Compensated for Life

Sex Work and Disease Risk

Raj Arunachalam
Manisha Shah

ABSTRACT

Sex workers draw a premium for engaging in unprotected sex. We theoretically motivate a test of whether this premium represents a compensating differential for disease, thereby mitigating sex workers' propensity to use condoms. Using transaction-level data and biological STI markers from sex workers in Ecuador, we exploit within-worker variation across local disease environments. We find that locations with low disease prevalence exhibit a very low, insignificant premium for unprotected sex. A one percentage point increase in the local disease rate increases the premium for noncondom sex by 33 percent. Market forces may curb the self-limiting nature of STI epidemics.

I. Introduction

To a greater extent than other epidemics, the spread of sexually transmitted infections (STIs) is shaped by individuals' behavioral responses. With an increase in awareness of the risk of contracting disease, individuals substitute away from risky sex toward abstinence (Kremer 1996); toward protected sex (Ahituv, Hotz, and Philipson 1996; Dupas 2011); or away from sex with men toward sex with women (Francis 2008). Viewing risky sex much like other commodities in the market, economists anticipate that demand declines as the expected cost increases (Posner 1992). Hence, economists tend to see behavioral responses to STI prevalence as generating

*Raj Arunachalam is an assistant professor of economics and research affiliate of the Population Studies Center at the University of Michigan. Manisha Shah is an assistant professor of public policy at the University of California, Los Angeles and Faculty Research Fellow at the NBER.**The authors would like to thank Anne Case, Catherine de Fontenay, Taryn Dinkelman, David Lam, Jeff Smith, and two anonymous referees for detailed and extremely helpful comments on previous drafts; as well as numerous seminar audience members for valuable insights. Annalisa Leibold provided excellent research assistance. The data used in this article can be obtained beginning October 2013 through September 2016 from Manisha Shah, UCLA Department of Public Policy, 3250 Public Affairs Building, Los Angeles, CA 90095. Telephone: (310) 825-2455. email: ManishaShah@ucla.edu*
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a self-limiting incentive effect of epidemics (Geoffard and Philipson 1996; Philipson 2000).

Evidence from the commercial sex sector, however, suggests that market forces may dampen the self-limiting feature of STI epidemics. Sex workers draw a premium for engaging in risky unprotected sex. Gertler, Shah, and Bertozzi (2005) find that Mexican sex workers draw a risk premium of approximately 15 percent per transaction to engage in sex without a condom; using different empirical strategies, researchers have identified risky sex premia in a number of settings.[1] Interpreting the premium for unprotected sex as a compensating differential similar to that in other occupations (Rosen 1986; Viscusi 1992; Cousineau, Lacroix, and Girard 1992), economists have argued that market incentives may explain the persistence of unprotected sex, thereby restricting the efficacy of typical public health interventions that aim to increase sex workers' knowledge of disease risk and increase condom use.

However, existing research has been unable to identify the risky sex premium as a compensating differential, as opposed to being derived solely from clients' preference for unprotected sex. Indeed, at the core of the compensating differential hypothesis—and of most explanations of noncondom use in nonprocreative sex—is the notion that men bear disutility from condom use. Even if sex workers are unaware of or indifferent to disease risk, their ability to charge clients more based on client preferences for noncondom use will generate a market premium for unprotected sex. In this setting, the presence of a price premium for risky sex does not represent evidence of a compensating differential. As such, even small-scale informational or marketing campaigns targeted at sex workers may prove successful at increasing condom use (Pisani 2008).

Directly identifying the source of the risky sex premium from survey data is challenging partly because the proliferation of such campaigns to increase condom use have made it difficult to assess sex workers' true responsiveness to disease risk. When encountering public health workers or survey enumerators, sex workers may overstate their responsiveness by giving the "right" answer to health-related questions. In addition, data sets generally do not have biological measures of disease risk, so that analyses typically rely on self-reports, which may themselves be shaped by normative perceptions.

We tackle these problems by focusing not on subjective indicators but on variation in the risky sex premium itself. More precisely, we examine the responsiveness of the premium for unprotected sex to local STI prevalence obtained from biological tests. To fix ideas, we write a simple model that captures client disutility for condom use as well as supply and demand side price elasticities of disease, nesting the two competing accounts of the risky sex premium. The key prediction is that if comprised by a compensating differential, the premium for unprotected sex will itself increase with higher disease prevalence. Effectively, market forces draw sex workers into engaging in risky sex because the risk premium increases with disease. The model also demonstrates that a premium for risky sex may arise even in the absence of disease risk, capturing

1. Recent examples include studies of sex workers in India (Rao et al. 2003), Kenya (Robinson and Yeh 2011), Mexico (de la Torre et al. 2010), Nicaragua (Willman 2008), Congo (Ntumbanzondo et al. 2006), Canada (Johnston et al. 2010), and Belgium and the Netherlands (Adriaenssens and Hendrickx, forthcoming).

the idea that the existence of a premium for unprotected sex does not in itself indicate evidence of a compensating differential.

Empirically, we take the predictions of the model to a unique data set of commercial sex transactions collected from Ecuadoran sex workers. The data include detailed information including type of sex provided, condom use, price, and client characteristics. We link the transaction-level data to biological measures of STI status, generating a proxy for disease risk in a given type of location. We first estimate premia for various types of risky sex, and then examine the responsiveness of the premium for unprotected sex to the estimated STI risk of the type of location. Because each sex worker provides details of three transactions, we are able to employ panel data techniques to control for unobserved worker-specific heterogeneity, effectively comparing a given sex worker's transactions with and without condoms across locations with varying disease risk.

Our results suggest that a large component of the risky sex premium represents a compensating differential for disease risk. First, the premium for unprotected sex itself increases with the riskiness of the sex act. Turning to disease risk, we find that in locations with very low STI prevalence, the premium for unprotected (relative to safe) sex is small and statistically insignificant—less than one quarter that in the market as a whole. As predicted by the compensating differential hypothesis, the premium for unprotected sex increases with local disease prevalence. More precisely, a one percentage point increase in local STI prevalence is associated with a 33 percent increase in the price of an unprotected (relative to protected) vaginal sex transaction.

This finding is of interest for two reasons. First, that the compensating differential for risky sex increases with disease prevalence indicates that the market dampens the self-limiting feature of STI epidemics. As disease risk and thereby the expected cost of unprotected sex rises, the compensating differential rises as well, leaving the marginal sex worker indifferent between unprotected and protected sex. Second, our model predicts that a premium for risky sex that increases with prevalence indicates that the supply-side conditional price elasticity (with respect to disease prevalence) is sufficiently higher than the demand-side elasticity. That is, as clients' expected cost of contracting disease increases, their willingness-to-pay for risky sex (relative to safe sex) declines, but this decline is more than offset by the decline in sex workers' willingness-to-accept. This indicates that existing public health campaigns aimed at the commercial sex sector, which are currently almost universally targeted at providing sex workers with condoms or information about STI and HIV risk, may be less effective than campaigns that consider targeting clients as well.

Our paper sits at the intersection of the classical literature on compensating differentials for occupational risk and a relatively recent body of work on economic epidemiology. Particularly in the wake of HIV/AIDS, economists have dedicated considerable attention to behavioral responses to increases in risk of infection and to public health interventions. More recently, scholars and policymakers have widened focus to include nonfatal STI infections, in part due to their role in facilitating transmission of HIV (Galvin and Cohen 2004; Steen et al. 2009); Oster (2005) shows that nonfatal STIs may be the central determinant of high HIV transmission rates in Africa. Economists have studied behavioral responses to information campaigns and public health interventions (Kremer 1996; Geoffard and Philipson 1996; Gersovitz and

Hammer 2004; Auld 2003); public testing (Boozer and Philipson 2000; Philipson and Posner 1993, 1995); and criminal prosecution (Delavande, Goldman, and Sood 2010). Empirical work has confirmed that individuals are more likely to use condoms when local STI prevalence increases (Ahituv, Hotz, and Philipson 1996; Auld 2006). Conversely, some evidence shows that decreases in the expected cost of an STI epidemic (either by decreasing the probability of infection or the disutility associated with the disease) lead to increases in risky sexual behavior (Lakdawalla, Sood, and Goldman 2006; Mechoulan 2007). Finally, a growing body of research examines the responsiveness of sexual risk-taking to economic incentives (Luke 2006, 2008; Luke et al. 2011; Dinkelman, Lam, and Leibbrandt 2008; Kohler and Thornton 2012; Robinson and Yeh 2011; Dupas and Robinson, forthcoming; Baird, McIntosh, and Özler 2011).

II. Survey and Data

Scholarship on commercial sex work has largely been limited by the paucity of large-sample data and the difficulties of obtaining random samples, since prostitution is often illegal. Ecuador provides a promising setting for research—as in much of Latin America, sex work in Ecuador is legal and regulated for those older than 18. The data we use in this paper are unusually rich. Collected in 2003 in a baseline survey as part of the Frontiers Prevention Project, approximately 2,800 female sex workers were interviewed in eight cities (Quito, Guayaquil, Machala, Esmeraldas, Santo Domingo, Quevedo, Milagro, and Daule). In each city, the universe was first mapped to develop a sample frame. Potential worksites were identified in interviews with key informants (for example, sex workers, madams, bar owners, workers at nongovernmental organizations, medical personnel, taxi drivers, police). Surveys were conducted both at worksites and at meeting places. Drawing from research on collection of sensitive information suggesting that data quality improves when respondents are matched with peers (Ozer et al. 1997), sex workers were hired and trained as survey enumerators. Sex workers' participation in the project probably contributed to high survey response rates (more than 95 percent). While every attempt was made to maximize representativeness of the sex worker population, the mapping likely omits some sex workers, such as women who occasionally sell sex from home. Because formal sites of sex work (brothels and areas reputed as sex work locales) are probably overrepresented, the sample is likely biased toward sex workers with a large number of clients.

The survey includes detailed demographic characteristics, indicators of risk behavior, and labor supply information. Particularly valuable for our purposes, the survey includes retrospective details of each sex worker's previous three transactions, yielding approximately 8,500 observations at the transaction level. Because most respondents have more than three transactions per week, the retrospective data are typically less than a week old, and we are able to construct a transaction-level panel without attrition. For each transaction, we have information about the nature of the sex act, condom use, price, type of location, and the worker's subjective assessments of client characteristics.

In addition to the questionnaire, biologicals (urine and blood) were collected from each sex worker and tested for various STIs. To our knowledge, the Frontiers Prevention Project are the only large-sample sex worker data to include both demographic information as well as biological samples. With this direct measure of STI status, we circumvent problems of systematic measurement error in self-reports of health status (Lokshin and Ravallion 2008). We code a sex worker as having an STI if she tests positive for chlamydia and/or gonorrhea. Because our question of interest is how the sex market responds to the *current* disease environment they currently face, we do not consider more long-term STIs such as herpes simplex, which is cumulative (once infected, the individual always tests positive). In addition, both chlamydia and gonorrhea are generally unobservable by clients and even often to individuals themselves in the absence of a medical diagnosis. This fact allows us to focus attention on a sex worker's responsiveness to the risk faced in the local disease environment, although we do explore the effect of a sex worker's own disease status below.

Sex workers around the world tend to be younger, less educated, and better paid than female workers in the general population (Ahlburg and Jensen 1998; Edlund and Korn 2002; Lim 1998). This pattern holds in our sample (Arunachalam and Shah 2008). The summary statistics in Table 1 indicate that sex workers have completed approximately seven years of education and their mean age is 27. Almost 50 percent are married or in civil union partnerships and over 80 percent have children. Interestingly, the demographic composition of these Ecuadoran sex workers is very similar to that of sex workers in Mexico (Gertler, Shah, and Bertozzi 2005) and Kenya (Robinson and Yeh 2011).

Table 1 gives descriptive statistics broken down by categories of self-reported condom use in the sex worker's last three transactions. Column 1 includes sex workers who did not use a condom in any of their last three transactions; Column 2 describes sex workers who sometimes used condoms in their last three transactions; and Column 3 corresponds to sex workers who used condoms in all three of their last transactions. Reported condom use is relatively high in Ecuador compared to sex workers elsewhere. Eighty-two percent of sex workers reported condom use in all of their last three transactions. These rates are similar to Mexico (where sex work is also legalized and partly regulated) (Gertler, Shah, and Bertozzi 2005) but more frequent than sex worker populations in India (Rao et al. 2003), Kenya (Robinson and Yeh 2011), and Chicago (Levitt and Venkatesh 2007). While our empirical strategy depends on self-reported condom usage, we are able to verify whether the sex workers possessed condoms at the time of the survey. Sixty percent of respondents reported having at least one condom available with her at the time of the interview; the enumerator was able to verify this claim in 97 percent of cases. This rate of condom possession is roughly twice that observed among street prostitutes in Los Angeles (Lillard 1998). Only a quarter of sex workers who reported no condom use within the last three transactions possessed condoms at the time of the interview, while for the other categories this fraction is more than 60 percent. Respondents also reported the number of condoms available (the Pearson correlation with the enumerator's own observation is 0.98); also, as we might expect, this number is larger for women who sometimes used and always used condoms in the previous three transactions.

Average transaction price is approximately 7US$, and (prior to controlling for characteristics) does not vary by condom use category. Sex workers set their own transaction prices in negotiation with potential clients. Unlike many settings in which sex work is illegal, sex workers in Ecuador typically do not have their prices set by pimps.

Table 1
Summary Statistics—Sex Workers by Condom Use

In last 3 transactions:	Never used condom (1)	Used condom 1–2 times (2)	Used condom 3 times (3)
Age	30.7	31.6	27.2
	(0.59)	(0.64)	(0.15)
Education (years)	6.2	6.8	7.6
	(0.20)	(0.25)	(0.07)
Married/civil union (=1)	0.50	0.44	0.48
Has children (=1)	0.87	0.91	0.86
STI knowledge[a] (=1)	0.45	0.55	0.74
Has condoms (=1)	0.26	0.60	0.64
Number condoms[b]	6.7	11.1	12.4
	(0.83)	(1.6)	(0.41)
STI (=1)	0.07	0.03	0.05
Average price (US$)	7.1	6.9	7.2
	(0.54)	(0.66)	(0.15)
Clients last week	12.3	15.0	23.5
	(0.91)	(1.19)	(0.65)
Works in brothel[c] (=1)	0.49	0.54	0.64
Works in nightclub[c] (=1)	0.13	0.13	0.22
Works in street[c] (=1)	0.06	0.04	0.02
Works in other[c,d] (=1)	0.39	0.40	0.16
Sample Size	288	228	2,317

Notes: Observations are by sex worker. Standard errors for continuous variables are given in parentheses. The categories are defined based on condom use in the respondent's last three transactions.
a. "STI knowledge" is coded as a 1 if the sex worker answers "higher" to the question: "If someone has a sexually transmitted infection, is there a higher or lower probability that they will contract HIV/AIDS?" where the other options are "same"; "lower"; "don't know."
b. "Number condoms" is calculated only for sex workers who responded yes to "has condoms."
c. The fraction of women in each work category does not sum to 1 as some sex workers worked in more than one location.
d. "Works in other" indicates that the sex worker's worksite is a massage parlor, hotel, truck stop, or her home.

Finally, Table 1 shows that STI prevalence (a positive test result for chlamydia and/or gonorrhea) is lower among sex workers who report having used a condom in the previous three transactions. STI prevalence is 7 percent amongst those who never used in their last three transaction, 3 percent amongst sometimes users, and 5 percent for those who used in all three transactions.

Transaction characteristics are described in detail in Table 2. The presentation anticipates our empirical design, which exploits variation in worksite and services provided. In Columns 1–4 transactions are disaggregated by worksite: brothel, nightclub, street, or "other" (which includes massage parlors, hotels, truck stops, or the sex

Table 2
Summary Statistics—Transactions by Location

	Brothel (1)	Nightclub (2)	Street (3)	Other[a] (4)	Switched location[b] (5)
Transaction price (US$)	5.5	10.8	5.6	7.7	13.5
	(0.06)	(0.33)	(0.51)	(0.20)	(0.96)
No condom use (=1)	0.09	0.06	0.36	0.24	0.19
Local STI rate	0.06	0.06	0.16	0.02	0.04
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Regular client (=1)	0.50	0.34	0.58	0.64	0.43
Clean client (=1)	0.88	0.90	0.89	0.90	0.89
Handsome client (=1)	0.12	0.14	0.08	0.11	0.18
Rich client (=1)	0.06	0.14	0.05	0.06	0.14
Foreign client (=1)	0.04	0.05	0.06	0.04	0.07
Risky client[c] (=1)	0.02	0.01	0	0.01	0.03
Vaginal sex (=1)	0.99	0.98	0.99	0.97	0.90
Anal sex (=1)	0.02	0.02	0.03	0.03	0.05
Oral sex (=1)	0.07	0.08	0.05	0.09	0.14
Nonsex services[d] (=1)	0.00	0.01	0	0.01	0.04
Sample size	5,056	1,533	132	1,499	391

Notes: Observations are by sex transaction. Standard errors for continuous variables are given in parentheses.
a. “Other” location indicates that the transaction took place in a massage parlor, hotel, truck stop, or the sex worker’s home.
b. “Switched location” refers to sex workers who worked in more than one location during their last three transactions.
c. “Risky client” is coded as 1 if the sex worker responds “very likely” to the question: “Relative to the average client, how likely was this client to have HIV/AIDS?” where the other options are “same as average”; “unlikely”; “not a chance.”
d. “Nonsex services” include massage, stripping, talking, or masturbation.

worker’s home). Approximately 5 percent of transactions were provided by women who switched locations across these four sites in the last three transactions. We report their characteristics in Column 5 of Table 2. While the proportion of women who switch locations is fairly small, our understanding from multiple focus group interviews and discussions with experts on the commercial sex market in Ecuador indicate that the majority of sex workers are not tied to a particular place of employment and freely work in multiple locations. Although we capture only the last three transactions for each sex worker, with a longer retrospective history we would likely characterize the majority of women as switching locations. Vaginal sex is almost always provided as a service, and in some cases, anal, oral and nonsexual services (massage, stripping, talking, or masturbation) also are provided.

Table 2 includes transaction-level reports by the sex workers about client characteristics. Sex workers were asked to describe their last three clients’ cleanliness, wealth, appearance, and country of origin. Sex workers described most of their clients as “clean.” Only 5 percent were described as foreign. Respondents were also asked whether a given transaction was with a “regular” client; about half of transactions involved regular clients, except in nightclubs where about a third of transactions were with regulars. Nightclub clients also are more likely to be reported as wealthy and attractive. In general, clients seem fairly similar across the various location types.

Sex workers were also asked to record their subjective perceptions of individual clients’ STI status. In Table 2, a client in a given transaction is coded as “risky” if the sex worker thought he had a higher than average likelihood of being HIV positive. Only 1–2 percent of transactions involved risky clients, with little variation across locations. Given that adult HIV prevalence in Ecuador is 0.3 percent (UNAIDS/WHO 2008) and sex worker HIV prevalence is estimated to lie somewhere between 1–2 percent, sex workers’ estimates of client riskiness appear to be relatively close to actual epidemiological estimates.

A. Local STI Rate

To address the central research question, we construct a measure of STI prevalence that captures the risk that a sex worker faces in each transaction. Ideally, we would observe clients’ STI status, but we are aware of no data set that contains such information, likely because clients rarely wish to be identified. To circumvent this problem, we construct a measure of local disease prevalence (which varies by location within each city) by using the STI status of other sex workers in that location. More precisely, for each sex worker, we generate a location-specific STI prevalence which is the STI prevalence of all transactions within that location and city, excluding each sex worker’s own transactions.[2]

In the model we describe below, sex workers and clients observe disease prevalence when choosing whether to have safe or risky sex. Similarly, in the empirical analysis we also assume that sex workers are aware of differences in STI risks from clients in different locations. Qualitative results from focus groups suggest this to be the case: Sex workers are aware of differences in the risk of contracting STIs from different locations. Furthermore, from focus group discussions in Ecuador, we have found that sex workers frankly and fairly frequently discuss disease risk amongst themselves; viewing infection as an occupational hazard, they are remarkably open about disclosing their own STI status to each other, with little stigma attached to infection for infections like chlamydia and/or gonorrhea. While this is not the most ideal measure of disease, it is the best we can do given data limitations.[3]

2. Formally, let i index sex worker and j index location types. N_j is the number of sex workers in location j. Then our measure STI_{kj} is the STI rate that sex worker k faces in location j is: $\widehat{STI}_{kj} = (1/N_j)\sum_{i \neq k}^{N_j} STI_{ij}$ where STI_{ij} is the observed STI status of k’s colleague i.

3. One concern is that our STI measure is simply proxying for variation in unobserved client characteristics. We think that our constructed measure of local STI rate is probably a good measure of disease risk, as there is substantial variation both within city and across cities in STI rates and the types of clients that frequent any given locale. We also test whether variation in sex workers’ transaction-level reports about their clients drive the variation in local STI rates, by estimating a sex worker fixed effects model regressing local STI rate on all the observable client characteristics. Of all client characteristics (regular, clean, handsome, rich, foreign, or risky), only foreign significantly predicts local STI rates, and all estimated coefficients are substantively small. We cannot reject that all coefficients in this regression are jointly equal to zero. (Results available upon request.)

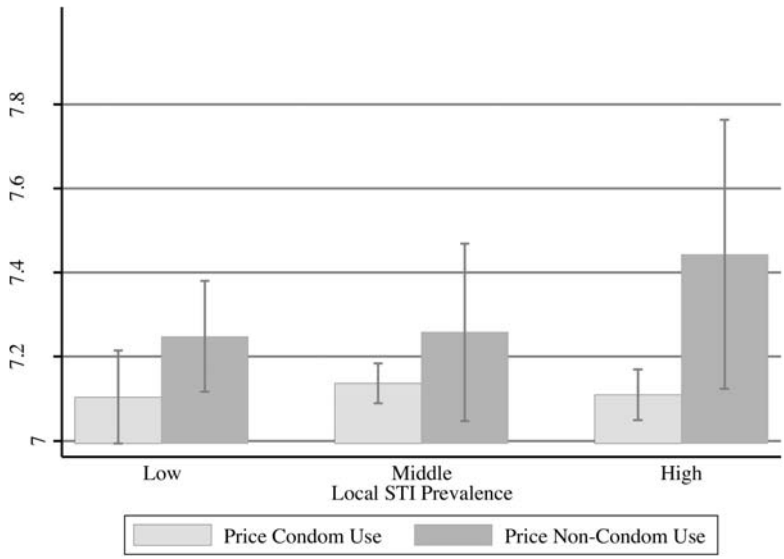

Figure 1
Average Price and Local STI Prevalence
Notes: Low STI prevalence is 0–1.4 percent, middle is 1.5–6.9 percent, and high is 7–43 percent.

The average local STI prevalence across cities is reported in Table 2 as “local STI rate.” In four of the eight cities in our sample, the street has the highest STI prevalence. Across cities, local STI prevalence in the street averages 15 percent, compared to 6 percent in brothels and nightclubs and 2 percent in other worksites. The street has the highest rate of noncondom use (35 percent) compared to brothels (6 percent), nightclubs (9 percent), and other worksites (25 percent).

Figure 1 graphs the average price (demeaned by city) of noncondom and condom use by local STI rate. While this is just raw data, the figure alludes to the main result of the paper. As local STI prevalence increases, the difference between the condom and noncondom price increases—that is, the risk premium increases. We explore this further empirically in Section B.

III. Conceptualizing the Market for Risky Sex

We fix ideas by writing a simple partial equilibrium model of the market for risky sex. To keep everything simple, we write linear supply and demand functions for risky and safe sex respectively. Disease risk is a parameter x which can vary by location. The local STI rate described above is our measure of x in the empirical analysis. Sex workers and clients observe x and then choose whether to have safe (condom) or risky (noncondom) sex. Indexing safe and risky sex by c and nc respectively, supply and demand for safe sex are given by:

(1) $Q_c^S = -\lambda_c + \tau_c^S P_c - \tau_{nc}^S P_{nc} - \zeta_c^S x$

(2) $Q_c^D = \mu_c - \tau_c^D P_c + \tau_{nc}^D P_{nc} - \zeta_c^D x$

where P is price and ζ captures the responsiveness of supply and demand to disease risk.

Similarly, supply and demand for risky sex is given by:

(3) $Q_{nc}^S = -\lambda_{nc} - \eta_c^S P_c + \eta_{nc}^S P_{nc} - \zeta_{nc}^S x$

(4) $Q_{nc}^D = \mu_{nc} + \eta_c^D P_c - \eta_{nc}^D P_{nc} - \zeta_{nc}^D x$

We assume that:

1. All parameters ($\lambda, \mu, \eta, \zeta$) are positive.
2. The own price effect dominates such that $\tau_c^S > \tau_{nc}^S$; $\tau_c^D > {}_{nc}^D$; $\eta_{nc}^S > \eta_c^S$; and $\eta_{nc}^D > \eta_c^D$. This implies that a price increase for a sex worker having risky (safe) sex has a greater effect on the demand for risky (safe) sex relative to safe (risky) sex. Similarly, a price increase for a sex worker having risky (safe) sex has a greater effect on the supply of risky (safe) sex relative to the supply of safe (risky) sex.
3. Price increases for safe sex reduce the total sex demanded ($\tau_c^D > \eta_c^D$); price increases for risky sex reduce the total sex demanded ($\eta_{nc}^D > \tau_{nc}^D$).
4. Price increases for safe sex increase the total sex supplied ($\tau_c^S > \eta_c^S$); price increases for risky sex increase the total sex supplied ($\eta_{nc}^S > \tau_{nc}^S$).

Under the assumptions spelled out above, we have that the price elasticity of risky sex with respect to disease is a function of the relative responsiveness of supply and demand to disease risk. In particular, we have the following results (proofs given in appendix):

Proposition 1: If supply is sufficiently responsive (relative to demand) to differences in disease risk between risky and safe sex, the premium for noncondom sex will increase with the disease rate.

That is, if $\zeta_{nc}^S - \zeta_c^S$ is sufficiently greater than $\zeta_{nc}^D - \zeta_c^D$, then the premium for risky sex will increase with the underlying disease environment, so that $[d(P_{nc} - P_c)]/dx > 0$. This result represents our main prediction in the paper: if the premium for risky sex increases with disease risk, this is evidence that sex workers are indeed responsive to the disease environment, so that at least part of the premium should be seen as a compensating differential.

In our context, it is natural to think of this condition holding. The expression $(\zeta_{nc}^S - \zeta_c^S) - (\zeta_{nc}^D - \zeta_c^D)$ captures the relative benefit of condom use for women relative to men in the presence of disease risk. If we think about these parameters as functions of disease transmission, we should expect the condition to hold insofar as sex workers are indeed aware of the risk of transmission inherent in condom vs. noncondom sex.

The fact that sex workers should benefit more from condom use relative to noncondom use than their clients has epidemiological roots. This is because male to female disease transmission rates in the absence of condoms are higher than female to male transmission rates for most sexually transmitted infections (Garnett and Bowden 2000). For example, on an annual basis, without the use of antivirals or condoms, the transmission risk of HSV-2 from infected male to female is approximately 8–10 percent while transmission risk from infected female to male is approximately 4–5 percent (Kulhanjian et al. 1992). The same is true for chlamydia and gonorrhea: Men are more effective transmitters of disease. Similarly, male to female transmission of HIV/AIDS is 1.9 times more effective than female to male transmission (European Study Group on Heterosexual Transmission of HIV 1992). With condoms, these STI transmission rates are typically thought to be proportionately reduced by 70–80 percent (Gertler, Shah, and Bertozzi 2005). Thus, insofar as the disease price elasticities are themselves functions of the technology of condoms, it is reasonable to expect that the difference between the two elasticities is larger for supply than for demand. However, we will explore this question empirically.

The simple model also generates additional predictions about the responsiveness of price—as opposed to the risk premium—to disease risk that we discuss below and which our empirical framework allows us to address.

Proposition 2: If demand is sufficiently responsive to disease risk (relative to supply), the price for both condom and noncondom sex will decrease with the disease rate.

That is, if $\zeta_c^S + \zeta_{nc}^S$ is not sufficiently greater than $\zeta_c^D + \zeta_{nc}^D$, then the equilibrium price for both risky and safe sex will decrease with disease risk, so that $dP_c/dx < 0$ and $dP_{nc}/dx < 0$. While Proposition 1 addresses the risk premium itself, this result shows that if demand of either type of sex is sufficiently responsive to disease risk (relative to supply), then the equilibrium price of both safe and risky sex will decline with disease risk. In particular, if the price for noncondom and condom sex declines with disease risk, it cannot be the case that demand responsiveness to disease is zero—but it may be the case that supply responsiveness is zero. The conditionals in Propositions 1 and 2 are not mutually exclusive, so that we may (and in fact empirically we do) observe both that the prices of risky and safe sex fall while the risky sex premium rises with disease risk. As such, Proposition 2 indicates that to test the compensating differential explanation, it is not sufficient to examine how disease risk affects the price of either type of sex; we must investigate how the premium itself responds to disease risk.

So far we have generated predictions about the responsiveness of equilibrium prices to disease risk. The model also yields another important result: It is ambiguous about the existence of a risk premium when there is no disease risk:

Proposition 3: If there is no disease risk, the premium for noncondom sex may be positive or negative.

That is, given our assumptions, $[P_{nc} - P_c|x = 0]$ is not signable. Formally, this is the case because there is no theoretical reason to suppose that supply and demand price elasticities are equal across condom use. This means the existence of a premium for noncondom sex does not require a compensating differential interpretation. In fact, such a premium can arise from reasonable assumptions about price elasticities.

The basic intuition behind the model's results is that testing for compensating differentials requires examining how a premium increases with risk. Under this intuition, one might suppose that evidence of a noncondom premium is evidence of a compensating differential, because this is an example of a risky action drawing a premium in the labor market. This is in fact the test employed by most or all empirical studies on this topic. However, taking the propositions together, the premium for noncondom use is actually uninformative of the existence of compensating differentials. That is, this premium may be positive or negative in any given data set, whether or not there is a compensating differential for disease risk. The intuition is that unlike many labor market settings, in a market for risky transactions, both supply and demand derive disutility from disease risk, so that it is (roughly speaking) the relative responsiveness of the two that determines the existence of a compensating differential. Thus, in order to empirically investigate the condom differential hypothesis, we must identify whether the premium for unprotected sex itself responds to disease risk.

IV. Specifications and Results

A. Premium for Risky Sex

The economic model nests existing studies which do not incorporate responsiveness to disease risk by setting the price elasticities of disease to zero. To examine how our data compare in this restricted framework to other studies, we begin our investigation by modeling log price of a transaction as a linear stochastic function of condom use, omitting STI prevalence:

(5) $$P_{ij} = \alpha + \sum_k \varphi_k X_{jk} + \sum_l \upsilon_l S_{ijl} + \beta NC_{ij} + \theta_i + \varepsilon_{ij}$$

Sex workers are indexed by i and transactions by j, and P_{ij} is the log transaction price. To control for sex worker specific variation and unobservable sex worker heterogeneity, we include the sex worker fixed effect (θ_i). X_{jk} are characteristics of the client, and S_{ijl} are services provided. NC_{ij} is a dummy indicating that a condom was not used in the transaction and ε_{ij} is a mean-zero random disturbance.

We begin with a parsimonious specification regressing the log transaction price on condom use; in later specifications we control for client characteristics and services provided. While we do not have data from clients and therefore cannot include client fixed effects, we attempt to control for client heterogeneity by using sex worker reports of client characteristics.[4] The empirical results are similar whether we control for client characteristics or not, suggesting demand side heterogeneity is an unlikely source of bias. The most complete models (Columns 3–6) interact noncondom use with other risk measures such as engaging in anal sex; and having sex with a "risky client" (high subjective likelihood of being HIV positive).

Table 3 reports the regression results. The coefficient of 0.12 on noncondom use in Column 1 represents a 13 percent risk premium for unprotected sex, which declines slightly to 11 percent when we control for services provided and client characteristics (Column 2). The estimated magnitude of the risk premium for unprotected sex is very similar to that for Mexican sex workers (Gertler, Shah, and Bertozzi 2005). Column 2 displays the premium once we control for client characteristics. Column 2 also displays the premium for risky services provided. For anal sex, the riskiest type of sex transaction in our data, the coefficient of 0.36 corresponds to a 43 percent premium relative to vaginal sex. We then interact anal sex with noncondom use, which results in an additional 8 percent premium (Column 3) though the standard becomes large.

4. In fact, except for Logan (2011), we are unaware of any papers that have transactional level data from the client side.

Table 3
Premium for Risky Sex

	Dependent Variable: ln Price					
	(1)	(2)	(3)	(4)	(5)	(6)
No condom	0.12	0.10	0.10	0.09	0.10	0.08
	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***
Risky client		0.17	0.16	0.03	0.14	–0.01
		(0.06)***	(0.06)***	(0.07)	(0.06)**	(0.07)
Anal sex		0.36	0.34	0.36	0.34	0.34
		(0.03)***	(0.04)***	(0.03)***	(0.03)***	(0.04)***
No condom × anal sex			0.08			–0.01
			(0.07)			(0.07)
No condom × risky client				0.41		0.24
				(0.09)***		(0.1)**
Anal sex × risky client					0.55	–0.31
					(0.16)***	(0.19)
No condom × risky × anal sex						2.5
						(0.35)***
Constant	1.74	1.69	1.69	1.69	1.69	1.69
	(0.003)***	(0.01)***	(0.01)***	(0.01)***	(0.01)***	(0.01)***
Client characteristics	N	Y	Y	Y	Y	Y
Sample size	8,489	8,489	8,489	8,489	8,489	8,489

Notes: Transaction-level regressions with sex worker fixed effects; dependent variable is log transaction price (mean 1.76 US$). Client characteristics include regular, clean, handsome, rich, foreign, and risky. In regressions which include anal sex, we also control for other services provided (oral, vaginal and nonsexual services). ***indicates significance at 1 percent level, ** at 5 percent level, * at 10 percent level.

When a sex worker engages in noncondom use with a risky client she receives a 50 percent premium (Column 4). Similarly, when the sex worker has anal sex with a risky client, there is an additional 73 percent premium (Column 5). In Column 6 we display results from the interaction of "Noncondom use × Anal sex × Risky client." As expected, the interaction is economically large, positive and significant at the 0.01 level, indicating that extremely risky types of sex draw an even larger premium when the sex worker has knowledge of STIs or the client seems particularly risky.[5]

At this point it is reassuring that our data and estimates correspond to results from other sources (Gertler, Shah, and Bertozzi (2005); Rao et al. (2003); Robinson and Yeh (2011)). Furthermore, interacting noncondom use with transaction characteristics that are likely to draw a compensating premium yields suggestive results; the estimates suggest that the risk premium responds dramatically to these measures of additional risk. However, we still cannot rule out an explanation simply grounded in male disutility from condom use. For example, it might be the case that risky clients are risky precisely because they experience great disutility from noncondom use, so that we are effectively capturing differences in willingness-to-pay. To assess this directly, in the next section we use the model presented above to frame an empirical specification that tests the compensating differential explanation by looking at the responsiveness of the noncondom premium to disease risk.

B. Is it a Compensating Differential?

Turning to the complete specification corresponding to the model in Section III, we test whether the compensating differential responds to local disease environment by estimating equations of the form:

$$(6)\quad P_{ij} = \alpha + \sum_k \varphi_k X_{jk} + \sum_l \upsilon_l S_{ijl} + \beta NC_{ij} + \gamma STI_{ij} + \delta(NC_{ij} \times STI_{ij}) + \theta_i + \varepsilon_{ij}$$

Here, sex workers are once again indexed by i and transactions by j, and P_{ij} is the log transaction price. Again, to control for sex worker specific variation and unobservable sex worker heterogeneity $[d(P_{nc} - P_c)]/dx$, we include the sex worker fixed effect (θ_i). We use k to index the client's characteristics in each transaction, given as X_{jk}, and services provided are S_{ijl}. NC_{ij} is a dummy indicating that a condom was not used in the transaction; STI_{ij} is the local STI rate; $NC_{ij} \times STI_{ij}$ is the interaction of noncondom use and the local STI rate; and ε_{ij} is a mean-zero random disturbance.

The main coefficient of interest is δ, which is the interaction between noncondom use and local STI prevalence, and corresponds to in our model. Here, the response of the price of protected sex to disease risk is given by γ; the risk premium for unprotected sex when the sex worker faces no disease risk is given by β; and δ captures the increase in the premium for noncondom use as local STI rates increase. The regression coefficients correspond directly to the expressions in the proofs of propositions in the Appendix.

5. One concern with these results is that sex workers who always use condoms and those who never use condoms may have different risk preferences and/or attract different types of clients along some unobservable dimensions than sex workers who sometimes use condoms. To check for this, we estimate the same regression models excluding sex workers who never and always use condoms. We find there is no statistical difference for the no-condom risk premium between the fixed effects using the whole sample and this model. In addition, the no-condom risk premium result is robust to including location fixed effects. Results available upon request.

Table 4
Risk Premium Increases with Local STI Prevalence

	Dependent Variable: ln Price					
	(1)	(2)	(3)	(4)	(5)	(6)
No condom	0.09	0.03	0.03	0.03	0.03	0.02
	(0.03)***	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Local STI rate	–2.36	–2.56	–1.75	–2.55	–0.87	–0.98
	(0.76)***	(0.66)***	(0.62)***	(0.67)***	(0.63)	(0.73)
No condom × Local STI rate		1.0	0.94	1.0	0.86	0.97
		(0.51)**	(0.49)*	(0.51)**	(0.48)*	(0.5)**
Local noncondom rate			0.53			–0.58
			(0.19)***			(0.62)
Enforcement				–0.001		0.12
				(0.02)		(0.07)*
Nightclub					0.11	0.10
					(0.05)**	(0.05)**
Street					0.07	0.38
					(0.12)	(0.34)
Other location					0.27	0.55
					(0.08)***	(0.26)**
Constant	1.86	1.82	1.71	1.82	1.64	1.55
	(0.04)***	(0.06)***	(0.06)***	(0.06)***	(0.07)***	(0.09)***
Client characteristics	N	Y	Y	Y	Y	Y
Sample size	8,382	8,300	8,300	8,300	8,300	8,300

Notes: Transaction-level regressions with sex worker fixed effects. Dependent variable is log transaction price (mean 1.76 US$). Client characteristics include regular, clean, handsome, rich, foreign, married, and risky. The default location is Brothel. All regressions which include client characteristics also control for services provided. ***indicates significance at 1 percent level, ** at 5 percent level, * at 10 percent level.

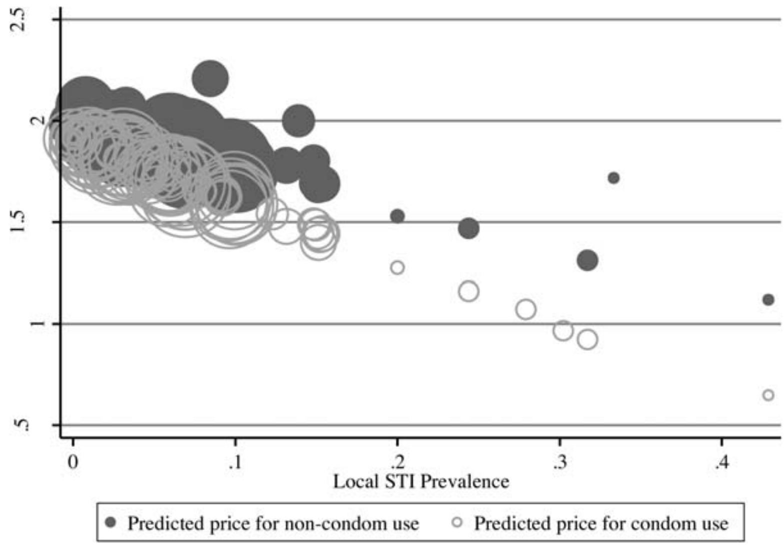

Figure 2
Predicted Transaction Price and Local STI Prevalence

Table 4 displays the regression results of Equation 6. In Column 1 we regress log price on condom use and the local STI rate. In Column 2 we then interact noncondom use with the local STI rate, adding controls for client characteristics. The results show that the risk premium is largely generated by disease risk. The Column 2 coefficient of 1.0 on the interaction between noncondom use and local STI ($\hat{\delta}$) implies that a one percentage point increase in the local STI rate increases the premium for noncondom use by approximately 33 percent. Furthermore, once the interaction with STI is included, the risk premium for noncondom use when disease prevalence is zero ($\hat{\beta}$) decreases to 3 percent and is no longer statistically significant. We also see that the effect of local STI rate on the price for protected sex ($\hat{\gamma}$) is substantial and negative: A one standard deviation in the local STI rate reduces price approximately 11 percent.

The results can be best seen graphically in Figure 2. We graph the predicted price from Column 2 for condom and noncondom use by local STI prevalence, weighting by the number of transactions in each category. While there are many observations of locations with close to zero disease, we do observe substantial variation in disease risk, ranging up to almost 45 percent STI prevalence. Propositions 1–3 are useful in interpreting the results in this figure. The risk premium—seen as the gap between the noncondom and condom prices—increases with disease risk. From Proposition 1, we can interpret the fact that the compensation for undertaking risky sex itself rises with disease as a statement that supply is sufficiently more responsive to disease risk (relative to demand). At the same time, the overall price for both condom and noncondom sex falls with disease risk. Proposition 2 explains that this result is not only consistent with the model, but also that the empirical finding requires that demand is responsive to disease risk. Finally, consistent with Proposition 3, the gap between the condom and noncondom price when STI prevalence is low represents that part of the risky sex premium that cannot be explained as a compensating differential. As seen in the figure, this no-disease risky sex premium is very small at zero disease, this premium is approximately one-fourth the size of the overall risk premium in the market as a whole.

Our theory suggests that the price differential is a function of the relative preferences of the client and sex worker. One concern is that condom use may be correlated with the error term in Equation 6, resulting in biased estimates. The sex worker fixed effect specified in Equation 6 controls for bias from both unobserved sex worker heterogeneity and client selection based on unobserved sex worker characteristics. However, while we control for observable client characteristics; there still may be important demand side unobservables biasing our results. When we include controls for client characteristics in our regressions, the coefficient on our main result does not change, suggesting demand side heterogeneity might not be a problematic source of bias. To get at this possibility more directly, we explore a series of alternate hypotheses.

One potential bias could result from client preferences for condom use at different locations which are driving the results, and not actual disease rates. In Column 3 of Table 4, we include a measure of average condom use (local noncondom rate) for each city and location. Our main result remains unchanged even after we control for average condom use at each location in each city.[6]

As noted above, Ecuador's sex sector is regulated, and Gertler and Shah (2011) study the effects of Ecuador's health regulation on STI outcomes. Gertler and Shah (2011) show in some detail that enforcement of regulation is not driven by disease rates or various city, client, or sex worker characteristics. We test whether enforcement of regulation affects the compensating differential. In Column 4 of Table 4 we include a measure of enforcement that is the average visits per month by the police to the location (the same measure used in Gertler and Shah 2011). The coefficient on enforcement is not statistically significant and does not affect the compensating differential. In addition, the coefficient on our main interaction of interest (local STI prevalence × noncondom use) is not affected by the inclusion of the enforcement variable.

Another potential source of bias from our main result could be that location, not disease, is driving the result. For example, because street sex workers have high disease rates, it could be the street location and not disease driving the main result. In Column 5 we include controls for the work location (street, nightclub, brothel, other). The estimated risk premium remains statistically significant (though the standards errors increase) and is only slightly lower in magnitude: A one percentage point increase in local STI prevalence increases the risk premium by 28 percent.

Our most complete specification reported in Column 6 of Table 4 includes all the control variables. The main result on the interaction term remains largely unchanged. The additional controls drive the estimated no-disease unprotected sex premium further down to 0.02 — close to zero and not statistically significant — suggesting that compensation for disease risk is in fact the main source of the risky sex premium. Insofar as our results may be extended to other settings, they indicate that the risky sex premia identified in the literature (Gertler, Shah, and Bertozzi 2005; Rao et al.

6. In an additional specification, we interact average noncondom use with transaction level noncondom use and the main STI result remains robust to this.

2003; Robinson and Yeh 2011) are best explained as a compensating differential for disease risk.

C. Sex Workers and their STI Status

At the core of the compensating differential account of the premium for unprotected sex is the idea that sex workers face different disease risks in different locations, and their responsiveness to these risks drives a commensurate compensation for performing risky sex. A natural extension of this story is that the compensating differential a sex worker requires will depend on whether or not she already has an STI. Ceteris paribus, women who are already infected should be willing to undertake risky sex for a lower premium. If individual disease status is largely unobservable to the client—likely the case for the STIs we study—infected women would attempt to masquerade, so that any difference in premium is driven by rationing of demand which reveals their lower willingness to accept.[7]

In Table 5 we reestimate the regressions from Table 4 for two different subsamples: Sex workers who currently have an STI (Columns 1–3) and sex workers who do not currently have an STI (Columns 4–6). The main results with all control variables are presented in Columns 3 and 6. Interestingly, for women who already have chlamydia and/or gonorrhea, the estimated compensating differential is substantially smaller and is not statistically significant. In contrast, uninfected sex workers require even greater compensation for undertaking risky sex in high disease environments—a one percentage point increase in the STI rate, increases their premium for noncondom use by approximately 50 percent. As we would expect, this result is larger than that estimated for the entire sample.[8]

V. Robustness

Our theory suggests that the price differential is a function of the relative preferences of the client and sex worker. One concern is that condom use may be correlated with the error term Equation 6, resulting in biased estimates. The sex worker fixed effect specified in Equation 6 controls for bias from both unobserved sex worker heterogeneity and client selection based on unobserved sex worker characteristics. We also estimate a random effects model (results available upon request). In addition to the usual control variables we include sex worker characteristics (age, experience, education, marital status, children, risk preference, beauty, weight, personality, communication skills) and city fixed effects. Though the coefficient on the interaction is slightly smaller than the fixed effects models and the standard errors increase, the main result basically holds. We perform a Hausman specification test to test the appropriateness of the random-effects estimator and reject random effects

7. Because having an STI increases the likelihood of HIV infection, noncondom use is riskier for infected women, which could actually increase their willingness to accept. However, risk of HIV infection is less than 1 percent in Ecuador, so this is less likely to be an issue in our context.

8. We can reject that the regression coefficients are the same across the two types of woman (STI and no STI).

Table 5
Risk Premium by STI Status

	Dependent Variable: ln Price					
	Sex Workers with STI			Sex Workers with no STI		
	(1)	(2)	(3)	(4)	(5)	(6)
No condom	0.05	–0.02	–0.01	0.09	0.04	0.02
	(0.05)	(0.07)	(0.06)	(0.03)***	(0.04)	(0.04)
Local STI rate	–3.44	–3.64	–4.07	–2.25	–2.69	–2.59
	(0.84)***	(0.69)***	(0.8)***	(0.82)***	(0.8)***	(0.74)***
No condom × local STI rate		0.67	0.59		1.05	1.09
		(0.65)	(0.6)		(0.58)*	(0.56)**
Constant	1.94	1.95	1.91	1.86	1.88	1.81
	(0.06)***	(0.05)***	(0.06)***	(0.04)***	(0.04)***	(0.06)***
Client characteristics	N	N	Y	N	N	Y
Sample size	437	437	433	7945	7,945	7,867

Notes: Transaction-level regressions with sex worker fixed effects. Dependent variable is log transaction price (mean 1.76 US$). Column 1–3 are the sample of sex workers who currently have an STI and and Columns 4–6 are sex workers who do not currently have an STI. Client characteristics include regular, clean, handsome, rich, foreign, married, and risky. All regressions which include client characteristics also control for services provided. ***indicates significance at 1 percent level, ** at 5 percent level, * at 10 percent level.

($\chi^2 = 225.58$). Because our focus in this paper is on the effects of variation in local disease environments, we do not favor the random effects model as it does not control for a lot of the unobservable sex worker heterogeneity that might be correlated with condom use and price. Instead, we favor the fixed effects model which allows us to direct attention to within sex worker differences in transaction price across locations.

While we explored various demand side heterogeneity issues in Section B, there still might be unobserved portions of the distribution of client preferences that are salient for the price differential and determinants of condom use. To identify client characteristics that might be correlated with client preferences for condom use, we estimate a random-effects model predicting noncondom use as a function of sex worker and client characteristics. Those characteristics that significantly predict noncondom use are correlated with sex worker and client preferences for condom use. We then take those significant predictors and interact them with noncondom use in the price equation. The results of this exercise are available upon request.

Client characteristics which significantly predict noncondom use are regular and clean. Many more sex worker characteristics are predictors of noncondom use such as having a pleasant personality, good weight, good communication skills, being single or divorced, less education, children, and age. We interact these significant predictors of noncondom use with noncondom use and then put them in the price equation. The results indicate that the client risk interactions are neither individually nor jointly significantly different from zero. This suggests that our estimations of the price differentials in Table 3 and 4 are not likely to be biased from unobserved portions of client risk preferences. While none of the client characteristic interactions are statistically significant, two of the sex worker characteristic interactions are significant but only at the 10 percent level. Divorced sex worker engaging in noncondom use command higher prices while older sex workers engaging in noncondom use command lower prices. However, because all of our models include sex worker fixed effects, we are less worried about these sex worker characteristics biasing the results.

VI. Behavioral Response to Local STI Prevalence

Perhaps the central tenet of the field of economic epidemiology is that individuals respond to increased risk of contracting disease by substituting away from risky behavior choices (Philipson 2000). While the compensating differential for risky sex may indeed increase with STI prevalence, this effect does not necessarily eliminate individuals' behavioral response. In Table 6 we report the results of fixed effect logits as odds ratios, where the dependent variable, noncondom use, captures potential behavioral responses to local STI prevalence. We begin with a parsimonious specification with only local STI prevalence and sex worker fixed effects (Column 1); we then add client characteristics and services provided as additional controls (Column 2).

While the coefficients do indicate that in higher disease locations, sex workers are less likely to engage in noncondom use, the results are not significantly different from zero.[9]

9. In alternate specifications where we do not incorporate sex worker fixed effects; we do find a significant behavioral response. Cross-sectional probits at the transaction level indicate that a 1 percent increase in local

Table 6
Is there a Behavioral Response?

Dependent Variable: No Condom Use		
	(1)	(2)
Local STI rate	0.001	0.001
	(0.006)	(0.005)
Client characteristics	N	Y
X^2	1.82	14.76
Sample size	598	598

Notes: Transaction-level logits with sex worker fixed effects; dependent variable is noncondom use. Client characteristics include regular, clean, handsome, rich, foreign, married, and risky. Regressions which include client characteristics also control for services provided. *** indicates significance at 1 percent level, ** at 5 percent level, * at 10 percent level.

VII. Conclusion

The commercial sex sector bears an importance disproportionate to its size. Epidemiological models suggest that the behavioral response of high-activity core groups is critical to the course of an epidemic (Shahmanesh et al. 2008). Understanding the economic incentives shaping the commercial sex market is crucial to effective targeting of public health interventions. In developing countries in particular, sex workers play a central role in the spread of STIs as they have higher infection rates and more sexual partners relative to the general population (UNAIDS 2010).

We find strong evidence that the risk premium for unprotected sex is best understood as a compensating differential for increased disease risk. Our empirical finding of a risk premium that increases with local STI prevalence indicates that targeting interventions only at sex workers may be less effective than campaigns designed to target their clients as well. Furthermore, the market's effect of mitigating workers' inclination to avoid risky sex in the commercial sex sector indicates that as awareness of STIs increases, individuals in the sex sector may be less likely to respond by limiting their risky sex behavior than individuals outside the sex sector who draw no such compensating differential. The result is that as STI prevalence increases, the fraction of sex incurred by high-prevalence individuals relative to the population as a whole increases. As Kremer (1996) shows, if the proportion of sex incurred by high-prevalence individuals increases, there may exist equilibria in which exist the likelihood of an STI epidemic persisting increases, even if the overall amount of sex declines. If high-risk people reduce their activity by a smaller proportion than low-risk individuals, the

STI prevalence results in a 1.3 percentage point decrease in noncondom use. However, because there are important unobserved sources of heterogeneity that are most likely driving the association of STI prevalence with condom use, the regression results in Table 6 with sex worker fixed effects are more reliable.

composition pool of available partners will worsen, increasing the probability of pairing with a high-risk individual. The compensating differential for risky sex that we identify in this paper operates on a core group at risk for STI infection—and possibly no other group in the population. As such, we offer a new justification for Kremer's (1996) concern with the persistence of STI epidemics that does not depend on the fatalism of high-activity individuals. The behavioral response of individuals in the general population, combined with the market's mitigating effect on this response in the core group, may serve to dampen the self-limiting nature of STI epidemics.

Appendix 1

Theory

We solve Equations 1–4 for equilibrium prices P_{nc} and P_c, and then take the derivative with respect to x. The solutions yield:

$$\text{(A1)} \quad \frac{dP_{nc}}{dx} = \frac{1}{\Phi}[(\zeta_c^S - \zeta_c^D)(\eta_c^D + \eta_c^S) + (\zeta_{nc}^S - \zeta_{nc}^D)(\tau_c^S + \tau_c^D)]$$

$$\text{(A2)} \quad \frac{dP_c}{dx} = \frac{1}{\Phi}[(\zeta_c^S - \zeta_c^D)(\eta_{nc}^D + \eta_{nc}^S) + (\zeta_{nc}^S - \zeta_{nc}^D)(\tau_{nc}^S + \tau_{nc}^D)] \equiv \gamma$$

where:

$$\Phi \equiv \eta_{nc}^D\tau_c^S + \eta_{nc}^D\tau_c^D + \eta_{nc}^S\tau_c^S + \eta_{nc}^S\tau_c^D - \eta_c^D\tau_{nc}^D - \eta_c^S\tau_{nc}^D - \eta_c^D\tau_{nc}^S - \eta_c^S\tau_{nc}^S$$

Given our assumptions, we have that $\Phi > 0$, since:

$$\underbrace{[\eta_{nc}^D\tau_c^S - \eta_c^S\tau_{nc}^D]}_{>0 \text{ since } \eta_{nc}^D > \tau_{nc}^D;\, \eta_c^S < \tau_c^S} + \underbrace{[\eta_{nc}^D\tau_c^D - \eta_c^D\tau_{nc}^D]}_{>0 \text{ since } \eta_{nc}^D > \tau_{nc}^D;\, \eta_c^D < \tau_c^D} + \underbrace{[\eta_{nc}^S\tau_c^S - \eta_c^S\tau_{nc}^S]}_{>0 \text{ since } \eta_{nc}^S > \tau_{nc}^S;\, \eta_c^S < \tau_c^S} + \underbrace{[\eta_{nc}^S\tau_c^D - \eta_c^D\tau_{nc}^S]}_{>0 \text{ since } \eta_{nc}^S > \tau_{nc}^S;\, \eta_c^D < \tau_c^D} > 0$$

Proposition 1: The difference $dP_{nc}/dx - dP_c/dx$ captures the responsiveness of the risk premium to disease prevalence. Subtracting, we have:

$$\text{(A3)} \quad \frac{dP_{nc}}{dx} - \frac{dP_c}{dx} = \frac{1}{\Phi}[\tau(\zeta_{nc}^S - \zeta_{nc}^D) - \eta(\zeta_c^S - \zeta_c^D)] \equiv \delta$$

where:

$$\tau \equiv \tau_c^S + \tau_c^D - \tau_{nc}^S - \tau_{nc}^D > 0 \quad \text{since} \quad \tau_c^D - \tau_{nc}^D > 0 \quad \& \quad \tau_c^S - \tau_{nc}^S > 0$$

$$\eta \equiv \eta_{nc}^S + \eta_{nc}^D - \eta_c^D - \eta_c^S > 0 \quad \text{since} \quad \eta_{nc}^D - \eta_c^D > 0 \quad \& \quad \eta_{nc}^S - \eta_c^S > 0$$

The sign of Equation A3 is ambiguous. However, if supply is sufficiently responsive to disease (relative to demand), so that $\zeta_{nc}^S - \zeta_c^S$ is sufficiently greater than $\zeta_{nc}^D - \zeta_c^D$, then expression (A3) will be positive.

Proposition 2: The result follows directly from Equations A1 and A2. Both expressions increase with $\zeta_{nc}^S + \zeta_c^S$ and decrease with $\zeta_{nc}^D + \zeta_c^D$. Because all other parameters are positive, a sufficient condition for the derivative to be negative is that the demand price elasticities of disease are sufficiently large relative to supply.

Proposition 3: Solving the model for equilibrium prices and setting x to zero yields:

$$(4) \quad [P_{nc} - P_c | x = 0] = \frac{1}{\Phi}[\tau(\mu_{nc} + \lambda_{nc}) - \eta(\mu_c + \lambda_c)] \equiv \beta$$

This expression is not signable given our assumptions.

Combining the results from the propositions yields a simple expression for the risk premium at any given level of disease: $\beta + \delta x$. Because β is not signable, this result suggests that the noncondom premium itself may be positive or negative regardless of the extent of a compensating differential.

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