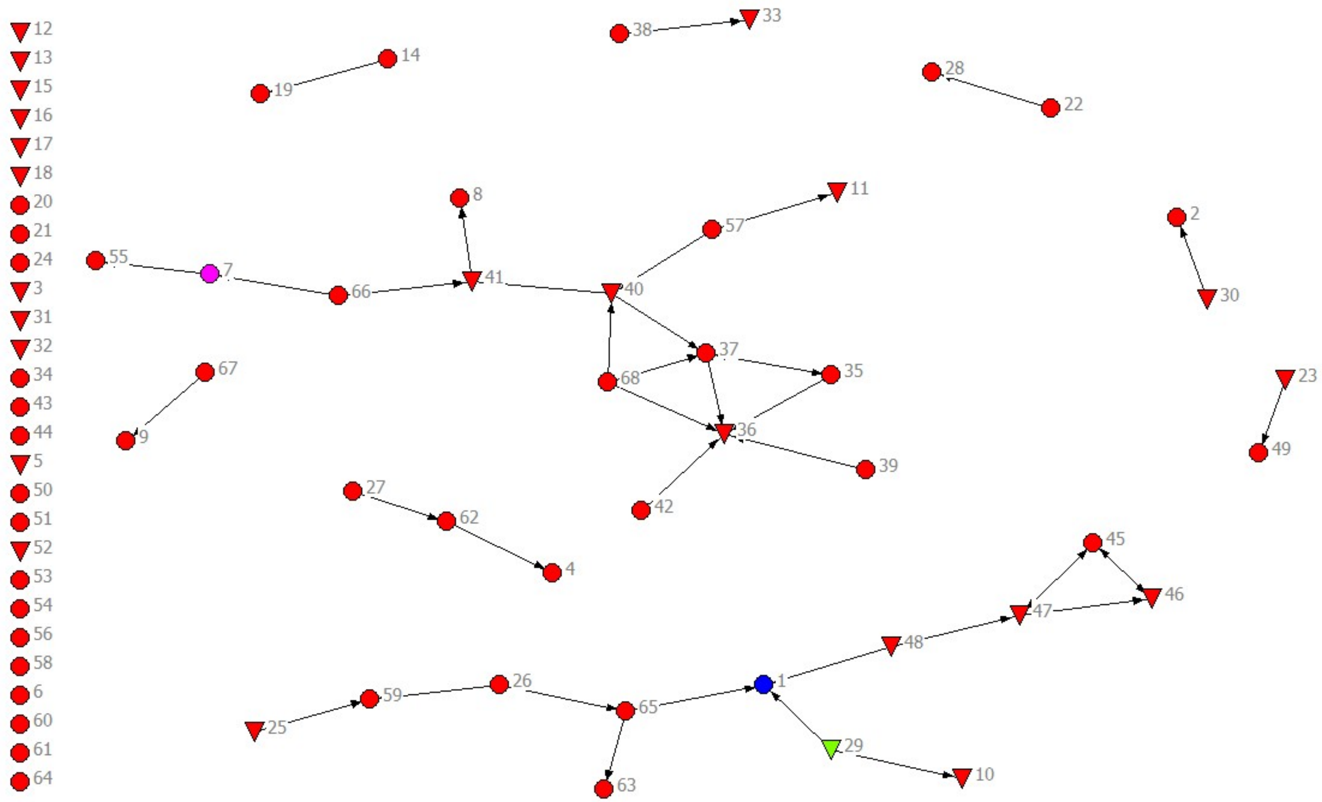
Legend: ▽ Alkalo's relative; ● Alkalo; ● VDC head; ● Marabout; ● Imam.
Macrostructure: $D(g^m)$: 0.041; $Cl(g^m)$: 0.006; $Cmp(g^m)$: 0.712.
Note: This figure was produced using UCINET-NetDraw software.

Figure 3: LABOR NETWORK IN TAMBA KUNDA VILLAGE



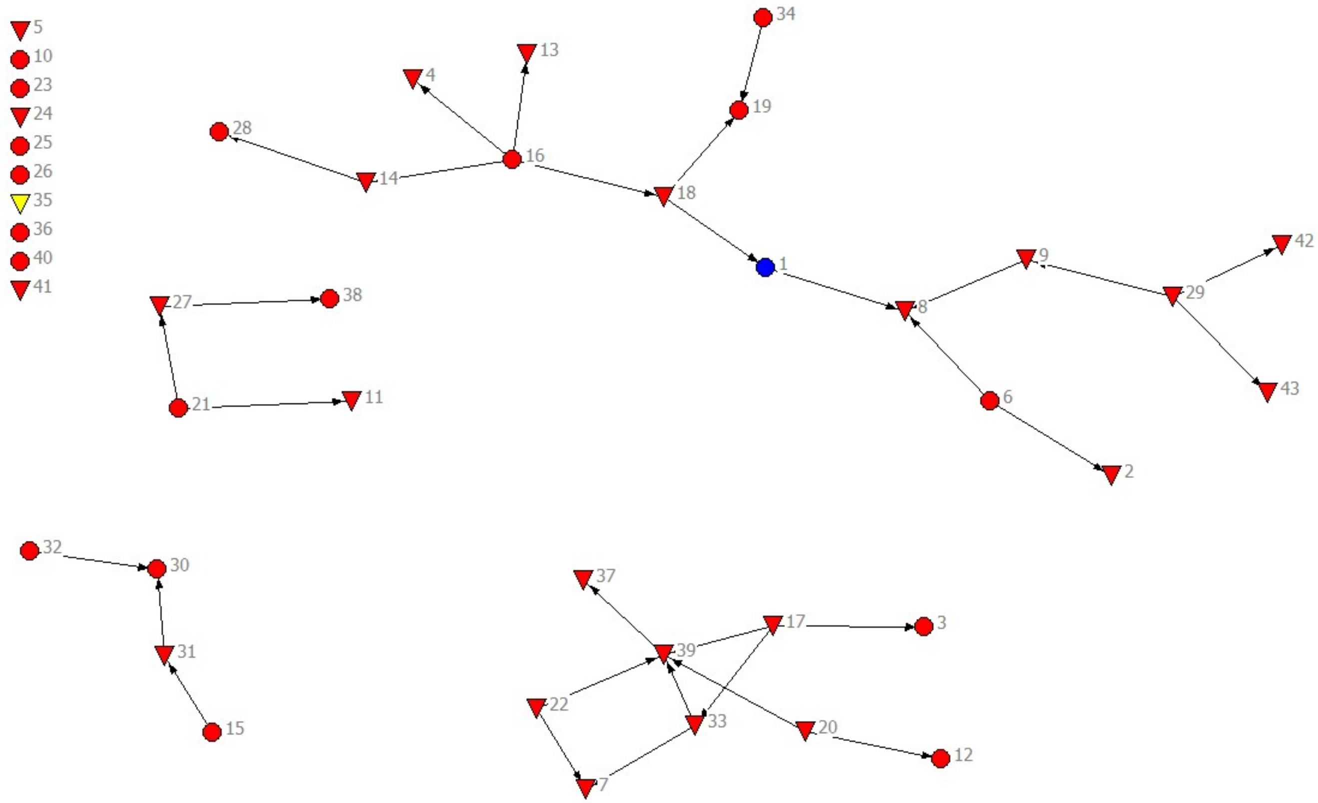
Legend: ▽ Alkalo's relative; ● Alkalo; ● VDC head; ● Marabout; ● Imam.
Macrostructure: $D(g^m)$: 0.0869; $Cl(g^m)$: 0; $Cmp(g^m)$: 0.622.
Note: This figure was produced using UCINET-NetDraw software.

Figure 4: LABOR NETWORK IN KERR JATTA VILLAGE



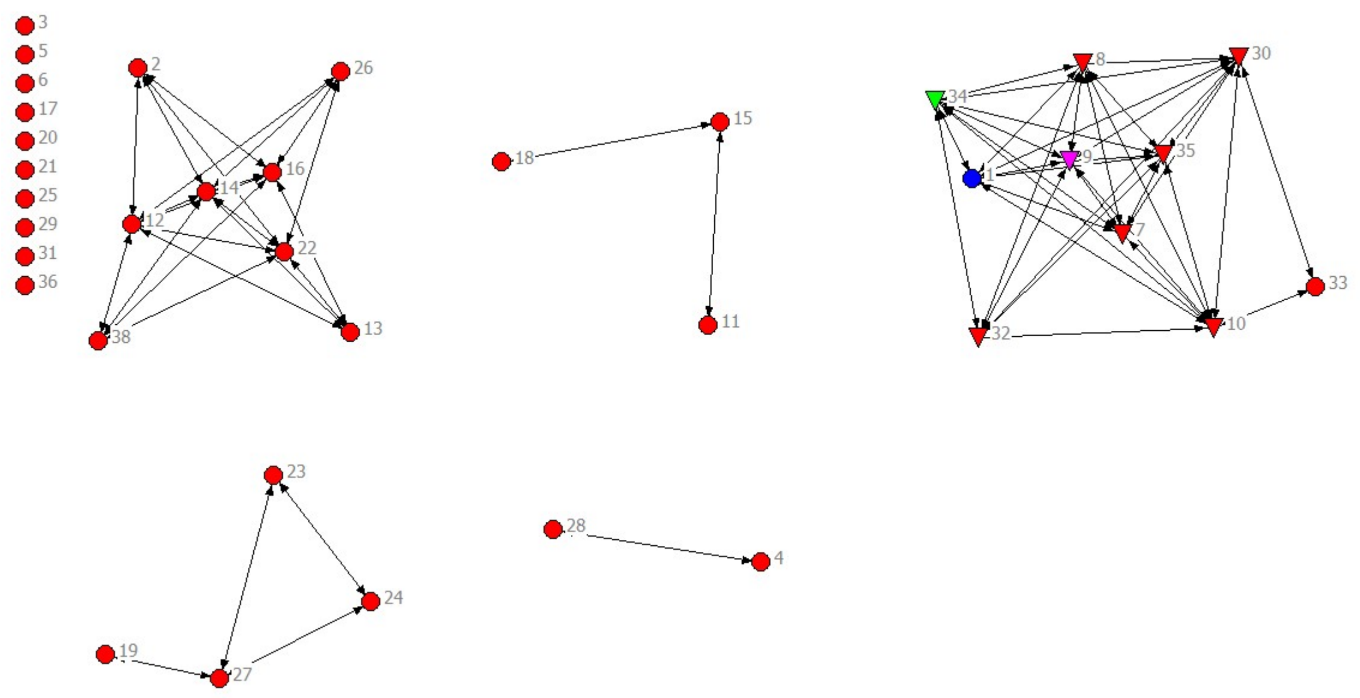
Legend: ▽ Alkalo's relative; ● Alkalo; ● VDC head; ● Marabout; ● Imam.
Macrostructure: $D(g^m)$: 0.017; $Cl(g^m)$: 0.156; $Cmp(g^m)$: 0.087.
Note: This figure was produced using UCINET-NetDraw software.

Figure 5: INPUT NETWORK IN JAKOI SIBRICK VILLAGE



Legend: ▽ Alkalo's relative; ● Alkalo; ● VDC head; ● Marabout; ● Imam.
Macrostructure: $D(g^m)$: 0.042; $Cl(g^m)$: 0.047; $Cmp(g^m)$: 0.205.
Note: This figure was produced using UCINET-NetDraw software.

Figure 6: KINSHIP NETWORK IN DARUSALAM VILLAGE



Legend: $\triangledown$ Alkalo's relative; ● Alkalo; ● VDC head; ● Marabout; ● Imam.
Macrostructure: $D(g^m)$: 0.128; $Cl(g^m)$: 0.587; $Cmp(g^m)$: 0.141. $log(n)/n$: 0.095.
Note: This figure was produced using UCINET-NetDraw software.

Table 1: VILLAGE DESCRIPTION

Variable	Mean	Std. Dev.	Min	Max
Approximate population	585	245	202	1,402
Household size (between villages, median number of members)	11.57	3.28	7.00	21.50
Household size difference (village standard deviation)	9.91	9.42	3.35	61.18
Population density (persons/square kilometers)	6,901	4,118	652.21	20,310
Income *per capita* (between villages, mean GMD)	3,208	1,705	450.65	11,695
Gini (from self-declared income)	0.34	0.11	0.13	0.66
Approximate available agricultural land (hectares)	337	364	0.00	2,044
Land per worker (between villages, mean hectares)	2.69	3.53	0.00	23.82
Land per worker differences (village standard deviation, hectares)	4.65	6.08	0.00	27.93
Diversity of ethnic groups (EDI)	0.30	0.23	0.84	0
Diversity of main economic activity (village Herfindahl index)	0.47	0.17	0.81	0
Diversity in educational level (village Herfindahl index)	0.29	0.12	0.53	0.05
No formal education (village %)	82	10	48	100
Koranic education (village %)	61	18	7	100
No access to electricity (village %)	97	4	84	100
No private toilettes (village %)	38	30	0	100
Not improved water (village %)	88	20	0	100
Grasshuts (village %)	38	29	0	94
Access to government news (% of TV and newspaper users)	16	16	0	57
Marabout in the village	0.5	0.5	0	1

Note: Village-level information. 60 observations for each variable.

Table 2: HOUSEHOLD DESCRIPTION

Variable	Mean	Std. Dev.	Min	Max
Household Size	12.67	11.40	1	400
Age of household head	51.70	15.54	15	100
Female Household head	0.06	0.25	0	1
Compound head	0.84	0.37	0	1
Polygamous	0.46	0.50	0	1
Monogamous	0.48	0.50	0	1
Non Muslim	0.04	0.19	0	1
Ethnic minority	0.19	0.40	0	1
Workers in the household (%)	1.27	0.66	0	6
Agricultural land (hectares)	8.06	21.22	0	400
Land per worker (hectares)	2.27	7.40	0	133
Income per capita (GMD)	3,514	4,735	43	125,000
Agricultural income (% of total)	0.12	0.24	0	1
High quality land	0.11	0.32	0	1
Kamanyango	0.05	0.22	0	1
Emigrants	0.48	0.50	0	1
Self respondent	0.73	0.45	0	1
Alkalo's relative	0.35	0.48	0	1
Alkalo's assistant	0.04	0.20	0	1
VDC member	0.19	0.39	0	1
Elder council member	0.19	0.39	0	1
Traditional healer	0.20	0.40	0	1
Griot	0.01	0.12	0	1

Note: Household-level descriptive statistics. 2,810 observations for each variable.

Table 3: SIMPLE CORRELATION IN HOUSEHOLD DEGREE

		LAND		LABOR		INPUT		CREDIT		MARRIAGE		KINSHIP
		Lender	Borrower	Lender	Borrower	Lender	Borrower	Lender	Borrower	Sender	Receiver	
LAND	Lender	1										
	Borrower	-0.0459*	1									
LABOR	Lender	0.0574*	0.1497*	1								
	Borrower	0.2574*	0.1008*	0.2219*	1							
INPUT	Lender	0.1760*	0.1157*	0.3419*	0.2849*	1						
	Borrower	0.0799*	0.1388*	0.3048*	0.2331*	0.5137*	1					
CREDIT	Lender	0.1244*	0.1234*	0.1418*	0.2106*	0.3030*	0.1724*	1				
	Borrower	0.1013*	0.1010*	0.2574*	0.1418*	0.2533*	0.2813*	0.1326*	1			
MARRIAGE	Sender	0.0702*	0.005	0.0098	0.0891*	0.0721*	0.0365	0.0810*	0.0441*	1		
	Receiver	0.0227	0.0318	0.0033	0.0518*	0.0389*	0.0181	0.0835*	0.0484*	0.1049*	1	
KINSHIP		0.1958*	0.0116	0.1842*	0.2762*	0.2320*	0.1469*	0.2123*	0.1863*	0.2076*	0.1355*	1

Note: 2,810 observations. * indicates that simple correlation is significant at 5% level.

Table 4: NETWORK DESCRIPTION

		HOUSEHOLD LEVEL				VILLAGE LEVEL				
Network		In-degree centrality	Out-degree centrality	External-in	External-out	Links	Density ($D(g^m)$)	Clustering ($Cl(g^m)$)	Compactness ($Cmp(g^m)$)	External links
LAND	Mean	0.010	0.010	0.082	0.055	29.2	0.032	0.009	0.210	0.153
	s.d.	(0.019)	(0.035)	(0.274)	(0.228)	(16.6)	(0.030)	(0.028)	(0.214)	(0.199)
LABOUR	Mean	0.014	0.014	-	0.068	29.9	0.030	0.046	0.253	0.082
	s.d.	(0.036)	(0.024)	-	(0.251)	(20.8)	(0.026)	(0.065)	(0.255)	(0.109)
INPUTS	Mean	0.021	0.021	0.078	0.031	39.8	0.048	0.067	0.325	0.127
	s.d.	(0.034)	(0.038)	(0.268)	(0.174)	(22.5)	(0.044)	(0.072)	(0.278)	(0.099)
CREDIT	Mean	0.009	0.009	0.122	0.048	23.0	0.022	0.034	0.159	0.161
	s.d.	(0.017)	(0.027)	(0.327)	(0.214)	(17.9)	(0.021)	(0.053)	(0.184)	(0.108)
MARRIAGE	Mean	0.018	0.018	0.738	0.600	49.9	0.046	0.059	0.285	0.871
	s.d.	(0.092)	(0.092)	(0.440)	(0.490)	(40.9)	(0.039)	(0.073)	(0.253)	(0.140)
KINSHIP	Mean	0.098	0.098	-	-	147.7	0.144	0.279	0.638	-
	s.d.	(0.091)	(0.091)	-	-	(76.5)	(0.105)	(0.134)	(0.257)	-

Note: 2,810 observations for household-level information. 60 observations for village-level information. ’s.d.’ refers to the standard deviation.

Table 5: NETWORK CHARACTERISTICS: POOLED DATA

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		DENSITY			CLUSTERING			COMPACTNESS	
	All	Economic	Family	All	Economic	Family	All	Economic	Family
Population	-1.429***	-1.323***	-1.499***	0.158	1.315**	-0.079	-1.372***	-1.483***	-1.534***
	(0.199)	(0.263)	(0.211)	(0.218)	(0.532)	(0.223)	(0.301)	(0.541)	(0.411)
Household size	1.404***	1.561***	1.227***	0.732**	1.110*	0.192	1.799***	2.125***	1.315**
	(0.272)	(0.363)	(0.296)	(0.327)	(0.626)	(0.424)	(0.428)	(0.754)	(0.520)
Population density	0.033	-0.037	0.086	-0.136	-0.722***	0.103	0.011	0.024	-0.013
	(0.100)	(0.146)	(0.104)	(0.116)	(0.279)	(0.206)	(0.202)	(0.273)	(0.203)
Gini	1.307**	1.125	1.322**	-1.254**	-0.339	-1.547**	3.174***	3.007*	3.218***
	(0.624)	(0.872)	(0.583)	(0.489)	(1.302)	(0.645)	(1.016)	(1.708)	(0.985)
Ethnic diversity	-0.343	-0.017	-0.610*	0.178	0.146	-0.058	-0.230	0.708	-1.027
	(0.305)	(0.392)	(0.357)	(0.315)	(1.017)	(0.390)	(0.584)	(0.728)	(0.693)
Sector diversity	0.459	0.643	0.345	1.428***	3.212***	1.195**	0.490	0.989	-0.510
	(0.363)	(0.495)	(0.371)	(0.461)	(1.051)	(0.577)	(0.692)	(0.936)	(0.826)
Income per capita	0.036	0.055	0.016	0.070	0.275	-0.093	0.101	0.149	-0.040
	(0.054)	(0.077)	(0.051)	(0.066)	(0.171)	(0.082)	(0.114)	(0.150)	(0.110)
No private toilettes	0.391**	0.374	0.391**	0.306	0.381	0.121	-0.296	-0.509	-0.468
	(0.181)	(0.239)	(0.181)	(0.220)	(0.644)	(0.222)	(0.345)	(0.423)	(0.495)
No improved water	0.888**	-0.062	1.368***	-0.948	-2.496	-0.712	1.893**	0.765	2.533**
	(0.399)	(0.637)	(0.441)	(0.682)	(1.791)	(0.657)	(0.776)	(1.217)	(1.020)
Grass huts	0.731**	1.190***	0.343	0.278	-0.158	0.490	1.961***	3.211***	-0.486
	(0.315)	(0.408)	(0.390)	(0.411)	(1.001)	(0.465)	(0.504)	(0.737)	(0.705)
External links		-0.679*			-1.029			-0.950	
		(0.356)			(0.780)			(0.750)	
Observations	360	240	120	360	240	120	360	240	120
$R^2_{deviance}$	0.822	0.729	0.845	0.627	0.471	0.670	0.571	0.570	0.746

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors are clustered at the village level.
Fractional logit estimation. Dummies for network, ward, main village activity, predominant ethnic group, semi-urban areas as well as presence of Marabout, household size diversity, education level diversity, percentage of illiterates, percentage of households with no electricity, percentage of Alkalo's relatives, percentage female household heads and average land per worker are included in the regression, but not reported.

Table 6: NETWORK CHARACTERISTICS

		Population	Household size	Gini	Ethnic diversity	Sector diversity	Grasshut	Not impr. water	External-in	External-out
Density	LAND	-1.320***	0.954**	1.139*	1.699***	-0.728	0.104	-0.899	-1.737	0.338
	LABOR	-0.783***	2.054***	0.916	-0.226	-0.884*	1.341***	2.111**		2.755***
	INPUT	-1.476***	2.580***	1.675*	0.028	-0.094	0.978*	-0.638	3.890**	6.488**
	CREDIT	-1.075***	1.669***	2.658***	0.360	-1.266*	1.852**	1.999**	-2.349**	4.387
	MARRIAGE	-0.740***	0.460	0.510	-0.378	-2.062***	-0.447	1.043*	-1.462***	1.275**
	KINSHIP	-1.341***	1.610***	1.007	-0.155	-0.658*	0.015	0.093		
Clustering	LABOR	1.675***	0.141	-2.352	0.593	2.468	2.916**	4.955**		-10.331***
	INPUT	-0.043	1.610	1.861	0.374	-0.430	1.176	0.069	-1.663	3.777
	CREDIT	0.628	2.322	-0.956	2.243	-8.173***	3.506	7.172**	-1.174	34.807***
	MARRIAGE	3.749***	-0.922	3.570*	-6.067***	-8.733***	-5.656***	-5.037*	1.068	0.698
	KINSHIP	-0.403*	0.455	-1.106*	0.765**	0.005	1.099***	-0.517		
Compactness	LAND	-2.180***	0.768	1.517	3.816***	0.093	0.377	0.685	-6.008***	0.607
	LABOR	-0.925**	3.324***	1.619	-0.195	-1.143	4.320***	8.299***		6.624***
	INPUT	-1.762***	1.937**	5.840***	-1.073	-1.019	2.769**	-0.092	-0.300	-2.492
	CREDIT	-1.435***	1.381	3.519**	0.125	-0.593	4.344***	5.270***	-2.804	12.848*
	MARRIAGE	-0.609	-0.622	-1.802	-0.969	-3.893***	-2.921***	4.207***	-5.941***	1.267
	KINSHIP	-2.078***	0.777	2.412*	-1.060	0.011	-2.670***	1.305		

60 observations for each regression.
Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors, clustered at the village level, in parentheses.
Fractional logit estimation. Dummies for ward, predominant ethnic group, semi-urban areas as well as presence of Marabout, percentage female household heads, percentage of Alkalo's relatives, percentage of illiterates, percentage of households with no electricity, and average land per worker are included in the regression, but not reported.
The quasi-MLE estimation of the clustering equation for $LAND$ was not feasible (most values for the dependent variable are around zero).

Table 7: HOUSEHOLD'S DEGREE CENTRALITY: ECONOMIC AND DEMOGRAPHIC FACTORS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
X_{iv}^{hh}	LAND		LABOR		INPUT		CREDIT		MARRIAGE		KINSHIP
	Lender	Borrower	Lender	Borrower	Lender	Borrower	Lender	Borrower	Sender	Receiver	
Household size	-0.001	0.357***	0.131	0.293**	0.316***	0.170*	0.655***	0.205**	0.643***	0.522***	0.182***
	(0.193)	(0.100)	(0.089)	(0.118)	(0.095)	(0.090)	(0.127)	(0.093)	(0.152)	(0.078)	(0.036)
Age	-0.020	-0.139	-0.419***	0.405**	-0.152	-0.334***	-0.263	-0.025	0.347***	0.163	0.269***
	(0.222)	(0.117)	(0.110)	(0.168)	(0.158)	(0.109)	(0.217)	(0.152)	(0.105)	(0.126)	(0.058)
Compound head	0.714***	0.128	-0.175*	0.118	0.034	0.050	-0.093	-0.008	0.727***	0.094	0.104*
	(0.174)	(0.136)	(0.090)	(0.143)	(0.103)	(0.100)	(0.195)	(0.137)	(0.093)	(0.099)	(0.057)
Education	0.013	-0.325**	0.016	-0.243	-0.155*	-0.269***	-0.283	0.013	-0.150*	0.029	-0.065*
	(0.169)	(0.132)	(0.078)	(0.167)	(0.087)	(0.081)	(0.175)	(0.110)	(0.089)	(0.069)	(0.039)
% Agriculture	-0.075	0.333*	0.344**	0.202	0.244*	-0.013	0.477*	-0.187	0.167	0.190	0.182**
in income	(0.265)	(0.177)	(0.139)	(0.167)	(0.133)	(0.120)	(0.251)	(0.170)	(0.140)	(0.138)	(0.076)
Land size	0.311**	-0.026	-0.050	0.161*	0.083	0.036	-0.015	-0.125	0.008	0.147*	0.057*
	(0.129)	(0.072)	(0.092)	(0.089)	(0.078)	(0.079)	(0.134)	(0.082)	(0.122)	(0.077)	(0.032)
Productive land	0.647***	-0.124	0.316	0.360**	0.383**	0.293**	0.514*	0.357	0.184	-0.006	0.215***
	(0.249)	(0.239)	(0.221)	(0.181)	(0.193)	(0.137)	(0.303)	(0.248)	(0.160)	(0.126)	(0.066)
Ethnic Minority	-0.388	0.337***	-0.095	-0.428***	-0.086	0.032	0.042	-0.258**	-0.957***	-0.972***	-0.882***
(< 30%)	(0.237)	(0.127)	(0.124)	(0.132)	(0.123)	(0.117)	(0.178)	(0.120)	(0.144)	(0.182)	(0.093)
Ethnic Minority	-0.907***	0.789**	-0.370*	0.440	0.068	0.317	0.404	0.337**	0.010	-0.670***	-0.140
(> 30%)	(0.240)	(0.359)	(0.195)	(0.293)	(0.252)	(0.234)	(0.262)	(0.158)	(0.192)	(0.185)	(0.118)
2^{nd} quartile	-0.042	0.067	0.171*	0.103	0.166*	0.163*	0.006	0.034	0.040	0.054	-0.012
	(0.137)	(0.094)	(0.091)	(0.123)	(0.094)	(0.096)	(0.184)	(0.072)	(0.068)	(0.110)	(0.036)
3^{rd} quartile	0.124	-0.011	0.043	0.143	0.181*	0.161*	0.208	0.139	0.218*	0.037	0.046
	(0.169)	(0.083)	(0.095)	(0.124)	(0.098)	(0.093)	(0.165)	(0.086)	(0.118)	(0.109)	(0.041)
4^{th} quartile	-0.078	0.103	-0.014	0.126	0.193	0.091	0.471**	-0.067	0.259***	0.088	0.085
	(0.158)	(0.108)	(0.124)	(0.152)	(0.138)	(0.121)	(0.189)	(0.131)	(0.094)	(0.123)	(0.054)
Observations	2810	2810	2810	2810	2810	2810	2810	2810	2810	2810	2810
$R^2_{deviance}$	0.452	0.348	0.362	0.373	0.434	0.440	0.367	0.344	0.402	0.423	0.635

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors, clustered at village level, in parentheses.
Fractional logit estimation for the model presented in Equation (2).
The model includes the same variables as in Tables 8 and 9, and dummies for village, ethnic group and main economic activity of the household head (not reported). The variables *percentage of active workers*, *access to newspapers*, *access to TV news*, *use of kamanyango system*, *self-respondent interviewed*, *female household head*, *polygamous household*, *non-Muslin* and *relevance of emigrants* were also included but are not reported due to lack of statistical or economic significance.

Table 8: HOUSEHOLD'S DEGREE CENTRALITY: TRADITIONAL ROLES

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
X_{iv}^{role}	LAND		LABOR		INPUT		CREDIT		MARRIAGE		KINSHIP
	Lender	Borrower	Lender	Borrower	Lender	Borrower	Lender	Borrower	Sender	Receiver	
Alkalo	1.484***	0.154	-0.019	0.392	0.702***	0.458***	1.243***	0.400**	0.205	0.152	0.553***
	(0.205)	(0.257)	(0.231)	(0.276)	(0.111)	(0.153)	(0.209)	(0.191)	(0.150)	(0.143)	(0.085)
Alkalo's relative	0.224*	-0.071	0.089	-0.064	0.112	-0.031	0.107	0.007	-0.199***	-0.071	0.128**
	(0.125)	(0.100)	(0.101)	(0.114)	(0.074)	(0.072)	(0.137)	(0.099)	(0.073)	(0.070)	(0.054)
Alkalo's assistant	0.316	0.057	0.198*	0.152	0.293**	0.143	0.036	0.146	0.146	0.055	0.155**
	(0.249)	(0.143)	(0.117)	(0.163)	(0.138)	(0.122)	(0.209)	(0.168)	(0.106)	(0.123)	(0.063)
VDC head	0.027	-0.312	0.182	0.503***	0.351**	0.026	1.240***	0.217	-0.105	-0.081	0.352***
	(0.240)	(0.274)	(0.162)	(0.185)	(0.155)	(0.192)	(0.240)	(0.211)	(0.209)	(0.156)	(0.091)
VDC member	0.207*	0.081	0.194**	-0.040	0.128*	0.162***	0.291***	0.223**	-0.026	-0.056	0.092***
	(0.118)	(0.078)	(0.078)	(0.114)	(0.073)	(0.058)	(0.108)	(0.089)	(0.074)	(0.083)	(0.033)
Elder's head	0.460*	-0.152	0.087	0.517	0.179	-0.087	0.703***	-0.192	0.040	0.167	0.186**
	(0.276)	(0.257)	(0.282)	(0.470)	(0.149)	(0.275)	(0.236)	(0.363)	(0.186)	(0.147)	(0.081)
Elder's council	0.079	0.073	-0.059	0.077	0.179**	0.044	0.341**	0.038	0.189**	-0.072	0.032
	(0.166)	(0.080)	(0.103)	(0.101)	(0.077)	(0.074)	(0.158)	(0.127)	(0.089)	(0.068)	(0.041)
Marabout	0.274	0.261	0.234	0.244	0.258	0.063	1.055***	0.150	0.235	0.100	0.065
	(0.346)	(0.162)	(0.231)	(0.249)	(0.232)	(0.171)	(0.270)	(0.166)	(0.178)	(0.191)	(0.077)
Imam	0.436	-0.002	-0.160	0.787*	-0.018	-0.145	0.415**	-0.324	-0.221	-0.037	-0.063
	(0.317)	(0.213)	(0.155)	(0.425)	(0.194)	(0.172)	(0.206)	(0.220)	(0.211)	(0.183)	(0.089)
Traditional healer	-0.008	0.080	0.081	0.213**	0.023	0.124**	0.237*	0.147*	0.032	0.171***	0.068**
	(0.117)	(0.079)	(0.080)	(0.096)	(0.061)	(0.052)	(0.123)	(0.087)	(0.068)	(0.055)	(0.031)
Griot	0.851***	-0.053	0.295	0.386*	-0.116	-0.172	0.720***	0.049	-0.185	-0.263	-0.094
	(0.288)	(0.187)	(0.254)	(0.211)	(0.154)	(0.167)	(0.227)	(0.228)	(0.178)	(0.232)	(0.114)
Observations	2810	2810	2810	2810	2810	2810	2810	2810	2810	2810	2810
$R^2_{deviance}$	0.452	0.348	0.362	0.373	0.434	0.440	0.367	0.344	0.402	0.423	0.635

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors, clustered at the village level, in parentheses.
Fractional logit estimation for the model presented in Equation (2).
The model includes the same variables used in Tables 7 and 9, and dummies for village, ethnic group and main economic activity of the household head (not reported).

Table 9: HOUSEHOLD'S DEGREE CENTRALITY: EXTERNAL LINK

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
X^{ext}_{ivm}	LAND		LABOR		INPUT		CREDIT		MARRIAGE		KINSHIP
	Lender	Borrower	Lender	Borrower	Lender	Borrower	Lender	Borrower	Sender	Receiver	
External-in *LAND*	-0.597**	-0.619***	0.142	0.025	0.174	-0.215*	0.352	0.139	-0.033	-0.222**	0.083
	(0.255)	(0.196)	(0.141)	(0.202)	(0.125)	(0.113)	(0.269)	(0.160)	(0.118)	(0.107)	(0.056)
External-out *LAND*	0.193	-0.723***	0.241*	-0.014	0.164	0.109	0.040	-0.311	0.170	0.083	0.018
	(0.185)	(0.277)	(0.140)	(0.157)	(0.134)	(0.128)	(0.244)	(0.205)	(0.140)	(0.098)	(0.064)
External-out *LABOR*	0.296*	0.063	-0.379**	0.018	0.108	0.069	-0.143	-0.089	-0.050	0.077	0.004
	(0.162)	(0.147)	(0.163)	(0.131)	(0.129)	(0.100)	(0.218)	(0.089)	(0.139)	(0.120)	(0.081)
External-in *INPUT*	0.354**	0.020	-0.021	0.009	-0.273***	-0.317**	-0.176	0.039	-0.113	0.061	-0.028
	(0.179)	(0.138)	(0.121)	(0.130)	(0.080)	(0.125)	(0.206)	(0.118)	(0.105)	(0.099)	(0.046)
External-out *INPUT*	-0.461*	-0.073	0.174	-0.548**	0.097	-0.544***	0.181	0.030	-0.131	0.046	-0.008
	(0.270)	(0.177)	(0.159)	(0.248)	(0.121)	(0.154)	(0.180)	(0.212)	(0.227)	(0.166)	(0.063)
External-in *CREDIT*	0.101	0.067	0.069	-0.050	-0.092	0.025	0.070	-0.542***	0.031	0.015	-0.038
	(0.141)	(0.124)	(0.101)	(0.118)	(0.124)	(0.089)	(0.169)	(0.149)	(0.160)	(0.082)	(0.040)
External-out *CREDIT*	0.478***	-0.177	0.291*	0.213	0.137	-0.025	0.015	0.024	-0.193	-0.024	0.065
	(0.153)	(0.190)	(0.166)	(0.218)	(0.126)	(0.106)	(0.199)	(0.143)	(0.167)	(0.091)	(0.095)
External-in *MARRIAGE*	-0.041	-0.039	-0.101	-0.006	0.028	-0.022	-0.209	-0.167**	-0.018	-0.858***	-0.041
	(0.140)	(0.090)	(0.066)	(0.099)	(0.107)	(0.075)	(0.157)	(0.067)	(0.078)	(0.102)	(0.030)
External-out *MARRIAGE*	-0.021	-0.000	0.035	0.102	0.208***	0.114	0.049	0.047	0.011	-0.050	0.039
	(0.123)	(0.068)	(0.065)	(0.095)	(0.079)	(0.074)	(0.162)	(0.068)	(0.078)	(0.059)	(0.032)
Observations	2810	2810	2810	2810	2810	2810	2810	2810	2810	2810	2810
$R^2_{deviance}$	0.452	0.348	0.362	0.373	0.434	0.440	0.367	0.344	0.402	0.423	0.635

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors, clustered at village level, in parentheses.
Fractional logit estimation for the model presented in Equation (2).
The model includes the same variables as those used in Tables 7 and 8, and dummies for village, ethnic group and main economic activity of the household head (not reported).

Table 10: DYADIC REGRESSION: HOUSEHOLD CHARACTERISTICS (FOR LENDERS)

X_{iv}^{hh}	(1) LAND	(2) LABOR	(3) INPUTS	(4) INPUT SHARER	(5) CREDIT
Direct kinship relation	0.524***	1.620***	1.220***	2.050***	1.339***
	(0.103)	(0.093)	(0.091)	(0.096)	(0.093)
Kinship through marriage	0.180	1.223***	0.827***	-0.067	0.910***
	(0.254)	(0.167)	(0.222)	(0.769)	(0.240)
Same ethnic group	-0.130	0.328***	0.088	0.235*	0.036
	(0.100)	(0.097)	(0.123)	(0.121)	(0.140)
Sum household size	0.185**	0.268***	0.270***	0.121*	0.210**
	(0.075)	(0.069)	(0.056)	(0.069)	(0.082)
Difference household size	-0.207***	-0.236***	0.184***	0.007	0.313***
	(0.075)	(0.075)	(0.057)	(0.063)	(0.077)
Sum age	-0.073	0.038	-0.037	-0.188	0.011
	(0.094)	(0.097)	(0.106)	(0.115)	(0.138)
Difference age	0.069	-0.384***	0.268**	0.019	-0.132
	(0.092)	(0.107)	(0.111)	(0.119)	(0.119)
Sum % agricultural income	0.126	0.307**	0.202	-0.112	0.234
	(0.149)	(0.128)	(0.128)	(0.185)	(0.189)
Difference % agricultural income	-0.241*	0.067	0.141	0.005	0.347*
	(0.145)	(0.117)	(0.120)	(0.169)	(0.191)
Sum income *per capita*	-0.005	0.005	0.010	-0.005	0.001
	(0.010)	(0.008)	(0.009)	(0.009)	(0.012)
Difference income *per capita*	0.009	-0.003	0.010	0.001	0.039***
	(0.008)	(0.007)	(0.009)	(0.009)	(0.011)
Sum land	0.099***	0.026***	0.015*	0.020*	-0.005
	(0.020)	(0.009)	(0.009)	(0.012)	(0.014)
Difference land	0.173***	-0.019**	0.013	-0.000	-0.023*
	(0.020)	(0.008)	(0.008)	(0.010)	(0.012)
Sum grass hut	0.025	0.056**	0.045**	0.138***	0.002
	(0.022)	(0.029)	(0.021)	(0.025)	(0.028)
Difference grass hut	-0.016	0.053**	-0.008	-0.002	-0.018
	(0.022)	(0.027)	(0.021)	(0.023)	(0.025)
Sum formal education	-0.172*	-0.105	-0.229**	0.048	-0.038
	(0.100)	(0.101)	(0.101)	(0.114)	(0.115)
Difference formal education	0.229**	0.068	0.086	-0.002	-0.070
	(0.094)	(0.096)	(0.099)	(0.113)	(0.112)
Observations	101940	101940	101940	75840	101940

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Two-way (i and j) clustered standard errors in parentheses. Logit estimates for the model presented in equation (3). Village dummies and other sums and differences of characteristics that were not statistically significant or have limited interest were included in the estimations but their associated coefficients are not reported. The model also include the same variables as those used in Tables 11 and 12.

Table 11: DYADIC REGRESSION: TRADITIONAL ROLE (FOR LENDERS)

X_{iv}^{role}	(1) LAND	(2) LABOR	(3) INPUTS	(4) INPUT SHARER	(5) CREDIT
Difference Alkalo	1.440***	-0.274	0.199	0.060	0.506**
	(0.212)	(0.182)	(0.153)	(0.142)	(0.198)
Difference VDC head	0.264	-0.072	0.146	0.023	0.648***
	(0.171)	(0.163)	(0.225)	(0.229)	(0.251)
Sum VDC member	0.192**	0.129*	0.046	0.082	0.275***
	(0.077)	(0.070)	(0.074)	(0.080)	(0.081)
Sum Alkalo's assitant	0.120	0.036	0.425***	0.001	-0.058
	(0.150)	(0.123)	(0.152)	(0.139)	(0.154)
Sum Alkalo's relative	0.106	-0.046	-0.063	-0.053	0.024
	(0.077)	(0.075)	(0.071)	(0.092)	(0.085)
Difference Alkalo's relative	0.226***	-0.001	0.059	-0.008	-0.032
	(0.070)	(0.067)	(0.071)	(0.076)	(0.094)
Difference Elders Council member	0.027	-0.159**	0.023	-0.011	0.149*
	(0.083)	(0.071)	(0.080)	(0.096)	(0.089)
Difference Elders Council head	0.285	-0.213	0.217	-0.008	0.464**
	(0.181)	(0.237)	(0.214)	(0.210)	(0.223)
Sum traditional healer	0.075	0.091	0.080	-0.049	0.176*
	(0.072)	(0.063)	(0.064)	(0.076)	(0.092)
Sum Marabout	0.325**	0.112	0.069	0.219	0.509***
	(0.163)	(0.169)	(0.155)	(0.210)	(0.172)
Sum Imam	0.330*	0.289	-0.130	-0.373**	0.042
	(0.185)	(0.220)	(0.184)	(0.149)	(0.220)
Difference Imam	0.226	-0.450**	0.122	0.003	0.465**
	(0.180)	(0.195)	(0.179)	(0.150)	(0.210)
Difference Griot	0.333*	0.071	0.052	-0.003	0.325*
	(0.181)	(0.181)	(0.186)	(0.252)	(0.187)
Sum compound head	0.357**	0.017	0.386*	-0.035	-0.043
	(0.153)	(0.173)	(0.199)	(0.120)	(0.185)
Observations	101940	101940	101940	75840	101940

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Two-way (i and j) clustered standard errors in parentheses. Logit estimates for the model presented in equation (3). Village dummies and other sums and differences of characteristics that were not statistically significant or have limited interest were included in the estimations but their associated coefficients are not reported. The model also include the same variables as those used in Tables 10 and 12.

Table 12: DYADIC REGRESSION: EXTERNAL LINKS (FOR LENDERS)

X^{ext}_{ivm}	(1) LAND	(2) LABOR	(3) INPUTS	(4) INPUT SHARER	(5) CREDIT
Sum land external-out	-0.267*	0.063	-0.049	0.393***	-0.109
	(0.142)	(0.116)	(0.111)	(0.134)	(0.151)
Difference land external-out	0.527***	0.110	0.032	-0.001	0.151
	(0.145)	(0.110)	(0.117)	(0.112)	(0.141)
Sum land external-in	-0.583***	0.186	0.023	-0.021	0.214
	(0.159)	(0.118)	(0.126)	(0.132)	(0.134)
Difference land external-in	0.001	0.150	0.376***	0.004	0.036
	(0.170)	(0.110)	(0.107)	(0.137)	(0.137)
Sum labor external-out	0.170	-0.114	0.176*	0.353***	-0.130
	(0.106)	(0.105)	(0.102)	(0.115)	(0.143)
Difference labor external-out	0.113	-0.140	0.027	0.002	-0.063
	(0.101)	(0.107)	(0.095)	(0.098)	(0.129)
Sum input external-out	-0.228	-0.086	-0.230*	0.132	0.131
	(0.161)	(0.129)	(0.138)	(0.134)	(0.161)
Difference input external-out	-0.189	0.207	0.472***	-0.009	0.007
	(0.173)	(0.131)	(0.150)	(0.134)	(0.154)
Sum input external-in	0.122	0.048	-0.187*	-0.678***	-0.038
	(0.096)	(0.096)	(0.102)	(0.152)	(0.153)
Difference input external-in	0.114	-0.055	0.059	0.004	-0.088
	(0.099)	(0.089)	(0.090)	(0.156)	(0.148)
Sum credit external-out	0.187	0.182	-0.011	0.152	0.085
	(0.118)	(0.133)	(0.129)	(0.117)	(0.133)
Difference credit external-out	0.251**	0.060	0.275**	-0.010	-0.129
	(0.121)	(0.128)	(0.138)	(0.128)	(0.123)
Sum credit external-in	0.039	0.025	0.049	-0.009	-0.090
	(0.093)	(0.084)	(0.090)	(0.090)	(0.130)
Difference credit external-in	0.011	-0.002	-0.144	0.003	0.333***
	(0.086)	(0.088)	(0.088)	(0.105)	(0.125)
Observations	101940	101940	101940	75840	101940

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Two-way (i and j) clustered standard errors in parentheses. Logit estimates for the model presented in equation (3). Village dummies and other sums and differences of characteristics that were not statistically significant or have limited interest were included in the estimations but their associated coefficients are not reported. The model also include the same variables as those used in Tables 10 and 11.