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Network Formation through a Gender Lens

Insights from rural Nicaragua

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March 2011

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ABSTRACT

This paper examines the relation between gender and network formation in rural Nicaragua. Applying dyadic regression techniques and controlling for individual socio-economic characteristics, we obtain insights into the determinants of the size and density as well as the socio-economic heterogeneity of individual networks. Assuming these network characteristics correlate with one's agency and benefits from network participation, we look for differences between men's and women's networks and its relation with gender. In general, the gendered private/public dichotomy and labor division is replicated in men's and women's networks. Furthermore, consistent with the restricted mobility of poor rural women, we observe that geographic distance limits the networks of women but not men. Next, female education and mobility, and newly-residing men, have a positive influence on the integration between men and women. Finally, clique formation is stronger around women than men.

Keywords: Social network analysis, dyadic regression, gender sorting, social integration.

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1. INTRODUCTION

Social capital, referring to resources accessed in social networks and their instrumental utility (Nan Lin 1999), has generated a large volume of literature. It has attracted the attention of several disciplines and been applied to different topics, including gender. Men's and women's constraints, opportunities, interests and needs (COIN) are all shaped by deep-rooted gender norms, which also influence participation in social networks and the benefits derived from them (i.e. social capital).

Most social capital literature underpins the importance of social networks as the basis for the formation of social capital (Joonmo Son and Nan Lin 2008). Social network analysis (SNA), which measures and analyzes the structure of social networks that link individuals in society, has proven to be very effective in revealing the mechanisms through which network structures and individual positions create benefits for the agents involved. While the relation between social networks and gender has been increasingly analyzed all over the world, the use of social network analysis has been mainly limited to studies in industrialized societies (Fischer 1982; Fischer Claude and Stacey Oliker 1983; Gwen Moore 1990; Pamela Popielarz 1999; Miller McPherson, Lynn Smith-Lovin and James Cook 2001; Claude Carolyn Liebler and Gary Sandefur 2002; Rachel Silvey and Rebecca Elmhirst 2003; Linda Crowell 2004; Kaivan Munshi and Jacques Myaux 2006; John Musalia 2006; Susan Bastani 2007). Within the growing literature that looks at the relation between gender, social networks and poverty in developing countries (Bina Agarwal 2000; Linda Mayoux 2001; Katharine N. Rankin 2002; Maxine Molyneux 2002; Cagla Okten and Osili Una 2004; Purkayastha, Bandana and Mangala Subramaniam 2004; Edna Arganosa-Matienzo 2005; Frances Cleaver 2005) most analysis is based on ethnographic evidence and so far little use has been made of social network analysis.

Moreover, most social network analysis has been limited to describe network structures. In this contribution, we illustrate how this method can be enriched by the use of dyadic regression techniques on network data. Regression analysis enables us to identify the importance of different individual socio-economic characteristics for the formation of dyadic relations. This provides us detailed insights into the determinants of the size and density as well as the socio-economic heterogeneity of individual networks. Assuming these network characteristics correlate with one's agency and benefits from network participation, studying differences between men's and women's networks may provide important gender insights.

The research documented in this article demonstrates the potential of such an approach for gender research in developing countries. Analyzing social networks in a rural Nicaraguan village, we distinguish between sex-specific relations (i.e. solely among men and solely among women) and mixed-sex relations. We also 'unpack' networks of different contents. This is necessary, as in most of the cases people are not only connected through one type of social relation, but are connected through overlapping networks of different contents. This is even more the case in poor rural societies in developing countries where social networks are mostly local and intensively used. Consequently, when studying social networks through a gender lens, we expect it to matter what network we look at.

2. GENDER AND SOCIAL NETWORKS

Social network analysis (SNA) looks at social relationships in terms of nodes and ties. Nodes are the individual actors within a network, and ties are the relationships between the actors. These relations together constitute a network. SNA has been very effective in revealing mechanisms through which network structures and individual positions therein create benefits for the agents involved and thus social capital.

For instance, according to James Coleman (1990), dense networks – where people are connected to many others – are beneficial as they reduce the cost of information access. Moreover, they facilitate sanctions and make reputation effective, which in turn stimulates trust, cooperative behavior and norm compliance. Ronald Burt (1992), however, focuses on the weaknesses in network structures. Groups of agents are often disconnected resulting in structural holes. Agents who manage to bridge these structural holes have a comparative advantage. They have access to higher volumes of information, they are often opinion leaders and they have preferential access to new opportunities.

To better understand variations in the constraints individual agents face, it is more useful to analyze how people are embedded in 'local' social structures. This is the goal of ego-network analysis. An ego-network is defined as the group of nodes one (i.e. 'ego') is directly connected to. These nodes are also referred to as 'alters'. There are at least three dimensions for the analysis of ego-networks that directly determine individual agency and access to resources and opportunities. It is to be expected that differences between men and women on these dimensions are closely related with gender-based differences in individual agency and the benefits derived from participation in networks.

First, the size and density of one's ego-network may be important. The size, defined as the number of relations of ego, indicates the degree to which ego is socially integrated, which may translate into economic and social opportunities. The density of one's ego-network, defined as the proportion of ties over all potential ties within the ego-network, may stimulate cooperative behavior and norm compliance, but at the same time may constrain individual agency (Coleman 1990). Consequently, comparing the size and density of male and female ego-networks may produce important insights in gender-related agency.

Studies on social networks in industrialized countries indicate that network sizes, on average, differ little between men and women (Fischer 1982; Marsden 1987 cited in Moore 1990: 726), but that differences do exist within groups of men and women. This intra-group heterogeneity is attributed mainly to life-cycle effects which are highly gendered (Fischer and Oliker 1983). For women there is a decline at child-bearing age when the burden of reproductive activities is particularly high (Moore 1990: 727). Liebler and Sandefur (2002) similarly demonstrated that young children constrain the networks of their parents, particularly their mothers, through increased time demands. Moore (1990) also found that at later ages women's networks again expand whereas those of men decline (when relations with co-workers diminish or end). Musalia (2006), studying the patterns of social relations between men and women in Kenya, observed, however, that having many young children actually increases women's networks. Young children increase the economic and social burdens on women, who are forced to enlarge their networks and intensify their interactions so as to cope with the need for instrumental, informational and emotional support.

With respect to the density of social networks, it has been documented that high density networks are particularly valuable for social support and social influence and also tend to play an important role in the stability of gender differentiation (Popielarz 1999; Munshi and Myaux 2006). An important mechanism that increases network density is 'clique formation' (also

referred to as clustering or network closure)[1]. Having ties in common may increase the likelihood that two agents form a direct tie as well (for a recent literature review, see Sheen Levine and Robert Kurzban 2006). In a study on social network formation among teenagers in Dublin, Deirdre Kirke (2009) found important gender differences with respect to clique formation, with females being more inclined than men to befriending the friends of their friends. Clique formation while increasing network density may also have a serious downside in terms of limiting access to new information and/or opportunities (Burt 1992). It is obviously better to become connected with someone one is not yet indirectly connected with.

Second, when looking at ego-networks, it is important to realize that ego can have different types of ties with his or her alters. In rural communities especially, where contact with the outside is limited, relations tend to be multi-stranded (Norman Uphoff 1993). People may not only have friendship relations, they may also help each other when needed or engage in economic transactions. Others may be connected through kinship or because they go to the same church, or they may meet at the village school when collecting their children, and so forth. Research has distinguished important differences between the contents of men's and women's networks. Men's networks, more often than female networks, include non-kin relations, particularly co-workers and friends, whereas women's networks most often include relations with kin and neighbors (Fischer and Oliker 1983; Moore 1990; Silvey and Elmhirst 2003; Crowell 2004). These differences obviously match the gendered division of labor, with women still overwhelmingly responsible for activities in the reproductive sphere. It also explains why networks of women who participate in market labor become centered more on kin and neighbors with the onset of child-bearing, while those of men remain unaffected (Crosby and Lowenstein 1987 cited in Smith-Lovin and McPherson 1993; Bastani 2007).

If anything, differences are likely to be more salient in settings where the female/male inside/outside dichotomy is more prevalent, where women have a lower geographic mobility, and where they are perceived as kin-keepers. Yet, relations with kin and neighbors, mostly characterized as 'strong,' are not always beneficial to the women concerned, at least not for 'instrumental' purposes. They have a strong potential for social and emotional support but they are less useful in providing access to information, jobs and new income opportunities (see also Jo Beall 2001). They often induce a lot of stress and strain on women, and their cost-benefit ratio to women is generally higher than it is for men as it are women who tend to invest more in the provision of emotional and social support (Pernille Due 1993 cited in Due et al. 1999). Strong kinship ties also put additional pressure on women to behave as prescribed by social norms and discourage social change (Silvey and Elmhirst 2003).

Third, besides the size and density of one's ego-network and the contents of social ties, it is equally important to take into account the diversity within one's ego-network. Multiple alters with similar characteristics show diminishing marginal returns for ego since they fulfill a similar function (Filip Agneessens, Hans Waege and John Lievens 2006). It is important, therefore, to diversify ego networks with alters that have different characteristics. Yet, as illustrated by McPherson, Smith-Lovin, and Cook (2001), social networks are often characterized by considerable homophily (i.e. the tendency for people to associate with similar others). For the purpose of our study, it is important to review whether and what types of social relations are sex segregated, and additionally, whether differences exist between men's and women's networks regarding the heterogeneity in individual socio-economic characteristics.

[1] This is an important phenomenon inherent in several influential network ideas, such as structural holes (Burt, 1992) and the importance of weak ties (Granovetter, 1973).

Sex segregation in networks may be contingent upon the network examined. Kinship networks, for instance, are mostly mixed on age and sex (Bastani 2007), whereas non-kin networks (for example, friend, neighbor, co-worker, and so forth) show higher levels of sex segregation (Marsden 1987 cited in McPherson, Smith-Lovin, and Cook 2001: 423). In general, the more voluntary is the focus (for example, friends as compared to kin), the more homogenous the tie (McPherson, Smith-Lovin, and Cook 2001; Barry Wellman 2007). This holds particularly in societies where gender norms are more strictly applied. Sex segregation of women's networks is also strongly affected by childbearing. While adult women's networks are initially more sex and age heterogeneous than men's (McPherson, Smith-Lovin, and Cook 2001), only post-childbirth ties with female kin and neighbors tend to remain (Fischer and Oliker 1983; Marsden 1990 cited in Smith-Lovin and McPherson 1993).

Besides sex segregation of networks, heterogeneity in men's and women's networks with respect to other socio-economic characteristics is also important. Women's non-kin networks tend to be more homogeneous with respect to income, education, marital and work status (Popielarz 1999) than men's non-kin networks. This lack of network diversity is often central to continued exclusion from opportunities (Silvey and Elmhirst 2003; Belliveau 2005). It is also believed that more heterogeneous networks have a higher 'integrative' potential and capacity to change existing gender relations (Popielarz 1999). In line with these findings, Crowell (2004) proposes a model to help women expand their opportunities by linking to networks that are more heterogeneous.

3. EMPIRICAL RESULTS

The empirical analysis in this work will add to the above described literature. By applying a network analysis in a poor village in rural Nicaragua it will produce insights on each of the three above described dimensions of ego-networks.

Before presenting our empirical analyses, however, some background information on gender in the country of study is required. Nicaragua is characterized by a high level of gender equality in education, contrasted with considerable inequalities in other dimensions. While education enrolment and attainment are among the lowest in the region, girls do better than boys, particularly among the poorest quintile (World Bank 2008). Strikingly high female/male gross enrolment and adult literacy ratios (1.017 and 1.019 respectively, see UNDP 2008) do not, however, translate into equal economic and political opportunities. The ratio of estimated female to male earned income is particularly low (0.32) and women hold only about 18.5% of parliamentary seats (UNDP 2008). The deeply-embedded machismo culture reinforces the gendered division of labor. Women are strongly associated with 'unpaid' care and/or labor, in particular 'mothering', and men with paid market labor (Dennis Rodgers 2007). Considerable fertility rates (an average of 3.0 births per woman over the period 2000-2005, UNDP 2008) combined with low access to services that accommodate practical gender needs (for example, child care facilities, water and sanitation, electrification, and so forth) render the burden of domestic work for women extraordinary in many households. Moreover, in order to cope with daily needs, women are often engaged in productive activities as well. These are mainly concentrated in areas that allow an easy match with 'domestic' responsibilities, such as a small shop and/or the cultivation of small crops or animals on their patio. Because of this close interlinkage, these income generating activities are often not considered 'work', even not by women themselves (Sarah Bradshaw 2002: 27). That households do not necessarily function as 'harmonious' husband-wife units is obvious from the high incidence of domestic violence (Bradshaw 2002; World Bank 2008) and the high prevalence of female-headed households (30% according to Douglas Massey, Mary Fischer and Chiara Capoferro 2006).

3.1 Methodology

For our empirical analyses, we make use of a social network survey in a rural village in the northern part of the Pacific region of Nicaragua, close to the border with Honduras. To gather data on individual networks, we used small cards, each card representing a household in the village. On each card we put the names of the household nodes[2]. For each card, we asked whether the interviewed person knew the household and whether he/she had a social relation of any kind with one of the household nodes. If a social relation was identified, we asked for details on its type. This enabled us to capture individual networks on multiple contents.

In particular, we elicited network data for the following types of relations. Friendship relations are relations where a person calls another one a friend. With a support relation, we refer to a relation where material support is given in at least one of both directions. Relations through social public activities are related to religion, political parties, the village school, sports, cooperatives, development projects or the village committee. Economic relations are relations

[2] With a 'household node,' we refer to either a household head or his/her spouse. This term does not make any judgment about who takes the lead in household decision-making.

that result from an exchange of land or labor, a commercial activity, a service provision or a lending activity. Neighbor relations are relations between two persons who consider themselves neighbors. Family relations are kinship relations with grandparents, parents, brothers/sisters, children or grandchildren. We extended traditional family relations by including godparents. In Nicaragua, a godparent of one's child(ren) is, de facto, part of the family (Tim Merrill 1993). Having captured the social ties of varying contents, we are now able to differentiate empirical analyses by network contents.

We gathered individual data for 100 of the 123 household nodes (81.3%), of which 62 were women and 61 men[3]. As in most rural villages, almost everybody knows one another (in 93.5% of all possible ties ego knows alter). To process the information on social relations we proceeded in the following way. Several of the reported relations are not symmetric, in the sense that a relation person A claims to have with person B is not confirmed by person B. In social network analysis, it is then common practice to symmetrize the social ties. To do so, for each possible relation we assumed a relation to exist if at least one node mentioned the relation. In this way, we obtained the so-called OR-networks which we will use in the analyses[4]. We will start our analysis by looking at the entire community network, differentiated by network contents and the sex of the nodes involved. This allows us to get an idea of the structure of the social networks in the community. Thereafter, we will move from the community networks to the ego-networks of individual community members. We will study the influence of gender on network size and segregation by comparing the size of ego-networks among men, women and mixed-sex relations. To further obtain insights into the size, density and heterogeneity of individual social networks, we will then move further to the dyad level. We will elaborate a series of dyadic regression models that explain the likelihood of a tie between two nodes and control for different individual socio-economic characteristics. This likelihood gives us a good proxy for an individual's network size. Studying differences in the characteristics of individual nodes we also obtain insights into the heterogeneity of the networks under study. Further, studying more advanced network measures, such as the number of common ties, we are able to study clique formation and resulting density.

3.2. Sex segregation in networks

To obtain an overview of the studied social networks, we plot all 123 nodes in the community and the ties they have among each other. In this way, we obtain the community network. To get insights into the influence of gender on network formation, the network is differentiated by the sex of the nodes. In particular, networks only of men, only of women and those of mixed sex are plotted separately. Networks are also differentiated by their contents.

[3] For the network survey we sampled the entire village, which allowed us to capture complete networks. This also enabled us to map the entire village network, and more importantly, to calculate advanced network measures such as the number of paths between two nodes (which we will later use in the regression analyses). The village is part of a wider cluster of similar villages and the reported results can thus be considered representative for the wider region.

[4] The alternative would have been to use so-called AND-networks where ties are taken to be valid only if both nodes mention the relation. There are several arguments however in favor of the use of OR-networks, both related to the risk of excluding existing ties when using AND-networks. First, those who have many ties are more likely to forget to mention a tie than those who have only a few ties. Second, people place a different emphasis on relations of different contents, which may lead to people excluding relations of certain contents. Third, there may be asymmetry in reporting the direction of benefits provided (e.g. between receiving support and giving support).

Annex III shows the different community networks. They are complemented with a density indicator which is simply the percentage of all possible ties that are actually present[5].

Important observations are as follows. First, friendship networks have a very high density (i.e. more than 12%). The network density of male friendship ties (i.e. 29.34%) is much higher than those among women or nodes of mixed sex. Second, all other networks have a much lower density of between 2% and 7%. We observe that networks partly overlap, but at the same time considerable variation exists across different networks. Third, we observe considerable variation as to the size of the ego-networks within each community network.

Given the substantial variation in the size of the ego-networks, it is relevant to compare them between men and women as it may provide insight into the influence of gender on network size and segregation. The size of one's ego-network is calculated as the percentage of all possible ties that are present[6]. We do so for each network type and then compare networks among men, women and networks with mixed-sex relations. To test whether average ego-network sizes are different between these categories we use a t-test. Table 1 shows the results.

Table 1: Comparison of average ego-network sizes

	Ego			**a-b**	**a-c**	**b-c**
	(a) Men only	*(b) Women only*	*(c) Mixed*	P value	P value	P value
General	47.43%	31.04%	30.14%	.000**	.000**	.645
Friendship	29.34%	12.37%	12.37%	.000**	.000**	.999
Support	3.28%	2.54%	2.01%	.270	.000**	.219
Social/public activity	5.08%	4.23%	0.05%	.463	.000**	.000**
Economic	4.37%	5.08%	2.83%	.602	.000**	.002**
Neighbors	6.67%	4.18%	5.02%	.004**	.001**	.268
Extended family	3.01%	2.38%	2.35%	.191	.051	.924
	N = 61	*N = 62*	*N = 61/62* [a]			

Notes: Comparisons a-b: independent samples t-test (two-sided p-values); comparisons a-c; b-d: paired samples t-test (two-sided p-values); significance levels: * = 5%; ** = 1%. Network sizes are equal to the number of direct ties relative to the possible number of ties. a Average sizes are equal between men and women.

We observe, comparing columns a and b of Table 1, that men on average have significantly larger ego-networks than women for friendship relations and neighbor relations. The latter is somewhat puzzling as most households consist of both a female and a male node. Yet, it is realistic to assume that in many instances people also consider those two or more houses distant as their neighbors as they belong to their close neighborhood. Differences between men and women suggest that, on average, women use a lower periphery when defining their neighbors. This is consistent with the generally lower mobility of women in rural Nicaragua. Another observation relates to the lack of significant differences for the networks formed through social/public activities and economic exchanges. This is important as these

[5] Total possible undirected ties among women: 1891 = (62 x 61)/2; possible undirected ties among men: 1830 = (61 x 60)/2; possible undirected mixed ties: 3724. The latter is the result of subtracting 1891, 1830 and 58 (the number of possible undirected intra-household ties) from 7503 = (123 x 122)/2 (i.e. the total number of undirected ties between all nodes).

[6] As we have 61 men and 62 women, the maximum number of ties for a male node with other men is 60, for a female node with other women 61, for a male node with women 62 and for a female node with men 61.

networks are generally instrumental in providing access to information, jobs and income opportunities.

Making the comparison with column c, we also observe that the average size of men's ego-networks of relations with men is significantly larger than theirs with women. Whereas this difference applies to relations of all different contents, for women such a significant difference is only observed for economic relations and relations through social/public activities. The fact that segregation is only observed in these two areas matches the gendered division of labor and the different types of social/public activities men and women engage in.

3.3. The likelihood of a dyadic tie

In this section, we estimate a series of regression models that explain the likelihood of an undirected tie between two persons. Controlling for the characteristics of two persons, we are able to study what characteristics increase the likelihood of a tie between them, and importantly, to what extent (dis)similarity matters. Moreover, by controlling for more advanced network measures, such as the number of common ties, we are able to study clique formation and resulting network densities. For the estimation of the models, we consider all potential ties between the 123 household nodes. We exclude intra-household ties because the motivation for having an intra-household tie is different than for establishing extra-household relations. Estimating different models for sex-specific and mixed-sex relations, we are able to study differences in network formation between men, women and across sexes. The individual characteristics that influence the likelihood that two persons have a tie can be broadly organized in the three following classes: time availability, human and physical capital and mobility.

First, tie formation requires time. People not only need to spend considerable time to form social ties. Opportunities for tie formation are not always available, and often time simply passes by without opportunities. That is why we expect older people and/or people with more years living in the community have a higher likelihood of having a tie with another particular village member. The number of children one has (i.e. defined as household members under 8 years) may also influence time availability, especially for women.

Second, the likelihood of forming social ties may depend on one's human and physical capital base. For people with higher education for instance, it may be easier to form social ties than lesser-educated people. The influence of wealth, however, may be mixed. People with more wealth have more resources to transfer through social interaction, but are less in need of resources from social exchanges. Good proxies for wealth in the region are land and cattle. Land property is important for its returns in agriculture and as a store of wealth. Cattle-breeding is one of the most lucrative economic activities in the region, as it is both an income source and an important savings instrument that enables local people to bridge the long and harsh dry season.

Third, mobility may also facilitate the formation of social ties, as it enlarges the pool of people one may make contact with. As proxies for individual mobility, we use the number of visits to the nearest urban center in the last month and the neighbor distance, measured by the minimum number of steps in the neighbor network needed to connect two persons. With women being more active in household-related activities in rural Nicaragua, we expect women to be much less mobile (which might be reflected in a stronger influence of neighbor distance on network formation).

The likelihood that a social tie exists between two specific agents may also depend on differences on these three classes of individual characteristics. According to the homophily argument (McPherson, Smith-Lovin, and Cook 2001), people have a tendency to associate with

similar others (This we will use as a general hypothesis to be tested by our data). For instance, individuals with similar ages may more likely form social ties than individuals whose ages differ significantly. In the regressions, we will test the influence of heterogeneity by controlling for the absolute difference on each of the attributes. We will also add the sum, which measures the effect of the combined level. For the estimation of the models, we use the following logistic regression model:

$$Logit\left(p_{ij}\right) = \ln\left(\frac{p_{ij}}{1-p_{ij}}\right) = \alpha + \beta_1\left|z_i - z_j\right| + \beta_2\left(z_i + z_j\right) + \gamma \cdot w_{ij} + e_{ij}$$

with p_{ij} being the probability of a dyadic tie between nodes i and j, with z_i and z_j being the characteristics of nodes i and j. w_{ij} represents the characteristics of the tie between i and j. One such characteristic discussed above is 'neighbor distance.' Another characteristic is the number of common ties which, as documented by the literature on 'clique formation', may increase the likelihood that two agents form a direct tie as well (Levine and Kurzban 2006). As clique formation may differ between men and women, we separately control for the number of common male and female ties.

Dyadic observations involving the same node, however, are not independent. $E\left[e_{ij}, e_{ik}\right] \neq 0$ for all k, and $E\left[e_{ij}, e_{kj}\right] \neq 0$ for all k. To correct standard errors for these dependencies we apply clustering on both dimensions separately (for a technical discussion, see Marcel Fafchamps and Flore Gubert 2007).

Finally, it is important to stress that the influence of the specified explanatory variables may vary between different network contents. For instance, the contact with the urban center may be especially important for the formation of economic networks, whereas years of residence may be more important for the formation of a support relation. Next, homophily may favor the formation of friendship and relations through social/public activities, but it may hamper economic exchanges and thus the formation of economic ties. Importantly for the purpose of our study, the influence of these variables may also substantially vary according to the sex of the agents involved. For example, neighbor distance and the number of children may be more important for women than for men.

Table 2: Descriptive statistics

	Men			Women				
	Mean	S.D.	N	Mean	S.D.	N	t-value	Two-sided P
Contact urban center	2.66	4.69	44	1.60	1.61	56	1.435	.157
Age	48.91	14.56	53	43.20	14.09	55	2.069	.041
Years of residence	35.89	15.52	44	31.13	15.53	56	1.522	.131
Years of education	3.74	3.54	53	4.47	3.66	55	-1.063	.290

Before looking at the regression results, we present some descriptive statistics of the explanatory variables used. According to Table 2, the female household nodes in our sample are significantly younger than the male household nodes. This is not surprising given our sampling procedure (i.e. including both husband and wife of the same household) and the average age differences between husbands and wives in rural Nicaragua. In addition to the individual socio-economic characteristics described in Table 2, we are also interested in household characteristics such land and cattle (as proxies for wealth at the household level)

and the number of children. On the basis of our sample of 58 households, only 35% of the households possess land (village average of 8.22 ha, std. dev. of 17.33) and 47% have cattle (village average of 3.55 cows, std. dev. of 9.44). The average number of children is equal to 4.74 with a standard deviation of 2.268.

3.4. Estimation results: sex-specific relations

Annex I shows the regression results of sex-specific ties (i.e. men and women separately). Analyzing *friendship* networks among men (first column), we observe that holding all other variables constant, the odds of a friendship tie increases with lower differences on the number of visits to the nearest urban center ($p < 0.05$). The lower this difference, the more time they spend together, either in their village or in the urban center. For example, with a difference of 4 days per month the odds reduces with 22.3%, being the result of $(0.939)4 = 0.777$. The likelihood of a friendship tie also increases with education differences ($p < 0.05$). With a difference of more than 6 education-years (i.e. the difference between primary and secondary school) the odds increases with more than 45%, being the result of $(1.064)6 = 1.451$. This suggests certain integration in friendship networks between men of different education levels. Friendship relations among men also depend on economic wealth. The odds of a friendship relation is almost half as large when at least one of both nodes does not have any cattle relative to a situation where both persons have cattle ($p < 0.01$). Finally, certain clique formation is observed, as indicated by the significant odds ratio of the number of common ties of the same sex ($p < 0.01$)[7]. The odds of a friendship tie between two men increases with 10% when they have one male friend in common relative to a situation where they do not have any common male friend.

For friendship relations among women, completely different variables are important. We observe that the neighbor distance between women strongly decreases the likelihood of a friendship relation. Women who are direct neighbors have a 70% higher odds of being friends than women at larger neighbor distances ($p < 0.01$). Such an effect is not observed for men, which is consistent with the lower mobility of women. If we also take into account the closer periphery of women when defining their direct neighbors (see discussion of Table 1), the difference between men and women may be even larger. In addition, friendship relations among women are significantly less likely the more children they have ($p < 0.05$). For example, in case two women have one additional child each and thus the sum of the number of children increases with 2, the odds of friendship tie reduces by 27.7%, being the result of $(0.850)2 = 0.723$. This is consistent with women simply having less time to invest in friendship relations because of the reproductive burden. Finally, substantial clique formation is observed here as well ($p < 0.01$). Noteworthy is the much higher coefficient of this variable in comparison with men's friendship ties, which is consistent with other studies (e.g. Kirke 2009). The odds of a friendship tie between two women increases with 35% when they have one female friend in common relative to a situation where they do not have any common female friend.

Studying the formation of (material) support relations among men, we observe that the general fit of this model is unsatisfactory, so that no conclusions can be drawn. From the model on support relations among women, we observe a similarly strong neighbor distance effect as with friendship relations. In addition, the likelihood of support relations decreases with

[7] We are aware that the inclusion of this variable may lead to potential endogeneity issues. We also estimated a model (not shown) without this variable and observed that the other coefficients do not change significantly, which provides evidence that the resulting estimates are not biased.

age ($p < 0.05$) and education ($p < 0.05$). Increasing the sum of the ages of two nodes with 25 while keeping the age difference constant, reduces the odds of a support relation by 52%, being the result of $(0.971)25 = 0.479$. Increasing the sum of the education levels with 8 years while keeping the education difference constant, leads to a similarly large reduction of the odds, i.e. $(0.911)8 = 0.474$. A plausible explanation for these results might be that older and/or higher-educated women have a lower need for support, and are therefore less inclined to request support. Finally, we observe very strong clique formation. The odds of a support tie between two women increases with more than 114% when they have one female support relation in common relative to a situation where they do not have any support relations in common ($p < 0.01$). That such clique formation goes through common ties with individuals of both sexes suggests an interesting avenue of integration between male and female networks.

Looking at the models on relations through social/public activities, we observe that for relations among men certain integration occurs between distant neighbors. At the same time, the significant and negative coefficient of the absolute age difference indicates, ceteris paribus, that male networks are segregated by age ($p < 0.01$). Increasing the age difference with 10 years reduces the odds with 35%, as indicated by $(0.958)10 = 0.651$. Moreover, we observe that education facilitates direct ties among men ($p < 0.01$). Increasing the sum of the years of education of two men by 6 increases the odds of a relation between them with 83%, i.e. $(1.106)6 = 1.830$. In other words, relations among men are more likely with men of high education, of similar age and between men from different parts of the village.

For women, we do not observe any education effects. This is probably the result of gender-based differences in social/public activities. In comparison with men, women tend to participate less in village committees, political parties and cooperatives for which education is an important asset. We also observe that the likelihood of ties among women is not affected by the general level of age and number of children, but reduces with higher differences on these variables. Increasing the absolute difference in the number of children between two women with 2 reduces the odds of a tie between them with 46% ($p < 0.05$). Ceteris paribus, increasing the age difference with 10 reduces the odds with 33% ($p < 0.05$). This is consistent with the homophily hypothesis.

In addition, we observe that neighbor distance does not exert any significant influence. Social/public activities tend to occur on different public spots in the village so that the neighbor distance between two specific women is less of an influence[8]. Finally, we observe substantial clique formation through common ties with both sexes ($p < 0.01$). Interestingly, whereas in male networks such clique formation was only observed through common ties with women, in female networks clique formation is observed through both men and women.

Analyzing economic relations, we observe that education levels exert an important influence for network formation among men. Increasing the sum of the education levels of two men with 6 years increases the odds of an economic relation between them with 86% ($p < 0.05$). For relations among women, it is rather (lack of) mobility that influences economic network formation. We observe that the likelihood that two women have an economic relation increases with more frequent contact with the urban center ($p < 0.01$), and ceteris paribus, the larger the difference on this dimension ($p < 0.05$). For instance, increasing the sum of the number of visits per month with 2 increases the odds with 68%, while increasing the absolute difference with 2 increases the odds with 24%. Economically-active women in rural Nicaragua

[8] This does not imply that female mobility is not an issue. To control for this, we should include a variable that measures the geographical distance to each public spot, information which we unfortunately did not capture.

often engage in small-scale commerce which requires them to travel to urban centers. They then sell to women in their village who do not engage in this activity (and who are thus much less mobile). In the network graph in Annex III, most economic ties among women are centered on a limited number of female nodes which have grocery shops in the village. These women are also among the richest in the village, which explains the significant influence of wealth as measured by the cattle proxy in the regression. The odds of an economic relation is 62.6% lower when at least one of both nodes does not have any cattle relative to a situation where both have cattle ($p < 0.01$). It is even 85.7% lower when both women do not have any cattle ($p < 0.01$). The formation of economic ties is also hampered by child raising. Increasing the sum of the number of children of two women with 2, reduces the odds of an economic relation between them with 43%, being the result of $(0.754)2 = 0.569$.

Economic relations are also more likely with fewer years of residence in the village ($p < 0.01$) and, ceteris paribus, with higher differences on this dimension ($p < 0.01$). Increasing the sum of the years of residence of two women with 10 reduces the odds of an economic relation between them with 29%, $(0.966)10 = 0.708$. Increasing the difference in years of residence with 10 increases the odds with 60%, the result of $(1.048)10 = 1.598$. In other words, recently-migrated women more easily form economic ties and more likely do so with women who have considerable years of residence. Whereas homophily is thus rejected on this dimension and on the contact with the urban center (as documented above), it is confirmed on age as demonstrated by the significant and negative coefficient of the absolute age difference ($p < 0.05$). Finally, as was the case for relations through social public activities we observe strong clique formation through both male ($p < 0.05$) and female ties ($p < 0.01$), while clique formation in male networks is observed only through common female ties.

3.5. Estimation results: mixed-sex relations

To investigate mixed-sex relations, we use the same regression models as in the previous section, but instead of controlling for the size and the absolute difference of each socio-economic characteristic, we control for the characteristics of the female agent and the male agent directly. Annex II presents the results.

Similar to the results of sex-specific networks, we observe that the likelihood of a friendship or a support relation between men and women falls with neighborhood distance. Moving from neighbor distance 1 (i.e. being direct neighbors) to neighbor distance 2 reduces the odds of a friendship tie with 71.6% ($p < 0.01$) and the odds of a support relation with 92.7% ($p < 0.01$). In addition, we observe that men with more years of residence in the village face a lower likelihood of a support relation with women ($p < 0.01$). The latter effect is also observed for relations through social/public activities ($p < 0.05$). Increasing the years of residence of men with 10 reduces the odds of a support relation with 26.3% whereas it reduces the odds of a relation through social/public activities with 18.3%. A plausible rationale for these results is related to the conservatism of men with many years living in the village and/or incipient changes in the direction of gender integration induced by newly-arriving men. The results also indicate that, ceteris paribus, the likelihood of a tie through social/public activities increases with the age of men ($p < 0.05$) and the education of women ($p < 0.05$) but reduces with the latter's wealth ($p < 0.05$). Increasing the age of men with 10 increases the odds with 16%, whereas increasing the education of women with 6 years increases the odds with 66.8%. The odds of a tie through social public activities is 53% lower for women with cattle.

Analyzing economic ties, we observe that women with more contact with the nearest urban center tend to more easily establish economic relations with men (a result we

also had with sex-specific relations). For instance, increasing the sum of the number of visits per month with 2 increases the odds with 49% ($p < 0.05$). The odds of an economic relation is also 155% higher with men with cattle than men without cattle ($p < 0.05$). No such wealth effect is found for women. Finally, for all network contents we observe significant clique formation (we did not distinguish between male and female common ties). This effect is the smallest for friendship relations, which is in line with the previously-observed absence of clique formation through agents of the other sex in sex-specific friendship ties.

4. CONCLUSION

In this contribution, we demonstrated how social network analysis enriched with dyadic regression analysis forms an interesting and promising approach to study the relationship between gender and social networks. Regression analysis provides us detailed insights into the determinants of the size and density as well as the socio-economic heterogeneity of individual networks. Assuming these network characteristics correlate with one's agency and benefits from network participation, looking for differences between men's and women's networks on these characteristics may provide important gender insights. Moreover, within the growing literature that looks at the relation between gender, social networks and poverty in developing countries, so far little use has been made of social network analysis. By using a social network survey in rural Nicaragua, we aimed to partially fill this gap.

In contrast with the existing literature on industrialized societies, we observed that in the village under study, men, in comparison with women, tend to have larger ego-networks of friendship and neighbor relations. Importantly, no significant differences are observed on the more instrumental networks formed through social/public activities and economic exchange. Social networks are also highly-gender segregated. Women have more ties with other women than with men in the areas of economic relations and relations through social/public activities. The fact that segregation is highest in these two areas matches the gendered division of labor and the types of social/public activities men and women engage in.

With the use of dyadic regression analyses, we obtained insights into important ego-network characteristics, such as size, density and heterogeneity. In general, we found that the existing gendered private/public dichotomies and labor divisions are visible in men's and women's social networks. Similar to studies in industrialized countries, friendship and economic relations among women are constrained by their number of children. Moreover, and in contrast to studies from industrialized countries, women's friendship and support networks are highly limited by geographic distance. This is consistent with the gender-based lower mobility of women often observed in developing countries.

With respect to homophily within networks, we noticed that the characteristics on which men and women tend to sort or integrate differ strongly. Whereas age differences tend to hamper social ties for both men and women, for women the number of children may also be a sorting factor. We also observed certain integration. Whereas friendship ties are more likely among men with different education levels, the formation of economic ties is more likely among women who vary on the years of residence and contacts with urban centers.

Interestingly, we observed significantly stronger clique formation around women than men. Clique formation increases local densities, which, according to Coleman (1990), facilitate sanctions and make reputation effective, which in turn stimulates trust, cooperative behavior and norm compliance. However, by safeguarding existing social norms it may hamper social change that is required to improve the conditions of men and women. Moreover, keeping the ego-network size constant, clique formation makes social ties redundant in terms of providing access to additional information and/or opportunities (Burt 1992).

Finally, our analyses shed light on the integration between male and female networks. The education of women while exerting only minor influences on sex-specific networks has a positive influence on the formation of mixed-sex networks. Next to higher-educated women, women with more contacts with urban centers and recently-residing village men have a higher likelihood of establishing relations with each other. This highlights the potential of such individuals to be catalysts for the formation of more integrative social networks.

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ANNEX I: NETWORK DYADS (LOGIT) – GENDER-SPECIFIC

	Friendship relation				Support relation				Social public activity				Economic relation			
	Men		Women		Men		Women		Men		Women		Men		Women	
	OR	S.E	OR	S.E	OR	S.E	OR	S.E	OR	S.E	OR	S.E	OR	S.E	OR	S.E
Mobility																
Contact urban center (sum)	1.031	0.747	1.054	0.684	0.937	1.103	1.024	5.688	1.044	0.636	1.142	0.782	1.021	1.571	1.295	0.468**
Contact urban center (abs. dif.)	0.939	0.396*	1.050	0.938	1.035	3.044	0.898	0.839	0.949	0.484	1.001	100.055	0.959	1.020	1.113	0.525*
Neighbor distance 2 (dummy)	0.666	0.453	0.255	0.045**	0.886	3.282	0.219	0.083**	4.708	2.452	1.356	2.608	1.172	4.184	0.765	0.832
Neighbor distance 3 (dummy)	0.832	1.320	0.253	0.051**	0.555	0.258*	0.292	0.135*	9.429	3.102**	0.810	2.794	1.005	100.541	1.170	3.773
Neighbor distance > 3 (dummy)	0.644	0.413	0.290	0.083**	0.834	2.605	0.155	0.050**	5.232	3.210	1.809	1.601	2.099	1.235	0.599	0.499
Time constraint																
Age (sum)	0.995	1.213	0.995	1.422	0.991	1.180	0.971	0.422*	1.002	8.351	1.006	1.438	0.996	3.689	1.014	1.208
Age (abs. dif.)	0.991	0.652	0.983	0.520	0.983	0.400*	0.989	1.940	0.958	0.307**	0.961	0.386*	0.995	3.826	0.957	0.431*
Years of residence (sum)	1.004	0.947	1.008	0.833	1.017	0.789	1.000	49.986	1.009	1.187	1.013	0.709	1.016	0.561	0.966	0.360**
Years of residence (abs. dif.)	1.001	3.453	0.997	3.324	0.984	0.955	1.001	16.689	1.003	3.236	0.992	1.654	0.983	0.840	1.048	0.311**
Number of children (sum)	0.969	1.563	0.850	0.330*	0.954	1.800	0.866	0.566	0.786	0.763	0.893	0.732	1.077	2.449	0.754	0.299*
Number of children (abs. dif.)	1.102	0.984	1.148	0.727	1.352	0.800	0.921	1.152	1.291	1.132	0.733	0.313*	1.112	1.711	0.741	0.488
Capital																
Years of education (sum)	0.986	1.297	1.024	0.883	1.043	0.966	0.911	0.451*	1.106	0.322**	1.021	1.277	1.109	0.526*	0.984	2.289
Years of education (abs. dif.)	1.064	0.488*	0.963	0.669	0.979	2.577	1.004	14.339	1.053	0.707	1.018	2.751	1.051	0.973	1.066	0.952
One node has land (dummy)	0.946	5.253	0.668	0.649	1.446	2.836	0.767	1.112	0.988	49.413	0.353	0.245	3.347	2.159	2.375	2.241
None has land (dummy)	1.089	4.033	0.768	1.259	1.666	3.029	0.828	2.070	1.064	15.199	0.428	0.424	2.978	2.810	4.507	3.219
One node has cattle (dummy)	0.569	0.116**	1.208	1.633	0.664	1.054	0.960	9.599	0.799	1.737	2.206	1.388	1.181	1.874	0.374	0.100**
None has cattle (dummy)	0.560	0.207**	1.132	2.135	0.293	0.181	0.481	0.609	1.061	13.261	1.411	2.475	0.584	0.822	0.143	0.050**
Common ties (same sex)	1.104	0.180**	1.350	0.261**	0.522	0.746	2.146	0.816**	1.589	0.929	2.098	0.593**	1.054	7.528	1.937	0.351**
Common ties (other sex)	1.109	0.689	1.044	0.590	0.982	24.553	2.751	0.580**	2.381	0.882**	1.908	0.477**	2.150	0.379**	1.579	0.619*
Pseudo R2	0.100		0.114		0.065		0.117		0.267		0.228		0.129		0.299	
LR chi2	127.3		133.4		22.48		45.42		138.47		131.10		59.25		174.29	
Prob. > chi2	0.000		0.0000		0.261		0.001		0.000		0.0000		0.0004		0.0000	

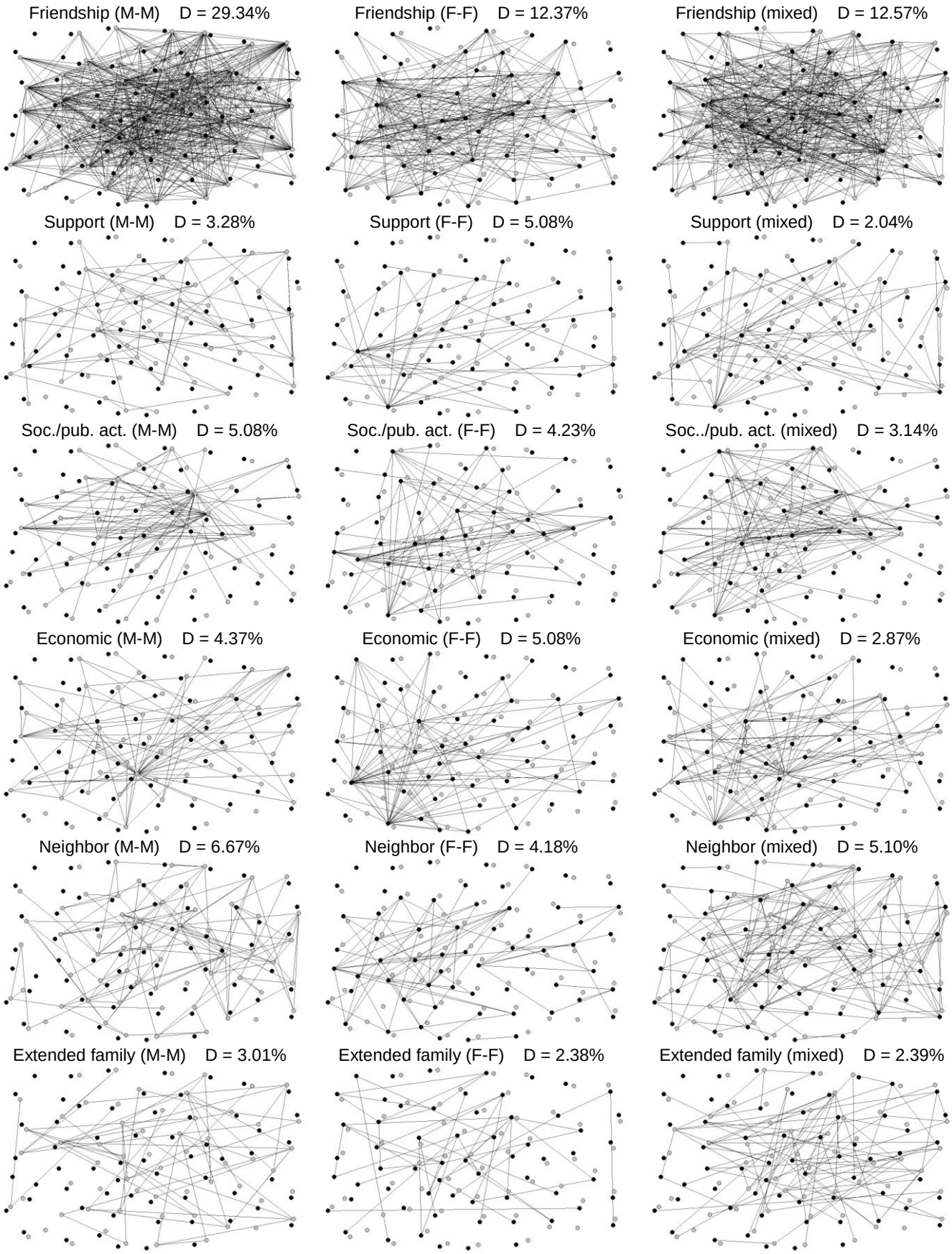
Notes: Only considering potential ties among persons of the same sex. Intra-household ties are not included. N = 946 (men). N = 1485 (women). Robust standard errors were obtained by means of two-way clustering. Significance levels (two-sided): * = 5%; ** = 1%.

ANNEX II: NETWORK DYADS (LOGIT) – MIXED GENDER

	Friendship relation		Support relation		Social/public activity		Economic relation	
	OR	S.E	OR	S.E	OR	S.E	OR	S.E
Mobility								
Contact urban center – male	1.013	1.582	0.994	3.825	0.952	0.627	1.045	0.597
Contact urban center – female	0.997	14.246	1.172	0.977	1.018	3.393	1.220	0.545*
Neighbor distance 2 (dummy)	0.284	0.043**	0.073	0.013**	0.534	0.434	1.122	4.488
Neighbor distance 3 (dummy)	0.293	0.041**	0.060	0.010**	0.674	0.887	0.863	2.270
Neighbor distance > 3 (dummy)	0.195	0.031**	0.052	0.011**	0.493	0.382	0.871	2.722
Time constraint								
Age – male	0.997	2.557	1.013	1.113	1.015	0.495*	1.005	4.189
Age – female	1.007	1.360	1.006	2.455	1.003	2.866	1.009	1.311
Years of residence – male	0.996	1.633	0.970	0.269**	0.980	0.435*	0.997	4.333
Years of residence – female	1.006	0.662	0.977	0.788	1.011	1.203	0.997	4.746
Number of children – male	1.040	1.763	1.311	0.814	1.167	1.297	0.890	1.680
Number of children – female	0.970	1.980	0.783	0.404	1.165	0.665	0.917	1.764
Capitals								
Years of education – male	1.002	16.699	1.009	5.933	1.092	0.581	1.076	0.722
Years of education – female	1.043	0.700	1.029	1.660	1.089	0.375*	0.981	1.582
Land – male (dummy)	0.965	6.436	1.102	4.790	1.163	2.424	0.336	0.191
Land – female (dummy)	0.875	1.055	1.028	14.683	1.427	1.585	1.277	1.798
Cattle – male (dummy)	1.349	1.030	2.306	1.469	1.495	1.099	2.551	1.226*
Cattle – female (dummy)	1.076	2.445	0.896	3.735	0.462	0.226*	1.091	3.761
Common ties	1.162	0.111**	2.640	0.497**	1.903	0.246**	1.824	0.344**
Pseudo R2	0.1368		0.2113		0.2780		0.1846	
LR chi2	278.49		108.93		227.09		141.36	
Prob. > chi2	0.000		0.000		0.000		0.000	

Notes: Only considering potential ties among persons of different sex. Intra-household ties are not included. N = 2378. Robust standard errors were obtained by means of two-way clustering. Significance levels (two-sided): * = 5%; ** = 1%.

ANNEX III: SOCIAL NETWORKS PER NETWORK TYPE



Notes: Nodes belonging to the same household are grouped; grey = male node, black = female node.

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