WORKING PAPERS

N° TSE - 991

February 2019

"Matching, cooperation and HIV in the couple"

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MATCHING, COOPERATION AND HIV IN THE COUPLE*

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This version: February 4, 2019

Abstract

We examine how cooperation within the couple protects the partners from HIV infection using survey data from southern Africa. The respective impacts of education and cooperation on HIV risk for both wives and husbands are estimated in a joint estimation model. We fully discuss and test the conflictual approach of the couple against a cooperative framework derived from a simple matching model. Our findings suggest that the larger the number of decisions husbands and wives jointly make, the less likely it is that they are infected with HIV. This is robust to assuming that cooperation is endogenous in the wife equation. Freedom and trust are also significantly related to the likelihood of infection for both partners while the women's views about whether marital violence is acceptable are not. These effects may come from a reduced likelihood of extramarital affairs among men and women living in more cooperative partnerships.

JEL Codes: I12, I26, J12, D10, O12

Keywords: Couples, Matching, HIV infection, Education, Africa.

Total word count: 12319.

*Data Availability Statement: The data used in this article can be obtained from the website of the Demographic and Health Surveys (http://dhsprogram.com/data/available-datasets.cfm). Additional replication materials will be provided in the Online Appendix if the manuscript is accepted for publication.

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I. INTRODUCTION

HIV contamination is still a devastating issue, particularly so in Southern Africa. This has led many economists and social scientists to investigate theoretically and empirically the determinants of the spread of the disease. As explained below, the dominant approach has a conflictual overtone, resulting in an emphasis put on women empowerment, e.g., via enhanced education, as a tool for controlling the epidemics. However, we argue that this assumes implicitly that couples are formed at random, and that the main vector of the spread of the epidemics has to be found in men's incentives. Our paper aims at improving our understanding of HIV contamination by looking more carefully at the matching process by which couples are formed and how this impacts the differential exposure to the disease across couples. We emphasize that matching is not based on incomes only but takes also into account some other personal characteristics that alter HIV risk within the couple. This process has been mostly overlooked in the literature, and the present paper offers both a theoretical framework and some econometric tests of its main prediction. We take due account of the possible correlation between the HIV status of both partners in the couple, if only because nearly all the contaminations has been through sexual intercourse in Sub-Saharan Africa since the beginning of the epidemics.

A large series of papers has documented health concordance within couples in different contexts (see Meyler et al. [2007] for a review). Couples have been found to have similar health-related practices, concordant health status and diseases. Three pathways have been proposed: assortative mating, shared resource hypothesis and social control. For instance, partners influence each other relative to smoking practices through social interactions and marital sorting via unobserved preferences (e.g. Clark and Etilé [2006]; Takagi et al. [2014]; Canta and Dubois [2015]). Partners are also found to suffer from the same disease in Hippisley-Cox et al. (2002) where partners of people with specific diseases such as asthma,

depression, hypertension, hyperlipidaemia, and peptic ulcer disease are at increased risk of suffering from the same disease themselves. In the context of HIV infection, as for any infectious disease, a fourth pathway is the fact that the individual may become contaminated by his or her partner. Even though unsafe sex is the primary mode of HIV transmission in sub-Saharan Africa (WHO [2003]), research on the likelihood of HIV infection has rarely been performed at the couple level. Men and women behaviors and risk of infection are mostly investigated separately, as two distinct health production functions, or pooled assuming that both sexes respond the same way to social factors or exogenous changes. Only de Walque (2007) considers the couple as the unit of observation and shows using data from the Demographic and Health Surveys, the prevalence of HIV in four types of couples according to sero-concordance or discordance. Our approach goes beyond the descriptive setting and tests for the role of intra-couple relationship in shaping each partner's likelihood of infection when this likelihood is jointly determined.

UN agencies, non-governmental organizations and civil society often claim that women's lack of power is the main reason for why women are particularly hit by HIV infection[1] [2]. Yet no formal test of the relationship between HIV risk of infection and women's relative power in her relationship has been undertaken, and this argument is grounded on the idea that women must gain power relative to men or their husbands to see their preferences materialize in decisions, and thus in actions. However, incentives for women to select carefully their partner have been analyzed in different contexts. Ashraf et al. (2014) have brought out the importance of hidden action and moral hazard regarding the use of contraceptives. Typically, the wife is unable to observe her husband's attitudes toward HIV-risk of infection

[1] In the resolution adopted by the UN General Assembly on August 2nd, 2001, it is acknowledged the following "Stressing that gender equality and the empowerment of women are fundamental elements in the reduction of the vulnerability of women and girls to HIV/AIDS" (UN General Assembly [2001])

[2] UNICEF (2003) guidelines state that UNICEF will support actions in programming for HIV/AIDS and Gender that aim to "Empower women and girls to protect themselves from HIV infection, promote responsible male partnership and participation, and address the gender inequities, violence, discrimination and unequal power relations that fuel the epidemic."

for any behavior outside the home. Given this feature, it is highly relevant for a woman to protect herself against the risk of infection not only by adopting healthy practices but also by choosing a husband that she believes is likely to adopt healthy practices as well. This holds true for many health outcomes beyond HIV. A symmetric incentive obviously exists for men.

We use a very simple theoretical framework to capture the essential features of this matching process, based on two assumptions. First, we assume that educated people have a wider range of personal characteristics than uneducated ones. This assumption can be traced back to Hayek who wrote in 1944: "In general, the higher the education and intelligence of individuals become, the more their views and tastes are differentiated and the less likely they are to agree on a particular hierarchy of values" (Hayek [2007], p.160). He adds a few lines below: "[...] the largest group of people whose values are very similar are people with low standards." This has been observed in many contexts, and might be due either to a selection effect, i.e., that people with more extreme worldviews are more prone to acquire some education than the others, or that these more heterogeneous worldviews are created by education itself, as people get to know their own type better when they are educated. Akerlof (1983) offers a neat framework to capture this kind of worldview effects in his "loyalty filters" theory, which allows for many mechanisms beyond education as preference-changing experiences. Azam (2012) uses Akerlof's hypothesis while restricting the source of this worldview effect to education for explaining why some educated people turn terrorist in some context. Todd and Zhang (2018) embed this kind of impact of education on people's types in a dynamic optimization model to derive some testable predictions. Their empirics show that this type-changing impact of education tends to taper off at about 28 years of age and that people with high cognitive and openness characteristics can be assigned to two different polar types (I and IV) with strikingly different personality traits in terms of stability, agreeableness, extraversion, etc. They conclude by stating: "We find that one of the

benefits of attending school is that it changes some personality traits [...]" (Todd and Zhang [2018], p.25). We use a similar argument, focused on differential propensities to cooperate within the couple among educated people to solve the following empirical puzzle. On the one hand, we conclude negatively when we test whether education is a significant determinant of HIV infection, along with some other variables, in what follows. On the other hand , this is a striking finding because we find a relatively high level of education among HIV-infected people (the proportion of women who have at least a secondary level of education is eight percentage points higher among HIV positive women than among HIV negative women). In other words, the data show that the probability of being educated is high among HIV-infected people while the fact of being educated does not increase the probability of being infected. Our theoretical framework neatly predicts this one-way correlation, as education is increasing the spread of HIV infection rates across couples without necessarily affecting its mean in this model.

The second assumption that we make is that the marriage market is matching partners as far as possible not only according to their similar income levels but also according to the similar values that they attach to cooperation within the couple. In this much idealized model, educated people attaching high values to intra-household cooperation will get married together, while the other couples of educated people will mainly get formed among people who attach lower values to such cooperation. However, in the African context of our data sets, we know that a lower fraction of women than men get educated, entailing an unavoidable mismatching for some couples. Nevertheless, in our framework, women are not randomly assigned to their husband. In the real world, the marriage market is probably not working as smoothly as in our simple model. However, even if the choice is constrained, there are still some elements of choice, based on different preferences, and men and women are in competition. There is some observed tendency for homogamy, men and women tend to marry partners of similar levels of education. Hypogamous and hypergamous unions occur

mainly because until very recently boys have been consistently more likely to enroll in school and to engage in longer studies than girls.

This paper sheds some empirical light on these two assumptions using data on married (or live-in) partners in Southern Africa surveyed in the most recent Demographic and Health Surveys collected in Malawi, Zambia and Zimbabwe. This survey data provides husband's and wife's current HIV status, as well as sociodemographic characteristics and how decisions are made within the household. Empirical tests are developed below to ascertain the extent to which HIV infection among partners are sensitive to the level of cooperation within the couple. This paper jointly estimates the likelihood of infection of both partners, what has never been done in previous research. It also tests for the influence of education levels as the theoretical framework points out that the level of cooperation may be greater or smaller among educated couples than among less-educated couples, but not necessarily so on average.

Our data suggest that ex-post, i.e., once couples have been formed, we will observe that some educated couples are more cooperative than are less educated couples, suggesting that education leads to greater cooperation for these households, while the opposite holds for some other educated couples. Educated men and women who have a strong willingness to cooperate will marry together and those who have a low willingness to cooperate will marry together. Our model predicts that cooperation will then protect the partners from being infected with HIV. Our data validate this prediction, while giving no empirical support to the conflictual view of the relationship between men and women where the woman must increase her market value to gain power in her couple. Cooperation protects both husbands and wives in a couple-integrated perspective while women market autonomy does not protect her, as cooperation significantly matters, while working, earning more than one's husband, taking decisions alone and rejecting marital violence do not protect women against HIV-risk.

The next section presents some simple statistics that do not provide much support to the dominant view that women's empowerment is the key tool for reducing the incidence

of HIV. Section 3 sketches the theoretical framework underpinning our matching approach. Section 4 describes the empirical setting and the data, while the main findings are presented in section 5. Some robustness checks are performed in section 6 and a brief conclusion is presented in the final section.

II. THE MISLEADING CONFLICTUAL VIEW OF THE COUPLE

A couple of indicators are used in the current literature to capture women's relative power in the household, gender equality and gender norms in favor of women's empowerment. These indicators are in line with a conflictual vision of the couple where the woman should accumulate more power to see her preferences materialize in decisions, choices and behaviors. The main condition for having more power is the relative earnings of women in the couple joint income. Accordingly, women's labor market participation and relative earnings have been used in the existing literature on female empowerment, as in Alesina et al. (2013). As the resulting outcome could be an increase in the ability to make her own decisions (Ambler [2015]), the self-reported decision-making process sheds light on the woman's level of power within her household. In Björkman Nygvist and Jayachandran (2017), decision making power is considered as the proportion of household decisions, across several domains, that the respondent reports making herself or himself. As such the making of joint decisions is neglected. Lastly, acceptance of marital violence is also studied in the literature as an indicator of gender norms in favor of the view that the woman is inferior to the man (see for instance Arestoff and Djemaï [2016]). This last indicator is in line with a conflictual vision of the relationships between men and women.

Using the latest waves of the Demographic and Health Surveys (DHS) collected in Malawi (2015), Zambia (2013) and Zimbabwe (2015), we explore the role of each of these three dimensions (labor participation and relative earnings, decision making and views about marital violence) in protecting women from HIV-infection. Appendix A provides a description of the

surveys and explains the choice of countries. The analysis relies on a sample of married or live-in couples for which both partners are interviewed and tested for HIV, called hereafter the analytical sample. Its determination is described in detail in Appendix Table B1. It comprises married (or live-in) couples where both partners have been interviewed and tested for HIV and where the woman has answered the module of questions about violence. The latter, which includes the questions about relative freedom that are used here, has been administered to a random subsample of women. All surveyed women are asked whether they are currently working, and 57% report working in our analytical sample. Among those who are currently working, 34% declare earning equally or more than their husband. Women are asked whether they participate in household-decision making along three dimensions[3]: decision about their own health, decision about whether to visit family and relatives, decision about large household purchases. We observe whether they make each decision alone, or not. It turns out that 26% of women are making the decision about health care alone, 18% about visiting family members and 13% about large household purchases (Table B1). Women are asked about their views regarding marital violence in several contexts. Specifically, women are asked whether they think it is acceptable that a man hits or beats his wife if she goes out without telling him, if she neglects the children, if she argues with him, if she refuses to have sex with him or if she burns the food. Over the sample, about 61% refuse any reasons for marital violence.

Whether the risk of HIV infection varies with the level of empowerment or autonomy is an open question not addressed yet in the literature. Some papers explore the role of gender power imbalance or women's empowerment on HIV-related attitudes such as partner communication about HIV, negotiation over condom use (see Cassidy et al. [2018], Gerritzen

[3]In Malawi and Zambia, men are also asked to declare who has the final say on visits to family or relatives, household purchases along with other dimensions, but the question is formulated in a different way in Zimbabwe "person who should have greater say". We keep apart the decision about how to use husband's earnings even though the question is asked in each country survey because it is not as relevant in our context.

[2016], Langen [2005]).

The DHS provides HIV status coming from the test performed right after the administration of a survey questionnaire among a randomly defined sample. Among the analytical sample, 12% of the wives are HIV-infected; they are 9% in Malawi, 12% in Zambia and 16% in Zimbabwe (see Table III). Table I shows the proportion of HIV-infected women along with measures of empowerment. 12% of women are HIV-infected and this proportion is 11% for the women who are currently working and 13% for those who are not (Panel A, columns 1 and 2 respectively). 15% of the working women whose earnings are equal or exceed their husbands' ones are infected and 14% of those working women who earn strictly less than their husband. The difference is not significant (column 3, panel B). Exploring marital violence refusal and the decision-making process brings different results. The proportion of infected women accepting or not any motive for marital violence is significantly larger for those who refuse all motives (panel C). The risk of infection is significantly different when comparing married women who make their decision alone to those who do not make. However, the sign goes in the direction that rejects the idea that empowerment protects women from infection. Married women who make their decisions alone are significantly more likely to be HIV-infected than their counterparts. The largest difference is found regarding the decision about the large household purchases where the difference is about 7 percentage points. Along these three dimensions of female empowerment, the hypothesis of empowerment as a risk-reducing device is thus rejected.

This rejection of the conflictual model might suggest that i) the analysis at the individual level is not the most appropriate approach as infection resulting from sexual contamination should be considered at the couple level, ii) women do not randomly choose their husband in the population, iii) the cooperative view of the couple may supersede the conflictual view of the relationships between men and women. Education assortative mating is highly relevant as suggested in Figure 1. In the DHS the education level is observed via the question about

the highest level attained. Respondents are split into four categories: no education, primary education, secondary education, or higher education. Observing both the educational levels of the husband and the wife allows us to explore relative education. The female partner has as much education as does the male partner in most couples in all the three countries. As shown in Figure 1, couples sort according to schooling and, for about 60 percent of the married couples, husband and wife have the same level of schooling. Homogamy is followed by hypergamy (women marrying up, i.e. a husband of higher education level). Hypergamous couples stand for about 40% of the couples in Zambia and 20% of the most recent generations. On average, around 10% only of the couples are formed between a female partner being more educated than her male partner (hypogamy). Unlike in Chiappori et al. (2009) for the US or Van Bavel and Klesment (2017) for Europe, a reversal of the gender gap in education is not observed in the youngest cohorts. In Zimbabwe, men born in the early-1980s onwards are less likely to marry a less educated wife, in favor of marrying a woman having as much education, suggesting that some catching up is occurring.

The theoretical framework below reconciles the role of education, matching and cooperation in shaping couples' joint decisions such as the protection against HIV.

III. THEORETICAL FRAMEWORK

The empowerment literature has emphasized the conflictual nature of the couple. The present model tries instead to give a more cooperative view of the latter and to derive some predictions that can be tested against actual household data. In particular, it focuses on the potential role of education in promoting cooperation within the couple.

The key assumption about the impact of education on the people who acquire it is similar to that in Azam (2012), itself derived from Akerlof's theory of "loyalty filters" (Akerlof [1983]). Education is doing two things to people who acquire it in this framework: (i) in the standard fashion, educated people get access to the higher-paying segment of the labor

market as skilled workers; (ii) it also affects their worldview in such a way that their behavior is significantly affected. Here, we focus on the case where education increases or decreases the value these people attach to cooperation within the couple relative to uneducated people, with some probability.

Let Gi, $i \in [0, n]$, $G \in \{M, F\}$ denote the individuals' indexes in each gender group, supposed to be in equal numbers n. The index Gi is assigned to individuals in increasing order of the value $v_{Gi} \in [v_L, v_H] \sim F(v_{Gi})$ that they attach to cooperation with their spouse, where $F(v_{Gi})$ is the cumulative probability distribution over the possible values of cooperation that the students can acquire. It is assumed identical across sexes and continuously differentiable. The education process allocates such a value to the individuals who participate in it while uneducated people have to be content with an average value:

$$v_{Gi} = \bar{v} = \int_{v_L}^{v_H} v_{Gi} F'(v_{Gi}) \, \mathrm{d}i \tag{1}$$

where $F'(v_{Gi})$ is the derivative of $F(v_{Gi})$. Let n_{GE} be the number of educated people of each gender, assumed exogenous, and assume that there are more educated men than women ($n_{ME} > n_{FE}$). This is the natural assumption to make given the dataset that we use for testing as shown above (see Figure 1).

Let y_{Gi} represent individual G_i's earnings such that uneducated people earn a wage $y_{Mi} = w_M$ or $y_{Fi} = w_F < w_M$, while educated ones earn a salary $y_{Mi} = s_M > w_M$ or $w_F < y_{Fi} = s_F < s_M$.

Now, couples are assumed to form according to a very simple matching process that solves the following mismatch-loss minimization problem, while celibacy, polygamy and homosexual marriages are ruled out for the sake of simplicity:

$$min \int_0^n \left[|y_{Mi} - y_{Fi}| + \mu \, |v_{Mi} - v_{Fi}| \right] \mathrm{d}i, \mu \geq 0 \tag{2}$$

Hence, this matching process is forming couples with people who are as similar as possible by their earnings level and the value they attach to cooperation with their spouse. The possible trade off between the two types of potential mismatches is captured by the relative value $\mu \geq 0$, assumed exogenously determined by custom or culture. Now, it is easily checked that the following result holds.

Lemma 1: The minimum aggregate earnings' mismatch is equal to:

$$\int_0^n (y_{Mi} - y_{Fi})\,\mathrm{d}i = (n - n_{ME})(w_M - w_F) + n_{ME}(s_M - s_F) + (n_{ME} - n_{FE})(s_M - w_F) \quad (3)$$

The reason is that the largest earnings gap occurs when an educated man marries an uneducated woman, which occurs necessarily as more men are educated than women, by assumption. Hence, minimizing the aggregate earnings gap will minimize the number of times that this mismatch occurs.

Because of the assumed additive separability of the matching process' objective function, Lemma 1 allows us to focus separately on the matching of partners according to their values of spousal cooperation. Figure 2 represents the matching outcome if $F(v_{Gi})$ is the uniform distribution. The continuous line represents the women's distribution of cooperative values and the broken line represents the men's one. For both genders, the uneducated people are located in the middle of the range, between the educated ones with below-average values and the educated ones with above-average values.

Denoting $\delta v \equiv v_L - \bar{v} = v_H - \bar{v}$, it is straightforward to check in this case that the minimum aggregate mismatch-loss can be decomposed into a pure gender-earnings gap (between brackets) and a composite mismatch loss as follows:

$$\Delta \equiv [(n - n_{ME})(w_M - w_F) + n_{ME}(s_M - s_F)] + (n_{ME} - n_{FE})(s_M - w_F + \mu\frac{\delta v}{2}) \quad (4)$$

Figure 2 predicts, among other things, that women are less cooperative than their husbands when they attach above-average values to cooperation, while they are more cooperative when they attach below-average values. This effect is due to the assumed relative scarcity of educated women and it would decrease were the number of educated women to increase. Another implication of Figure 2, which is validated empirically below, is that the highest values of cooperation are found in couples where both partners are educated, and the worst ones as well. Given that the assumed distribution over values of cooperation is the same for both genders and that the assumed number of educated women is lower relative to men, it is easily checked that the matching outcome depicted at Figure 2 is robust to various relaxations of the uniform distribution assumption. Even asymmetric distributions would give qualitatively similar results, which are summarized in proposition 1.

Proposition 1: Because the number of educated women is assumed to be lower than that of the educated men, the outcome of the assumed matching process yields the following predictions:

i. all uneducated men are matched with uneducated women,

ii. educated men are matched either with educated women whose value of cooperation lies on the same side of the mean as theirs, or with uneducated ones, and

iii. a ceteris paribus increase in the number of educated women improves the matching and hence increases the dispersion of cooperative values across households.

Proof: Assume the matching could be improved by swapping an educated woman and an uneducated one across two matches with an educated and an uneducated man, respectively. Then, both the earnings gaps and the value gaps would increase (weakly) between the educated man and his new wife, as well as between the uneducated man and his new educated wife, contradicting the assumption. Then, assume that the matching could be improved by

swapping two educated women with cooperation values from each side of the mean between two educated men from each side of the mean. Then, the value gaps would increase, another contradiction. Lastly, (iii) follows as educating more women will replace women with mean cooperation values by women with new values that differ from the mean.

For the sake of empirical analysis, we now translate the outcome sketched at Figure 2 by capturing within household cooperation by the following two variables:

Empirical assumptions: More cooperative couples are such that (i) women have more say in the household's decision process, and (ii) partners take less risk in their sexual behavior so that the incidence of HIV/AIDS is lower among them.

The key prediction deriving from these assumptions is that education as such would not be a key predictor of HIV/AIDS across couples from an empirical point of view, although it plays a key part in shaping households' behavior, while cooperation and sexual safety should move in the same direction.

IV. EMPIRICAL MODEL AND DATA

IV. A. Empirical specification

The theoretical model analyzed above yields the following testable predictions: (1) Partners in a cooperative couple are less likely to be HIV-infected than partners in a non-cooperative couple. In other words, the probability that a woman is infected with HIV would be decreasing with the level of cooperation she experiences in her partnership. The same is true for men. (2) When both partners are educated (resulting from educational marital matching), HIV-status is determined by the level of cooperation.

Cooperation is empirically measured by wives reporting participating in decision-making jointly with their husbands in three domains (large household purchases, her own health care and visiting family members). Two indicators are used: a score equal to the percentage of

decisions jointly made and, a score drawn from a principal component analysis computed using the three domains and keeping the distinction between making the decision alone, the husband alone or both together. It turns out that 35% of the sampled couples jointly make all the three types of decisions.

On average 56% of the decisions are jointly made between husbands and wives (see table B2). The value of the indicators is strongly dependent upon the level of education of the partners. This feature gives strong support to the model assumption about education revealing individual's type, or individual's preferences toward cooperation. Our data suggest that the percentage of joint decisions is 62% in couples where the wife attended college or more against 52% in couples where the wife did not attend college (Table II, col. 1 vs col. 2). In couples where the husband attended college or more the average cooperation is 60% against 52% in couples where the husband has a lower level of education (col. 4 vs. 5). The percentage of joint decisions is 63% in couples where both partners attended college, and 52% in couples where at least one partner did not attend college (col. 7 and 8 respectively). The same pattern is found when the score from the principal component analysis is used as the score is much higher when the wife is educated, the husband is educated, or both are educated.

To test our hypotheses, we estimate a simultaneous equation model through a bivariate Probit estimation where our dependent variable HIV_{ic} is the HIV status of individual i, i being either husband M or wife F, forming couple c. Estimating jointly the HIV equations of husband and wife relies on the idea that men and women are not randomly matched and that HIV being sexually transmitted, both status are intrinsically linked. As such, the correlation between the error terms in the husband's and in the wife's equations is allowed. Note that our approach differs from the method used to estimate peer effects in smoking behaviors as in Takagi et al. (2014) and Canta and Dubois (2015) where they control for spouse's behaviors in the estimation of one's own behaviors. The main reason why we do not

adopt this approach is that we do not observe when the spouse has been contaminated with HIV. In the case of smoking behavior, the econometrician observes whether the respondent is currently working at the time of the survey. In the case of HIV infection, one does observe the HIV status at the time of the survey but this status is related to behaviors that could be adopted up to 10 years before the survey date, depending on the year of contamination, and if the respondent is not under antiretroviral therapy.

One could argue that cooperation measured by the variable *coop* is endogenous to the wife's risk of infection due to reverse causality. The HIV status may influence the degree of cooperation within couples if the wife perceives that her husband loses confidence, and even more so that here cooperation is declared by the wife. Let Z_{Fc} be F's family background characteristics that serve as instruments to predict their observed degree of cooperation in their couple in the first-stage equation specified in Equation 5. The possible instrumental variables considered in the analysis are the likelihood of declaring that the respondent's father has ever beaten her mother, the likelihood of sibling mortality at young age, and the rank of birth.

$$coop_c = \beta_0 + \beta_1 Z_{Fc} + \beta_2 X_{Fc} + \beta_3 X_{Mc} + \beta_4 H_c + \nu_c; \forall F, M, c \tag{5}$$

X_{Fc} and X_{Mc} respectively are the set of socio-demographic characteristics of wives and husbands, namely: age, age squared, religion (catholic, protestant, other, muslim being the omitted category). H_c is the set of characteristics defined at the couple level, namely wife's education, husband's education, urban residence, wealth categories and region fixed effects. All exogenous variables used in the second stage equation are included in the right-hand side of Equation 5, as stated in Wooldridge (2002). Hence, Equation (5) uses all the available information to explain the level of cooperation with her husband (or partner) that the women declared in the survey. Consequently, the residuals of this equation measure

the deviations from that predicted value that are due to the information that she uses to make her assessment and is not available to the econometrician. They might in particular reflect the intuition that she developed on the marriage market about her spouse's personal propensity to cooperate at the time of matching or later on.

We control for endogeneity in the woman's HIV status equation by the control-function method, taking these residuals from the first-stage equation $\hat{\nu}_c$ as an additional regressor in the second-stage equation. If these residuals are significant, cooperation is endogenous as they affect simultaneously cooperation and her HIV risk[4], and its impact on the risk of infection α_1^F is consistently estimated (Rivers and Vuong [1988])[5]. The final second-stage two-equation system is summarized in Equation 6.

$$\begin{cases} HIV_{Fc} = \alpha_0^F + \alpha_1^F coop_c + \alpha_2^F X_{Fc} + \alpha_3^F H_c + \alpha_4^F \hat{\nu}_c + \varepsilon_{Fc}; \forall F, c \\ HIV_{Mc} = \alpha_0^M + \alpha_1^M coop_c + \alpha_2^M X_{Mc} + \alpha_3^M H_c + \varepsilon_{Mc}; \forall M, c \end{cases} \tag{6}$$

We first test whether cooperation (or lack of cooperation) is associated with HIV-status (Hypothesis 1). Next, we test whether the effect changes after we add measures of education level to the model (Hypothesis 2).

IV. B. Data description

Table III reports the summary statistics for our key variables, based on the analytical sample of married or live-in couples for which both partners are interviewed and tested for HIV. Over the whole sample, 12% of the wives are HIV-infected; they are 9% in Malawi, 12% in Zambia and 16% in Zimbabwe. In every country except for Malawi, the proportion of infected husbands is slightly larger than the proportion of wives: 9% in Malawi, 14% in

[4]These residuals fail to be statistically significant when included in the man's HIV-status equation, rejecting endogenous cooperation for men, i.e., the husband's infection risk is unaffected by his wife's private information about his propensity to cooperate.

[5]However, were the level of cooperation also significantly affected by some information unobserved by the wife either, the resulting attenuation bias would lean towards rejecting endogeneity, contrary to our findings.

Zambia and 17% in Zimbabwe. 37% of the women report that their father has ever beaten their mother, ranging from 30% in Malawi to 40% in Zambia and Zimbabwe. On average, women are their mother's 3.6th chilld. The average proportion of siblings who died before reaching 5 is 6%, ranging from 4% in Zimbabwe to 7% in Malawi.

The DHSs provide our key control variables: age, age squared, education, urban residence, wealth categories[6], religion and regional dummies (23 administrative regions in total). Concerning educational attainment, both men and women are asked to self-report their highest education level, coded as no education, primary education, secondary education or higher. Our data suggest that only 5% of husbands and 9% of wives in our analytical sample have no education. In Malawi and Zambia the majority of both wives and husbands reach the primary level, while in Zimbabwe more than half of the sample reaches the secondary level. On average men are more educated than women. The same is true when looking at the average years of education. The average number is 7.8 for men and 6.6 for women.

The average age in the entire sample is 30 and 35.6 years old for wives and husbands respectively. The largest share of respondents is protestant in every country including both wives and husbands. 32% live in urban areas:17% in Malawi, 37% in Zambia and Zimbabwe.

V. FINDINGS

V. A. Couples' HIV risk and education

Figure 3 shows the distribution of the couples for whom at least one member is infected with HIV, according to the level of schooling (some college and less than college) of the two spouses. We see that 21% of the couples for whom both wife and husband attended secondary schools are affected with HIV (last bar), while this affects only 14% of the couples

[6]These categories are the quintiles 1 to 5 of a continuous wealth index provided by the DHS. The index is a score drawn from a principal component analysis based on durable good ownership and dwelling characteristics.

for whom neither the wife nor the husband attended college (first bar). The largest burden is for couples for whom the wife is educated, and the husband is not: 22% are affected with HIV.

The proportions of couples in which both partners are HIV-positive over the above subgroups suggest that the smallest proportion is found in couples for whom no spouse attended college as 5.6% are made of two HIV-positive spouses. This group is followed by the couples for whom the husband attended college and the wife did not, where 9% are both HIV-infected. Then the rate of infection is about 10% in the two remaining groups: the couples from whom both attended college (9.6%) and the couples for whom the wife attended college and the husband did not (10%). If we compare the spread of HIV among couples for whom the husband attended college, the shares are very similar whether the wife attended college or not. 20% of these couples are affected with HIV: in around 10%, both spouses are infected, and in the remaining proportion, one of the spouses is infected, being more likely the husband.

V. B. First-stage estimation

Table IV shows the estimates from the first-stage regressions. Different instrumental variables are used. The instrumental variable in column 1 is the dummy variable equal to one if the wife declares that her father has ever beaten her mother. This variable is highly significantly related to the score of cooperation at the 1% threshold. Having perceived such a marital violence during childhood or later reduces the level of cooperation the wife is experiencing in her own partnership. Column 2 tries the wife's rank of birth as an instrumental variable, the rationale being that parental investment could vary with the rank of birth either due to preferences, time or financial constraints and this might influence the woman's ability at adulthood. This variable however is found to be non-significantly related with cooperation. Column 3 uses another indicator of family background and investment in health,

namely the percentage of siblings who died before reaching five years old. The relationship between cooperation and under 5-mortality is found to be significant and negative. Lastly, all three instrumental variables are used in column 4, and the two significant instruments in column 5. Again marital violence and mortality among the wife's siblings are significantly and negatively related to cooperation. The F-statistics on excluded instruments are in favor of using marital violence alone instead of jointly with rank of birth and under 5-mortality (F-statistics equal to 10.2 in column 1 vs. 6.68 in column 5).

V. C. Second-stage estimation of HIV-infection in the couple

Table V reports the estimates from the second-stage regressions using marital violence experienced by the wife's mother as the unique instrumental variable for cooperation. Model 1 jointly estimates the effect of cooperation on the probability of being HIV-infected for both wives (column 1) and husbands (column 2) controlling for the sociodemographic characteristics except for education. For both partners, more cooperation in the couple significantly reduces the risk of infection. Model 2 controls for education level rather than cooperation. Taking the less restrictive definition of education as we estimate the effect of having attended primary or secondary and higher, compared with having no education, our results suggest that having these levels of education rather than having never been enrolled in school does not significantly influence the HIV-infection. This finding holds for both wives and husbands, and for both their own level of education and that of their spouse.

Model 3 tests Hypothesis 2 by using both cooperation and education level as determinants of HIV-infection. Cooperation significantly influences HIV-risk while education does not for either wives or husbands. Model 4 supersedes Model 3 by controlling for the endogeneity of cooperation in the equation for wives by the control-function method, using the residuals of the first-stage equation based on marital violence experienced by the wife's mother as instruments for cooperation (equation shown in column 1 Table IV). The previous findings

hold: cooperation significantly protects husbands and wives from HIV-infection, and education does not play any significant role. Notice that her secondary or higher education level has a positive impact at the 10% significance level in column (7), undermining again the "empowerment" view. Note also that the impact of cooperation increases in size, suggesting that it was under-estimated in column 5 compared to column 7. As mentioned above, these residuals reflect all the information used by the wives who provide the assessment of the level of cooperation within their couple and that is not available to the econometrician. Hence, this suggests that the intuition that she used to select her partner on the marriage market plays a significant part in determining the actual level of cooperation in her couple.

Additional findings from these estimations are that (i) cooperation is endogenous in the wife's equation as the residuals from the first-stage regression are significant (see Nakamura and Nakamura [1981]), and (ii) the residuals of the second-stage equations of HIV-infection are highly and significantly correlated between wife and husband, as the correlation coefficient is around 0.8 in every specification.

VI. ROBUSTNESS CHECKS

VI. A. Other measures of education- Education match and mismatch

As a robustness check, we test Hypothesis 2 in Table VI by replicating Model 4 in Table V above using alternative measures of education in Panel A. The relationship between the risk of infection and the number of years of schooling is positive and concave for both men and women in Model 1. Both their own level of education and that of their spouse are significantly related to HIV risk, without affecting the size and significance of the estimated effects of cooperation. The positive impact of education confirms that it does not protect people against infection in our context. Models 2-4 consider educational matching. Model 2 controls for the couple having the same level of education (homogamy) using as omitted

category the fact that the couple does not have the same level, meaning that we do not consider whether the wife is more educated that her husband or the opposite. Model 3 makes this distinction explicit by controlling for the union being homogamous or hypergamy, the omitted category being the case where the wife is more educated than her husband. In both models, the benchmark results hold, and the size of the effect of cooperation does not vary. Lastly in Model 4, to fit closer the theoretical framework a dummy for both partners being educated (having attended at least college) is used. The results are robust to this specification. The effect of education is non-significant in determining HIV-infection for husbands, while it is significant at 10% for wives.

In Panel B, we evaluate whether the effect of cooperation on individual risk of infection is sensitive to the level of education by including an interaction term between the score of cooperation and the educational pairing variable. The effect of cooperation is not significantly different between homogamous and non-homogamous couples (interaction term not significant in columns 3 and 4). When Model 3 makes the distinction between the wife having a greater or a lower level of education than that of her husband, we found that the effect of cooperation does not vary according to the educational pairing for husbands (see column 6). From the female perspective, cooperation does significantly protect them, if they are more educated than their husband (omitted category in column 5), while it does it even more so if they have the same level of education as their husband, a prediction that can be read off figure 2. Lastly, the effect of cooperation on the wife's risk of infection is significant and equally negative whether both partners had attended college, or not. For husbands, cooperation significantly reduces their risk of infection only if both partners had attended college (column 8).

VI. B. Other measures of empowerment and the specific roles of cooperation, freedom and agency

Replicating Model 4 in Table V and changing the indicators of wife's position in her partnership provides the results shown in Table VII. Using the percentage of decisions jointly made in Row A1 shows that cooperation significantly reduces the risk of infection for both wives and husbands. Row A2 considers the percentage of decisions that are made by the husband only. This indicator has no significant effect on the risk of infection for both partners, suggesting that from the woman's perspective, living in a couple where the husband has full control over the decisions does not make her more vulnerable to HIV-infection. Panel B considers the role of trust or freedom instead of cooperation using a specific set of five questions summarized in an index. The survey questions related to relative freedom or spousal control are part of the violence module. The proportion of married women who declared that their husband restricts somehow their freedom of moving and is not confident about her is summarized in Appendix Table A2. Describing the data with the initial framing of the questions: over the three countries, half of women (55%) reported that their husband was jealous or angry if she talked to other men. 54% declared that their husband insisted on knowing where she was at any time. 28% reported to be frequently accused of being unfaithful. Women are also asked whether their husband tries to limit her contact with her friends and family:15 and 10% respectively declared Yes. Before creating the index, answers have been recoded so that the value one means freedom and zero limited freedom. Row B1 uses the percentage of answers in favor of freedom over the five possible items, and row B2 uses a score drawn from a principal component analysis. Both indicators of relative freedom and trust suggest that in couples where the degree of trust perceived by the wife is greater, husbands and wives are less likely to be HIV-infected compared to couples where the degree of trust is low, and significantly so. Panel C turns to refusal of marital violence. Using the survey questions

detailed earlier, we use either the percentage of domains for which the woman reports that marital violence is not justified over the five domains (row C1), or the score drawn from a principal component analysis (row C2). For any measure, our results suggest that the likelihood of refusing marital violence does not significantly influences HIV-risk. Lastly row D1 estimates the effect of a composite index that integrates all three dimensions (freedom, decision making participation, refusal of marital violence) drawn from a principal component analysis. Results suggest that as soon as the score increases, the HIV risk of both partners significantly decreases.

VI. C. Mechanisms

So far, the findings suggest that wives and husbands' risks of HIV-infection are a function of the level of cooperation measured by participation in households' decision making, controlling for education or educational pairing. Table VIII explores to which extent these effects could be explained by variation in husband's attitudes toward HIV risk. As part of survey questionnaire, men are asked about their sexual behaviors. Our behavioral analysis considers whether the husband reports having paid for sex over the last 12 months (col. 1), the number of sexual partners excluding the wife or live-in partner (over the last 12 months, col. 2), whether this latter number is strictly positive (col. 3). Additional survey questions concern the last three intercourses. For any of the three last intercourses, men are asked the type of partner and whether a condom was used. We use this information to generate a dummy variable being equal to one if at least one of the last three intercourses was with someone else than the spouse or live-in partner, and zero otherwise (col. 4), and a dummy variable equal to one if at least one of the last three partners was not the spouse or live-in partner and no condom was used during that (or those) intercourse(s) (col. 5). The respective role of cooperation, freedom and women' agency is investigated in separate regressions. Using the composite score encompassing all the three dimensions (cooperation, freedom or agency), it

is found to have negative impacts on husband's willingness to have paid sex, extra-marital partners (col. 3-4) and risky sex in Panel 1. Decomposing the dimensions suggest that freedom and trust, and cooperation are the dimensions that drive most of the composite relationship. Refusal of marital violence is marginally significant, and our findings suggest that refusing marital violence tends to increase the number of extramarital partners one's spouse has over the last 12 months. The proportion of decisions made independently by one's husband also increases the probability of having at least one extramarital partner.

VII. CONCLUSION

This paper has explored the determinants of HIV infection through the lenses of a theoretical framework focusing on cooperation within the couple rather than the more common empowerment-based approach. Our framework rests on two main assumptions, namely that (i) education is affecting individual preferences by increasing the spread of individual characteristics without affecting significantly their mean; and (ii) the marriage market is assorting people with similar characteristics regarding both their income or education levels and their personal propensity to cooperate. Assumption (i) can be viewed as a special case of Akerlof's "Loyalty Filters" theory (Akerlof, 1983). This framework thus predicts that, although it plays a key part in shaping their behavior, education as such is not protecting people from the HIV epidemics, while couples with a shared enhanced propensity to cooperate are less exposed than the others. These predictions have been tested using DHS data from Southern Africa (Malawi, Zambia and Zimbabwe), and not rejected. These findings have some implications for the role of education in the fight against the HIV epidemics. Although our findings unambiguously reject the idea that education per se is offering some significant protection to the women who have it, it may have instead a positive role to play at a more systemic level. First, our findings suggest that increasing women's education would be a simple mechanism to improve the matching performed by the marriage market, as it would bring the supply of

educated women closer to that of educated men, thus reducing the incidence of mismatches. Second, the content of education might also be re-directed away from the current focus on knowledge as an asset in the competition for good jobs in favor of its potential for enhancing the community's welfare via enhanced cooperation.

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APPENDIX A: DATA DESCRIPTION - SAMPLING

The Demographic and Health Surveys collected in Malawi, Zambia and Zimbabwe are used in the present analysis. The choice of countries is based on the data availability and homogenous context in southern Africa.

The Demographic and Health Surveys are representative household surveys collected in developing countries since the mid-1980s. The surveys collected information on health outcomes essentially. The questionnaires and sampling design are standardized in such a way that the data collected in the three countries is comparable.

The DHS primary sample is defined in two steps. First, the enumeration areas are selected. Second, in each enumeration area, sampled households are selected based on a list of households completed in the context of the DHS. In the sampled households, all women aged 15-49 who were either permanent residents of the households or visitors present in the households on the night before the survey are eligible for interviews. For men, the eligibility and the sample are survey-specific. In Zambia and Zimbabwe, all men who are were either permanent residents or visitors present in the households on the night before the survey are eligible for interviews, and the age range is 15-59 in Zambia, and aged 15-54 in Zimbabwe. In Malawi a fraction of one-third of households is randomly selected to male interview and in this subsample of households, all men aged 15-54 were eligible for interview. In Zambia and Zimbabwe, all women and men who were eligible for interviews were asked if they would voluntarily give a finger prick blood sample to test for HIV. In Malawi, both men and women living in the households randomly selected for the male survey are asked to give a blood sample to be tested for HIV.

Table A1: Sample size
Number of women and couples in the final analytical sample

	All	Malawi 2015	Zambia 2013	Zimbabwe 2015
1. Married women	31,616	15,952	9,649	6,015
2. (1) in households selected for HIV testing	21,075	5,411	9,649	6,015
3. (2) who consent for HIV test	19,952	5,231	9,112	5,609
4. (3) with non-missing HIV status	19,613	5,057	9,101	5,455
5. (4) whose husband resides with them	16,894	4,278	8,443	4,173
6. (5) whose husband has been interviewed	13,665	3,575	6,868	3,222
7. (6) whose husband has non-missing HIV data	12,727	3,235	6,522	2,97
8. (7) and selected for module on violence	11,019	2,920	5,553	2,546
9. (8) and answered the module on violence	10,949	2,870	5,536	2,543

Source: Authors' calculations from the Demographic and Health Surveys.

Table A1 shows the sample sizes based on the successive restrictions and the final analytical sample. The full sample is composed of 31,616 women who declared being married or living with their partner. In Malawi, not all households are selected for blood sample, only one-third. Withdrawing the women living in households not selected for HIV testing, it remains 21,075 married women. Most of them give their consent for HIV testing, only 5% refuse. Among the sample of 19,952 married women who accept, 19,613 have a non-missing HIV status. We can match this sample with husband's information as soon as the husband is living in the same household as the wife, otherwise he cannot be sampled. 13,665 women are matched with their husband who has been interviewed and for 12,727 of them we observe the HIV status of the husband. Lastly, the questions about trust are used. The module on violence where questions about relative freedom and trust are asked has been administered to a randomly-defined subsample of women. Among the sample satisfying the above restrictions, 11,019 were randomly selected and 10,949 women have answered this module, the difference being mostly because privacy was not possible to obtain. Our analytical sample is made of married and live-in partners who both have been tested for HIV as part of the survey and whose wife has asked the module on violence (row 9).

APPENDIX B: DATA DESCRIPTION - MEASURES OF EMPOWERMENT, TRUST AND COOPERATION

In the questionnaire, women are asked a set of questions about the decision-making process in her household, about her relationship with her husband and about her views about marital violence in general. The way these questions are formulated is described below.

Questions about decision making:

"Who usually makes decisions..."

- "About health care of yourself?"
- "About making major household purchases?"
- "About visits to your family or relatives?"

Questions about relative freedom: "Please tell me if these [statements] apply to your relationship with your husband"

- "He is jealous or angry if you talk to other men"
- "He frequently accuses you of being unfaithful"
- "He does not permit you to meet your female friends"
- "He tries to limit your contact with your family"
- "He insists on knowing where you are at all times"

Questions about acceptance of marital violence: "In your opinion, is a husband justified in hitting or beating his wife in the following situations":

- "If she goes out without telling him"
- "If she neglects the children"
- "If she argues with him"
- "If she refuses to have sex with him"
- "If she burns the food"

Table B1: Descriptive statistics of women's empowerment
Full decomposition

	Full sample	Malawi	Zambia	Zimbabwe
Panel A: Decision making				
Decisions about large household purchases				
Wife alone	0.13	0.06	0.10	0.25
joint decision	0.56	0.53	0.55	0.63
Husband alone	0.31	0.40	0.35	0.12
Decisions about the wife's health care				
Wife alone	0.26	0.15	0.29	0.31
joint decision	0.49	0.53	0.45	0.55
Husband alone	0.25	0.31	0.27	0.15
Decisions about visiting family or relatives				
Wife alone	0.18	0.13	0.18	0.23
joint decision	0.61	0.66	0.57	0.64
Husband alone	0.21	0.21	0.25	0.13
Panel B: Refusal of marital violence				
if she goes out	0.75	0.93	0.64	0.78
if she neglects children	0.74	0.92	0.62	0.80
if she argues with him	0.74	0.93	0.59	0.84
if she refuses sex	0.76	0.92	0.64	0.86
if she burns food	0.82	0.95	0.71	0.93
Refuses all 5 motives	0.61	0.85	0.47	0.64
Panel C: Freedom				
If she replies "No" to:				
"He is jealous or angry if you talk to other men"	0.45	0.53	0.37	0.51
"He frequently accuses you of being unfaithful"	0.72	0.79	0.66	0.78
"He does not permit you to meet your female friends"	0.85	0.89	0.82	0.86
"He tries to limit your contact with your family"	0.90	0.91	0.89	0.89
"He insists on knowing where you are at all times"	0.46	0.42	0.46	0.50
Panel D: Other				
Currently working	0.57	0.67	0.58	0.42
Earns more than her husband (if working)	0.34	0.36	0.34	0.34
Observations	10949	2870	5536	2543

Source: Authors' calculations from the Demographic and Health Surveys.
Notes: Statistics based on the analytical sample. No weights.

Table B2: Descriptive statistics
Scores of women's empowerment, cooperation

	Full sample	Malawi	Zambia	Zimbabwe
Score of the three dimensions (pca)	-0.09	0.84	-0.78	0.32
Score of cooperation (pca)	0.07	0.32	-0.02	-0.01
Perc. decisions jointly made	0.56	0.58	0.52	0.61
Perc. decisions made by husband alone	0.26	0.31	0.29	0.13
Score of freedom (pca)	-0.07	0.13	-0.25	0.09
Score of freedom (percent)	0.68	0.71	0.64	0.71
Score of violence refusal (pca)	-0.10	0.81	-0.77	0.32
Score of violence refusal (percent)	0.76	0.93	0.64	0.84

Source: Authors' calculations from the Demographic and Health Surveys.
Notes: Statistics based on the analytical sample. No weights.

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TABLES

Table I: Proportion of HIV-positive women by group and Test of differences

		(1) Yes	(2) No	(3) Difference
A. Currently working	Prop.	0.11	0.13	0.02**
	N	6,629	4,700	
B. Wife earnings >= husband's	Prop.	0.15	0.14	-0.014
	N	1,225	2,335	
C. Refuses all motives for marital violence	Prop.	0.13	0.11	-0.022***
	N	6,681	4,259	
D. Makes alone the decision about:				
Large household purchases	Prop.	0.18	0.11	-0.072***
	N	1,366	9,554	
Her own health care	Prop.	0.15	0.11	-0.034***
	N	2,793	8,096	
Visiting family members	0.16	0.11	-0.044**	
	N	1,951	8,954	

Source: Authors' calculations from the Demographic and Health Surveys.
Notes: Statistics based on the analytical sample. No weights. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table II: Cooperation and educational level

	CG + wife			CG + husband			Both CG +		
	Yes (1)	No (2)	Difference (3)	Yes (4)	No (5)	Difference (6)	Yes (7)	No (8)	Difference (9)
Perc. of joint decisions	0.62	0.52	-0.098***	0.60	0.52	-0.081***	0.63	0.52	-0.111***
PCA score of cooperation	0.15	0.02	-0.126***	0.13	0.01	-0.125***	0.20	0.01	-0.183***
N	4,024	6,805	10,829	5,408	5,423	10,831	3,255	7,571	10,826

Source: Authors' calculations from the Demographic and Health Surveys.
Notes: Statistics based on the analytical sample. No weights. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The variables refers to the proportion of decisions that partners jointly take (row 1), and to the score computed from a principal component analysis using the three domains of decision making (large household purchases, own health care, visiting family and relatives) (row 2).

Table III: Descriptive statistics

	Full sample	Malawi	Zambia	Zimbabwe
Panel A: HIV-infection				
Wife infected	0.12	0.09	0.12	0.16
Husband infected	0.13	0.09	0.14	0.17
Panel B: Instrumental variables				
Father-to-mother violence	0.37	0.30	0.40	0.40
Rank of birth	3.58	3.50	3.70	3.42
Prop. siblings dead before 5 y.o.	0.06	0.07	0.05	0.04
Panel C: Educational attainment at the individual level				
Wife				
No education	0.09	0.12	0.11	0.01
Primary education	0.54	0.66	0.59	0.29
Secondary education	0.34	0.20	0.27	0.64
Higher level of educ.	0.03	0.02	0.03	0.06
Number of years of education	6.59	5.67	5.90	9.10
Husband				
No education	0.05	0.08	0.05	0.01
Primary education	0.45	0.59	0.48	0.23
Secondary education	0.42	0.29	0.39	0.64
Higher level of educ.	0.08	0.04	0.07	0.12
Number of years of education	7.83	6.87	7.44	9.76
Panel D: Other controls				
Wife's characteristics				
Age	30.00	29.10	30.33	30.29
Age, squared	960.46	906.28	981.92	974.88
Catholic	0.14	0.17	0.17	0.05
Protestant	0.81	0.73	0.81	0.87
Other religion	0.02	0.00	0.01	0.07
Husband's characteristics				
Age	35.57	34.14	36.16	35.88
Age, squared	1337.36	1237.07	1383.07	1351.04
Catholic	0.16	0.18	0.19	0.07
Protestant	0.73	0.68	0.79	0.66
Other religion	0.08	0.03	0.01	0.26
Household's characteristics				
Urban	0.32	0.17	0.37	0.37
Poorest	0.20	0.18	0.21	0.19
Poorer	0.22	0.22	0.24	0.18
Intermediate wealth category	0.21	0.21	0.23	0.16
Richer	0.21	0.20	0.20	0.26
Observations	10949	2870	5536	2543

Source: Authors' calculations from the Demographic and Health Surveys.
Notes: Statistics based on the analytical sample. No weights.

Table IV: First-stage estimations (OLS models)
*Dependent variable*s: PCA score of cooperation

	(1)	(2)	(3)	(4)	(5)
Father ever beats mother	-0.110***			-0.102***	-0.103***
	(0.034)			(0.035)	(0.035)
Rank of birth		-0.002		0.005	
		(0.007)		(0.007)	
Perc. siblings dead before 5 y.o			-0.265**	-0.274**	-0.271**
			(0.123)	(0.129)	(0.129)
N	9,937	10,453	10,444	9,638	9,638
Other control variables	Yes	Yes	Yes	Yes	Yes
F of excluded instruments	10.2	0.08	4.65	4.67	6.68
Prob> F	0.0014	0.77	0.0312	0.003	0.0013

Source: Authors' calculations from the Demographic and Health Surveys.
Notes: The measure of cooperation is the score computed from a principal component analysis using the three domains of decision making (large household purchases, own health care, visiting family and relatives). Controls are urban residence, wealth categories, wife's age in level and in square, and husband's age in level and in square, wife's religion, husband's religion, wife's education, husband's education and regional dummies. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors clustered at the enumeration area level are in parentheses.

Table V: Second-stage estimations (biprobit models)

	Model 1		Model 2		Model 3		Model 4	
	HIV_F	HIV_M	HIV_F	HIV_M	HIV_F	HIV_M	HIV_F	HIV_M
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
score of cooperation	-0.036***	-0.027***			-0.037***	-0.028***	-0.657***	-0.029***
	[0.010]	[0.010]			[0.010]	[0.010]	[0.236]	[0.010]
residuals cooperation							0.617***	
							[0.236]	
Her education								
(ref=no educ)								
Primary			0.037	0.092	0.033	0.085	0.025	0.074
			[0.061]	[0.060]	[0.062]	[0.060]	[0.067]	[0.064]
Secondary or higher			0.067	0.106	0.065	0.103	0.152*	0.097
			[0.071]	[0.069]	[0.071]	[0.070]	[0.078]	[0.074]
His education								
(ref=no educ)								
Primary			-0.055	-0.062	-0.043	-0.072	-0.060	-0.069
			[0.080]	[0.081]	[0.082]	[0.081]	[0.084]	[0.084]
Secondary or higher			0.044	0.024	0.051	0.012	0.131	0.019
			[0.086]	[0.085]	[0.087]	[0.085]	[0.095]	[0.089]
score, instrumented	No	No	Na	Na	No	No	Yes	No
Rho	0.806		0.803		0.804		0.807	
Wald test of $\rho = 0$	1338.9		1357.7		1338.4		1240.7	
N	10,795		10,902		10,787		9,937	

Source: Authors' calculations from the Demographic and Health Surveys.

Notes: HIV_F and HIV_M are the HIV status of wives and husbands respectively. The measure of empowerment is the score computed from a principal component analysis using the three domains of decision making (large household purchases, own health care, visiting family and relatives). Other controls are urban residence, wealth categories, wife's age in level and in square, and husband's age in level and in square, wife's religion, husband's religion and regional dummies. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors clustered at the enumeration area level are in parentheses.

Table VI: Second-stage estimations (biprobit models)
Robustness to education measures

	Model 1		Model 2		Model 3		Model 4	
	HIV_F	HIV_M	HIV_F	HIV_M	HIV_F	HIV_M	HIV_F	HIV_M
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: No interaction								
score of cooperation	-0.569**	-0.028***	-0.686***	-0.028***	-0.681***	-0.028***	-0.571**	-0.028***
	[0.251]	[0.010]	[0.226]	[0.010]	[0.227]	[0.010]	[0.237]	[0.010]
residuals cooperation	0.530**		0.649***		0.643***		0.533**	
	[0.251]		[0.226]		[0.227]		[0.237]	
Her education:								
Years	0.055***	0.044***						
	[0.016]	[0.015]						
Years, squared	-0.003**	-0.003***						
	[0.001]	[0.001]						
His education								
Years	0.030*	0.032**						
	[0.017]	[0.016]						
Years, squared	-0.001	-0.002*						
	[0.001]	[0.001]						
Educational pairing:								
Hypergamy					-0.020	-0.021		
					[0.061]	[0.058]		
Homogamy			-0.139***	-0.076**	-0.154***	-0.091		
			[0.033]	[0.032]	[0.057]	[0.056]		
Both college or more							0.131*	-0.006
							[0.073]	[0.046]
N	9934		9937		9937		9937	9934
Panel B: with interaction terms								
score of cooperation			-0.671***	-0.019	-0.630***	-0.004	-0.563**	-0.013
			[0.225]	[0.015]	[0.227]	[0.029]	[0.237]	[0.012]
residuals cooperation			0.646***		0.637***		0.535**	
			[0.226]		[0.226]		[0.237]	
Homogamy			-0.139***	-0.076**	-0.159***	-0.094*		
			[0.033]	[0.032]	[0.057]	[0.056]		
score * homogamy			-0.023	-0.015	-0.055*	-0.031		
			[0.021]	[0.019]	[0.032]	[0.031]		
Hypergamy					-0.026	-0.024		
					[0.061]	[0.058]		
score * hypergamy					-0.044	-0.022		
					[0.035]	[0.033]		
Both college or more							0.133*	-0.005
							[0.073]	[0.046]
score *								
Both college or more							-0.027	-0.042**
							[0.022]	[0.021]
N			9937		9937		9937	

Source: Authors' calculations from the Demographic and Health Surveys.

Notes: HIV_F and HIV_M are the HIV status of wives and husbands respectively. The measure of empowerment is the score computed from a principal component analysis using the three domains of decision making (large household purchases, own health care, visiting family and relatives). Other controls are urban residence, wealth categories, regional dummies while wife's age in level and in square, wife's religion appear in the wife equation only, and husband's age in level and in square, husband's religion in the husband's equation only. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors clustered at the enumeration area level are in parentheses.

Table VI: Sensitivity analysis: Second-stage estimations using specific dimensions of empowerment (biprobit models)

	HIV_F (1)	HIV_M (2)
Panel A: decision making		
A1. perc. decisions jointly made	-2.230**	-0.106**
(N= 9,937)	[1.133]	[0.042]
A2. perc. decisions made by husband alone	-3.787	0.038
(N= 9,937)	[2.613]	[0.051]
Panel B: freedom, trust		
B1. score of freedom (percent)	-1.148**	-0.259***
(N= 9,932)	[0.460]	[0.056]
B2. score of freedom (pca)	-0.236***	-0.049***
(N= 9,932)	[0.089]	[0.010]
Panel C: refusal of violence		
C1. score of violence refusal (percent)	-0.474	0.048
(N= 9,890)	[0.479]	[0.057]
C2. score of violence refusal (pca)	-0.086	0.009
(N= 9,890)	[0.088]	[0.010]
Panel D: all three dimensions		
D1. score of the three dimensions (pca)	-0.120*	-0.018*
(N= 9,692)	[0.066]	[0.010]

Source: Authors' calculations from the Demographic and Health Surveys.
Notes: HIV_F and HIV_M are the HIV status of wives and husbands respectively. All estimations are biprobit models in which the score is assumed endogenous for wife and not for husband. Other controls are each spouse level of education (no education, primary), urban residence, wealth categories, regional dummies while wife's age in level and in square, wife's religion appear in the wife equation only, and husband's age in level and in square, husband's religion in the husband's equation only. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors clustered at the enumeration area level are in parentheses.

Table VIII: Exploring the mechanisms: husband's exposure to HIV risk

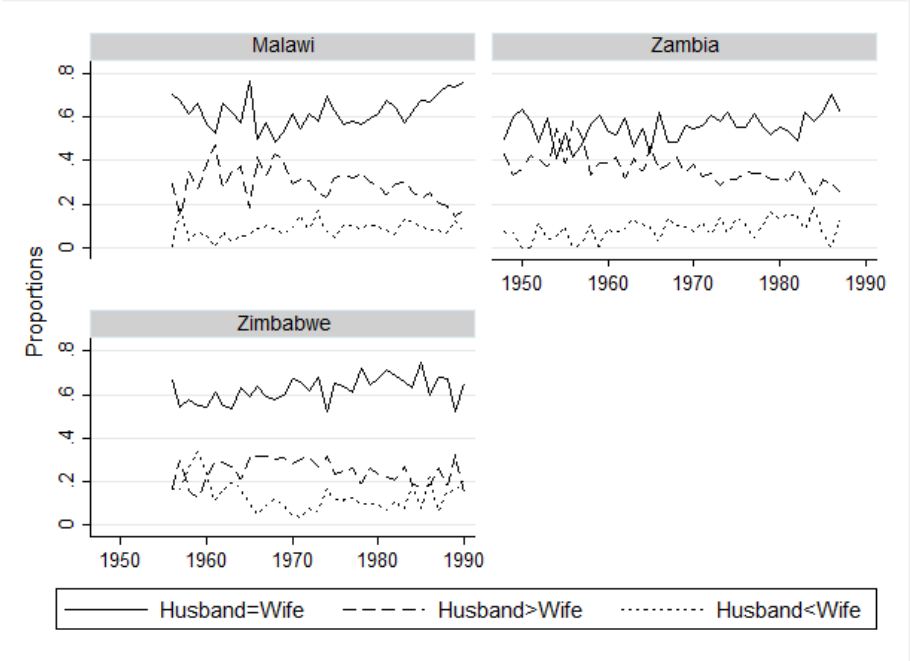
	1 if paid for sex, last 12 months (1)	Number of sexual partners, excluding wife, last 12 months (2)	1 if any other partner than the wife, in last 12 months (3)	1 if one of the last 3 intercourses was not with spouse (4)	1 if one of the last 3 intercourses was not with spouse and no condom was used (5)
1. score of the three dimensions (pca)	-0.0282**	-0.0011	-0.0272***	-0.0291***	-0.0311***
	[0.014]	[0.006]	[0.009]	[0.009]	[0.012]
N	10379	10514	10514	10515	10515
2. score of cooperation (pca)	-0.0129	-0.0207*	-0.0423***	-0.0432***	-0.0344**
	[0.015]	[0.011]	[0.010]	[0.010]	[0.014]
N	10668	10803	10803	10804	10804
3. perc. decisions jointly made	-0.0214	-0.0733*	-0.1611***	-0.1625***	-0.1208**
	[0.059]	[0.041]	[0.041]	[0.041]	[0.058]
N	10668	10803	10803	10804	10804
4. perc. decisions made by husband alone	-0.0423	0.0294	0.0800*	0.0752	0.0468
	[0.068]	[0.030]	[0.048]	[0.047]	[0.065]
N	10668	10803	10803	10804	10804
5. score of freedom (pca)	-0.0262*	-0.0182***	-0.0472***	-0.0479***	-0.0652***
	[0.015]	[0.006]	[0.010]	[0.010]	[0.014]
N	10656	10792	10792	10793	10793
6. score of freedom (percent)	-0.1524*	-0.0990***	-0.2693***	-0.2738***	-0.3703***
	[0.080]	[0.029]	[0.055]	[0.055]	[0.078]
N	10656	10792	10792	10793	10793
7. score of violence refusal (pca)	-0.0227	0.0114*	-0.0022	-0.0040	-0.0015
	[0.014]	[0.006]	[0.010]	[0.010]	[0.013]
N	10606	10742	10742	10743	10743
8. score of violence refusal (percent)	-0.1254	0.0619*	-0.0118	-0.0218	-0.0071
	[0.078]	[0.033]	[0.054]	[0.055]	[0.072]
N	10606	10742	10742	10743	10743

Source: Authors' calculations from the Demographic and Health Surveys.

Notes: Estimations of columns 1, 3, 4 and 5 are probit models and of column 2 is OLS model, in which the score is assumed endogenous for wife and not for husband. Other controls are each spouse level of education (no education, primary), urban residence, and wealth categories, regional dummies while wife's age in level and in square, wife's religion appear in the wife equation only, and husband's age in level and in square, husband's religion in the husband's equation only. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors clustered at the enumeration area level are in parentheses.

FIGURES

Figure 1: Educational attainment of spouses by husbands' year of birth



Source: Authors' calculations from the Demographic and Health Surveys.

Figure 2: Matching Outcome

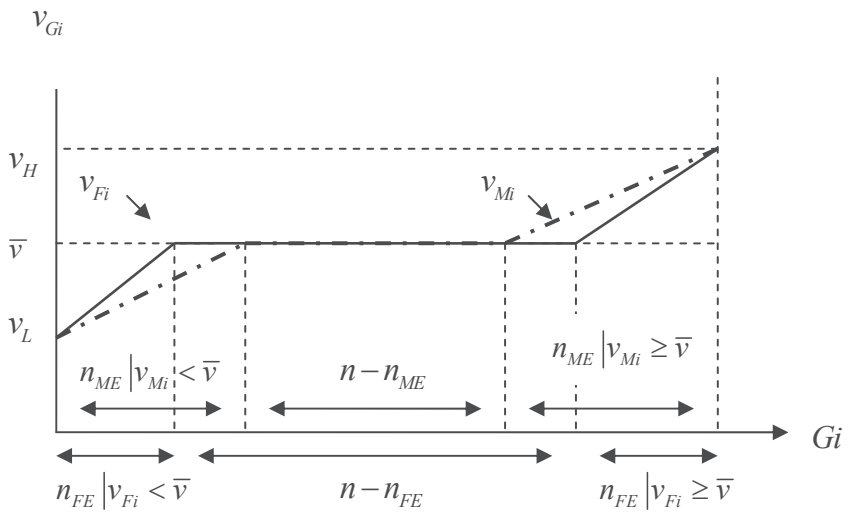
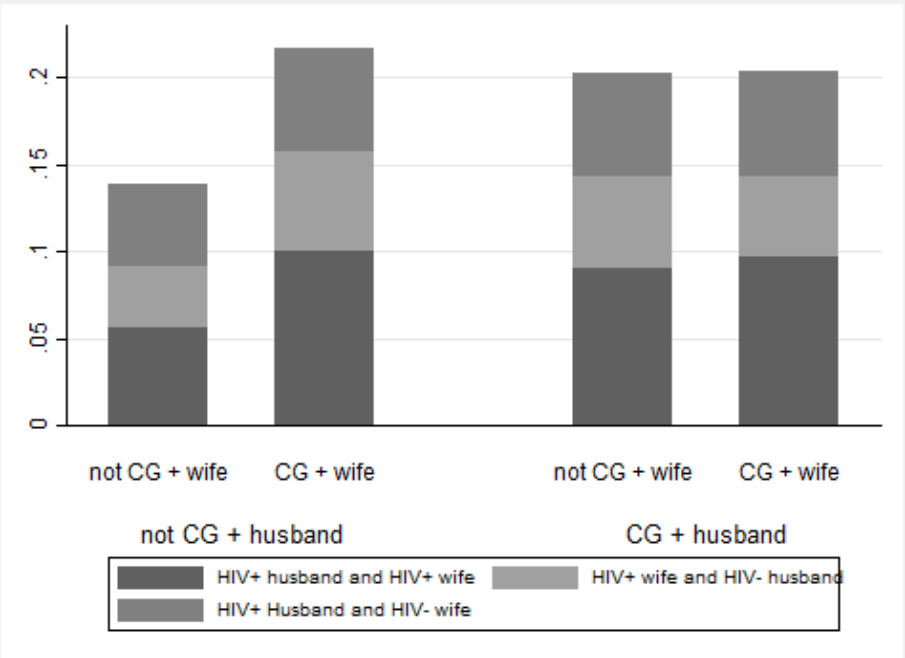


Figure 3: Couples' HIV risk by spousal education



Source: Authors' calculations from the Demographic and Health Surveys.
Notes: Statistics based on the analytical sample. No weights.