Fidelity Networks: Female Discrimination, Male Competition, and the Spread of HIV/AIDS

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The spread of HIV/AIDS is a serious problem for the world. It has already been studied from several perspectives, including medical, epidemiological, sociological and also economic. However, within economics, one aspect that had not been studied was the application of the theory of social networks. This is surprising, since one would expect that the structure and evolution of social networks, viewed as entities that describe sexual behavior, must have some bearing on the problem and may shed new light on it.

To this end, the doctoral dissertation of one of us –Roland's– is devoted to the study of *fidelity networks*. The two of us have joined forces in one of its chapters, and in a recent working paper of the department, we have undertaken the analysis of a fully dynamic model of such sexual networks. The analysis also provides answers to other interesting questions, such as: Why is it men that generally court women? Why do women seem to bear a greater share of the HIV/AIDS burden? What explains serial monogamy in some societies and stable polygyny in others? Obviously, all these questions are related to sex, a "good that we should consume only moderately," according to Thomas Malthus, but "something that constitutes the primary drive of all humans," according to Sigmund Freud, and so, we proceed to describe the model of fidelity networks.

The fidelity model proposes to study network formation in a two-sided mating economy, with men being one side of the market and women the other side. Men enjoy having relationships with women and vice-versa, but having multiple partners is an act of infidelity, something that is punished if detected by the cheated partner. It is assumed that infidelity is punished more severely for women than for men. We call fidelity networks those networks that arise from this environment. We study their static and dynamic stability. Static stability is a notion of *equilibrium networks* in an environment in which pairs of agents of opposite sex are given an opportunity to change their sets of partners: no individual wishes to sever an existing link in which he or she is involved, and no man-woman pair wishes to form a new link between them while perhaps severing others. *Dynamic stability* pays attention to the formation of networks over time and uncovers those network configurations that are more likely to emerge in the long run.

Utility functions turn out to be single-peaked, with utility being increasing to the left of the peak and decreasing to its right. The assumption that the punishment to women after infidelity is higher than it is for men leads to

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women having an optimal number of partners that is smaller than men's. This implies that women are the "short side of the market" and therefore, men must compete for them. Indeed, under our assumptions, equilibrium networks are characterized by configurations in which each woman has exactly her optimal number of partners, while each man may be matched with anywhere from no woman at all to his optimal number.

The following example is illustrative of this argument. There are 3 men and 3 women; each man desires 3 partners while each woman desires only 1. So in this economy, women can supply a total of only 3 links while men as a whole are demanding 9. It can be checked that networks g_1, g_2 and g_3 are equilibrium networks. In all three, each woman has exactly 1 partner, her optimal number. In g_1, each man is matched to a woman; in g_2, man m_1 is matched with two women, while m_2 is unmatched and m_3 is still matched with one; in g_3, m_1 is matched with all three women while the other men are unmatched.

Turning to dynamics, we analyze the long-run predictions of the fidelity model. We use two processes in which people form and sever links over time based on the reward from doing so, but may take non-beneficial actions with small probability. In the first process, an individual who invests more time in a relationship makes it stronger and harder to break by his/her partner; in the second, such an individual is perceived as weak or dominated. These two processes depict two sociological realities. Under the first process, we find that only egalitarian equilibrium networks (in which all agents have the same number of partners) –like g_1 above– are the long run prediction, while under the second, only anti-egalitarian equilibrium networks (in which all women are matched to a small number of men) –like g_3 above – are.

Suppose now that each agent in society can get infected by the HIV/AIDS virus due to some exogenous reason, such as a blood transfusion. Next, assume that those individuals directly or indirectly linked to an infected person become infected through sexual transmission. How the disease will spread depends on the specific network. Based on a novel approach to analyzing such diffusion in a network, we apply our results to find that under the first process, HIV/AIDS is equally prevalent among men and women in the long run, while under the second, women bear a greater burden. To see this, the reader can check that in g_1 the expected number of men infected is 1, which equals the expected number of infected women (in both cases, the average of six 1's). In contrast, in g_3, while the former continues to be 1 (still the average of six 1's), the latter is 2 (the average of four 3's and two 0's).

The key message is that female discrimination does not necessary lead to higher HIV/AIDS prevalence among women in the short run, but it does in the long run. In the first process, which may resemble patterns in Western societies, the long run prediction does not favor women, even if the disease began affecting mostly males, as in the US. The second process, perhaps more related to sociological factors present in some African societies, identifies a serious gap in prevalence against women.