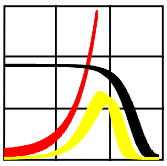

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The Structure of Social Networks and Fertility Decisions: Evidence from S. Nyanza District, Kenya

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The Structure of Social Networks and Fertility Decisions: Evidence from S. Nyanza District, Kenya

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Abstract

Demographers have increasingly argued that social interaction is an important mechanism for understanding fertility behavior. Yet, substantial uncertainty exists whether 'social learning' or 'social influence' constitutes the dominant mechanism through which social networks affect individual's contraceptive decisions. This paper argues that these mechanisms can be distinguished by analyzing the density of the social network and its interaction with the proportion of contraceptive users among network partners. Our analyses indicate that in areas with high market activity social learning is most relevant, whereas in regions with only modest market activity social influence constitutes the dominant mechanism of how social networks affect women's contraceptive use. In areas in which social influence currently retards diffusion of family planning, therefore, with sufficient market development social learning may become more important than social influence and accelerate diffusion.

JEL Classification: J13, D83

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1 Introduction

Fertility transitions in developing countries pose an apparent contradiction between the timing and pace of fertility change, and the timing and pace of change in socioeconomic conditions or program efforts. Although both factors are often assumed to be primary determinants of fertility, the time path of fertility change is typically different than can be accounted for by conventional measures of socioeconomic or program change (Bongaarts and Watkins 1996). Moreover, the illiterate and rural

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residents are often not far behind in adopting fertility control as compared to those who are educated and live in cities. Further, family size and family planning messages that are spread through clinic lectures or radio programs, frequently reach those who are not in direct contact with the program (Fawcett, Somboonsuk, and Khaisang 1967; Freedman and Takeshita 1969; Rogers 1995).

In order to explain these patterns of fertility change, demographers have increasingly argued that social interaction is an important mechanism influencing contraceptive knowledge, attitudes towards low fertility and the adoption of family planning (e.g., Bongaarts and Watkins 1996; Kohler 1997; Montgomery and Casterline 1996; Entwisle et al. 1996, Entwisle and Godley 1998). Social interactions in these theories encompass *social learning*, in which individuals learn about the existence and technical details of new phenomena (e.g., new contraceptive techniques, new diseases) and *social influence*, in which individual's preferences are influenced by the behavior and opinions of others. For instance, relatives, friends and neighbors learn from each other about the experiences with small or large families and with the use of family planning and they assess what others think about the legitimacy of deliberate control of fertility within marriage.[1]

In this paper we analyze the role of these social interactions in the adoption of modern contraception in S. Nyanza Distinct, Kenya, and we focus on the distinction between the two mechanisms, *social learning* and *social influence*. This analytic differentiation between learning and influence is of considerable significance for at least three reasons: First, it is relevant for our theoretical understanding of whether fertility preferences are fixed or endogenous in economic models of demographic behavior (Easterlin, Pollak, and Wachter 1980; Pollak and Watkins 1993). Second, the differentiation is central for our understanding of the specific processes by which networks influence fertility behavior, and it is thus essential for moving towards the 'culturally smart microeconomics' espoused by Hammel (1990, p. 455). Third, because the existence of social interaction modifies the evaluation of family planning programs (Behrman, Kohler, and Watkins 1998; Montgomery and Casterline 1996), knowledge of the different processes of social interaction facilitates the design and optimal use of such programs.

The analyses in this paper utilize a new household survey gathered in S. Nyanza Province, Kenya that includes social networks and measures of the contraceptive prevalence among friends. Most analyses of the role of social networks with these and similar data have focused on one of the determinants of fertility, the adoption of modern methods of family planning. These analyses typically find a significant relation between a woman's contraceptive use and the prevalence of family planning in her social networks: women whose network partners use family planning are more likely to use it themselves. These analyses, however, focus usually implicitly on the messages that are presumably part of the content of the interaction, and do not address the structure of the interaction. These analyses, therefore, do not address whether these influences of social networks on behavior are modified by the structure of one's network. The literature on networks, however, suggests that it is not only the content of conversations in social networks that matters, but also network structure – characteristics such as size, heterogeneity and density (Granovetter 1973; Marsden and Friedkin 1993; Valente 1994; Wasserman and Faust 1994).

In this paper we include measures of the social structure in logistic regressions of contraceptive

[1] Watkins (1998) further separates from these two functions the *joint evaluation* of information, behavior and opinions by members of social networks, but in this paper we focus only on the distinction between social learning and social influence.

use, and we interact these measures with the prevalence of family planning among network partners. These analyses allow us to address whether the effect of social networks on behavior is modified by the structure of a woman's network. For instance, is the contraceptive behavior in a dense network of friends, i.e., a network where all the members know each other, more influential than the behavior of socially unconnected individuals? Based on recent advances in network theory we argue in this paper that social learning is maximized, all else equal, when the structure of the network is very sparse so that the network partners do not interact with one another, but provide relatively independent sources of information. In contrast, the more dense the network, the greater the social influence because groups and cliques exert a larger normative influence than isolated individuals. The different implications of network structure for social learning versus social influence allows us to distinguish empirically between these two mechanisms.

In addition to the distinction between learning and influence, we also situate networks in a socioeconomic context, specifically the extent of market activities. The expansion of markets is one of the features of economic development: local markets become increasingly linked into regional, national and global markets. Functions that formerly were provided within the household or by other relatives and friends – ranging from providing labor to providing insurance – are increasingly provided through markets (Ben-Porath 1980; Pollak 1985). The expansion of markets is likely to alter social interaction, both in terms of its influence on individual behavior and in terms of the structure and geographic range of networks (Watkins 1991). Our data include areas with a different prevalence of markets. We are therefore able to analyze whether the role of social networks in contraceptive decision-making is affected by the exposure of women to market activities.

Our findings point to an interesting interaction between the network structure, the use of family planning among friends, and the prevalence of market activities in an area. In areas with low market activities, dense networks without family planning users have a constraining effect that impedes the adoption of modern contraception. Dense networks with family planning users, on the other hand, have a strong positive effect on the propensity to adopt contraception. The proportion of family planning users among friends no longer affects contraceptive adoption directly, but influences contraceptive use only through its interaction with the density of the social network. This result indicates that social influence is a relevant aspect for understanding the diffusion of modern contraception in areas with little market activity. In contrast, the pattern is different in areas with a high level of market activity. In particular, the presence of markets seems to affect how women interact with their family planning network: our estimate indicate that social learning is more relevant when market activities are prevalent, and we find that social influence is unimportant in areas with high market activities.

The results in this paper suggest that the content of social interaction, measured by the number of contraceptive users in a woman's social network, is not sufficient for understanding the use of family planning. Additionally, the social structure, as captured by network structure, and the degree of economic development, as captured by the presence of market activities, exert important influences on how social interaction affects contraceptive decisions. Markets affect the opportunities to establish and maintain network relations, and they provide new opportunities for communication. Markets may also affect how networks affect individual behavior. In particular, our analysis finds that the presence of markets influences the relative importance of social influence versus social learning as

mechanisms through which networks affect the use of family planning. In combination with the network structure, markets therefore determine whether social interaction about family planning unambiguously facilitates the use of modern contraception, or whether social interaction can also reinforce a status-quo with low contraceptive use and hence impede the diffusion of modern family planning. Market development, moreover, can shift the relative importance of social influence versus social learning. In areas in which social influence currently dominates and reinforces behaviors that retard diffusion, for example, sufficient market development over time may lead to the dominance of social learning that accelerates diffusion.

In the following section we discuss network density and how it can be used to distinguish between social influence and social learning. We then describe the available Kenyan data and we estimate the dependence of women's contraceptive use on individual and social network characteristics. In Section 3 we integrate our empirical findings with a theoretical model of contraceptive use that includes social network effects, and we use this model to analyze the role of markets on the relative importance of social learning versus social influence. Section 4 concludes the paper.

2 Social Structure and Fertility Decisions

The existing evidence on the interaction between social networks and fertility has been based on analyses of an individual's fertility behavior and the fertility behavior or contraceptive use of social network partners. A common econometric formulation based on Montgomery and Casterline (1996) is specified as:

$$Y^* = X\beta_1 + Z\beta_2 + \delta \sum_j \omega_j W_j + u, \tag{1}$$

where Y^* is the propensity to adopt contraception, X represents conventional socioeconomic covariates, Z includes measures of family planning effort and W_j represents the fertility related behavior (e.g., contraceptive use) of the respondent's network partners $j = 1, \ldots, N$. The parameter ω_j assigns different weights to the network partners, and δ measures the overall influence of the behavior of network partners on the respondent's contraceptive use.

This and similar specifications have been used in various studies (e.g., Arends-Kuenning 1997; Behrman et al. 1998; Montgomery and Chung 1998; Valente et al. 1997). A frequent finding in these analyses is that a larger number (or proportion) of network partners who have used family planning is positively related to the probability that the respondent herself is using family planning. However, the interpretation of this result as demonstrating the influence of social networks on the adoption of modern family planning, remains problematic in several respects. *First*, the size and composition of networks may be correlated with unobserved individual characteristics. For instance, women with a higher willingness to use modern contraception may spend more effort in talking to other women about contraception and family planning and they may therefore have social networks that exhibit a higher prevalence of contraceptive users. *Second*, members of a social network often live in the same area, and are thus subject to conditions that affect the fertility behavior of all members in the social network (e.g. an increase in school fees or a new family planning program; see also Manski 1993). In both cases we would expect to find that individual contraceptive use and the prevalence of modern family planning in the social network are correlated. Nevertheless, in neither case is the

correlation an indication that the decision to adopt or use modern contraception is indeed influenced by the behavior of one's network partners.

Even if one assumes that the above aspects are only of secondary relevance for the interpretation of our findings, the results are only partially satisfying from a theoretical standpoint. In particular, the findings do not tell us how social networks affect a woman's decision to use family planning.

The two most important mechanisms through which networks affect women's contraceptive decisions are social learning and social influence. Social learning emphasizes the role of information in reducing uncertainty. In Nyanza, we found collective uncertainty and individual ambivalence about desirable family size: in semi-structured interviews and focus groups some said, for example, that larger families were a protection against the possibility of that all one's children would die, whereas others countered with the smaller costs (school fees, clothing, childcare) that those with few children would bear. Similarly, some worried about excessive bleeding or weight loss that they associated with the use of modern family planning, whereas others countered that those who began to use family planning were notably healthier than they had been previously (Rutenberg and Watkins 1997). Learning through social networks about the experience of other women may reduce these uncertainties, and it therefore may increase the probability that a risk averse woman herself will adopt modern contraception (Kohler 1997).

The second aspect, social influence, extends beyond the pure processes of learning. It allows for the fact that a woman's preferences for children may be influenced and altered by those with whom she interacts. Her friends may disparage a woman believed to be using family planning for caring about her looks, even seeking to attract other men; alternatively, they may praise a woman believed to be using family planning for being a responsible mother, concerned about feeding, clothing and educating her children. The existence of both these mechanisms has a long tradition in sociology and social psychology (see for instance Moscovici 1985 for a review). Yet, little direct evidence exists in the area of contraceptive adoption that allows a distinction between social learning and social influence, or an evaluation of their relative importance.

According to semi-structured interviews with women that we conducted in Nyanza in 1994, conversations about family size provide an opportunity to assess the support or opposition of relatives, friends and neighbors for the deliberate control of fertility within marriage: what appears to be important is how those with only a few children are viewed by others (Watkins 1998). When respondents talk with their network partners about family planning, however, what appears to be important is learning what others have experienced or heard about the risks that the use of modern family planning is believed to pose to their bodies: are the side effects tolerable or not? (Rutenberg and Watkins 1997) Thus, our qualitative evidence indicates the presence of both social learning and social influence in women's interaction about family planning.

This qualitative evidence, however, leads to an important question: Is it possible to evaluate the relative importance of these two mechanisms, and can we discriminate between them quantitatively, using data on social networks?

In this paper we give an affirmative answer to this question. We argue that by looking beyond the direct links between the respondent and her network partners, and by additionally incorporating information about the social structure of networks, we can distinguish and evaluate the relative importance of social learning and social influence.

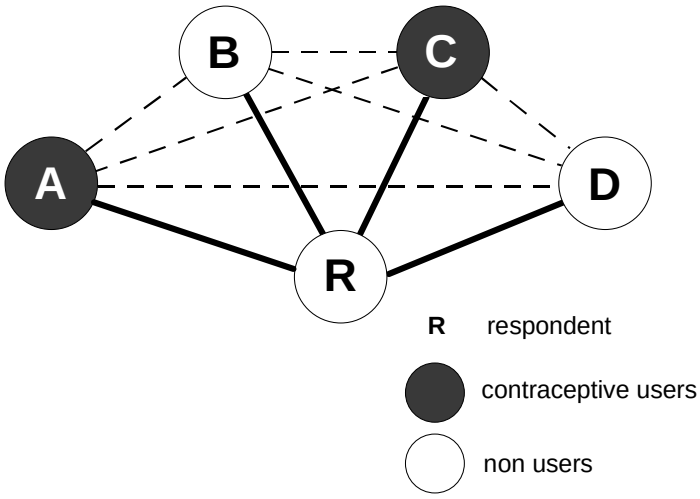

Figure 1: Social network with four network partners: how structure matters for contraceptive decisions

2.1 Looking beyond direct links: network structure and fertility

In a study of corporate networks, Burt (1992) distinguished the characteristics of networks in terms of providing optimal information about innovations or changes in the market place and in terms of the constraints that these networks exert on the freedom of an actor to decide independently. Although markets in Burt's analysis are more like those in highly developed capitalist economies than the small local networks of Nyanza, the concepts he presents are useful. Networks in Burt's analysis provide opportunities to increase the returns on investments and they allow controlling or influencing the behavior of other actors in the market place. However, these advantages of social networks are not without costs. In particular, networks can restrict the freedom to make independent decisions because an individual has to avoid conflict with other members of his or her social network.[2]

According to Burt, the opportunities and constraints implied by a specific network depend on the existence of *structural holes.* Networks are a social structure; structural holes describe the existence of individuals (or, in a large network, clusters of individuals) who are not connected with other individuals (or clusters), but rather are social isolates. In the following we will build on a similar idea in order to investigate how networks influence the decision to adopt family planning. Consider for instance the social network *ABCD* depicted in Figure 1 with four network partners, some of whom may use modern contraception. The respondent has not yet used modern methods, and we will address how the presence of the network partners *A, B, C, D* affects the respondent's decision about family planning.[3]

[2] Burt is certainly not the first author to observe the ambivalent role of social networks in term of offering opportunities and imposing constraints on choices at the same time. Earlier analyses, for instance, include Simmel (1922) and Bott (1971).

[3] Because the data that is available for the later estimation provides ego-centric networks, we will concentrate our theoretical development on this specific case. The extension to complete (e.g., village) networks is straight forward and can be implemented if the data are available.

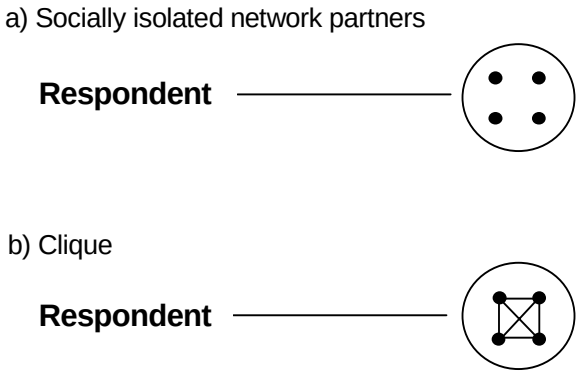

Figure 2: Social network as a constraint on behavioral choices

In Figure 1, we know that the respondent has direct social ties with each of the four network partners. Additionally, we have information about an aspect of network structure, the relationship of the network partners among themselves: we know, for instance, whether *A, B, C* and *D* know each other directly, or only at second hand through their relation to the respondent. The formal concept that we use to represent the degree of social connectedness among the network partners is *density.* Density is the proportion of all possible social links that actually exist in the observed network. For instance, in a network of size four, a total of six possible links exists, and the density is the number of existing links divided by six. We will call a network *very dense* if the density equals one. We will denote it as *very sparse* if the density is zero and *A, B, C, D* share no direct links.[4]

It has been argued at least since Granovetter's (1973) analysis that weak social ties are most relevant in situations where obtaining information about opportunities or innovations is crucial. In similar vein, Burt (1992) argues that the network in Figure 1 is most effective for obtaining information when it is sparse, because then it reaches four different areas of social activity that can provide (relatively) independent information. On the other hand, dense networks are inefficient for information purposes: if the network partners know each other, then *A, B, C, D* provide redundant information. They already share most of the information available to them and there is little or no additional advantage gained from maintaining contacts with all four network partners. A structural hole describes the fact that there exist unconnected people within a social structure who can provide distinct pieces of information to the respondent. An efficient information network is therefore characterized by the existence of structural holes among the network partners. Equivalently, an efficient information network exhibits a structure in which the network partners *A, B, C, D* in Figure 1 share relatively few links among themselves.

The structural conditions that maximize information benefits, according to Burt, also favor entrepreneurial opportunity. In other words, networks that exhibit few structural holes constrain an individual's opportunity to decide freely, to innovate, or to deviate from prevailing behavior. Consider, for instance, Figure 2 with two women interacting with differently structured sets of network partners. In situation (a) the woman interacts with socially isolated individuals, and in situation (b) the interaction is with a dense network which constitutes a clique. In the former case

[4] For a further discussion of density and related measures see, for instance, Wasserman and Faust (1994).

the respondent's social network bridges the structural hole between the network partners, in the latter situation structural holes are absent. If information is the relevant constraint and the primary purpose of social interaction is learning, then the sparse network (a) is either equivalent to or even more effective than the dense network (b). This ranking of networks (a) and (b) changes, however, if social norms or acceptance of one's behavior by friends and community members are important concerns in the adoption of modern family planning.

Although proponents of diffusion often assume that social interaction only facilitates innovative behavior, increased social interaction can also impede innovative behavior (Behrman, Kohler, and Watkins 1998; Kohler 1998). Social networks may discourage women from using modern methods if family planning is not used by the members of the network, but it may encourage the use of modern methods if the prevalence of modern contraception among the network partners is high. The direction of the influence thus is related to use of family planning by the network members. For example, if many in the network do not use family planning, they may justify their choice by drawing on community norms that support high fertility, such as the expectation that many children bring wealth and prestige to the family; in contrast, if many in the network use family planning, they may justify their choice by drawing on other community norms that stress the importance of having few children so that one can rear them properly (for the flexibility of norms, see Lockwood 1995).

Stated more generally, social influence constrains an individual's ability to decide independently. If all of the members of one's network favor (or oppose) family planning, it is more difficult to decide to use (or not use) family planning, regardless of one's own preference. Implementing one's own preference is even more difficult if social influence is strong. The strength of social influence, however, depends on the social structure among the network partners. Burt (1992) and Moscovici (1985) argue that the extent of social influence on the respondent's behavior depends on the respondent's ability to influence the behavior of network partners, and the ability of the respondent to substitute the social relation to a specific network partner with an alternative relation. In a network with relatively isolated network partners, as in (a), the behavioral constraint of the network is minimal. Links between the respondent and her network partners are easily substitutable because all relations between the respondent and her network partners are merely dyadic and do not integrate the respondent into a larger group. Due to this simple dyadic link, a social relation can be more easily substituted by relations to other individuals with potentially different knowledge and attitudes. When interacting with a clique, as in (b), this substitutability of social contacts is diminished because the relations are no longer merely dyadic but define groups and cliques to which the respondent belongs. Due to this low substitutability, the potential influence of the respondent on the behavior of others in negotiations about the mutual relations is weak. Thus, in the absence of structural holes among the network partners, as in (b), the respondent's only alternatives are to accept the influences, e.g., attitudes of the clique or cut the cluster from the network. The latter alternative, however, may not always be possible, for example in situations such as the patrilocal villages of rural Nyanza where many women's network partners are relatives or wives of their husband's relatives.

In the case of the network displayed in Figure 1, this implies that a network partner exerts a relatively strong influence on the respondent's contraceptive decisions if she has not only a direct link to the respondent, but also indirect links through the other network partners. On the other

hand, a network partner who is linked only to the respondent, but has no indirect links through the other network partners, exerts only a relatively weak influence.

In evaluating the total constraint that is exerted by the network *A, B, C, D* on the respondent's behavior, this reasoning suggests an interaction between the prevailing contraceptive behavior in the network and the density of the social network. The former measures the direction in which the constraint or influence is operating, and the latter reflects the strength of this constraint.

We will utilize the idea that a social network is a benefit and constraint at the same time in our estimation in section 2.3 in order to distinguish which of these aspects is more relevant in the context of family planning diffusion.

2.2 Data and context

The subsequent analyses are based on data from the Kenyan Diffusion and Ideational Change Project (KDICP). The data consist of a longitudinal household survey, and a set of semi-structured interviews and focus groups, that were collected by Watkins and collaborators during 1994-96 in Nyanza Province, Kenya.[5]

The four study sites, Obisa, Owich, Kawadhgone and Mfangano South, are rural sublocations (administrative units) in South Nyanza District (now called Homa Bay District). The locations are culturally quite homogeneous. The vast majority of the inhabitants in this area are Luo, an ethnic group that is patrilineal, patrilocal and polygynous with exogamous marriages. The rural study sites are also clearly underdeveloped: none had electricity, roads are poor, and village stores sell few items (e.g., pens, kerosene, salt), particularly in the last three sublocations. Subsistence agriculture is supplemented by male wage labor (e.g. fishing in Lake Victoria and quarrying stone) and female small-scale retailing (e.g. buying bananas in a larger market and reselling them locally).

Contraceptive prevalence is still relatively low in South Nyanza, compared to some other parts of Kenya. Our household survey found 12% of married women were currently using family planning in 1994 and 16% in 1996, and 23% in 1994 had ever used family planning in 1994, rising to 30% in 1996.

An unusual feature of the data is that they reflect women's interactions about family planning. In particular, the data include information on egocentric networks, i.e., networks that contain the respondent and up to four network partners with whom the respondent has interacted about family planning (see Figure 1). The network data were collected by first asking the respondents with how many network partners they had talked about family planning (i.e., the size of their family planning network). They were then asked a series of questions about a maximum of four of these network partners. These networks are egocentric because the network partners by definition are linked to the respondent (the ego). The questions asked of the respondent about her network partners included relationship (sister-in-law, sister, etc.), degree of closeness (confidant, friend, acquaintance), and whether they lent the network partner money or borrowed from her, as well as the network partner's age, wealth, and family planning use. In addition, the respondent was asked whether each of her network partners knew each of the others, and how well. On the basis of this information we are able to calculate the density of the family planning social networks.[6]

[5] For a more detailed description of the data see Watkins et al. (1996) and Rutenberg and Watkins (1997).

[6] About 34% of all respondents in 1996 have a family planning network with a size larger than four. The estimator

Although the previous description of the socioeconomic context holds for all four sublocations, there is evident variation in the level of market activity. In particular, one of our sites, Obisa, differs from the other three sublocations because of the presence of a relatively large market in the town of Oyugis. Thus, women in Obisa are more likely to buy and sell in a large market than are women in the other three sublocations. More than 80% of women sell goods at the market, and more than 75% visit the market at least once a week, which is substantially higher than in the other sublocations (see Table 1).

The expansion of markets is one of the features of economic development: local markets become increasingly linked into regional, national and global markets. The expansion of markets is likely to alter social networks by extending their geographic range (Watkins 1991), thus reducing their density. If women buy and sell from each other in a small local market, buyers and sellers are more likely to know each other's companions than when local women travel to a more distant larger market, or when local women transact business in a local market that attracts sellers and buyers from further afield. The more extensive the market, the greater is the likelihood that participants in the market will interact with a wider range of people, and therefore the less the likelihood that market interactions will involve people who know each other. In addition, markets can alter how individual's behavior is affected by social interaction: After all, an important aspect of markets is the spread of information, and market participants may focus more on the information provided by their personal contacts than on the social acceptance regarding their family planning behavior.

The following analyses are based on the second (1996) wave of data collection, in which more detailed questions were asked about network partners than in the first wave. Because unobserved individual characteristics related to contraceptive use may be correlated with the size of a respondents network, we condition our analysis on those respondents who have given detailed information about three or four social network partners. The women in the analysis are therefore not representative of all respondents in the sample; nevertheless, our inference about the mechanisms of how social interaction influences contraceptive decisions is not affected by this conditioning.

Table 1 reports some summary statistics about the respondents' characteristics and their contraceptive use for the whole sample, as well as for women who will be used in the subsequent analysis. Because the distinction will be relevant when we turn to markets, we report the summary statistics separately for the region defined by the three sublocations where market activity is relatively low (Owich, Kawadhgone, Mfangano South), and the sublocation of Obisa, where market activity is relatively high. Obisa is also characterized by higher contraceptive use (measured by both ever used and currently using family planning) and a more widespread ability to speak a language other than Luo (primarily English and Kiswahili – the latter is the lingua franca of commerce).

Respondents typically reported on the household surveys that they talked about family planning with their network partners at each other's homes, or walking about in the course of their daily activities (e.g., collecting water and firewood, going to a river or the lake to bathe or wash clothes, or walking to and from the market). Almost all social interaction outside the home appears to be

of the density calculated on the basis of only four network partners is a biased estimator of the true density of the respondent's family planning network when the size of the true network exceeds four. We are currently developing estimators for the density that eliminate or reduce this bias. Because the four network partners probably include the most influential network partners, we are relatively confident that the subsequent results continue to hold even with a modified density estimator.

Table 1: Some summary statistics for women in the sample, and for women with a network of size three or four. (1996 data, currently married women only)

Sample	**women with a network of 3 or 4 network partners**		**All women**	
Region	Owich, Kawadhgo and Mfangano S.	Obisa	Owich, Kawadhgo and Mfangano S.	Obisa
N	270	118	497	197
ever used family planning	38.9%^{c}	51.7%^{b,d}	27.0%	37.6%^{a}
currently using family planning	20.0%^{c}	33.1%^{b,d}	14.3%	25.4%^{a}
age	32.3	34.1^{b}	32.4	33.2
	(8.41)	(8.15)	(8.42)	(8.61)
children ever born	5.34	5.91	5.36	5.55
	(3.06)	(3.15)	(3.11)	(3.21)
% of respondents with at least primary education	84.8%^{c}	89.0%^{d}	77.9%	82.7%
% of respondents with at least secondary education	17.4%^{c}	19.5%	12.5%	16.2%
% of respondents speaking Luo only	36.7%^{c}	16.9%^{b,d}	44.9%	22.8%^{a}
% of respondents speaking English	25.6%^{c}	33.1%^{b}	21.3%	31.0%^{a}
% of respondents with metal roof on hut (an indicator of wealth)	25.6%	42.4%^{b}	20.1%	38.6%
% of respondents going to the market at least weekly	40.5%	71.7%^{b}	39.3%	76.5%^{a}
% of respondents selling at market	33.0%	80.5%^{b}	33.3%	80.2%^{a}
% of respondents with family planning network	–	–	82.1%	82.7%
(Uncensored) Size of network[1]	7.68^{c}	5.71^{b,d}	4.71	3.88^{a}
	(4.95)	(3.82)	(5.00)	(3.81)

Notes: Standard deviation in parentheses. (1) Uncensored network size is the respondent's answer to the question about how many persons they had talked to about family planning (more detailed questions about the family planning use and the interaction the respondent were only asked for at most four of these network partners). *Results of two-sided tests for equal means:* (a) the difference between Obisa and OKM is significant at the 5% level for all women; (b) the difference between Obisa and OKM is significant at the 5% level for women with a network of 3 or 4 network partners; (c) women with a network of 3 or 4 network partners differ significantly (5% level) from the remaining women in OKM; (d) women with a network of 3 or 4 network partners differ significantly (5% level) from the remaining women in Obisa.

gender specific. For example, during our fieldwork we rarely saw men and women walking together. When we asked local men and women why this was the case, they were at first surprised and then explained that husbands and wives see each other enough at home. Moreover, walking with an unrelated person of the opposite sex is perceived as a sign of sexual interest or activity. It is thus not surprising that networks are highly gender-specific (96% of the women's network partners were female).

In Table 2 the characteristics of the respondents can be compared to the characteristics of the network partners with whom women in South Nyanza interact about family planning. Together with Table 1 the analyses reflect two aspects of selectivity that are important for understanding social interaction. First, the social networks are not a random sample of the population because women in the social networks are reported by the respondent to have a higher level of contraceptive use and a higher level of education than the average population. Second, women who have interacted with at least three network partners about family planning are not a random sample of the population: they are more educated and have a higher rate of contraceptive use than the average population. The latter finding is clearly consistent with the argument that social interactions facilitates the use of contraception. However, the association between a higher individual probability of use and a higher prevalence of contraceptive use in the network is inconclusive about whether selection or social interaction underlies this result. If it is the latter, the above association does not reveal whether network structure is important, or whether learning or influence is the dominant aspect of social interaction.

2.3 Econometric Analysis

In the following analysis we use the information on the social structure to investigate these questions further. First, we condition on respondents with three or four network partners and hence avoid the problem that the size of the network is correlated with unobserved characteristics.[7] Second, we distinguish between the information advantage of a social network and the constraints it places on behavior. If the former is most relevant, we expect that the proportion of contraceptive users among the network partners influences the respondents' family planning use, with the density of a network playing a minor role. If the latter is most relevant, we expect that the interaction between the network density and the proportion of users is most important for a woman's adoption.

[7] The analysis assumes, however, that after controlling for the size of the network, the structure of the social network and the proportion of users in the network is not correlated with unobserved individual characteristics. The analysis thus assumes the social network is the result of a search or social interaction process in which a woman spends a certain amount of effort in contacting other women, but learns about the contraceptive use and the social links of these network partners only after they have been contacted. Controlling for the network size controls for this effort spent in establishing the social network, and it therefore controls for any unobserved characteristics that lead to differential efforts by women.

In an empirical investigation of the potential selectivity of network parterns, Warriner and Watkins (1999) have compared the characteristics of network partners across different social networks (i.e., the network partners with whom the respondent has interacted with about family planning, AIDS, a local female disease called 'rariew', and wealth flows). Based on the characteristics the respondent reports about her network partners, Warriner and Watkins (1999) find no evidence for a different composition of these different networks, and they argue that the selection of network partners into the family planning network is largely determined by mechanisms unrelated to the respondent's unobserved characteristics related to family planning.

Table 2: Comparison of women's social networks in the regions 'Obisa' and 'Owich, Kawadhgo and Mfangano South' (currently married women with networks of size 3 and 4 only)

Sample	**women with 3 or 4 network partners**	
Region	**Owich, Kawadhgo and Mfangano S.**	**Obisa**
N	270	118
Family planning use by network partners:		
average proportion of network partners using family planning	0.578	0.585
average proportion of network partners advising to use family planning	0.642	0.641
Density		
average density of network among network partners	0.846	0.782[a]
Average proportion of network partners that are		
female	0.931	0.950
female relatives of respondent	0.683	0.671
friends only (unrelated to respondent)	0.193	0.194
confidance of respondent	0.465	0.478
aquaintances only	0.098	0.114
known for five or more years by respondent	0.694	0.686
younger than respondent	0.235	0.304[a]
living in same compound or village	0.556	0.522
living in Nairobi or Mombassa	0.019	0.013
Average proportion of network partners		
respondent lent money to	0.391	0.423
respondent helps often in network partner's household	0.207	0.208
respondent talks with at least weekly	0.631	0.684
that are known by respondent's husband	0.352	0.372
with at least primary education	0.807	0.767
with secondary education	0.247	0.289

Notes: (*a*) the difference between Obisa and OKM is significant at the 5% level (two-sided test).

Table 3: A simple analysis of contraceptive use and networks (Sample: currently married women with a family planning network of size three or four)

	Ever used fp		**Currently using fp**	
	Model 1	Model 2	Model 3	Model 4
constant	-6.732	-6.480	-7.770	-7.662
	(1.926)***	(1.988)***	(2.146)***	(2.062)***
age	0.187	0.176	0.262	0.252
	(0.109)*	(0.111)	(0.118)**	(0.113)**
age^2	-0.002	-0.002	-0.003	-0.003
	(0.002)	(0.002)	(0.002)**	(0.002)*
children ever born	0.164	0.139	-0.014	-0.038
	(0.070)**	(0.068)**	(0.057)	(0.053)
resp. has primary education	1.126	1.169	0.821	0.885
	(0.386)***	(0.400)***	(0.422)*	(0.423)**
resp. has secondary education	0.935	1.133	0.461	0.658
	(0.268)***	(0.277)***	(0.335)	(0.322)**
% of nwp using family planning	1.746		1.724	
	(0.348)***		(0.331)***	
% of nwp advising to use planning		0.986		1.107
		(0.261)***		(0.371)***
N	388	388	388	388

Notes: Standard errors in parentheses. The standard errors are adjusted for the clustering of respondents in villages using the Huber-White estimator of variance.
p-values: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

To examine these hypotheses, we estimate a logistic model for the use of contraception, where contraceptive use is measured through 'current use', as well as 'ever use' of family planning:[8]

$$\Pr(y = 1|X, \textit{social network}) = X\beta + \delta_1 \cdot (\%\textit{users}) + \delta_2 \cdot \textit{density} + \delta_3 \cdot (\%\textit{users}) \cdot \textit{density}, \qquad (2)$$

where y equals 1 if the respondent uses (has ever used) family planning, X is a set of individual characteristics, *%users* is the percentage of users of modern methods of family planning by the network partners, and *density* is the density of the social relations among the network partners.

Table 3 displays a simple analysis of a woman's contraceptive choice and its dependence on individual and social network characteristics. In the context of this paper, the strong relation between the respondent's likelihood of using family planning and the proportion of contraceptive users in the network is most important.

Although this finding is interesting, its interpretations are limited. In particular, the analyses in Table 3 do not reveal the mechanisms by which social network are related to contraceptive behavior, and the above results do not allow a distinction between social learning and social influence. In order to investigate this distinction further, Table 4 reports the logistic regression obtained from estimating relation (2). The table only reports the coefficients δ_1, δ_2, δ_3 for the network variables because the coefficients on individual characteristics remain almost unchanged from the coefficients

[8] Although we report the results for both dependent variables, we favor 'ever used family planning' as the dependent variable. We think that it is a better indicator of innovative behavior than is current use, because of the high discontinuation rates and the frequent short-term use of modern contraception for spacing in South Nyanza.

reported in Table 3.

In our initial analyses we examined the relation between density and the proportion of the network using family planning for each sublocation separately, in order to learn whether the relation was the same in all and whether the four sublocations could be considered together as a single region. We found that they could not: the relation between the use of family planning and social networks differed between Obisa, on the one hand, and Owich, Kawadhgone and Mfangano South (OKM) on the other.[9]

The first column of Table 4 reports again a positive coefficient of *%users* in both regions, similar to the results that we presented in Table 3. In the second column of Table 4 the density of the social network is added to the covariates, which yields a mostly insignificant coefficient δ_2 and results in virtually no change in the coefficient δ_1. In the third column, the interaction term *density* $\times$ *%users* is also included.

Once this interaction term is included in the analysis, the pattern of coefficients changes substantially in the OKM region: the initially significant coefficient δ_1 of *%users* looses its statistically significant influence on contraceptive choice, and the point estimate of this coefficient even changes its sign. The coefficient of *density,* δ_2, becomes negative and strongly significant. At the same time, the interaction term between the density and the proportion of contraceptive users in the network emerges as a strong positive factor influencing contraceptive adoption. The same pattern of parameter estimates is found if currently using contraception is used as a measure of contraceptive use (Panel B in Table 4), and it reoccurs when the percentage of users is replaced by the percentage of network partners, *%advisors*, who advise the respondent to use family planning (the latter regressions are not reported).

In Obisa the inclusion of density and the interaction terms reveals a different pattern. Contrary to the results in the OKM region, the probability of using family planning becomes even more strongly related to the proportion of family planning users in a woman's network: the coefficient of δ_1 increases in Obisa as the additional terms are added to the covariates. At the same time, the interaction between density and the proportion users (δ_3) becomes negative.

Together with the theoretical arguments in Sections 2.1, these results shed new light on how social networks influence family planning decisions in these sublocations. When learning is the primary factor in explaining the relevance of networks for the adoption of modern contraception, then we expect that the percentage of network partners that use or advise modern contraception is of primary importance. Since learning is not enhanced if the sources of information share social links among themselves, we expect that network *density* or the interaction *density* $\times$ *%users* are either mute in the analysis or that *density* $\times$ *%users* has a negative effect because dense networks are more inefficient sources of information than sparse networks. This pattern is revealed in Obisa. Hence, we conclude that in Obisa social learning seems to be the dominant mechanism of how social networks lead women to use, or not to use, family planning.

The above analyses, however, also reveal that learning about aspects of family planning such as side effects, may *not* be the primary factor that renders social interaction a relevant factor in the

[9] We test for the similarity of the coefficients across sublocations using a Wald test. This test rejects that the coefficients are equal across all four sublocations, but it does *not* reject the hypothesis of equal coefficients in Owich, Kawadghone and Mfangano South. These sublocations are thefore pooled into a single region 'OKM', and we allow all parameters to vary between the two regions 'OKM' and 'Obisa'.

Table 4: Lostisitc regression of contraceptive use on individual and network characteristics (the analyses included the same individual characteristics as those in Table 3; only the coefficients on the network characteristics are reported below)

Panel A	**ever used family planning** network and individual characteristics as of 1996, contraceptive use in 1996		
	Model 5	Model 6	Model 7
for Owich, Kawadhgo and Mfangano S.			
%users (δ_1)	1.619	1.596	-1.712
	(0.442)***	(0.442)***	(1.053)
density (δ_2)		-0.248	-2.756
		(0.531)	(0.787)***
density × *%users* (δ_3)			3.867[a]
			(1.268)***
for Obisa			
%users (δ_1)	2.271	2.290	4.495
	(0.623)***	(0.542)***	(2.197)**
density (δ_2)		-1.850	-0.337
		(0.831)**	(1.654)
density × *%users* (δ_3)			-2.814[a,b]
			(2.614)
Panel B	**currently using family planning** network and individual characteristics as of 1996, contraceptive use in 1996		
	Model 8	Model 9	Model 10
for Owich, Kawadhgo and Mfangano S.			
%users (δ_1)	2.008	1.996	-0.766
	(0.391)***	(0.411)***	(0.930)
density (δ_2)		-0.180	-2.488
		(0.752)	(0.847)***
density × *%users* (δ_3)			3.303[a]
			(1.236)***
for Obisa			
%users (δ_1)	1.485	1.503	2.501
	(0.463)***	(0.442)***	(1.551)*
density (δ_2)		-0.336	0.459
		(0.830)	(1.751)
density × *%users* (δ_3)			-1.302[a]
			(1.907)

Notes: Standard errors in parentheses. The standard errors are adjusted for the clustering of respondents in villages using the Huber-White estimator of variance. *p-values:* * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. *Additional tests:* (*a*) The linear combination $\delta_1 + \delta_3$ measures the effect on the probability to use family planning due to a change in *%users* in a network with *density* $= 1$. A Wald test of the null hypothesis $\delta_1 + \delta_3 = 0$ is rejected at the 1% level for OKM in Panel A and B, and for Obisa at the5% level in Panel A and B. (*b*) The linear combination $\delta_2 + \delta_3$ measures the effect on the probability to use family planning due to a change in *density* in a network with $\%users = 100\%$. A Wald test of the null hypothesis $\delta_2 + \delta_3 = 0$ is rejected at the 5% level for Obisa in Panel A.

adoption of family planning in OKM. On the contrary, our results for OKM imply that networks impose limitations on individual decisions and that social influence is the dominant aspect of how networks affect contraceptive decisions in OKM. In particular, the coefficients in the right column of Table 4 for OKM suggest that a dense social network with no users of modern contraception exerts a strong negative effect on the probability that the respondent uses contraception herself. On the other hand, an increase in the percentage of users of modern contraception has a strong positive effect on the probability of uses family planning in a dense network ($density = 1$). Therefore, a dense network exerts a constraint on the family planning behavior of a woman such that her behavior becomes more similar to the behavior of her network partners.

One general conclusion from the above analysis is that a focus on the direct links between the respondent and her network partners misrepresents the mechanism of how social interaction influences fertility decisions. In particular, the simple Models 5 and 8 in Table 4 ignore the possibility that the influence of *%users* on the respondent's contraceptive use is modified by the structure among the network partners.

However, Models 7 and 10 in Table 4 reveal that the structure, which extends beyond the direct links between the respondent and her network partners, is of considerable importance in understanding how social interaction affects fertility decisions. In particular, social networks emerge in the above analysis as an ambivalent institution with respect to the diffusion of family planning. Networks not only offer information, but they also operate as a constraint on individual behavior. The strength of these constraints depends on the density of the network: the denser is the network in Owich, Kawadhgone and Mfangano South, the stronger are the constraints which are implied by social interaction. These constraints operate against the adoption of modern contraception when the prevalence of family planning among the network partners is low; the constraints favor the adoption of modern methods when their prevalence among network partners is high. Although there are also dense networks in Obisa, it is only the proportion of family planning users in a network that is related to contraceptive decisions in Obisa, not the density.

These two distinct relationships between the social network and a woman's contraceptive decision agree with the implications of social learning and social influence developed above: the pattern in Obisa is characteristic for social learning, whereas the pattern in OKM is characteristic for social influence.

3 Towards a Model of Social Interaction and Fertility

In this section we develop a theoretical model that exhibits the relationships between social networks and contraceptive use which we found in Obisa and OKM. Furthermore, we use this model to investigate the reasons for the distinct patterns of social interaction across the two regions.

Consider a women (respondent) who is part of a social network similar to the structure shown in Figure 1. Let $y = 0$ if the woman chooses *not* to use family planning, and let $y = 1$ if she chooses family planning. Let $\bar{y}_{nw}$ be the proportion of women in the respondent's network who are using modern contraception, and let D_{nw} be the density of this network.[10]

[10] We do not consider the fact that, depending on the size of the network, the proportion $\bar{y}_{nw}$ of women using modern contraception in the network and the density D_{nw} can only take specific values. In the formal analysis, we

We can measure the behavioral constraint that results from this network with contraceptive prevalence $\bar{y}_{nw}$ and density D_{nw}, on the respondent's decisions via a 'social utility' term. Through this social utility term, the network partners affect the respondent's decisions about using family planning. Depending on the parameter values, this social utility term can represent either social learning or social influence.

Whether the direction of the network effect is towards using or not-using family planning is determined by a term $(-\phi + \bar{y}_{nw})$. If the proportion of network partners who use modern contraception $\bar{y}_{nw}$ exceeds ϕ, then $(-\phi + \bar{y}_{nw}) > 0$ and the social network favors the adoption of family planning; if $\bar{y}_{nw}$ is lower than ϕ, then $(-\phi + \bar{y}_{nw}) < 0$ and social interaction influences a woman's decision towards not using contraception. The influence is stronger the more $\bar{y}_{nw}$ deviates from the 'neutral' level ϕ: when $\bar{y}_{nw} = \phi$, then network effects on contraceptive adoption are absent and the respondent's decision is not affected by the presence of social interaction.

The level of ϕ is related to the question of whether social influence or learning is most relevant. If it is the former, then we expect ϕ to be relatively large since ϕ represents a critical level of contraceptive use among her network partners that needs to be exceeded before networks have a positive effect on the adoption of modern contraception. When social learning is most relevant, ϕ is small because already a small proportion of users in a network can provide useful information about modern contraception that reduces the respondent's uncertainty about this innovation.

Based on our earlier results, we assume that the strength of these network effects is affected by the density of the network. The estimates in Section 2.3, for instance, suggest that in the OKM region the percentage of users among network partners may have a stronger influence on the respondent's behavior in dense networks than in sparse networks. We reflect this relation in the social utility term by including an additional effect $\alpha(D_{nw})$ that multiplies $(-\phi + \bar{y}_{nw})$. When $\alpha'(D_{nw}) > 0$, the influence exerted by a network becomes more and more relevant the higher is the density of the network: an increasing density of the network exerts a stronger social influence towards not using contraception when the prevalence of family planning among network partners is low, and it increases the utility of modern contraception when the proportion of contraceptive users in the network is high. When $\alpha'(D_{nw}) < 0$, this relation is reversed.

Combining the two terms $(-\phi + \bar{y}_{nw})$ and $\alpha(D_{nw})$ yields a social utility term of the form $\alpha(D_{nw})(-\phi + \bar{y}_{nw})$ that reflects the influence of social interaction for choosing or not choosing family planning.

We now derive this social utility term and the probability of choosing family planning from utility maximization. For this purpose we assume that a woman derives utility V_1 from using a modern contraception and utility V_0 from not using family planning. This utility depends on her individual characteristics and the level of family planning effort x. For simplicity, we assume for this theoretical model that the population is homogeneous with respect to observed characteristics. Individuals differ only with respect to the unobserved characteristics ε_i that affect the preferences for not using $(i = 0)$ or using $(i = 1)$ family planning. The utility the woman obtains from each alternative is affected by her social network via a social utility term $\alpha_i(D_{nw})(-\phi + \bar{y}_{nw})$, $i = 0, 1$. In order to obtain the properties of social influence that are outlined above, we assume that $\alpha_0(D_{nw}) < 0 < \alpha_1(D_{nw})$.

therefore assume that the network is relatively large (e.g., more than 10 members) and that we can ignore these integer constraints.

Under these assumptions the utility derived from each choice is

$$V_i = \alpha_i(D_{nw})(-\phi + \bar{y}_{nw}) + \beta_i x + \gamma_i + \varepsilon_i, \qquad i = 0, 1 \tag{3}$$

where γ_i is a constant that includes the effect of the individual characteristics. The differential utility between the use and non-use of family planning is $V = V_1 - V_0 = \alpha(D_{nw})(-\phi + \bar{y}_{nw}) + \beta x + \gamma + \varepsilon$, where $\alpha(D_{nw}) = \alpha_1(D_{nw}) - \alpha_0(D_{nw})$ with $\beta = \beta_1 - \beta_0$, $\gamma = \gamma_1 - \gamma_0$ and $\varepsilon = \varepsilon_1 - \varepsilon_0$. Family planning is chosen if $V \geq 0$. Assuming the extreme value distribution for ε_i, the probability of a woman choosing modern contraception is

$$\Pr(y = 1|\bar{y}_{nw}, x, D_{nw}) = F(\alpha(D_{nw})(-\phi + \bar{y}_{nw}) + \beta x + \gamma), \tag{4}$$

where F is the cumulative logistic distribution.

The extent to which a woman's contraceptive decision is influenced by social interaction in equation (4) depends on the density of the network D_{nw}. In particular, the theoretical model (4) translates into our estimation in Table 4 when a linear model for $\alpha(D_{nw})$ is specified, where $\alpha(D_{nw}) = \tilde{\alpha}_1 + \tilde{\alpha}_2 D_{nw}$. Multiplying out the terms of $\alpha(D_{nw})(-\phi + \bar{y}_{nw})$ in this linear specification and comparing the terms of the model to the coefficients in the estimated equation (2) yields the following correspondence between the model parameters and the estimated coefficients in Table 4: $\tilde{\alpha}_1 = \delta_1$, $\phi = -\delta_2/\delta_3$, and $\tilde{\alpha}_2 = \delta_3$.

Figure 3 displays the probability of adopting family planning as a function of the density D_{nw} and the percentage of users in the network (*%users*) for Obisa and for the OKM region. The parameter estimates are taken from Model 7 in Table 4, and the individual characteristics are chosen to represent the 'average woman', i.e., a woman with the individual characteristics shown in the second and third column of Table 1.

The lines in this figure show how the probability of adopting family planning changes with the percentage of contraceptive users in a woman's social network. The different lines reflect the effect of networks with different densities, ranging from a relatively sparse network with a density of 0.5 to a dense network with a density of one.[11]

The two graphs in Figure 3 reflect the different level of contraceptive use in the two areas. Given the same social network, the contraceptive use is higher in Obisa as compared to Owich, Kawadhgone and Mfangano South. In addition, the graphs visualize the different mechanisms of how social networks affect the contraceptive adoption in the two regions.

Consider first the left graph for Obisa. The parameter estimates for Obisa yield a $\phi < 0$ and a level of $\alpha(D_{nw}) > 0$ for all density levels. The social utility term $\alpha(D_{nw})(-\phi + \bar{y}_{nw})$ hence is positive and favors the adoption of modern contraception whenever $\bar{y}_{nw} > 0$. If we begin with the solid line at the bottom, where density=1 (all the members of the respondent's network know each other), we see that the probability that an individual uses family planning is clearly related to the proportion in her network that uses family planning. The probability that a respondent with a dense network uses family planning goes from .20 when none of her network partners are using family planning to .60, when all of her network partners are using family planning. If we now look at the line representing a sparse network (density=.5), we see the same relationship: the more of her network partners use family planning, the more likely the respondent is to use it herself.

[11] Only about 11% of the women in the sample used for the estimation have a network that has a density of less than 0.5.

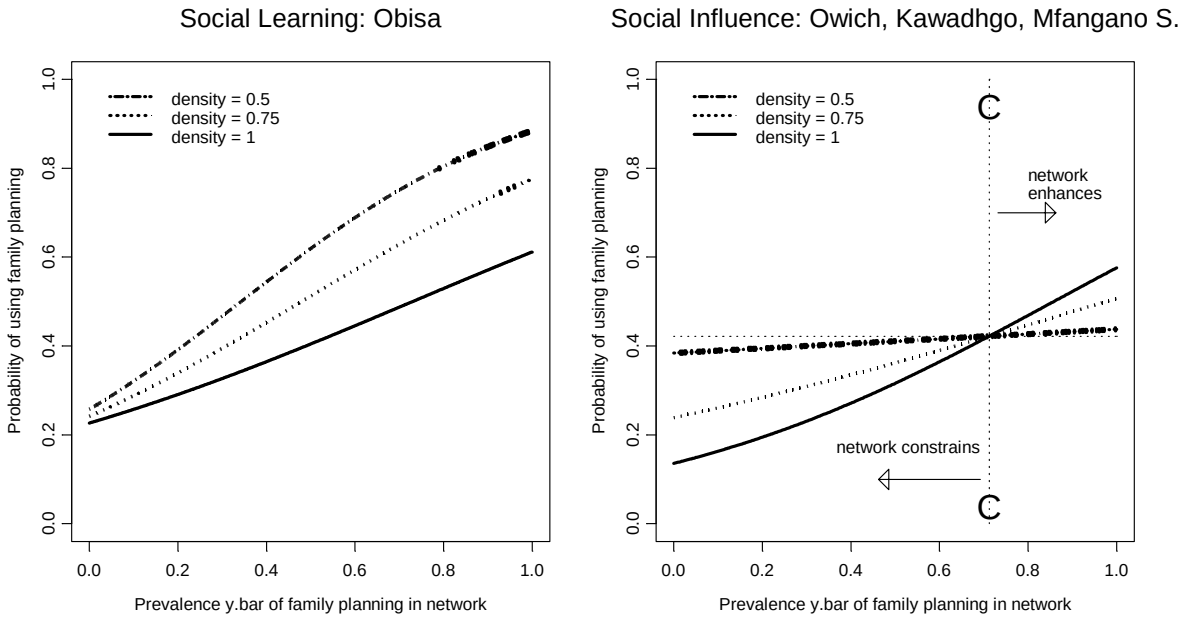

Figure 3: The effect of contraceptive prevalence in the network on the probability of adopting family planning for networks with different density (parameter values are derived from Model 7 in Table 3)

If we compare the lines for dense networks and sparse networks in Obisa, we see that a woman is more likely to use modern contraception if she has a spares network as compared to a dense network, given the same level of $\bar{y}_{nw}$. For instance, when the proportion of her network members using family planning is .60, the probability that the respondent is using family planning is about .45 if her network is very dense, but considerably higher, about .70, if her network is sparse. Moreover, as the proportion of network partners using family planning increases, the lines diverge. When the prevalence of users within the network is low, women with sparse networks are about as likely to use family planning as women with dense networks. When the prevalence of modern contraception in the network is high, however, women in sparse networks are considerably more likely to use than women in dense networks.

The higher probability that a woman with sparse networks uses family planning as compared to a woman with dense networks reflects the implications of social learning outlined in Section 2.1. Because a dense network implies that the information obtained from network partners is likely to be redundant, dense networks impede the ability to learn through social networks. A larger proportion of users in the network is still associated with more information, but the effect of increases in the proportion of a network that is using is larger for sparse networks than for dense networks.

The right graph in Figure 3, on the other hand, reflect a relation which is typical for a social influence situation. The probability of contraceptive use increases again with the prevalence of use among network partners (i.e., $\alpha(D_{nw}) > 0$ for $D_{nw} \geq 0.5$). However, the effect of increases in $\bar{y}_{nw}$ is rather minimal and not substantively important for networks with a density of 0.5. Only for relatively dense networks (i.e., density > 0.75) does the proportion of contraceptive users in the

network have a relevant influence on the respondent's probability to use family planning. In addition, the lines no longer diverge for increasing levels of $\bar{y}_{nw}$ as in the left graph, but rather intersect at a level of $\bar{y}_{nw} = 0.71$ that is indicated by the line CC. To the left of the line CC an increasing density of the network reduces the probability of contraceptive use, holding the prevalence $\bar{y}_{nw}$ constant. This is due to the fact that to the left of the line CC the social utility term in (4) is negative, and the network exerts a social influence towards not using family planning. In other words, the network constrains the individual towards using no contraceptive methods. This constraint is small when the density is about 0.5, but it reduces the adoption probability substantially when the network is dense. To the right of the line CC the social influence is towards modern contraception. In this case, an increasing density of the network, holding the prevalence $\bar{y}_{nw}$ constant, increases the probability of using family planning.

The transition when the social influence switches from favoring the non-use to favoring the use of family planning, occurs at a relatively high level of contraceptive prevalence in the network of about $\phi = 0.71$ (i.e., at the line CC in Figure 3). About 43% of the respondents used for the estimation, i.e., women in OKM with a network size of three or four, have a social network with more than 75% contraceptive users. For the remaining 57%, the social interaction exerts a behavioral constraint towards not using modern contraception.

In understanding the different implications of the graphs in Figure 3 it is central to ask about the reasons that render Obisa different from the other sublocations Owich, Kawadhgone and Mfangano South. Two possible explanations seem to be most pertinent to the current context. First, Obisa could differ because the networks have a different composition and structure than the family planning networks in the remaining sublocations. Second, the dominance of social learning in Obisa as compared to the OKM region could be due to a different interaction between the respondent and her network partners because of a different socioeconomic context.

In Table 1 we have already pointed out the higher overall contraceptive use Obisa (38% of women in Obisa ever-used family planning, compared to 27% in the other region), and the higher prevalence of market activities in this region. On the other hand, the regions do not seem to differ substantially with respect to the characteristics of the networks (Table 2). Contrary to the expectations that markets facilitate communication, about the same proportion of women have a family planning network and the (uncensored) size of the network is even larger in OKM where market activity is low.[12] In both regions networks are characterized by about the same proportion of users or her network partners that advise family planning. On average, about half of the network partners are confidants of the respondent, and only a small percentage are described as merely acquaintances. In all regions, moreover, the networks are predominantly local; despite the difference in market activities, the family planning networks consist of more than 50% of women living in the same compound or village, and only a small proportion of network partners lives in either Nairobi or Mombasa. The higher prevalence of market activities in Obisa is also not associated with a higher prevalence of weak ties (Granovetter 1973): in all regions the networks are dominated by network

[12] Table 1 reports the uncensored size of the family planning network for all women, and for women with a network of at least three members. Because the distribution of the network size is skewed (a few women report very large family planning networks with 15 or more members), we also compared the network sized between OKM and Obisa using quartiles. A similar pattern prevailed: women in OKM tend to have larger family planning networks than women in Obisa.

partners whom the respondent has known for five or more years, mutual help (lending money or help in household) is common, and a substantial fraction of network partners is also known by the respondent's husband.

The similarity of network characteristics between the sublocations in Table 2 suggests that the different implications of networks in Obisa and the region OKM in Figure 3 are not related to a different composition of the networks themselves. On the contrary, the different implications seem to be due to a different interaction between the respondent and her network partners. In Obisa, women in sparse networks are more likely to use family planning than women in dense networks, suggesting that in Obisa networks primarily provide an opportunity for social learning. In the region OKM, however, sparse networks have little significance, whereas dense networks are quite important in either encouraging or discouraging contraceptive use, suggesting that in OKM dense networks are primarily related to social influence.

The distinction between social learning and social influence, however, is not necessarily mutually exclusive; on the contrary, the distinction between these two aspects of why social networks may matter for women's contraceptive decisions is a question of relative importance. In the following we will therefore investigate the socioeconomic conditions that tend to favor social learning, and those that tend to favor social influence.

In terms of our theoretical model (4) outlined above, the primary differences between Obisa and the OKM region in Figure 3 are that the social learning situation in Obisa is characterized by (a) a shift of the critical level ϕ (indicated by the line CC) to the left, and (b) a stronger effect of sparse networks (e.g. density ≤ 0.75) on the respondent's contraceptive behavior. Both of these effects are consistent with our theoretical reasoning above.

In social learning, already a small proportion of users in the respondent's social network can provide a reduction of uncertainty in contraceptive decisions, and we therefore expect that the term $(-\phi + \bar{y}_{nw})$ is positive already for small levels of $\bar{y}_{nw}$. If social influence dominates in social interaction, however, then we expect that the critical level ϕ is relatively large, since only a relatively large proportion of users in the social network can overcome the normative influence against modern contraception.

The second aspect in which social learning and social influence differ is the effect of sparse networks on the respondent's contraceptive use. In a social influence situation, sparse networks do not substantially affect the probability of using modern contraception because her relatively isolated network partners have a small social influence on the respondent as compared to her network partners who represent a dense network or clique (see also our discussion following Figure 2). When social learning is most relevant, on the other hand, a sparse network is most advantageous because it tends to provide uncorrelated sources of information or because it represents weak ties which are most likely to provide information about innovations. The more relevant is social learning, therefore, the more we expect that increases of the proportion of users in sparse networks are associated with increases in the respondent's probability of using modern contraception.

The two graphs in Figure 3, thus, are both consistent with our theoretical framework (4). They merely reflect different parameter values for ϕ and $\alpha(.)$ that represent a shifting relative importance of social learning as compared to social influence between the regions of our study.

This distinction between social learning and social influence based on ϕ and $\alpha(.)$ can be further

investigated with our data. In particular, we propose that the relative importance of social learning as compared to social influence is related to the prevalence of markets in these regions. The degree of engagement in market activities is one of the few systematic differences between the sublocation of Obisa as compared to OKM in our data. Moreover, the argument that social learning is favored by market activities is plausible. After all, an important aspect of markets is the spread of information, and market participants may focus more on the information provided by their personal contacts than on the social acceptance regarding their family planning behavior. In order to investigate how the prevalence of market activities affect the critical level ϕ and the marginal effect of $\bar{y}_{nw}$ on the respondent's probability of using family planning, we extend our earlier model (4) and allow for a dependence of ϕ and α on both the density D_{nw} of the social network and the prevalence M of market activities in villages. In particular we estimate the model

$$\begin{aligned} \Pr(y=1|\bar{y}_{nw},x,D_{nw},M) &= F\left(\alpha(D_{nw},M)\cdot[-\phi(D_{nw},M)+\bar{y}_{nw}]+\beta x+\gamma\right) \qquad (5)\\ \text{where } a(D_{nw},M) &= \tilde{\alpha}_1+\tilde{\alpha}_2 M+\tilde{\alpha}_3 D_{nw}+\tilde{\alpha}_4 D_{nw}M \\ \phi(D_{nw},M) &= \tilde{\phi}_1+\tilde{\phi}_2 M+\tilde{\phi}_3 D_{nw}+\tilde{\phi}_4 D_{nw}M \end{aligned}$$

for the same sample of women already used in Table 4.

Our earlier estimates in Table 4 and calculations in Figure 3 assumed that the coefficients $\tilde{\alpha}_3,\tilde{\alpha}_4,\tilde{\phi}_2,\tilde{\phi}_3,\tilde{\phi}_4$ in (5) are zero, and we allowed the remaining parameters to vary across the regions Obisa and OKM. In the analysis below we constrain the parameters to be equal across regions, and explore whether the different relevance of social learning and social influence can be captured by including the dependence of α and ϕ on both density D_{nw} and the prevalence of market activities M. In addition to the individual characteristics already used for the estimates in Table 4, the current estimation also includes a dummy for Obisa to account for the different level of contraceptive use in this sublocation.

Table 5 reports the coefficients for $\alpha(D_{nw},M)$ and $\phi(D_{nw},M)$ that are obtained by a maximum likelihood estimation of (5) for women with three or four network partners. In Model 11 a Wald test does not reject the null-hypothesis that $\tilde{\phi}_3$ and $\tilde{\phi}_4$ both equal zero, and we therefore concentrate our discussion on Model 12 (Table 5 focuses on ever used contraception, but similar results are also obtained for current use).

We measure the prevalence of market activities by the proportion of women in each village who are selling at a market. There are a total of 29 villages in the four sublocations with a proportion of women who sell at markets ranging between 0.15 to 0.58 (across villages in the three sublocations of OKM) and 0.62 and 0.91 (across villages in Obisa).[13]

The estimates for the critical level $\phi(D_{nw},M)$ indicate that the critical level ϕ in (5) depends on the prevalence of market activities M, but not on the density of the network D_{nw}. Consistent with our earlier discussion, we find that a higher prevalence of market activities within villages is associated with a decreasing critical level ϕ. Hence, more market activity in this estimation is associated with a lower critical value ϕ above which the proportion of contraceptive users in the

[13] Information regarding 'going to the market' or 'selling at a market' is only available for the first wave of the survey. We therefore calculated the market activities using these responses. When calculating the market activity for each respondent, the respondent herself was excluded and the proportion of women selling at markets was calculated using the remaining residents in each village.

Table 5: Estimation of 'ever used family planning' according to relation (5) (only the coefficients for $\alpha(D_{nw}, M)$ and $\phi(D_{nw}, M)$ are reported; the covariates for the respondent include age, age^2, children ever born, and education, as well as a regional dummy for Obisa)

	ever used family planning	
	Model 11	Model 12
Parameters of $\alpha(D_{nw}, M)$		
constant ($\tilde{\alpha}_1$)	-6.89	-7.52
	(2.27)***	(2.15)***
market ($\tilde{\alpha}_2$)	12.00	14.75
	(4.76)**	(3.37)***
density ($\tilde{\alpha}_3$)	8.82	9.56
	(2.62)***	(2.47)***
market $\times$ *density* ($\tilde{\alpha}_4$)	-11.59	-14.96
	(5.34)**	(3.66)***
Parameters of $\phi(D_{nw}, M)$		
constant ($\tilde{\phi}_1$)	0.96	1.13
	(0.55)*	(0.24)***
market ($\tilde{\phi}_2$)	-1.44	-1.18
	(1.39)	(0.57)**
density ($\tilde{\phi}_3$)	0.21	
	(0.68)	
market $\times$ *density* ($\tilde{\phi}_4$)	0.49	
	(1.33)	

Notes: Standard errors in parentheses. The standard errors are adjusted for the clustering of respondents in villages using the Huber-White estimator of variance. *p-values:* * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

network has a positive effect on a woman's probability to use family planning. This reduction in the critical level ϕ is one indicator that points towards an increased relevance of social learning as compared to social influence in villages with high market activities.

The parameter estimates for $\alpha(D_{nw}, M)$ indicate that the relevance of the term $(-\phi + \bar{y}_{nw})$ in (5) depends on both the density of the network and the prevalence of market activities. The magnitudes of the parameters $\tilde{\alpha}_2$ and $\tilde{\alpha}_4$ are approximately equal, but the parameter estimates are opposite in sign. This implies that for dense networks variations in the market activity have very little effect on $\alpha(D_{nw}, M)$. For sparse networks, on the other hand, increases in market activity imply larger values of $\alpha(D_{nw}, M)$.

The estimates in Table 5 are therefore consistent with our earlier discussion about the effects of market activity on the relative importance of social learning versus social influence. Social influence is characterized by a relatively high level of ϕ and a relatively high level of α for dense networks but not for sparse networks. Social learning, on the other hand, is characterized by a relatively low level of ϕ, and a level of α that tends to be higher for sparse networks than for dense networks. According to the coefficients in Model 12 of Table 5, an increasing level of market activity therefore shifts the parameters $\alpha(D_{nw}, M)$ and $\phi(M)$ towards social learning and it diminishes the relevance of social influence.

Table 6: Summary statistics for the market activity (M), and the estimated levels of $\alpha(D_{nw}, M)$, $(-\phi(M) + \bar{y}_{nw})$, and the social utility term $\alpha(D_{nw}, M)(-\phi(M) + \bar{y}_{nw})$ based on Model 12 in Table 6

	Region	density	25%-ile	Median	75%-ile
market activity M	OKM	–	0.26	0.31	0.40
	Obisa	–	0.74	0.75	0.79
$\phi(M)$	OKM	–	0.66	0.77	0.82
	Obisa	–	0.19	0.25	0.26
$\alpha(D_{nw}, M)$	OKM	low density ($D_{nw} \leq 0.75$)	-1.41	-0.19	0.64
		high density ($D_{nw} > 0.75$)	1.92	1.97	1.98
	Obisa	low density ($D_{nw} \leq 0.75$)	2.43	2.72	3.27
		high density ($D_{nw} > 0.75$)	1.87	1.88	1.89
social utility	OKM	low density ($D_{nw} \leq 0.75$)	-0.12	0.04	0.33
$\alpha(D_{nw}, M)(-\phi(M) + \bar{y}_{nw})$		high density ($D_{nw} > 0.75$)	-0.91	-0.31	0.34
	Obisa	low density ($D_{nw} \leq 0.75$)	0.10	1.15	2.03
		high density ($D_{nw} > 0.75$)	0.09	0.76	1.39

Table 6 reports summary statistics for the market activity associated with each woman in the sample, and the estimated levels of $\alpha(D_{nw}, M)$ and $\phi(M)$ based on the coefficients of Model 12 in Table 5. The Table shows that there is some limited variation in $\phi(M)$ within the regions of OKM and Obisa; the primary difference in $\phi(M)$ occurs between the two regions, with Obisa exhibiting a considerably lower level of ϕ due to the higher market activity. Table 6 also reports the summary statistics for $\alpha(D_{nw}, M)$, separately for low and high densities. For low density there seems to be considerable variation within regions, whereas $\alpha(D_{nw}, M)$ is relatively constant within regions for high densities. This is due to the fact that only for low densities do variations in market activities affect the level of $\alpha(D_{nw}, M)$, whereas $\alpha(D_{nw}, M)$ is relatively unaffected by such changes when the network is dense. The latter effect also implies that $\alpha(D_{nw}, M)$ is almost constant across the regions for relatively dense networks, whereas for sparse networks $\alpha(D_{nw}, M)$ is substantially larger in OKM than in Obisa.

The last part of Table 6 reports on the values of the social utility term in the two regions, separately for high and low densities. Consistent with our argument that social learning dominates in Obisa, this social utility term is mostly positive, indicating an effect of social networks that tends to favor the adoption of modern contraception. In the OKM region, on the other hand, the social utility term ranges from negative to positive values, where dense networks are associated with the most negative social utilities. These negative social utilities are a reflection of the fact that social influence can impede the diffusion of modern contraception, especially when networks are characterized by a high density and low contraceptive use among her network partners. Nevertheless, for more that 25% of women the social utility term is positive even in the OKM region.

4 Conclusions

Theories of fertility change increasingly incorporate aspects of diffusion, associating the adoption of deliberate fertility control with the spread of contraceptive knowledge, attitudes towards low fertility and other ideational changes. Within this framework, attention has recently been given to

the possible role of social interactions, i.e., the process by which members of a population interact with each other, exchanging information, exerting social influence, and evaluating both information and influence. Although in principle social interaction could influence both preferences for smaller (or larger) family size and the adoption (or not) of modern contraception, previous studies have emphasized contraceptive use. Several of these conclude that women who interact with a high proportion of contraceptive users have a higher probability of using modern contraception than do women whose social networks include few users of modern family planning.

Although the evidence suggesting an important role of social networks in the adoption of modern contraception is accumulating, considerable uncertainty exists regarding the mechanisms by which social networks affect individuals' contraceptive decisions. We focus on two of the mechanisms that are emphasized in the literature: *social learning* and *social influence*. The former stresses that contraceptive adoption decisions are subject to substantial uncertainty about the medical side effects and/or the cost and benefits of modern methods of family planning. Learning about the experiences of other women through social networks may reduce this uncertainty and therefore may increase the probability that a risk averse women adopts modern contraception herself. The second aspect, social influence, on the other hand, emphasizes normative influences on behavior rather than processes of learning about unknown characteristics. Social influence therefore implies that a woman's preferences regarding modern contraception and/or the number of children are influenced and altered by the contraceptive practice and the fertility level of her social network partners, as well as their opinions.

In this paper we argue that these mechanisms can be distinguished by looking beyond the direct links between the respondent and her network partners. We argue that when social learning is most important, the density of the social network should *not* have strong effects on the adoption decision after the proportion of contraceptive users is controlled. If, however, social influence is most relevant, then the density of the social network should affect the decision about using family planning. In particular, dense networks with a low proportion of contraceptive users should tend to reduce the probability to use family planning, whereas sparse networks with few contraceptive users should be relatively neutral. In the presence of social influence, an increase in the proportion of contraceptive users in a sparse network should have a small effect on a woman's contraceptive decision, whereas a similar increase in dense networks should have a large effect on this decision.

We estimate the probability of using modern contraception on the basis of new data gathered in S. Nyanza District, Kenya. In these estimates we include the proportion of contraceptive users in the social network, and also interact this proportion with the density of the network.

By taking network density into account, we are able to show that it is not just the presumed content of the interaction between an individual and her network partners that matters for her use of family planning, but also the extent to which her network partners know each other. We find that in some contexts, the probability of contraceptive use by a woman is primarily affected by the proportion of her network partners who use family planning, and the density of her network has little relevance. In other contexts network structure is quite important. In particular, dense networks discourage an individual from using contraception if the network is composed of few contraceptive users. When the contraceptive use in the network is relatively high, on the other hand, dense networks encourage the adoption of family planning. Social networks in this analysis emerge as

an ambivalent institution with respect to the diffusion of modern family planning. Networks not only offer information and thus facilitate the adoption of family planning, but they operate also as a constraint on individual behavior that can impede the adoption of modern contraception. The strength of this constraint depends on the density of the network: the denser is the network of her network partners, the stronger are the constraints which are implied by social interaction. In other settings, however, dense networks might encourage rather than impede the adoption of modern contraception.

We are able to relate these different patterns of how networks affect contraceptive decisions to the prevalence of market activities. In particular, the difference between the two regions points to an interesting interaction between family planning use by others, network structure, and the extent of market activities. Because the expansion of markets is associated with economic development, this interaction suggests that development may be usefully considered not only by the characteristics of individuals but by the characteristics of an area. The two regions in our analysis (Obisa as one region, the other three sublocations as the other) are not distinguished by the characteristics of the networks of the respondents who reside there, but rather by the extent of market activities: in Obisa, more women are engaged in market activities, and they buy and sell at a larger market, than in the other sublocations. We find that it is only where market activity is low that social influence is important; only in the region where market activity is low do dense networks discourage or encourage the use of modern family planning. Thus, where market activity is low the dominant mechanism by which networks affect the use of family planning is social influence, whereas social learning dominates areas where market activity is high. Although the available data do not allow us at the moment to investigate the interdependence of social interaction and market activities in detail, the notion that higher market activities favor social learning is plausible. After all, an important aspect of markets is the spread of information, and market participants may focus more on the information provided by their personal contacts than on the social acceptance regarding their family planning behavior.

Based on these findings, this paper develops a simple formal model of fertility decisions that allows for both social learning and social influence. A social utility term in this model represents the effects of social networks on women's contraceptive decisions, and the relative importance of social learning versus social influence depends on the parameter values of this social utility term. We are able to estimate the dependence of these parameters on the density of the social network and the presence of market activities, and we use these estimates to calculate the different social utilities for areas with low and high market activities.

The estimates suggest that the critical level for contraceptive use among network partners, above which the social network has a positive influence on a woman's decision to use family planning, is shifted downward by the presence of market activities. This critical level is not affected by the density of the network. Hence, with increasing market activity a smaller prevalence of contraceptive use among network partners is necessary in order to obtain a positive effect of social interaction on a woman's contraceptive adoption probability. In addition to this critical level, changes in the market activity affect the weight of the social utility term. In particular, increases in the market activity tend to increase this weight for sparse networks, but not for dense networks. Both of these changes are characteristic for a shift from social influence to social learning as the prevalence of market increases.

The inclusion of network structure and market context thus permits a characterization of the different mechanisms through which social networks affect women's contraceptive decision in S. Nyanza District, Kenya. In particular, we have distinguished between social learning and social influence, emphasized the relative importance of these two mechanisms in understanding the role that social networks may play in encouraging or retarding fertility change, and shown that the relative importance of the mechanisms varies according to the extent of market activities. Thus, even in areas in which social interactions currently retard the diffusion of family planning as in three of the four sublocations that we study in Nyanza, Kenya, if market development is sufficient there may be a shift from dominance of conservative social influence to social learning that will accelerate this diffusion. We thus end by emphasizing the importance of social structure, as measured by network density, in all contexts, and the importance of economic development-market activities in fertility transitions.

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