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Abstract of the Dissertation

Essays on the Economics of Illegal Markets

by

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Doctor of Philosophy in Economics
University of California, Los Angeles, 2016
Professor Adriana Lleras-Muney, Chair

This dissertation investigates how policies and regulation can impact both firm and worker behavior in the illegal black market for commercial sex.

In the first chapter, "Optimal regulation of illegal goods: the case of massage licensing and commercial sex," I analyze how regulating barriers to entry can alter market structure and risk-taking behavior in the black market for commercial sex, and consequently impact associated health and crime externalities. Despite its illegality, prostitution is a multi-billion dollar industry in the U.S. A growing share of this black market operates covertly behind massage parlor fronts. I examine how changes to licensing in the legal market for massage parlors can impact the total size and risk composition of the black market for prostitution, which operates either illegally through escorts or quasi-legally in massage parlors. I find that lower barriers to entry for massage parlors makes the black market for prostitution larger, but also less risky. Consequently, the incidence of gonorrhea and rape falls in the general and sex worker populations, and the incidence of chlamydia falls in the predominant sex worker demographic.

In the second chapter, "Product differentiation by legal status: estimating the demand for commercial sex," I model the quasi-legal and illegal sectors of prostitution as a differentiated product demand system. I use a Logit model and online review data from California to estimate the own-price and cross-price elasticities of demand for quasi-legal

and illegal prostitution. I instrument for prices using two marginal cost variables – massage licensing fees, and the interaction between fees and the adult Asian population. I find that demand for quasi-legal prostitution is highly elastic and weakly substitutable with illegal prostitution.

In the third chapter, "Reducing the risk premium for unprotected sex through community-based HIV prevention: evidence from India and Ecuador," I further examine the risk behavior and health outcomes of commercial sex workers, however in the context of developing countries. Using individual survey data from two randomized control trials in India and Ecuador, I document how community-based HIV prevention programs helped reduce the risk premium for unprotected sex. As a result, condom use increased and the incidence of syphilis decreased among sex workers. I explore the possible mechanisms for this change, such as health education, sex worker empowerment, and income

The dissertation of Amanda Maitram Nguyen is approved.

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2016

To Mom, Dad, and Chi. Thank you for believing in me.

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CHAPTER 1

Optimal regulation of illegal goods: the case of massage licensing and commercial sex

1.1 Introduction

Generating an estimated $14.6 billion in annual revenue, the U.S. black market for prostitution ranks as the fifth largest in the world and accounts for approximately 1% of GDP.[1] There has been renewed debate on the optimal regulation of prostitution, with the International AIDS Conference and Amnesty International endorsing full decriminalization, in the interest of protecting sex workers' human rights and combating HIV and other STIs.[2] However, there is also significant heterogeneity in the risk of these externalities across prostitution types.

In the U.S., the massage industry has historically been linked to prostitution, with some firms using legal massage to camouflage illegal black market activity.[3] As a result, massage regulation often imposes significant barriers to entry relative to comparable personal care services. This chapter analyzes how barriers to entry, via occupational licensing in the legal market for massage, can in turn affect the black market for prostitution and its associated health and crime externalities.

Massage parlors that serve as a front for prostitution (which I refer to throughout the paper as the quasi-legal prostitution sector) comprise an increasingly large portion

[1] Numbers estimated from Ssewakiryanga (2004) and Havocscope (2015).

[2] International AIDS Conference (2014), Amnesty International (2015)

[3] Dank et al. (2014), Gold (2014)

of the black market for commercial sex, due to growth in Internet-based and indoor prostitution.[4] As a result, cities have favored policies that limit the size of this quasi-legal sector. However, these quasi-legal firms are also relatively safer than other types of prostitution, trading lower-risk services with better customer screening and monitoring. By quantifying the causal impact of licensing regulation on the size of the quasi-legal sector, this paper contributes to a more nuanced discussion of the optimality of different regulatory regimes in the market for commercial sex.

To identify the causal effects of changing barriers to entry, I exploit a natural experiment in California that differentially changed regulatory requirements and licensing fees across cities. Prior to 2009, all California cities set their own massage licensing fees, which were often correlated with local demand for quasi-legal prostitution due to cities' desire to curb consumption. As a result, cities with relatively high demand for quasi-legal prostitution also had prohibitively high fees, strict background checks, and costly zoning requirements. In an industry where 92% of firms employ fewer than 20 workers, these monetary and non-pecuniary costs served as a significant barrier to entry for both legal massage and quasi-legal prostitution firms.[5]

However, in 2009, California instituted a state licensing option that effectively reduced barriers to entry for cities with high local licensing costs. Cities with higher local fees experienced larger fee reductions, while cities where local licenses were cheaper than the state license experienced no change. 17% of cities experienced no decline, while the remaining cities experienced a median fee decrease of 84%.[6] This policy was essentially reversed in 2015, introducing a second change in licensing regulation that subsequently increased barriers to entry. I use the resulting time and city-level variation in a difference-in-differences framework to estimate the consequent changes in prostitution market structure and externalities. This strategy compares changes in licensing fees to

[4]Dank et al. (2014), Urban Justice Center (2005), The Economist (2014)

[5]Own calculations using United States Census Bureau (2013)

[6]Own calculations using new data on massage licensing fees.

changes in market structure and other outcomes. Because cities with higher fees (and therefore large fee decreases) may also have faster growing quasi-legal demand, I also instrument for massage licensing fees using the fees for alternative business sectors, namely retail and professional service occupations. I also verify that increases in fees, which occurred after the initial decline, had similar sized effects in the opposite direction. This makes it unlikely that pre-existing trends can explain the results.

To investigate the effects of licensing on the illegal sex trade, I collect and utilize an original, new dataset that exploits the Internet's critical role in illegal market transactions. I join publicly available city-level data on the massage market, rate of STIs, and rape, with online business listings from customer review websites. This dataset contains the first city-level panel of prices, supply, and product characteristics for two types of black market firms: purely illegal prostitution, as measured by escorts on TheEroticReview.com, and quasi-legal prostitution, as measured by erotic massage parlors on Rubmaps.com. I use similar customer review website data from Yelp.com to measure the size of the legal massage market as well. The data on externalities and market structure are then matched to hand-collected data on massage licensing fees over time, creating an unbalanced panel that tracks 227 cities over the first policy change and 148 cities over the second policy change, covering 2008 to 2015.[7] The natural experiment in California allows me to study regulatory variation at a finer level than in the previous literature, with licensing fees varying at the city level.

Using an epidemiological model for STI transmission, I show that the net effect on prostitution externalities depends on the changes in total size and relative riskiness of the black market. When barriers to entry fall, I find that the incidence of gonorrhea and rape declines for the general population, and chlamydia rates decrease among the predominant quasi-legal sex worker demographic, Asian females. This seems to suggest that the growth in the total size of the black market is offset by the consequent shift towards the quasi-legal sector and lower-risk services. Indeed, I find that reducing the

[7]The first policy change covers 2005 to 2014, while the second policy change covers 2009 to 2015.

barriers to entry for massage increases the total size of the black market by increasing the quasi-legal prostitution sector, albeit at the expense of legal massage firms. As quasi-legal prostitution becomes relatively cheaper for buyers and more profitable to sellers, the illegal prostitution sector shrinks, and both buyers and sellers switch to quasi-legal prostitution. I also confirm a direct relationship between barriers to entry and the probability of high-risk behavior in the quasi-legal sector. This implies that when licensing fees fall, the wage premium and propensity for high-risk services also decrease, directly reducing the riskiness of quasi-legal transactions. As a result of the reduced risk at both the market and individual level, I estimate that a 10% increase in the supply of quasi-legal prostitution translates to a 0.1% reduction in the supply of illegal prostitution, a 2.8% reduction in the overall gonorrhea rate, a 2.3% reduction in the Asian female gonorrhea rate, a 0.3% reduction in the Asian female chlamydia rate, and a 2.2% reduction in rape cases. Thus, for the average massage licensing fee reduction observed in California, gonorrhea rates fell by 16.3% and the incidence of rape declined by 19% for the general population, while chlamydia rates fell by 1.73% for Asian females.

The magnitude of the estimated impact on health is comparable to Gertler and Shah (2011)'s previous findings that examine enforcement within a legalized policy regime in Ecuador. The authors show that greater street enforcement improves STI incidence, while greater indoor enforcement exacerbates STIs by driving sex workers into the street sector. Similarly, the reduction in licensing fees positively impacts health outcomes by shifting black market activity into the lower risk sector. However, enforcement through police raids is costly, while lowering barriers to entry can achieve similar improvements without additional government expenditure. This suggests that simply reducing prohibitively high licensing fees to a more moderate level can be a cost-effective approach to addressing the negative health externalities associated with prostitution.

Using licensing fees as my source of regulatory variation also allows me to consider changes in policy with varying degrees of liberalization, ranging from abolition, i.e. a licensing fee at which there is zero entry, to full decriminalization, i.e. free entry into the quasi-legal sector. A counterfactual exercise estimating the effects of free entry for

massage suggests that the impact on gonorrhea and rape is comparable to that of full indoor decriminalization, as estimated by Cunningham and Shah (2014). This suggests that changing barriers to entry via licensing fees can affect the black market significantly, and may provide a means for black market regulation when political constraints limit the capacity for decriminalization. However, this comes at a cost to the legal massage market, and thus policymakers face a tradeoff between maximizing legitimate consumption and targeting prostitution externalities.

Other literature on the regulation of prostitution is scarce and has been constrained by the illicit nature of the market, a lack of reliable data, and insufficient regulatory variation at more granular levels. Lee and Persson (2013) propose a theoretical model for comparing criminalization versus decriminalization, while existing empirical work has studied the effects of decriminalization at a state or country level (Cho et al. (2013), Jakobsson and Kotsadam (2013), Cunningham and Shah (2014), Kotsadam and Jakobsson (2014)). While important, the existing literature on decriminalization does not shed light on the effects of regulation when prostitution is illegal, as it is in most of the U.S. and many other countries. This paper is the first to examine occupational licensing and barriers to entry as a medium for affecting the black market for a good that is already illegal.[8] I also provide the first estimates of prostitution supply elasticity with respect to licensing fees, a type of regulation also common in legal prostitution markets.

The rest of the chapter proceeds as follows: Section 1.2 describes market characteristics and the regulatory environment for both prostitution and massage, and Section 1.3 sets up a conceptual framework to predict how changing barriers to entry for massage may impact the externalities associated with prostitution. Section 1.4 describes the natural experiment and Section 1.5 describes the new data used for empirical analysis. Section 1.6 outlines the identification strategy and Section 1.7 discusses the first set of

[8]In addition to highlighting the case of prostitution, this work also fits more generally into the literature on black markets and smuggling. While existing research has looked at the effects of regulation on smuggling-like behavior in the context of medical marijuana (Anderson et al. (2014), Pacula et al. (2015), Smart (2015)), cigarette taxes (Thursby et al. (1991), Yurekli and Zhang (2000)), and prescription pill diversion (Camera and Engelhardt (2014)), to my knowledge this is the first paper to empirically quantify the unintended consequences of black market regulation on legitimate firms.

empirical results on externalities and market structure. Section 1.8 discusses the policy reversal and presents the results on market structure and riskiness in the quasi-legal sector. Section 1.9 concludes.

1.2 Background

1.2.1 The market for prostitution in the U.S.

The sale and purchase of commercial sex, generally known as prostitution, is almost universally criminalized in the United States. With the exception of select rural counties in Nevada, the production, consumption, and facilitation of prostitution is illegal.[9] However, the market for prostitution continues to operate underground as a black market.

Estimates of the size of the prostitution market are scarce, due to the illicit nature of the black market. A more detailed study by the Urban Institute estimates $1 billion in annual revenue generated by prostitution markets in eight major U.S. cities.[10] Compared with the $689 million market for drugs and the $781 million market for unregistered weapons in those cities, prostitution makes up the largest underground market for an illegal good. California represents a significant portion of that market, with San Diego alone generating $124 million in annual prostitution revenue in 2003. Furthermore, cities can spend up to an estimated $7.5 million annually on efforts to control prostitution.[11] By all calculations, the U.S. black market for prostitution and its respective enforcement costs are significantly large.

The economic argument for regulation of prostitution largely stems from the negative externalities associated with the market and the idea that prostitution is not "a victimless

[9]Knowles (2013). Licensed brothels are legal in twelve counties in Nevada; however only eight counties have at least one active licensed brothel. As of 2008, there are an estimated 28 legal brothels in Nevada.

[10]Dank et al. (2014) estimates for cash-based underground markets in Atlanta, Dallas, Denver, Miami, San Diego, Seattle, and Washington DC in 2003.

[11]Pearl (1987)

crime."[12] Public health and crime externalities have long been linked with the market for prostitution.[13] Epidemiologically, commercial sex workers have multiple sexual partners and often engage in higher risk sexual behavior, thus experiencing greater risk and higher infection rates of HIV and other STIs. In particular, high risk sex and high STI rates are significant determinants of HIV transmission.[14] As such, the CDC cites sex work as a risk factor for gonorrhea and chlamydia, and sex workers comprise one of the key affected populations for HIV and AIDS.[15] Infants born to sex workers also experience higher rates of mortality, HIV, and STI complications.[16]

Exploitation of sex workers has also been well documented. Many sex workers are victims of human trafficking and work under coercion.[17] As of 2012, there have been an estimated 4.5 million victims of sex trafficking and an estimated 2 million sex trafficking victims are children.[18] There are both male and female sex workers; however, female sex workers outnumber male sex workers, while buyers are predominantly male.[19] Both involuntary and voluntary sex workers are more vulnerable to violent physical, sexual, and verbal abuse at the hands of their employers (e.g. traffickers, pimps, escort agencies) and clients.[20] This greater exposure to violence and infectious disease, in addition to drug use, results in an estimated 459 deaths per 100,000 sex workers every year – almost six times the fatality rate in the general population.[21] Consequently, occupational safety is a significant concern in the market for prostitution, especially in case of the unregulated

[12]Farley and Malarek (2008)

[13]Ross et al. (2012)

[14]Steen and Dallabetta (2003), Korenromp et al. (2005).

[15]Centers for Disease Control and Prevention (2010), International AIDS Conference (2014)

[16]Rekart (2006)

[17]Dank et al. (2014)

[18]International Labor Organization (2014), UNICEF (2005)

[19]Edlund and Korn (2002)

[20]Jaget (1980), Silbert et al. (1982), Nemoto et al. (2004), Rekart (2006)

[21]Potterat et al. (2004)

black market.

However, there is substantial product differentiation within the market for commercial sex, which creates heterogeneity in the severity of these health and crime externalities across prostitution types. Prostitution can be segmented into two broad sectors: street and indoor. Street prostitution is widely considered the most dangerous, with greater drug use among sex workers, greater violence and health risks due to lack of customer screening, and lower prices than the indoor sector.[22] Meanwhile, the market share for indoor prostitution has grown in the U.S., as the Internet has become an increasingly important facilitator through advertising, client communication and screening, and reputation-building review websites.[23] Indoor commercial sex can be further categorized into brothels, escorts, and erotic massage parlors. Brothels generally characterize the legal, regulated form of prostitution, as seen in the Netherlands, Germany, and Nevada. This paper focuses primarily on escorts and erotic massage parlors, which are cited as the most significant venues for the indoor black market in the U.S. Escorts account for approximately 41% of black market revenue, while erotic massage parlors are responsible for roughly 44% of prostitution revenue.[24]

Escort prostitution primarily differs from massage parlor prostitution in terms of regulation and organization. Escort prostitution is largely unregulated; sex workers operate informally and do not obtain any form of licensing. In contrast, erotic massage parlors are subject to occupational licensing for massage technicians and massage establishments under the local or state government. As such, I categorize these two types of prostitution firms in two different sectors that vary by legality: escorts work in the purely illegal prostitution sector, while erotic massage parlors are in the quasi-legal prostitution sector. Illegal prostitution firms operate by directing consumers to contact the escort agency or

[22]Potterat et al. (2004), Levitt and Venkatesh (2007)

[23]The Economist (2014)

[24]Percentages are calculated from the Erotic Review and Rubmaps data on market size, annual revenue estimates from Dank et al. (2014), and estimate market share for indoor prostitution from Urban Justice Center (2005)

sex worker online or by phone. Communication is facilitated through local newspaper and Internet classified advertisements such as Backpage. The prostitute will then arrange a meeting location, to where either the sex worker will travel ("outcall") or the customer will travel ("incall"); this location is generally not fixed (e.g. the sex worker will use different hotels and/or different hotel rooms). In contrast, the quasi-legal sector is organized into fixed, brick-and-mortar establishments, where the location is known to buyers beforehand.[25] Buyers visit the massage parlor and pay a given "house price" upfront for the massage; after the massage is done, the sex worker will evaluate the buyer and offer illicit services for an extra tip. Thus, quasi-legal firms effectively receive two prices: the legal price of massage and the illegal price of commercial sex.

Quasi-legal prostitution and illegal prostitution offer differentiated services and can be considered imperfect substitutes.[26] Health risks vary across prostitution types, as different sexual acts and health behaviors have different probabilities of disease transmission. One of the key differentiating product characteristics is condom use. Unprotected sex is associated with price premiums as large as 46%, which can be interpreted as a compensating wage differential for increased STI risk.[27] Other ways in which prostitutes differentiate themselves is through the types of sexual services offered and implicitly, the respective health risks associated with these sexual acts. Quasi-legal prostitutes are much more likely than illegal prostitutes to offer low-risk sexual activity, such as manual stimulation and protected oral sex. As such, the prevalence of STIs and risky sexual contact are lower in the quasi-legal sector than in the illegal sector.

Previous literature has also found that the degree of legality in prostitution markets

[25]The quasi-legal sector also poses a lower risk of arrest to buyers, since "reverse-sting operations," where law enforcement pose as sex workers in order to identify buyers, are highly unlikely in the quasi-legal sector where workers must be hired by the establishment owners.

[26]In a separate paper, Nguyen (2015b), I estimate the cross-price elasticity and confirm that quasi-legal prostitution and prostitution are substitutes. While I focus on the supply-side aspect of product differentiation for this paper, these product characteristics also interact with buyer characteristics. For example, buyers with low-risk preferences – both in terms of health risks and risk of arrest– will likely derive a higher utility from quasi-legal prostitution than illegal prostitution.

[27]Nemoto et al. (2004), Gertler et al. (2005)

can also affect crime. Cunningham and Shah (2014) show that decriminalizing prostitution significantly reduces rape, while Bisschop et al. (2015) find that where prostitution is legal, licensing can reduce drug-related crime and registered sexual assault. Thus, it is likely that the risk of sexual violence differs across illegal and quasi-legal sectors in the U.S. Due to a lack of monitoring, in-person customer screening, and third-party security in the illegal sector, particularly with outcall transactions, illegal sex workers are left considerably more vulnerable to violence by customers. In contrast, quasi-legal firms are run by establishment owners, who can vet customers at the door prior to meeting the sex worker. Quasi-legal sex workers are also not fully isolated with the customer, as there are usually other workers, customers, the establishment owner, and in some cases security on the premises. All of these factors contribute to a plausibly safer environment for quasi-legal sex workers.

In addition to health and violent crime externalities, there is still the concern of exploitation and coercion in both of these sectors. Since trafficked sex workers experience greater violence and lower condom use, one can expect that higher levels of trafficking also correspond to worse health and crime externalities.[28] While anecdotal evidence suggests that most child trafficking originates from the illegal sector and the majority of quasi-legal sex workers are voluntary, I cannot accurately measure trafficking at a granular level in existing data and do not use trafficking as an outcome of interest in this paper.[29]

1.2.2 The market for massage

The market for massage is sizable as well, with the American Massage Therapy Association (AMTA) estimating annual revenue at $11.7 billion for approximately 300,000

[28]Decker et al. (2010)

[29]Dank et al. (2014) estimates 70% of quasi-legal prostitutes in Dallas work voluntarily. In the U.S., quasi-legal massage parlors are typically staffed by foreign women, often from developing countries in East Asia, and have ties to organized crime. Meanwhile, illegal prostitution has been linked to sex trafficking, requiring websites such as Backpage to monitor their listings for the sexual exploitation of minors (Kristof (2012), Backpage.com v. McKenna, et al. (2012)).

massage therapists in 2014.[30] The AMTA cites health and wellness benefits associated with massage such as pain management, injury rehabilitation, and lower blood pressure. Massage technicians can work in a variety of settings, including medical spas, beauty salons, athletic clubs, as well as massage establishments. Larger massage parlors are frequently part of a franchise or chain, while smaller massage parlors are typically operated by Asian women, who are often immigrants with limited English proficiency.[31] Similar to other personal care services such as beauty salons, massage therapy is also subject to occupational licensing.[32]

However, unlike other personal care services, the massage industry has long been associated with the black market for prostitution. As a result, obtaining a massage technician license also requires fingerprinting and background checks, while licensing massage parlors can require additional background checks, costly conditional use permits for adult entertainment zoning, and prohibitively high massage establishment fees.[33] In many cases, these monetary and non-pecuniary barriers to entry are set specifically to discourage the quasi-legal prostitution sector.[34] And while occupational licensing under normal circumstances typically serves to the benefit of existing workers through reduced competition, the AMTA advocates for "fair and consistent licensing of massage therapy," in the form of lower licensing fees, comparable to other personal care services.[35]

The quasi-legal sector also impacts legal massage through competition. Since quasi-legal prostitution firms are also licensed and legally offer massage services, buyers are

[30]American Massage Therapy Association (2014)

[31]Nemoto et al. (2004), American Massage Therapy Association (2014), Flores and Wong (2015)

[32]A study by Thornton and Timmons (2013) finds no evidence of a well-functioning black market for legal massage as a result of occupational licensing; thus, it is reasonable to assume that observed massage firms are licensed.

[33]For example, San Diego municipal code for Development Services required an $8,000 conditional use permit, in addition to massage establishment license fees (City of San Diego Development Services (2008))

[34]Paterson (2014)

[35]Maurizi (1974), Shepard (1978), Kleiner (2000), American Massage Therapy Association (2014)

unable to perfectly observe firm legitimacy ex-ante. As a result, legal massage consumers may utilize quasi-legal firms, while quasi-legal consumers may also visit legal massage firms with the hopes of receiving extra illegal services. However, while quasi-legal prostitution cannot be substituted with massage, legal massage can be (imperfectly) substituted with quasi-legal prostitution. With the dual pricing structure of the quasi-legal sector, it is possible for quasi-legal firms to charge lower massage prices and make up profits with the higher prostitution prices, thus pricing some legal firms out of the market. Consequently, legal firms directly compete with quasi-legal firms, but not vice versa.

This competition externality is exacerbated by the additional costs of signaling legitimacy. For example, in order to signal legitimacy to legal consumers, legal firms may pay membership fees to join the AMTA or purchase advertising on Yelp. To signal legitimacy to quasi-legal consumers, legal firms may hire security to ensure that male customers do not inappropriately touch the female massage technicians.[36] Even with these additional expenses, legal massage firms may still be subject to costly sexual harassment against workers.

Thus, the markets for prostitution and massage are closely intertwined. Any changes in massage regulation is likely to ripple through each market, with significant consequences for the underground commercial sex economy. In the next section, I outline a conceptual framework for understanding how massage licensing regulation can impact black market externalities on health and crime.

[36]Excerpt from a Rubmaps.com review (2015) for Happy Foot Care Spa in San Gabriel, CA: "I tried to touch around but she would either move out of the way or try to block my hands in a sneaky way...There was a dude outside making sure nobody touches his girls"

1.3 Conceptual framework

1.3.1 STI transmission model

The epidemiology of STI transmission is particularly complex due to the interplay between population-level factors, such as prevalence within the partner pool, and individual-level factors, such as choice of sexual activity and condom use. To delineate how changes to barriers to entry in the quasi-legal prostitution sector may affect health externalities, I use a simple model for STI transmission from Shiboski and Padian (1996).[37]

The outcome of interest is the number of new infectives in the next period, I_{t+1}, which follows a binomial distribution with parameters S_t, the current number of susceptibles, and Pr(infected), the transmission probability. Assuming that susceptible individuals share the same average level of sexual activity, then one can model STI transmission from period t to $t+1$ as follows:

$$I_{t+1} = S_t[\Pr(\text{infected})] \tag{1.1}$$

where the probability of STI transmission takes on the functional form:[38]

$$\Pr(\text{infected}) = 1 - \exp(-\nu\rho_t\theta) \tag{1.2}$$

An individual's probability of STI transmission depends on the degree of exposure to infected partners and the nature of the sexual contact once exposed to an infected partner. Thus, the probability of infection for an individual is a function of ν, the average number of partners each susceptible individual contacts, ρ_t, the STI prevalence in the pool of potential partners in the current period, and θ, the probability of infection, conditional

[37] Shiboski and Padian (1996) review both population- and individual-based approaches to STI transmission.

[38] While the epidemiology literature has used various functional forms to estimate risk factors for transmission, I abstract from this question and choose the simple functional form proposed by the authors in order to focus on the relationships of interest in my paper.

on contact with an infectious partner. Plugging equation (1.1) into equation (1.2), STI group prevalence can be expressed as a function of these population- and individual-level parameters:

$$I_{t+1} = S_t[1 - \exp(-\nu\rho_t\theta)] \tag{1.3}$$

Massage licensing and the black market

To understand how massage regulation impacts the parameters of STI prevalence, consider a reduction in licensing fees for massage parlors. Figure 1.1 depicts how the aggregate quasi-legal prostitution market responds when barriers to entry fall. Potential quasi-legal entrants who would not have previously entered the market now find it profitable to enter and operate as a massage parlor, increasing quasi-legal supply at the extensive margin. These new quasi-legal firms increase the total size of the black market, $N = N_{quasi} + N_{illegal}$. Additionally, the quasi-legal sector may also grow due to switching from the illegal sector. This increase in quasi-legal supply at the intensive margin does not increase the total size of the black market; rather only the risk composition of prostitution changes. Overall, when the supply of quasi-legal prostitution, N_{quasi}, increases, quasi-legal consumption rises and price falls. The drop in quasi-legal price, P_{quasi}, has important implications for the individual risk behavior of sex workers, as well for the illegal prostitution sector, since the two types of prostitution are substitutes.

Figure 1.2 depicts how the aggregate illegal prostitution market responds to a reduction in massage licensing fees. When barriers to entry fall and some illegal prostitutes switch to quasi-legal firms, the intensive margin response reduces illegal prostitution supply, $N_{illegal}$. At the same time, since illegal and quasi-legal prostitution are substitutes, the demand for illegal prostitution falls and consumers substitute towards the relatively cheaper quasi-legal sector. As a result, illegal consumption unambiguously decreases; however, illegal price may increase or decrease. The net change in illegal price depends on which effect is larger – the substitution effect on demand or the intensive margin effect on supply. By observing the changes in quasi-legal and illegal prices, I am able to verify

the expected changes in consumption.

These changes in size and composition affect the prevalence of STIs through two channels: the size of the sex worker population and the riskiness of sexual contact. First, the population of susceptible individuals will be a function of the total size of the black market: $S_t = S_t(N)$. Second, the probability of selecting an infected partner will depend on the size of the high-risk illegal sector: $\rho_t = \rho_t(N_{illegal})$. Lastly, the probability of infection conditional on selecting an infected partner will depend on quasi-legal prices, which vary with the size of the low-risk quasi-legal sector: $\theta = \theta(P_{quasi}(N_{quasi}))$. Consequently, licensing fees f affect STI prevalence through the population-level parameters $S_t(N)$ and $\rho_t(N_{illegal})$, and the individual-level parameter $\theta(P_{quasi}(N_{quasi}))$.[39] The marginal effect of raising massage licensing fee f on STI prevalence I_{t+1} can be expressed as a function of prostitution market structure:

$$\frac{\partial I_{t+1}}{\partial f} = \frac{\partial S_t}{\partial N}\frac{\partial N}{\partial f}[1 - \exp(-\nu\rho_t\theta)] + S_t\Big[- exp(-\nu\rho_t\theta)\Big(- \nu\theta\frac{\partial \rho_t}{\partial N_{illegal}}\frac{\partial N_{illegal}}{\partial f} - \nu\rho_t\frac{\partial \theta}{\partial P_{quasi}}\frac{\partial P_{quasi}}{\partial N_{quasi}}\frac{\partial N_{quasi}}{\partial f}\Big)\Big] \quad (1.4)$$

Therefore, changes in the total size and composition of the black market for prostitution determine the net impact of changes in licensing fees on STI prevalence.

STI prevalence and the size of the black market

Epidemiological simulations have shown that an increase in the size of the sex worker population relative to the general population increases the overall prevalence of gonorrhea.[40]

[39] I assume that the average number of partners, ν is not changing. However, the epidemiological model can be modified to allow ν to be a function of illegal prostitution consumption, $Q_{illegal}$. The general implications still hold, although I cannot verify this in the data since I cannot distinguish between regular and new partnerships. Under the current assumptions, markets with a higher proportion of "regular" customers will have lower rates of STIs.

[40] Ghani and Aral (2005). The same study finds that the the relative size of the client population is not a significant factor in determining prevalence.

This relationship can be shown by examining the effect of licensing fees on the number of susceptibles, S_t. The total population of susceptible individuals is an increasing function of the total supply of prostitution, N:

$$\frac{\partial S_t}{\partial N} > 0 \tag{1.5}$$

Furthermore, I hypothesize that the total supply of prostitution N is a decreasing function of massage licensing fees, as higher barriers to entry cause the black market to shrink:

$$\frac{\partial N}{\partial f} < 0 \tag{1.6}$$

Therefore, the relationship between the population of susceptibles and fees can be expressed as follows:

$$\frac{\partial S_t}{\partial N}\frac{\partial N}{\partial f} < 0 \tag{1.7}$$

The larger the barriers to entry, the smaller the supply of prostitution and the smaller the population of susceptibles. As a result, the first term in equation 4 is negative.

STI prevalence and the riskiness of the black market

At the population-level, the distribution of black market activity across the illegal and quasi-legal sectors will also impact the prevalence of STIs through the riskiness of partner choice. The illegal prostitution sector has lower rates of condom use and higher rates of high-risk sexual activity, relative to the quasi-legal sector. Existing epidemiology literature finds that condom use significantly reduces the prevalence of STIs and HIV among sex workers, while high-risk sexual contact such as vaginal and anal intercourse increases the risk of transmission.[41] Consequently, STI prevalence should be higher in the illegal sector, making the probability of choosing an infected partner an increasing

[41]Ngugi et al. (1996), Aklilu et al. (2001), Dunkle et al. (2005), Sarkar et al. (2005), Rojanapithayakorn (2006), Lawan et al. (2012)

function of illegal sector supply:

$$\frac{\partial \rho_t}{\partial N_{illegal}} > 0 \tag{1.8}$$

Meanwhile, if barriers to entry for the quasi-legal sector fall, then some illegal sector firms will find it profitable to exit and switch to the quasi-legal sector. Consistent with Hopenhayn (1992), firms in the sector with lower barriers to entry should have less selection and higher expected lifetime. Consequently, I hypothesize that the size of the illegal sector is an increasing function of barriers to entry for the quasi-legal sector:

$$\frac{\partial N_{illegal}}{\partial f} > 0 \tag{1.9}$$

Thus, licensing can affect population-level risk factors for STI infection by changing STI prevalence among potential partners.

Licensing may also impact individual-level risk factors for STI infection by changing the riskiness of sexual contact, conditional on selecting an infectious partner. Gertler and Shah (2011) model a wage premium for unprotected sex that serves as a compensating risk differential for sex workers; the quasi-legal price captures this risk premium. Hence, I hypothesize that when quasi-legal prices increase, the risk premium and incidence of high-risk activity also increase:

$$\frac{\partial \theta}{\partial P_{quasi}} > 0 \tag{1.10}$$

And as shown in Figure 1.1, quasi-legal price is inversely related to quasi-legal supply, and quasi-legal supply is inversely related to licensing fees:

$$\frac{\partial P_{quasi}}{\partial N_{quasi}} < 0 \tag{1.11}$$

$$\frac{\partial N_{quasi}}{\partial f} < 0 \tag{1.12}$$

Thus, higher barriers to entry may induce sex workers to increasingly engage in high risk activity, such as intercourse and unprotected sex, in order to capture a larger wage premium.

From equations 1.8 through 1.12, I can then derive the following expression for the marginal effect of licensing fees on the probability of infection:

$$-exp(-\nu\rho_t\theta)\Big[-\nu\theta\frac{\partial\rho_t}{\partial N_{illegal}}\frac{\partial N_{illegal}}{\partial f}-\nu\rho_t\frac{\partial\theta}{\partial P_{quasi}}\frac{\partial P_{quasi}}{\partial N_{quasi}}\frac{\partial N_{quasi}}{\partial f}\Big]>0 \qquad (1.13)$$

If barriers to entry increase, then both the pool of potential partners and the nature of sexual contact become riskier, increasing the probability of infection. Consequently, the second term in equation 1.4 is positive. This suggests that the marginal effect of licensing fees on STI prevalence depends on which effect is larger: the change in S_t due to changes in the total size of the black market, or the change in Pr(infected) due to changes in the riskiness of the black market. This is the key empirical question of this paper, with equations 1.4, 1.6, 1.9, 1.11, and 1.12 representing the key parameters for estimation.

1.3.2 Rape

Farley (2005) argues that increasing the total size of the black market for prostitution always increases sexual violence against sex workers. However, there are two possible mechanisms through which reducing barriers to entry may actually reduce the incidence of rape. The first plausible explanation, which affects rape among sex workers, is a change in the riskiness of the black market via the latent distribution of illegal and quasi-legal firms. If barriers to entry fall and more illegal sex workers and buyers switch to the relatively safer quasi-legal sector, then the incidence of rape among all sex workers decreases.

A second explanation, which affects rape among the general population, is an improved "matching" mechanism, as modeled by Bhuller et al. (2013).[42] In this context,

[42]Bhuller et al. (2013) documents how greater Internet accessibility increases the incidence of sex crime. They propose several possible mechanisms for this effect: reporting, matching, and a direct effect

growth in the size of the black market and increased access to quasi-legal prostitution may allow for better matching of commercial sex buyers and sellers. Potential offenders who would normally commit acts of sexual assault in the general population can find better quality matches in a consensual outlet with voluntary sex workers. In this context, marginal offenders substitute away from sexual violence towards quasi-legal prostitution.[43] As a result, the incidence of rape in the general population falls when barriers to entry for massage are reduced.

Given the available data, which only reports rape rates for the general population, I cannot separately identify which mechanisms are present and driving any observed changes. Thus, this paper focuses on identifying the net effect on rape in the general population, including sex workers.

1.4 State policy as a natural experiment

While there is no massage regulation at the federal level in the U.S., all but six states have some form of state regulation. California is one of the more recent states to implement massage licensing.

Prior to 2009, California did not directly regulate the massage industry. During this period, all licensing and enforcement was handled at the city-level. In addition to the standard business license, most cities also required individual workers to have a massage technician license and firm owners to have a massage establishment license. The costs of these regulatory licenses were determined by the local city government. These fees covered the costs of administrative processing, background checks (often through the police or public health department), and additional investigative inspections. Furthermore, in many cities, massage establishment fees were set to be prohibitive, often requiring an expensive conditional use permit and special zoning, similar to adult entertainment

on sex crime propensity.

[43] Posner (1992)

businesses. Licenses required annual renewal, usually at a cost comparable to the initial entry fees.

Due to lobbying from the legal massage sector and the California Chapter of the AMTA, in 2009, California passed SB731, establishing the California Massage Therapy Council (CAMTC), a nonprofit that issued voluntary state licenses for massage therapists.[44] If individual workers had CAMTC-issued state licenses, they were exempt from paying any local regulatory massage license fees. Meanwhile, SB731 did not regulate owners of massage establishments. As long as all employees held state licenses, then the business was exempt from paying any local massage establishment fee. CAMTC fees were $150 renewed biannually and covered the cost of the certification process, including fingerprinting and background checks. At an average cost of $75 per year, the new CAMTC licensing system represented a significant reduction in total massage licensing fees for many cities. Furthermore, by removing affected cities' power to enforce special zoning requirements and conduct additional inspections, the CAMTC system also decreased the non-pecuniary costs of licensing regulation, which were especially large for quasi-legal firms.[45] For an industry characterized by small businesses, this policy change represented a significant reduction in barriers to entry, for both legal massage and quasi-legal prostitution firms.[46] Thus, from 2009 to 2014, the effective cost of entry for all massage parlors decreased in cities where the local licenses were more expensive than the state license. The effective cost of entry for massage parlors remained the same in cities where the local licenses were still cheaper than the state license. As a result, some cities' regulatory fees remained constant over the treatment period, while other cities experienced varying levels of fee changes. Figure 1.3 shows the distribution of fee declines,

[44]McLeod (2010). One may be concerned that the timing of the state law is correlated with the black market for prostitution and its externalities. However, news coverage of SB731 confirms that the initial policy was simply the result of lobbying efforts by the legal massage sector, unrelated to health and crime outcomes associated with the black market for prostitution.

[45]For instance, after 2009, massage firms that were raided and identified as quasi-legal could easily re-open with a new establishment owner, rather than shut down for the period of investigation and prosecution (Gold (2014)).

[46]American Massage Therapy Association (2014), Dank et al. (2014).

expressed as a percentage of the initial fee level; there is significant heterogeneity in fee changes across cities.

With SB731 scheduled to sunset in 2015, California policymakers passed an amended bill, AB1147, which retained the CAMTC state license option but restored city-level establishment licenses. The new legislation maintains the same state license exemption for individual massage technicians, but allows cities to require similar zoning requirements and massage establishment fees from firm owners as well. As a result, many cities experienced an increase in massage regulatory fees and barriers to entry in 2015.

Thus, there are two treatment periods for each policy change: the treatment period for the fee decrease, post-SB731, lasted from 2009 until 2014, and the treatment period for the fee increase, post-AB1147, covers 2015. Figure 1.4 illustrates the impact of the changes in state regulation on average massage licensing fees over time. In cities where the state licensing fee was not binding, there is no significant change in the effective licensing fee level. In cities where the state licensing fee was binding, there is a considerable drop in fees from 2009 until 2015, when fees increased again.

The empirical analysis of this paper will begin by examining the effect of the fee decrease in 2009 on health and crime externalities and the size of the total massage market. I then exploit both the initial fee decrease and the policy reversal in 2015 to estimate the effects on the size of the legal massage market and the market structure of illegal prostitution. Due to data limitations, the quasi-legal prostitution sector cannot be reliably observed prior to 2009, so I utilize the policy reversal to directly quantify the impact on quasi-legal market structure and risk behavior.

1.5 Data

1.5.1 Licensing fees

To exploit this state policy natural experiment, I collected the regulatory fees for massage parlors, retail businesses, and professional services over time from each city. The

appropriate local government agencies – e.g. business license divisions, police departments, planning departments – were contacted by phone and email to provide the city's regulatory fee schedule before and after each state policy change in 2009 and 2015. Table 1.1 reports the average fees before and after each policy change. Prior to 2009, fees are relatively stable, only adjusting for inflation in select cities. Information on state licensing fees, which remained constant from 2009-2015, was gathered from the CAMTC website.

1.5.2 Health and crime

For health and crime outcomes, I use data from the California Department of Public Health and the Uniform Crime Report (UCR).[47] Table 1.2 reports the summary statistics for health and crime externalities over the observed time period. Under state mandate, healthcare providers must report STI data on chlamydia and gonorrhea to the California Department of Public Health. I observe the STI counts and rates for each local health jurisdiction from 2006 to 2014. This data is reported for the total population, as well as by race and gender. For data on sexual violence, I utilize UCR crime data on rape reports from 2006 to 2012.[48]

1.5.3 Market structure

One of the most significant challenges to analyzing illegal markets has been the paucity of detailed data on supply and prices. However, with the rapid growth of Internet access and utilization, the web has become an increasingly useful and rich source of data on illegal black markets. In particular, seller-submitted online business listings with buyer-submitted reviews have become popular among economists as an approximation of the indoor market for prostitution (Edlund et al. (2009), Cunningham and Kendall (2010),

[47]Federal Bureau of Investigation (2012), California Department of Public Health (2014)

[48]In 2011, the FBI approved a broader definition of forcible rape that includes assaults against male victims. This definition went into effect in 2013, hence my analysis ends in 2012.

Cunningham and Kendall (2011a), Cunningham and Kendall (2011b), Cunningham and Shah (2014), Dank et al. (2014)). The proportion of black market transactions captured by these data sources is significant, as the Internet has become a critical facilitator in commercial sex transactions, and prostitution firms find it in their best interests to advertise and cultivate reputation online. In order to empirically estimate the effects of licensing on the size and composition of the black market for prostitution, I have assembled a unique new dataset that combines public records with Internet review data for the state of California.

For annual data on the total licensed market for massage, which includes both legal and quasi-legal workers, I utilize the American Community Survey (ACS), using the six-digit NAICS industry codes to identify massage parlor workers and massage technicians.[49] At the public use microdata (PUMA) level, I observe the number of people working in the massage parlor industry and as massage technicians from 2006 to 2013.[50] At the individual level, I observe data on labor (employment, income, hours worked) and socioeconomic characteristics (race, gender, education). Together, this data represents the total supply of legal massage and quasi-legal prostitution, both of which are subject to the same occupational licensing regulations.

To separately identify the effects of regulation on legal massage, quasi-legal prostitution, and illegal prostitution firms, I utilize data from the review websites Yelp, Rubmaps, and the Erotic Review, respectively.[51] These online business listings and buyer-submitted reviews report information on market size and geographic location over time.[52] Yelp is

[49]Ruggles et al. (2015). NAICS industry code for massage parlor workers is 812199 and 621399 for massage technicians.

[50]PUMAs roughly correspond to cities or clusters of cities.

[51]Yelp.com (2015), Rubmaps.com (2015), TheEroticReview.com (2015)

[52]While all cities have equal access to these websites, one may be concerned that utilization by both buyers and sellers is growing differentially across treated and control cities. To check this, I compiled news articles and Google queries for each website over time, as a measure of awareness of these websites. Mentions of the Erotic Review are stable over time and across California cities. After the formation of Rubmaps, there is a spike in queries and news mentions for Rubmaps; however, the number of articles mentioning Rubmaps remains stable across California cities thereafter. Overall, I do not find evidence of selection into the Erotic Review or Rubmaps; see Data Appendix for further details.

a popular business listing website sourced by public records, third party data providers, and user submissions. Listings and reviews are filtered for "inappropriate content" such as lewdness, as set by Yelp's community guidelines. To measure the legal massage market, I filter the sample of Yelp businesses categorized under the search term "massage" and exclude any firms that also appear on the quasi-legal prostitution website, Rubmaps. Both the Erotic Review and Rubmaps websites both cater to the black market for prostitution, operating under the disclaimer of "fiction" written for fantasy purposes, despite common knowledge to the contrary.[53]

The Erotic Review represents the illegal sector, as measured by individual escorts, whose services can range from escort and outcall massage services to niche markets such as S&M. Meanwhile, Rubmaps represents the quasi-legal sector, as measured by erotic massage parlors. These websites operate in the same manner as Yelp, with seller-reported business listings and consumer-submitted reviews, but also provide further details on illegal transactions, e.g. prices paid, services offered, and sex worker characteristics. Through the services offered, I am able to observe the incidence of riskier health behaviors, such as foregoing condoms and offering "full service" intercourse, at the transaction level over time. Table 1.3 reports the summary statistics for the massage and prostitution markets over the observed time period. I merged this final dataset with city and PUMA level demographic variables from the Census.[54] For more details on the Internet data collection, please refer to the Data Appendix.

Table 1.4 compares the distribution of product characteristics in the illegal and quasi-legal prostitution sectors. Data from the Erotic Review and Rubmaps shows that the quasi-legal prostitution sector is much more likely to trade services that carry a lower risk of STI transmission than the prostitution sector. Quasi-legal prostitution firms most frequently offer manual stimulation, whereas illegal prostitution firms most frequently offer intercourse. Unprotected sex is also much more likely in the illegal prostitution

[53]Cunningham and Kendall (2011a), Cunningham and Kendall (2011b), Dank et al. (2014), The Economist (2014)

[54]United States Census Bureau (2014)

sector, with 42% of illegal prostitutes offering oral sex with no condom as opposed to only 5% of quasi-legal transactions. Thus, the distribution of the black market across sectors is likely an important determinant of overall STI prevalence.

1.6 Empirical strategy

In order to understand the impact of regulatory licensing fees on externalities and the markets for prostitution and massage, I am interested in estimating β in the following model for STI prevalence:[55]

$$ln(STI_i) = \alpha + \beta MassageFee_i + X_i\lambda + \mathcal{E}_i$$

and β in the following model for rape and prostitution market structure:

$$Y_i = \alpha + \beta MassageFee_i + X_i\lambda + \mathcal{E}_i$$

where Y_i is a vector of city-level outcome variables – rape, N_{quasi}, $N_{illegal}$, P_{quasi}, $P_{illegal}$ – and X_i is a vector of city-level covariates such as city-average education, race, income, etc. β represents the effect of changing massage licensing fees on the externalities and market outcomes of interest. Understanding the sign and magnitude of β for each outcome is necessary in order to evaluate the effectiveness of licensing regulations.

Ordinary least squares (OLS) estimates of β are unbiased in this model if and only if massage licensing fees are uncorrelated with local unobservables $\mathcal{E}_i$. Thus, licensing fees are endogenous if local governments set them in a way that is correlated with the city's underlying demand for quasi-legal prostitution, relative to illegal prostitution. There is anecdotal evidence of this being the case in cities with relatively large quasi-legal sectors. For instance, government officials from Marina explained that the fees were meant to serve a prohibitory function: "...the rules governing these businesses [were] designed to

[55]I use a log-linear regression to reflect the nonlinearity STI transmission. The results are similar in size and magnitude for the linear approximation.

discourage them, as Marina was adjacent to a large military base from early in the 20th century."[56] Since proximity to the military base's large male population resulted in high demand for quasi-legal prostitution, the city of Marina endogenously set high licensing fees. As a result, the correlation between massage fees and demand for quasi-legal prostitution is likely positive.

Furthermore, the correlation between quasi-legal supply and quasi-legal demand is positive, but the correlation between illegal supply and quasi-legal demand is negative, since the sectors are substitutes. Thus, OLS estimates of β for quasi-legal sector outcomes are positively biased, while OLS estimates of β for illegal sector outcomes are negatively biased. Since externalities are directly related with the illegal sector, OLS estimates for β on externalities should also be negatively biased. Measurement error is another possible source of bias. Massage licenses often required separate paperwork and fees from the standard business license tax form, involving multiple agencies such as the police and planning departments. In many cases, massage fees were not printed on forms but had to be collected verbally from city officials. As a result, there is likely to be some measurement error in the reporting of massage licensing fees, also biasing estimates of β downwards.[57]

To address the concerns of endogeneity in licensing fees, I employ a difference-in-differences approach to estimate the effect of lowering licensing fees in cities where the state policy is binding. To address further concerns of measurement error and differential trends in unobservables, I repeat the difference-in-differences analysis while instrumenting for massage licensing fees with the business license fees for unrelated occupations such as retail and professional services.

[56]Paterson (2014)

[57]Nonetheless, I expect the most significant source of bias to be the endogeneity of licensing fees. I compare ordinary least squares estimates for the pre-treatment years with the difference-in-differences and instrumental variables results of this paper. Estimates of β appear biased towards zero in the ordinary least squares specification, supporting the positive correlation between licensing fees and unobservables such as quasi-legal demand.

1.6.1 Difference-in-differences with state policy impact

While city-level licensing fees may be endogenous, the level and timing of the state licensing fee is likely to be uncorrelated with unobservables at the city-level, such as the local demand for quasi-legal prostitution. Thus, I can use geographic variation in the impact of state policy changes as exogenous shocks to suppliers' entry costs. The treated group consists of cities for which state license fees were binding, while the control group consists of cities for which state license fees were not binding.

Employing a difference-in-differences framework, I estimate the following regressions for city i and year t:[58]

$$ln(STI_{it}) = \alpha + \beta MassageFee_{it} + \delta Year_t + \gamma_i + W_{it}\lambda + \mathcal{E}_{it} \tag{1.14}$$

$$Y_{it} = \alpha + \beta MassageFee_{it} + \delta Year_t + \gamma_i + W_{it}\lambda + \mathcal{E}_{it} \tag{1.15}$$

controlling for time trends, city fixed effects, and observable group trends in relevant covariates, W_{it}. In order to capture different intensities of treatment, I use the fee level over time, $MassageFee_{it}$, as a continuous treatment variable. For control cities, the fee level remains unchanged over each treatment period. Meanwhile, cities that experience larger fee changes are allowed to have a higher treatment intensity in order to reflect the state policy having a greater impact on local barriers to entry. Thus, β represents the effect of an incremental change in the city-level massage licensing fee.[59]

The difference-in-differences identification strategy relies on the assumption that there are common group trends over time: trends in local unobservables are uncorrelated with how much fees change due to state policy. For example, if quasi-legal demand is growing

[58] Observations are at the PUMA and MSA level for the massage market regressions

[59] One may be concerned that any observed changes in Y are not due to changes in the actual market structure, but rather firm and buyer migration. For example, if the initial policy change simply reduces firm and buyer migration from high-cost cities, then the city-level regression is capturing a change in the spatial distribution of externalities, not a change in total levels. To address this concern, I replicate my analysis at various levels of aggregation, e.g. county and MSA level, and find that the results are robust. I also graph the market size time series for California as a whole, and still observe increased growth in quasi-legal massage supply.

faster relative to illegal demand in treated cities at the time of the policy change, then the difference-in-differences regression may still be biased. Figures 1.5, 1.6, and 1.7 show that this assumption appears valid for some outcomes such as the number of legal firms, STIs, and rape; the trends do not diverge prior to 2009. However, for other outcomes, the validity of this assumption is not graphically evident.[60]

Possible violations of the common trends assumption could be generated by other relevant policies coinciding with the state massage policies, as well as endogenous timing and choice of the state licensing fee level.[61] However, I use both variation in fees from the initial policy change in 2009 and the subsequent policy reversal in 2015, and find that the coefficient on fees remains the same throughout. Thus, it is unlikely that the results can be explained by pre-existing trends or another policy change that takes place without a reversal in 2015. Consequently, the biggest threat to identification remains possible differential trends in unobservables over the treatment period.

1.6.2 Instrumenting for massage fees over time

To further address concerns of bias in the difference-in-differences specification, I propose instrumenting for massage licensing fees using business fees for other types of firms, namely, professional services and retail. The first stage specification is as follows:

$$MassageFee_{it} = \omega + OtherBusinessFee_{it}\tau + \eta Year_t + \psi_i + W_{it}\zeta + u_{it} \tag{1.16}$$

[60] I have also replicated the results excluding outlier observations as well as Los Angeles, where multiple geographic markets are subject to the same regulatory licensing. I have also restricted the sample to treated cities, excluding cities that were completely unaffected by the state policies. The results are robust to these exclusions.

[61] I searched news archives for articles mentioning other prostitution, massage, sexual health, and domestic violence related policies in California over the treatment period. There are no specific health or violence related programs; however, the city of Los Angeles did begin to phase in a prostitution-targeted program in 2008 called the Prostitution Diversion Program. The intent of this program was to reduce demand for prostitution. However, this program targeted buyers in the street sector, rather than the indoor illegal or quasi-legal sectors. Furthermore, I find that my results are robust to excluding Los Angeles. I also exclude cities with news articles mentioning large prostitution raids and find similar results.

where $OtherBusinessFee_{it}$ is a vector that includes business fees for retail businesses and professional service businesses.

Massage licensing fees serve several purposes. First, at minimum, massage licensing fees must cover administrative processing costs. These fees may also reflect the local business climate and demand for business tax revenue. Second, the fees may also cover the cost of public health inspections, police investigations, and background checks. Third, the fees may serve a prohibitory function, set at higher levels specifically to discourage quasi-legal prostitution entry. These determinants can be categorized into exogenous and endogenous factors. Administrative costs and general business tax revenue demand arguably make up the exogenous portion of total massage fees, as they are most likely uncorrelated with city-level demand for prostitution. However, the costs of enforcement and prohibitory incentives are correlated with city-level demand for prostitution, and thus make up the endogenous portion of total massage fees.

The basis for this instrument is to predict the variation in massage fees using only variation in administrative costs and general business tax revenue demand, as proxied by business fees for other industries that are not subject to enforcement and prohibitory incentives. These fees are also arguably less prone to measurement error than massage licensing, since these fees are always clearly published on the standard business license form. In order for $OtherBusinessFee_{it}$ to serve as valid instruments, the level of other business fees must strongly predict massage licensing fees ($Corr(OtherBusinessFee_{it}, MassageFee_{it}) \neq 0$) but remain uncorrelated with any changes in local demand for massage and prostitution over the treatment period ($Corr(OtherBusinessFee_{it}, \mathcal{E}_{it}) \neq 0$).

Relevance assumption

Fees for other occupations capture the administrative costs of processing and local business climate, which determine the base level for massage-specific fees as well as fees for retail and professional service businesses. The first stage excluded instruments tests support the strength of using other business fees as an instrument. The smallest F-test

statistic for the excluded instrument is 36.08, well above the rule of thumb for weak instruments.

Exclusion restriction

Fees for other occupations should not directly affect prostitution and massage costs or local STI and crime rates. License fees for other occupations may violate the exclusion restriction for instrumental variables if unobservable changes in local markets for prostitution and massage are correlated with the changes in other business fees over time. This would be the case if other fees grow differentially across treated and control cities due to different trends in the local business climate and demand for tax revenue. However, qualitative evidence from interviews with local government officials suggests that this is unlikely, since changes in these fees are approved one to two years in advance and generally only set to adjust for state measures of inflation. Using retail business fees and professional service fees as instruments for massage fees, I also conduct a test of over-identifying restrictions and fail to reject instrument validity. Going forward, I assume that the trends in retail and professional service fees are uncorrelated with trends in unobservables such as relative demand for quasi-legal prostitution.

1.7 Results

1.7.1 Prostitution externalities

Health externalities: gonorrhea and chlamydia

I estimate equation 1.14 and identify the effect of the fee decrease on gonorrhea and chlamydia rates for the general population and for Asian females. Ex-ante, if the fee decrease had an impact on health outcomes, I expect to see the strongest effects on gonorrhea and in the Asian female sample. Due to greater symptom visibility, gonorrhea is typically endemic to the high-risk heterosexual population, since high-risk individuals are

more likely to continue engaging in sexual activity even after becoming symptomatic.[62] In contrast, chlamydia has low symptom visibility and thus can spread more easily through the general population, including low-risk individuals who are less likely to be involved in the black market for prostitution. Furthermore, I expect to see stronger results in the Asian female population, as this demographic group makes up 94.3% of quasi-legal workers.

Table 1.5 reports the results for both gonorrhea and chlamydia, controlling for city-year covariates. Instrumenting for massage fees significantly increases the magnitude of the difference-in-difference coefficients, suggesting measurement error in massage licensing fees and that cities that experience larger fee reductions do have significantly faster growing demand for quasi-legal prostitution. Thus, I use the instrumented difference-in-differences as my preferred specification.

Columns 1-4 show that reducing the barriers to entry for massage significantly decreases gonorrhea rates for both the general population and Asian females. For the instrumented estimates in column 2 and the mean fee change, gonorrhea rates decrease by approximately 16.3%. Using the estimates in column 4, the gonorrhea rate among Asian females decreases by approximately 13.5%. At the means, a 1% reduction in fees decreases the gonorrhea rate by 0.18% for the general population and 0.15% for Asian females, on average. These findings are consistent with the prior that buyers and sellers of commercial sex are especially vulnerable to gonorrhea.

Columns 5-8 report the results for chlamydia, finding similar effects among Asian females, but not the general population. For the instrumented estimates in column 8 and the mean fee change, Asian female chlamydia rates decreased by approximately 1.73%. This corresponds to an elasticity with respect to licensing fees of 0.019. These findings are consistent with the prior that Asian women working in the quasi-legal sector are particularly vulnerable to chlamydia infection. The lack of an effect on chlamydia rates in the general population seems to suggest that the health benefits of such a policy

[62] Cunningham and Shah (2014)

are most significant for the high-risk population. It also serves as a placebo check that there are no other general sexual health-related policies or trends coinciding with the changes in massage licensing.

The overall reduction in health externalities as a result of reduced barriers to entry suggests that the shift in black market riskiness dominates any increase in total black market size. Furthermore, the true gains to health may be even larger than reported in this paper, as sex workers infected with gonorrhea have a higher risk of HIV infection and consequently, improving gonorrhea rates can also reduce HIV prevalence.[63]

The magnitudes of these results are significant when compared with other regulatory efforts targeting the commercial sex market. Gertler and Shah (2011) find that increasing licensing enforcement in the street sector by one standard deviation reduces the probability of ever having any STI (syphillis, chlamydia, and gonorrhea) by 11% among sex workers in Ecuador. Taking the Asian female sample results as a proxy for the effect on sex workers, the 13.5% reduction in gonorrhea rates found in this paper appears reasonably effective. Furthermore, licensing enforcement through police raids is costly, whereas reducing licensing fees to a level that is comparable to other personal care services only reduces the excess revenue collected.[64] Thus, reducing prohibitively high licensing fees to a more moderate level can be a potentially cost-effective approach to alleviating the health externalities associated with sex work.

Crime externalities: rape

Table 1.6 provides evidence that reducing barriers to entry for massage also reduces the incidence of rape. For the instrumented estimates in column 4 and the mean fee change, the incidence of rape decreases by 5.22 cases, or by approximately 19.27% of the mean number of rape cases prior to SB731. A 1% decrease in fees corresponds to a 0.14%

[63]Dunkle et al. (2005)

[64]In the context of California cities, this excess revenue was not directed towards any special programs for sex workers.

decrease in rape cases. As the data represents only reported rape cases, these results can be interpreted as a lower bound for the effect on sexual violence.[65]

In other literature, Cunningham and Shah (2014) report up to a 45% reduction in female gonorrhea cases and a 39% reduction in rape cases following the de facto decriminalization of indoor prostitution in Rhode Island. To simulate a change in licensing fees comparable to the scale of full decriminalization, I consider a 100% reduction in licensing fees. Using the elasticity estimates at the mean fee, there is a 19% reduction in gonorrhea rates and a 28% reduction in rape cases.[66] The improvements to health are about half as effective, but the results for rape are comparably large. Furthermore, these effects would be even larger in areas with high fees and therefore larger fee reductions. This suggests that, even in the presence of political constraints that may limit the possibility of full decriminalization, similar improvements to health and crime can be achieved by allowing free entry into the quasi-legal prostitution sector.

1.7.2 Market structure

To explore the mechanisms behind my findings on externalities, I need to estimate equations 1.6, 1.9, 1.11, and 1.12 from the epidemiological model. In this section, I show that reducing the barriers to entry for massage increases the size of the black market, as in equation 1.6, but reduces the size of the illegal sector, as in equation 1.9.

Total massage market

First, I examine whether or not lowering barriers to entry had the expected effect – more entry into the formal massage market. Columns 1 and 2 of Table 1.7 report the results for the supply of workers in the formal massage industry. Since the Census

[65]Assuming that sex workers are not more likely to report rape than the general population. This assumption seems reasonable, given the covert nature of the market. Church et al. (2001) finds evidence that sex workers are actually less likely to report an assault.

[66]The elasticities with respect to licensing fees at the mean fee for treated cities is 0.19 for Asian female gonorrhea rates and for 0.28 forcible rape; the mean fee for treated cities is $936.

data does not distinguish between legal and quasi-legal activity, I capture entry in the total massage market. For all specifications, the coefficient on massage licensing fees is negative and statistically significant: higher fees result in fewer massage workers. While the instrument estimates get larger in magnitude, as expected, the changes in magnitude are small compared to the previous results on externalities. This may be due to the negative bias from measurement error attenuating the positive bias from fee endogeneity.

Using the estimates from column 2, I find that lowering licensing fees by the mean observed fee change increases the supply of massage by 0.5 workers per 100,000 population, a 3.8% increase in the mean supply of massage workers. For comparison, this is over half the effect estimated by Timmons and Thornton (2010) for licensed barbers in the U.S.[67] Looking at the total massage market alone, it appears as though supply is highly inelastic with respect to licensing fees, with a 1% reduction in fees translating to a 0.02% increase in supply of workers. However, the observed supply response may be attenuated due to the crowding out of legal massage. To determine what types of massage workers are entering, I turn to the individual-level data on income.

The estimated coefficient on income, reported in columns 3 and 4 of Table 1.7, is negative under all specifications, indicating that when fees decrease as they did in 2009, expected total massage income increases. Using the estimates from column 4, lowering licensing fees by the mean observed fee change is estimated to increase total annual income for massage workers by $2,186.71, or by 5.13% of the mean income in the massage industry. Again, income is relatively inelastic with respect to licensing fees, with a 1% reduction in fees translating to a 0.03% increase in total income. These income gains characterize the marginal entrant in the formal massage market and support two explanations. First, if entry into the massage market is driven by the quasi-legal sector, then total income could increase if the average quasi-legal entrant earns more than the average legal entrant through additional tips for sexual services. Second, increased

[67]Timmons and Thornton (2010) uses a summated license rating scale to measure the strictness of regulation. The authors estimate 1 unit increase licensing strictness corresponds to a 6.56% increase in the mean supply of barbers.

observed income could also be the result of a reduction in the number of legal massage workers. If the supply of legal massage shrinks as firms face increased competition with the quasi-legal sector, then the wages for surviving legal massage workers may increase.

Legal massage sector

Competition between legal and quasi-legal firms could be costly for legal firms, resulting in less entry than otherwise or even crowding out of existing firms. Legal massage firms face competition and signaling externalities from quasi-legal prostitution firms. And since quasi-legal prostitution is a substitute for massage, demand for legal massage should also fall, further lowering prices in the legal sector and attenuating any positive supply response at the extensive margin.

The results reported in Table 1.8 support the hypothesis that legal firms face an externality from competition with quasi-legal firms, and that this cost is increasing with the number of quasi-legal firms in the market. For all specifications, the coefficient on fees is positive, indicating that cities that experienced a fee decrease in 2009 also saw a reduction in the number of legal massage businesses. For the instrumented estimates and mean fee change, the supply of legal massage is expected to shrink by 0.42 firms per 100,000 population, or by approximately 45.6% of the mean number of firms per 100,000 population. Supply of legal massage appears relatively inelastic with respect to licensing fees, with a 1% decrease in fees translating to a 0.21% decrease in number of firms. Thus, despite enjoying lower barriers to entry, the competition and signaling externality dominates any extensive margin entry into legal massage.

Consequently, while the total supply of massage appears to grow, the number of legal massage firms falls, suggesting that massage industry growth is actually driven by the quasi-legal sector.[68] This growth in the quasi-legal sector increases the total size of

[68]One may be concerned that enforcement is an increasing function of the size of the quasi-legal sector – i.e., as the supply of quasi-legal prostitution grows, law enforcement prioritizes quasi-legal prostitution raids. If this is the case, then the initial quasi-legal prostitution supply response is attenuated and my estimates represent a lower bound. Anecdotal evidence suggests that this is not a large concern for many cities, as the language barrier and lack of cooperation between quasi-legal sex workers and law

the black market if the change is larger than the intensive-margin response for illegal prostitutes. Thus, to estimate equation 1.6, I compare the effect on the number of massage workers to the effect on the number of illegal prostitution workers.

Illegal prostitution sector

In order to check that the growth in quasi-legal prostitution is not entirely supplied by the displacement of illegal prostitution, I examine the impact of licensing fee changes on the supply of escorts. The results from columns 1 and 2 of Table 1.9 provide evidence that illegal prostitutes – namely, escorts specializing in massage – do switch into quasi-legal prostitution after barriers to entry are reduced. Some potential entrants who would have otherwise entered as illegal prostitutes instead choose to enter into quasi-legal prostitution, and some existing illegal prostitutes now find it more profitable to work for quasi-legal firms. The sample is filtered for escorts categorized under massage services on the Erotic Review, as these escorts are most likely to find switching profitable.[69]

Using the instrumented estimates in column 2 and the mean fee decrease in 2009, the supply of purely illegal prostitution decreases by 0.09 escorts per 100,000 population, or by approximately 1.32%. Illegal prostitution supply is inelastic with respect to licensing fees; for a 1% decrease in fees, the number of illegal prostitution workers decreases by 0.008%. Furthermore, the magnitude of the coefficient on fees is approximately three times smaller than in the regression on massage workers. This implies that for every escort who exits the illegal sector, 5.6 massage workers enter the quasi-legal sector. Thus, the extensive margin entry of quasi-legal prostitutes exceeds the intensive margin displacement of illegal prostitutes, and the total size of the black market for prostitution, S_t, grows by approximately 4.6 prostitutes per 100,000 population.

This negative shock to illegal prostitution supply increases the price of illegal prosti-

enforcement has shown to be unsuccessful in securing arrests for trafficking and pimping (Dank et al. (2014)). Consequently, law enforcement deprioritizes investigating the quasi-legal sector.

[69]The intensive margin supply response is attenuated for all escort categories.

tution, all else constant. However, illegal prostitution suppliers are not the only agents affected by growth in supply of quasi-legal prostitution. Since illegal prostitution and quasi-legal prostitution are substitutes, demand for illegal prostitution should also fall, driving the price of illegal prostitution down. The net effect on illegal prostitution prices will depend on the relative elasticities of prostitution supply and demand with respect to licensing fees.

Columns 3 and 4 of Table 1.9 report the results. I find that when fees fall, illegal prostitution prices decrease, suggesting that the reduction in demand is greater than the reduction in supply of illegal prostitution due to switching at the intensive margin. If fees decrease by the mean change in 2009, the expected hourly price decreases by $16.42, or by approximately 5.22%. In other words, a 1% decrease in licensing fees causes a 0.03% decrease in hourly price for purely illegal prostitution. Both sectors have highly elastic demand, supporting the large substitution response.[70]

This, in conjunction with the negative supply shocks to illegal prostitution, results in a significant, unambiguous reduction in total consumption of illegal prostitution. Thus, the implied effect of licensing fees on the risk of selecting an infected partner, ρ_t, is sizable, particularly in comparison to the effect on total black market size, S_t. As a result, reducing licensing fees actually improves externalities.

1.8 Policy reversal

The final mechanism through which licensing affects externalities is the direct effect on quasi-legal market structure and risk behavior. Thus, to estimate equations 1.11 and 1.12 from the epidemiological model, I utilize the policy reversal in 2015 to show that increasing barriers to entry reduces the size of the quasi-legal market and increases the wage premium and propensity for high-risk behavior. I utilize the same empirical strategy as previously, however applied to the Rubmaps dataset and second policy change in 2015.

[70]In Nguyen (2015b), I use the state policy changes in licensing fees as an instrument for price and estimate the price elasticities of demand for both sectors and find large estimates.

In addition to equations 1.15 and 1.16, I also estimate the following model for transaction j, city i, and year t:

$$\begin{aligned} Price_{jit} = \alpha + \beta_1 MassageFee_{it} + \beta_2 (MassageFee \times Intercourse)_{ijt} \\ + \beta_3 (MassageFee \times NoCondom)_{ijt} + \delta Year_t + \gamma_i + W_{ijt}\lambda + \mathcal{E}_{ijt} \end{aligned} \tag{1.17}$$

where W_{jit} is a vector of transaction covariates, including dummies for sexual service type. This specification allows me to estimate the wage premium for high-risk sexual services over time.

To verify the inverse relationship between licensing fees and quasi-legal supply, I estimate the impact of the second policy change, AB1147, which increased fees in 2015. Figure 1.8 shows the size of the quasi-legal sector before and after the policy reversal for cities that experienced no fee change and cities that experienced some fee change. It appears that treated cities experienced faster growth in quasi-legal supply prior to 2015. The results reported in columns 1 and 2 of Table 1.10 confirm the inverse relationship between fees and size of the quasi-legal prostitution market. Using the estimates from column 2, increasing licensing fees by the mean observed fee change due to AB1147 is estimated to reduce the number of quasi-legal prostitution firms per 100,000 population by 89.61%.[71] The coefficients imply that quasi-legal prostitution, while still inelastic, is relatively more elastic with respect to licensing fees than illegal prostitution and legal massage, with a 1% increase in fees translating to a 0.64% decrease in the number of quasi-legal firms.

Extrapolating the estimation results from AB1147 to the mean fee decrease in 2009, this implies that the initial policy change increased the number of quasi-legal prostitution firms per 100,000 population by as much as 137.59%.[72] For comparison, Cunningham

[71]For comparison, Law and Kim (2005) estimate that the introduction of licensing regulation reduced the growth rate of physicians by 63% and veterinarians by 68%. The authors find that a 1 unit increase in their composite licensing strictness index reduces supply by 4 physicians per 100,000 population. This is comparable to a $1,000 increase in massage licensing fees, which I estimate reduces quasi-legal supply by approximately 6 firms per 100,000 population.

[72]Due to data limitations, results are reported as percentage of the mean for the entire observed time

and Shah (2014) find that full decriminalization of indoor prostitution – which includes both illegal and quasi-legal sectors – is associated with an 85% increase in prostitution reviews. Thus, it appears the effects of reducing barriers to entry are quite large, and quasi-legal supply is relatively more elastic with respect to licensing fees than total black market supply. This is likely due to quasi-legal entry at both the extensive and intensive margins.

For the negative coefficients on licensing fees, the instrumented estimates are significantly larger in magnitude, despite measurement error and fee endogeneity bias moving in opposite directions. One possible explanation is the instruments picking up heterogeneity in the quasi-legal firm's supply response at the extensive margin. In this case, the instrumented estimates represent the local average treatment effect for cities where massage parlors were regulated and licensed similarly to retail and professional service businesses. This is likely to describe cities that did not have a large prostitution market – quasi-legal or illegal – prior to the change, and thus experience a greater supply response at the extensive margin than the intensive margin. In these cities, potential new quasi-legal entrants may also gain a first mover advantage, and thus the extensive margin response is even larger than in cities with saturated quasi-legal markets and the instruments have less predictive power.

Columns 3 and 4 of Table 1.10 report the results for total quasi-legal prostitution prices. Consistent with economic theory, prices are inversely related to supply, and thus directly related with licensing fees. For the mean fee increase in 2015, total price paid increases by \$10.30, a 10.8% increase from the pre-2015 average.[73] Applying these estimates to the previous policy change in 2009, this implies that a 1% reduction in fees translates to a 5.16% reduction in total price. Thus, we can confirm that the price of quasi-legal prostitution fell after the fee decrease in 2009, consequently raising the relative

period, rather than the pre-treatment period mean.

[73]This result is comparable to licensing educational requirements in the cosmetology industry. Adams et al. (2002) estimates that an extra year of required schooling increases cosmetology prices by \$8.68 to \$14.50 and reduces cosmetology consumption by 2.87 to 6.46 units per capita.

price of substitutes such as illegal prostitution and legal massage.

Combining these results with the effect on externalities, I estimate that a 10% increase in the supply of quasi-legal prostitution translates to a 0.1% reduction in the supply of illegal prostitution, a 2.8% reduction in the overall gonorrhea rate, a 2.3% reduction in the Asian female gonorrhea rate, a 0.3% reduction in the Asian female chlamydia rate, and a 2.2% reduction in rape cases. Figures 1.9 and 1.10 illustrate this inverse relationship between externalities and quasi-legal supply after the initial policy change. Ultimately, increasing the size of the quasi-legal sector effectively reduces health and crime externalities by shifting the black market towards lower-risk activity.

Wage premium for high-risk services

Thus far, I have shown that lower massage licensing fees reduce negative health and crime externalities, despite growth in quasi-legal prostitution. I attribute this in large part to the reduction in illegal prostitution, which generally carries a higher risk of STI transmission and violent crime than quasi-legal prostitution. In this section, I also consider how growth in the quasi-legal sector itself can directly alter the riskiness of sexual contact.

First, I estimate the effect of an increase in barriers to entry on the quasi-legal price of the legal good, massage, as measured by the price paid to house. Second, I estimate equation 1.17 for the quasi-legal price of the illegal good, commercial sex, as measured by the tip paid to the sex worker. The results are reported in Table 1.11. For the mean fee increase in 2015, expected price paid to house increases by $2.92, or by approximately 5.89% of the mean massage price prior to the policy change. This translates to a licensing fee elasticity of 2.82. Meanwhile, the expected tip for a transaction without sexual services falls by $2.23, or by approximately 4.86% of the mean tip prior to the policy change. This implies that for a 1% increase in massage fees, tips without extra sexual services fall by 2.32%. This "crowding out" of tips may be due to buyer behavior, as quasi-legal buyers likely only consider the total price paid when making consumption decisions. Since tips

to sex workers are not fixed, buyers are able to adjust tipping behavior in response to higher prices paid to house.[74]

These results suggest that quasi-legal firm owners are passing off increased licensing costs to buyers through the price paid to the house; at the same time, it appears that quasi-legal buyers are reducing the baseline tip amount. Previous literature has found that sex workers receive a very small proportion, if any, of the price paid to house; rather, sex workers typically make all their earnings through tips.[75] Thus, the reduction in baseline tip has important implications for sex worker behavior.

Column 3 of Table 1.11 shows evidence of large tip premiums for sexual intercourse, fellatio, and manual simulation. The observed 24% tip premium for unprotected sex in cities with no fee change is large and comparable to the baseline 23% premium previously estimated by Gertler et al. (2005). To augment their income, sex workers can choose to offer more and riskier sexual services. The tip premium is larger for higher risk services such as intercourse and fellatio, which can raise the average tip by almost $20 each. Moreover, the tip premium for the highest risk services, intercourse and unprotected sex, is larger in cities where licensing fees increased. Thus, for the average fee change in 2015, tip premiums for intercourse were 75.5% higher.

This reduction in baseline tip and increase in tip premiums may incentivize sex workers to change their behavior and offer riskier sexual services. Columns 4 through 9 of Table 1.11 examine this formally, looking at the effect of the increase in fees on the probability of high risk behavior. For the instrumented specification and the average fee increase in 2015, quasi-legal prostitution firms offer their most common sexual service, manual stimulation, in 16.6% more transactions. The proportion of transactions selling protected intercourse also increases by 65.9% relative to the proportion of transactions prior to 2015. Moreover the probability of no condom use increases by 49.5%. Sex work-

[74]Cross-sectional evidence from the data also appears to support this explanation. While European massage parlors charge significantly higher prices paid to house than Asian massage parlors, tips are also proportionally lower, conditioning on transaction and sex worker level covariates.

[75]Dank et al. (2014) reports massage sex workers in San Diego, CA only keep $10 of a $60 house price, plus tips.

ers in treated cities increasingly engage in high-risk activity, implying that the effect of licensing fees on contact risk, θ, is quite large. With respective fee elasticities of 7.9, 27.7, and 21.9, these outcomes are highly elastic with respect to licensing fees, suggesting that suppliers respond to changes in regulatory costs largely by adjusting the type of services offered. As the fee increase from AB1147 shifts the distribution of quasi-legal prostitution services towards higher risk activity, STI prevalence is likely to increase.

1.9 Conclusion

Reducing the barriers to entry for a related legal market can significantly impact the black market for illegal goods and services. In the case of prostitution and massage, reducing licensing costs for the quasi-legal sector increased the total size but also reduced the overall riskiness of the black market for prostitution. For the average massage licensing fee reduction observed in California, gonorrhea rates fell by 16.3% for the general population and by 13.5% for the predominant sex worker demographic, Asian females. Chlamydia rates also fell by 1.73% for Asian females, while forcible rapes declined by 19% for the general population. These improvements to health and crime can be attributed to reductions in illegal prostitution consumption and risk-taking behavior in the quasi-legal prostitution sector. However, the consequent 138% growth in quasi-legal prostitution also reduced the supply of legal massage by 45.6%. Thus, reducing the barriers to entry makes the black market safer at the expense of the legal sector. In pursuing this type of policy, policymakers will have to weigh the value of legitimate consumption against targeting negative health and crime externalities.

The recent policy reversal in 2015 presents opportunities for future research. The increase in licensing fees in areas with existing quasi-legal prostitution markets could exacerbate health externalities by pushing sex workers into higher risk activity. Future work will be able to quantify the impact of this increase in licensing fees on externalities, and compare with the results of this paper for asymmetries.

For a more complete evaluation of this policy, future research can also incorporate

data on HIV and human trafficking. The improvements in STI prevalence could translate to significant improvements in mortality, through reduced HIV transmission rates. Future research focusing on sex trafficking should also consider distinguishing between the differentiated sectors of prostitution, as intensive margin supply responses and substitution effects can be important in the black market.

1.10 Appendix

1.10.1 Tables and Figures

Table 1: City-level licensing fees for massage and other businesses in California

	2008		**2009-2014**$^{+}$		**2015**$^{++}$	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Massage establishment license	657.24	1,086.43	2.39	10.44	653.22	1,245.40
Massage technician license	85.80	238.72	60.89	28.68	45.63	35.23
Total massage license fees	743.04	1,152.44	63.28	25.28	698.85	1,253.35
Professional service license fees	222.94	726.94	240.24	745.15	237.58	749.87
Retail business license fees	76.87	117.72	82.64	133.41	79.17	123.55
N	227		227		148	

City-level observations. Units are USD. Data collected from city officials, police departments, and CAMTC. $^{+}$ If the city total fees were greater than the state's, the establishment fee was set to 0 and the technician fee was set equal to the state fee. $^{++}$ If city total fees were greater than the state's, the technician fee was set equal to the state fee. Fees for 2015 could not be gathered for all 227 cities. Estimations using only the first policy change include all 227 cities; estimations using the second or both policy changes use 148 cities.

Table 2: Sexually transmitted infections and crime in California

	2006-2008			**2009-2014**		
	Mean	Std. Dev	N	Mean	Std. Dev	N
Panel A: Local health jurisdiction-level data on STIs*						
Gonorrhea rate per 100,000 population*	74.453	43.034	681	76.594	43.504	1362
Asian females*	23.908	16.273	662	17.987	13.471	1343
Chlamydia rate per 100,000 population*	371.173	106.395	681	409.646	114.491	1362
Asian females*	273.033	126.57	675	274.518	119.339	1344
Panel B: City-level data on forcible rapes**						
Rape rate per 100,000 population^{+}	23.651	17.184	587	20.441	14.493	777

*California Department of Public Health (local health jurisdictions are counties and selected cities)

**U.S. Department of Justice FBI Uniform Crime Report, 2003-2012. In 2011, the FBI approved a new definition of rape that includes male victims. This definition went into effect in 2013, so I exclude 2013-2014.

Table 3: Characteristics of the massage and prostitution markets in California

	2006-2008			2009-2014		
	Mean	Std. Dev	N	Mean	Std. Dev	N
Panel A: PUMA-level data on total massage workers*						
Number of massage technicians per 100,000 population	5.923	8.303	350	5.915	8.082	399
Number of massage parlor employees per 100,000 population	8.002	8.190	350	8.211	8.297	399
Panel B: Individual-level data on total massage workers**						
Annual massage industry income	42,627.91	56,607.31	2,730	39,512.83	54,860.92	3,101
Usual weekly hours worked	30.874	17.550	2,730	29.358	17.658	3,101
Proportion of massage workers unemployed	0.033	0.180	2,730	0.062	0.241	3,101
Proportion of massage workers white	0.729	0.445	2,730	0.736	0.441	3,101
Proportion of massage workers Asian	0.127	0.333	2,730	0.127	0.333	3,101
Proportion of massage workers black	0.042	0.202	2,730	0.044	0.205	3,101
Proportion of massage workers Hispanic	0.181	0.385	2,730	0.201	0.401	3,101
Proportion of massage workers with less than high school	0.315	0.465	2,730	0.298	0.457	3,101
Proportion of massage workers with high school degree	0.153	0.361	2,730	0.174	0.379	3,101
Proportion of massage workers with some college	0.532	0.499	2,730	0.529	0.499	3,101
Panel C: City-level data on legal massage firms***						
Number of legitimate massage firms per 100,000 population	0.109	0.407	263	1.379	2.165	481
Panel D: City-level data on quasi-legal prostitution firms++						
Number of erotic massage parlors per 100,000 population				4.839	6.463	618
Panel E: City-level data on illegal prostitution workers+						
Number of escorts per 100,000 population	45.046	74.464	268	39.305	67.742	506

*American Community Survey 2006-2013, aggregated at the PUMA-level. **American Community Survey 2006-2013, sample of massage workers
***Scraped from Yelp.com. +Scraped from TheEroticReview.com. ++Scraped from Rubmaps.com.
See Data Appendix for further details on data collection.

Table 4: Prices and services offered in the illegal and quasi-legal prostitution sectors

	Illegal prostitution*			**Quasi-legal prostitution****		
	Mean	Std. Dev.	N	Mean	Std. Dev.	N
Total price	224.67	159.58	23,233	95.79	44.33	17,467
Price for massage escorts	172.01	76.80	2,455	–	–	–
Price paid to house	–	–	–	49.64	16.76	17,467
Tips	–	–	–	46.15	37.92	17,467
Proportion offer fellatio	0.784	0.411	23,233	0.360	0.480	17,467
With condom	0.579	0.494	18,218	0.151	0.358	6,280
No condom	0.421	0.494	18,218	0.051	0.220	6,280
Proportion offer sexual intercourse	0.794	0.404	23,233	0.290	0.454	17,467
Female condom	0.001	0.033	18,452	–	–	–
Male condom	–	–	–	0.173	0.378	5,072
Proportion offer anal sex	0.067	0.250	23,233	–	–	–
Proportion offer manual genital stimulation	–	–	–	0.612	0.487	17,467

* Data on escorts scraped from TheEroticReview.com, 2006-2015

** Data on erotic massage parlor transactions scraped from Rubmaps.com, 2006-2015.

See Data Appendix for further details on data collection.

Table 5: Effect of fee decrease on gonorrhea and chlamydia

Dependent variable:	ln(Gonorrhea cases per 100,000 population)		ln(Asian female gonorrhea cases per 100,000 population)		ln(Chlamydia cases per 100,000 population)		ln(Asian female chlamydia cases per 100,000 population)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Diff-in-diff	IV$^+$	Diff-in-diff	IV$^+$	Diff-in-diff	IV$^+$	Diff-in-diff	IV$^+$
Massage fee (thousands)	0.0546**	0.240**	0.0386*	0.198*	0.00262	-0.00414	0.0310**	0.0255
	(0.0127)	(0.0800)	(0.0198)	(0.114)	(0.00467)	(0.0243)	(0.00925)	(0.0495)
Year	0.0157**	0.128**	-0.0906**	-0.0628	0.0222**	0.0283**	-0.00918*	-0.0260*
	(0.00714)	(0.0232)	(0.0121)	(0.0390)	(0.00262)	(0.00707)	(0.00519)	(0.0144)
Population (thousands)	0.000676**	-0.00205**	0.00202**	0.00125	0.0000777	0.0000127	0.000688**	0.00123**
	(0.000312)	(0.000838)	(0.000513)	(0.00130)	(0.000115)	(0.000255)	(0.000227)	(0.000519)
Population over 25 with bachelor's or higher	-0.00209	-0.00758	0.00334	0.00808	-0.00348**	-0.00428	-0.00288	0.00654
	(0.00455)	(0.0126)	(0.00736)	(0.0185)	(0.00167)	(0.00384)	(0.00331)	(0.00783)
Constant	-29.54**	-246.9**	178.0**	124.6*	-38.76**	-50.85**	21.89**	53.71*
	(13.58)	(44.77)	(22.96)	(74.88)	(4.984)	(13.62)	(9.882)	(27.74)
City fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
N	745	745	701	701	745	745	743	743
Cities	101	101	101	101	101	101	101	101
Mean dependent variable	75.88	75.88	19.94	19.94	396.82	396.82	274.02	274.02
First stage F-statistic	–	202.49	–	202.49	–	202.49	–	202.49
R-squared	0.064	0.296	0.142	0.139	0.267	0.310	0.030	0.064

City-level regressions, 2006-2014. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$. $^+$Massage fee is instrumented with retail fee and professional service fee Data on STI rates from California Department of Public Health. Data on city population and education from Census. Regressions cover first policy change.

Table 6: Effect of fee decrease on sexual violence

Dependent variable:	Number of forcible rapes	
	(1)	(2)
	Diff-in-diff	IV^{+}
Massage fee (thousands)	2.839**	7.686*
	(0.772)	(4.588)
Year	-1.385**	-1.465
	(0.373)	(1.258)
Population (thousands)	0.474**	0.847**
	(0.0946)	(0.279)
Number of law enforcement per capita	205.1**	505.9*
	(97.50)	(289.9)
Mean household income (thousands)	-0.144	-0.399
	(0.127)	(0.330)
Male population aged 18-24	-0.00147**	-0.000979
	(0.000417)	(0.000770)
Constant	2740.1**	2754.5
	(744.9)	(2501.5)
City fixed effects	Y	Y
N	519	519
Cities	93	93
Mean dependent variable	25.71	25.71
R-squared	0.152	0.288
First stage F-statistic	–	36.37

City-level regressions, 2003-2012. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$.

$^{+}$Massage fee is instrumented with retail fee and professional service fee

Data on rape and law enforcement from FBI Uniform Crime Report.

Data on city population and income from Census. Regressions cover first policy change.

Table 7: Effect of fee decrease on total massage (quasi-legal + legal) supply & income

Dependent variable:	Number of massage workers per 100,000 population		Total annual income for massage workers	
	(1)	(2)	(3)	(4)
	Diff-in-diff	IV^{+}	Diff-in-diff	IV^{+}
Massage fee (thousands)	-0.338**	-0.387**	-1311.6**	-1456.3*
	(0.0864)	(0.165)	(607.4)	(856.0)
Year	-0.101**	-0.0982	-1621.9**	-815.0
	(0.0454)	(0.133)	(466.9)	(1031.8)
Total population (thousands)	-0.0952**	-0.153**		
	(0.0101)	(0.0328)		
Mean household income (thousands)	-0.000702	-0.00587		
	(0.0120)	(0.0248)		
Education			6755.5**	6439.6**
			(332.7)	(487.0)
Black			-5948.6	-5826.7
			(3865.0)	(5166.3)
Hispanic			-1151.5	-3477.6
			(2218.6)	(3213.8)
Asian			-3523.8	-3482.4
			(2343.0)	(3592.8)
Constant	246.8**	278.9	3245112.2**	1628200.2
	(90.43)	(263.2)	(938047.8)	(2073706.2)
PUMA fixed effects	Y	Y	Y	Y
N	370	370	5721	5721
PUMAs	101	101	195	195
Mean dependent variable	13.92	13.92	40971.27	40971.27
R-squared	0.309	0.277	0.080	0.082
First stage F-test	–	396.15	–	1595.74

Columns 1-2: PUMA-level regressions, 2006-2013. Columns 3-4: Worker-level regressions, 2006-2013. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$. $^{+}$Massage fee is instrumented with retail fee and professional service fee. Data on worker industry, income, education, and race from ACS. Data on city population and income from Census. Data represents NAICS industry code for massage parlors (812199) and technicians (621399). Regressions cover first policy change. Omitted race category is white.

Table 8: Effect of fee decrease and reversal on legal massage supply

Dependent variable:	Number of legal massage firms per 100,000 population			
	(1)	(2)	(3)	(4)
	Diff-in-diff	IV^{+}	Diff-in-diff	IV^{+}
Massage fee (thousands)	0.0900	0.818**	0.0604	0.609**
	(0.0646)	(0.317)	(0.0648)	(0.294)
Year	0.365**	0.491**	0.341**	0.450**
	(0.0235)	(0.0472)	(0.0275)	(0.0519)
Population	0.0150**	0.00282	0.0135**	-0.00142
	(0.00633)	(0.0110)	(0.00639)	(0.0107)
Mean household income			0.0308**	0.0428**
			(0.00946)	(0.0150)
Proportion aged 25-34			-2.947	1.004
			(2.975)	(5.293)
Proportion aged 35-44			-4.583	-3.897
			(3.357)	(5.439)
Proportion aged 45-64			-4.646	-7.747
			(3.220)	(5.528)
Constant	-735.1**	-985.7**	-686.1**	-903.1**
	(46.92)	(94.31)	(55.11)	(103.9)
City fixed effects	Y	Y	Y	Y
N	732	732	728	728
Cities	99	99	99	99
Mean dependent variable	0.930	0.930	0.930	0.930
R-squared	0.364	0.410	0.375	0.453
First stage F-statistic	–	50.09	–	61.13

City-level regressions, 2005-2015. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$

$^{+}$Massage fee is instrumented with retail fee and professional service fee.

Data on legal firms from Yelp. Data on city population, income, and age from Census. Regressions cover first policy change and policy reversal.

Table 9: Effect of fee decrease & reversal on illegal prostitution supply & prices

Dependent variable:	# of illegal prostitution workers per 100,000 pop.		Illegal prostitution price per hour	
	(1)	(2)	(3)	(4)
	Diff-in-diff	IV^{+}	Diff-in-diff	IV^{+}
Massage fee (thousands)	0.0763**	0.125*	3.238**	6.592**
	(0.0178)	(0.0746)	(1.265)	(3.347)
Year	-0.0442**	-0.0246	-1.735**	-0.0961
	(0.00731)	(0.0160)	(0.695)	(0.906)
Sex ratio	-0.236	-1.387**		
	(0.292)	(0.564)		
Proportion Asian	1.223*	0.317		
	(0.680)	(1.229)		
Mean household income (thousands)	-0.0122**	-0.00594		
	(0.00297)	(0.00581)		
Male population 25 and over	0.00584	-0.00799		
with bachelor's or higher	(0.00969)	(0.0168)		
Total population 25 and over	-0.00443	0.0151		
with bachelor's or higher	(0.0126)	(0.0221)		
Total length of service (minutes)			-4.013**	-2.083**
			(0.161)	(0.0977)
Erotic massage			-14.58**	18.81**
			(7.296)	(3.847)
Fellatio			30.57**	-54.08**
			(7.510)	(7.869)
Intercourse			-81.34**	-76.51**
			(5.784)	(8.822)
Black sex worker			-58.49**	-87.41**
			(8.595)	(6.051)
Asian sex worker			-63.13**	-95.52**
			(7.088)	(4.651)
Latina sex worker			-24.19**	-50.55**
			(7.373)	(5.331)
Fit body rating			26.76**	43.51**
			(5.284)	(3.913)
Positive breast rating			21.70**	34.29**
			(2.606)	(4.269)
Sex worker aged 18-20			14.27	32.02*
			(13.98)	(19.45)
Sex worker aged 21-25			16.97**	13.82**
			(3.057)	(5.009)
Sex worker aged 26-30			36.26**	38.40**
			(3.492)	(5.619)
Sex worker aged 31-35			43.60**	46.18**
			(8.297)	(7.401)
City fixed effects	Y	Y	Y	Y
N	577	577	23244	23244
Cities	75	75	207	207
Mean dependent variable	6.79	6.79	298.10	298.10
R-squared	0.228	0.131	0.127	0.136
First stage F-statistic	–	197.03	–	270000

Col 1-2: city-level regressions for massage specialty escorts, 2005-2015. Col 3-4: worker-level regressions for all escorts, 2005-2015. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$. $^{+}$Massage fee is instrumented with retail fee and professional service fee. All columns include constant term. Data on illegal workers from the Erotic Review. Data on city population, race, sex, and income from Census. Regressions cover first policy change and policy reversal. Omitted race category is white. Omitted age category is age 36 and over.

Table 10: Effect of fee increase on quasi-legal prostitution supply and total price

Dependent variable:	Number of quasi-legal firms per 100,000 population		Total quasi-legal price	
	(1)	(2)	(3)	(4)
	Diff-in-diff	IV^{+}	Diff-in-diff	IV^{+}
Massage fee (thousands)	-1.575**	-5.936*	1.352**	5.180**
	(0.441)	(3.239)	(0.439)	(1.696)
Year	1.783**	2.326**	-0.217	-3.050**
	(0.123)	(0.408)	(0.281)	(0.587)
Total population (thousands)	-0.296**	-0.840**		
	(0.548)	(0.116)		
Black population (thousands)	-0.984**	-0.203**		
	(0.166)	(0.351)		
Asian population (thousands)	0.436**	0.799**		
	(0.109)	(0.256)		
Constant	-3522.0**	-4401.8**		
	(247.9)	(823.1)		
Sexual intercourse			21.30**	21.52**
			(0.671)	(1.170)
Fellatio			20.93**	22.29**
			(0.636)	(1.081)
Manual stimulation			17.87**	20.74**
			(0.613)	(1.026)
Sex worked aged 18-24			14.22**	9.598
			(3.166)	(6.181)
Sex worker aged 25-30			9.672**	2.579
			(1.700)	(3.295)
Constant	377.8	4605.5**	507.2	6209.1**
	(656.8)	(1343.6)	(566.3)	(1181.1)
City fixed effects	Y	Y	Y	Y
N	952	952	17467	17467
Cities	99	99	144	144
Mean dependent variable	2.975	2.975	95.79	95.79
R-squared	0.297	0.455	0.258	0.259
First stage F-statistic	–	78.78	–	226.66

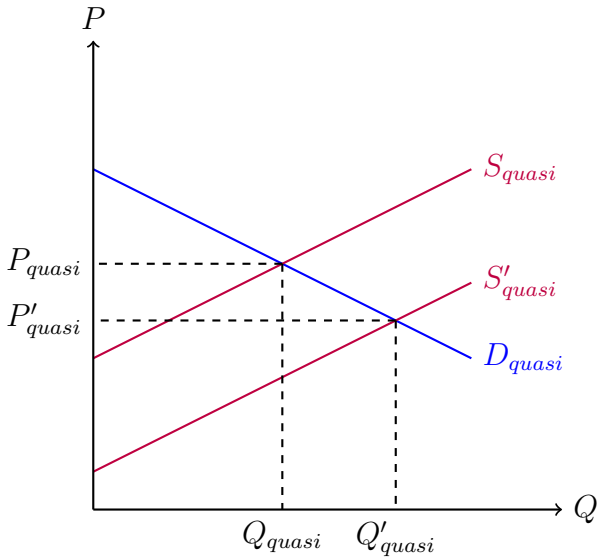
Columns 1-2: city-level regressions, 2009-2015. Columns 3-4: transaction-level regressions, 2009-2015. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$. $^{+}$Massage fee is instrumented with retail fee and professional service fee. Data on quasi-legal firms and transactions from Rubmaps. Data on city population and race from Census. Regressions cover policy reversal only. Population variables for 2015 are imputed assuming population growth rate for 2014. Omitted age category is age 31 and over.

Table 11: Effect of fee increase on quasi-legal prostitution risk premia and probability of high-risk behavior

Dependent variable:	Legal price of massage: Price paid to house		Illegal price of sex: Tip paid to worker	Pr(Manual stimulation)		Pr(Protected intercourse)		Pr(No condom use)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Diff-in-diff	IV^{+}	Diff-in-diff	Diff-in-diff	IV^{+}	Diff-in-diff	IV^{+}	Diff-in-diff	IV^{+}
Massage fee (thousands)	0.241	1.468*	-1.056**	0.0120**	0.0509**	0.0120**	0.0146*	0.00372**	0.00425
	(0.199)	(0.854)	(0.435)	(0.00588)	(0.0218)	(0.00269)	(0.00867)	(0.00169)	(0.00507)
Massage fee × Intercourse			7.038**						
			(1.007)						
Intercourse	2.017**	3.627**	18.55**						
	(0.305)	(0.589)	(0.569)						
Massage fee × Unprotected			129.8**						
			(38.33)						
No condom use			11.11**						
			(1.686)						
Fellatio	2.170**	3.415**	18.05**						
	(0.288)	(0.544)	(0.538)						
Manual stimulation	2.482**	2.713**	15.54**						
	(0.278)	(0.517)	(0.512)						
Sex worker aged 18-24	5.134**	1.951	7.047**	-0.0523	-0.271**	0.107**	0.171**	0.0392**	0.0606**
	(1.436)	(3.112)	(2.651)	(0.0424)	(0.0780)	(0.0194)	(0.0311)	(0.0122)	(0.0182)
Sex worker aged 25-30	4.355**	3.655**	3.564**	0.00860	-0.0669	0.0744**	0.0779**	0.0159**	0.0276**
	(0.771)	(1.659)	(1.435)	(0.0228)	(0.0416)	(0.0104)	(0.0166)	(0.00653)	(0.00971)
Year	-0.0375	-0.885**	-0.660**	-0.00678*	-0.00392	0.00636**	-0.000909	0.00351**	0.0000284
	(0.128)	(0.295)	(0.245)	(0.00377)	(0.00745)	(0.00173)	(0.00297)	(0.00108)	(0.00174)
Constant	122.1	1828.4**	1353.6**	14.27*	8.473	-12.75**	1.863	-7.052**	-0.0466
	(256.9)	(594.6)	(493.3)	(7.591)	(15.00)	(3.473)	(5.976)	(2.175)	(3.497)
City fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	17467	17467	17467	17467	17467	17467	17467	17467	17467
Cities	144	144	144	144	144	144	144	144	144
Mean dependent variable	49.64	49.64	46.15	0.612	0.612	0.050	0.050	0.019	0.019
R-squared	0.023	0.027	0.286	0.0005	0.0004	0.008	0.010	0.002	0.004
First stage F-statistic	–	226.66	–	–	327.85	–	327.85	–	327.85

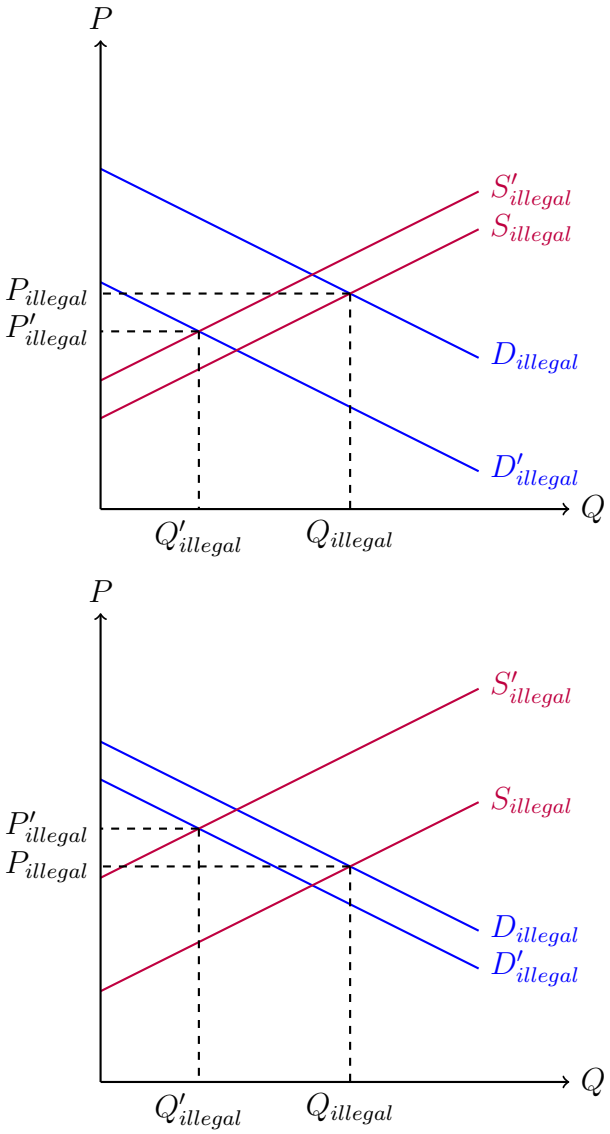
Transaction-level regressions, 2009-2015. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$. $^{+}$Massage fee is instrumented with retail fee and professional service fee. Data from Rubmaps. Regressions cover policy reversal only. Omitted age category is age 31 and over.

Figure 1: Aggregate quasi-legal prostitution market after massage licensing fee reduction



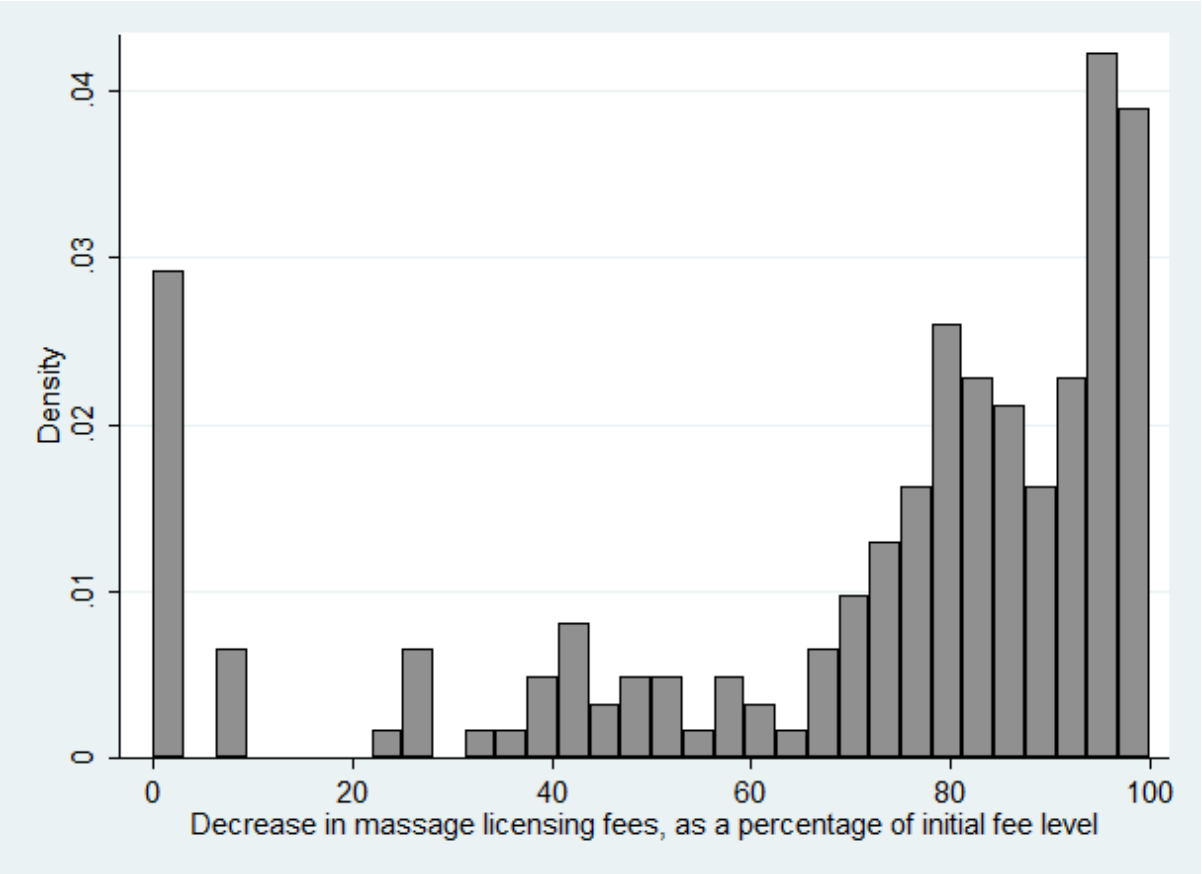
When massage licensing fees fall and barriers to entry for the quasi-legal sector decrease, new entrants will increase quasi-legal supply. Prices fall and consumption increases.

Figure 2: Aggregate illegal prostitution market after massage licensing fee reduction



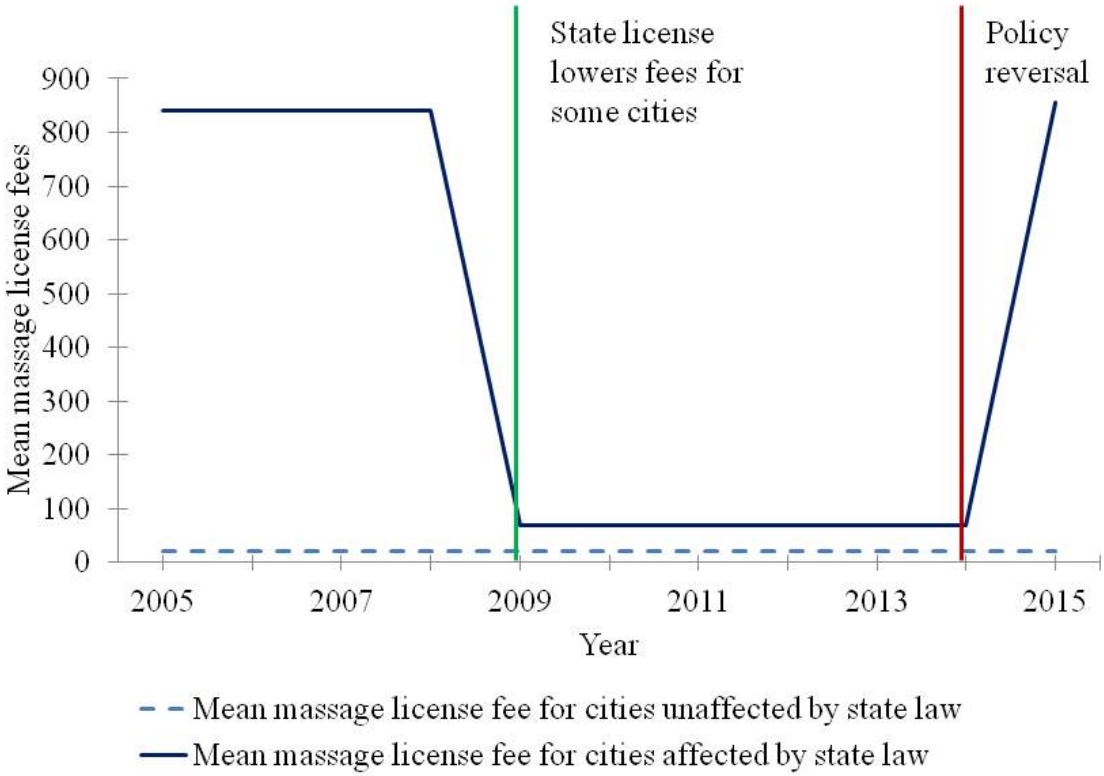
When massage licensing fees fall and barriers to entry for the quasi-legal sector decrease, some illegal suppliers will exit, switching to the quasi-legal sector and decreasing illegal supply. Since quasi-legal prices fall in Figure 1 and quasi-legal prostitution is a substitute for illegal prostitution, illegal demand will also fall. Illegal consumption falls unambiguously, but the effect on price depends on the relative elasticities of illegal supply and demand with respect to massage licensing fees.

Figure 3: Distribution of decrease in massage licensing fees, expressed as a percentage of initial fee level



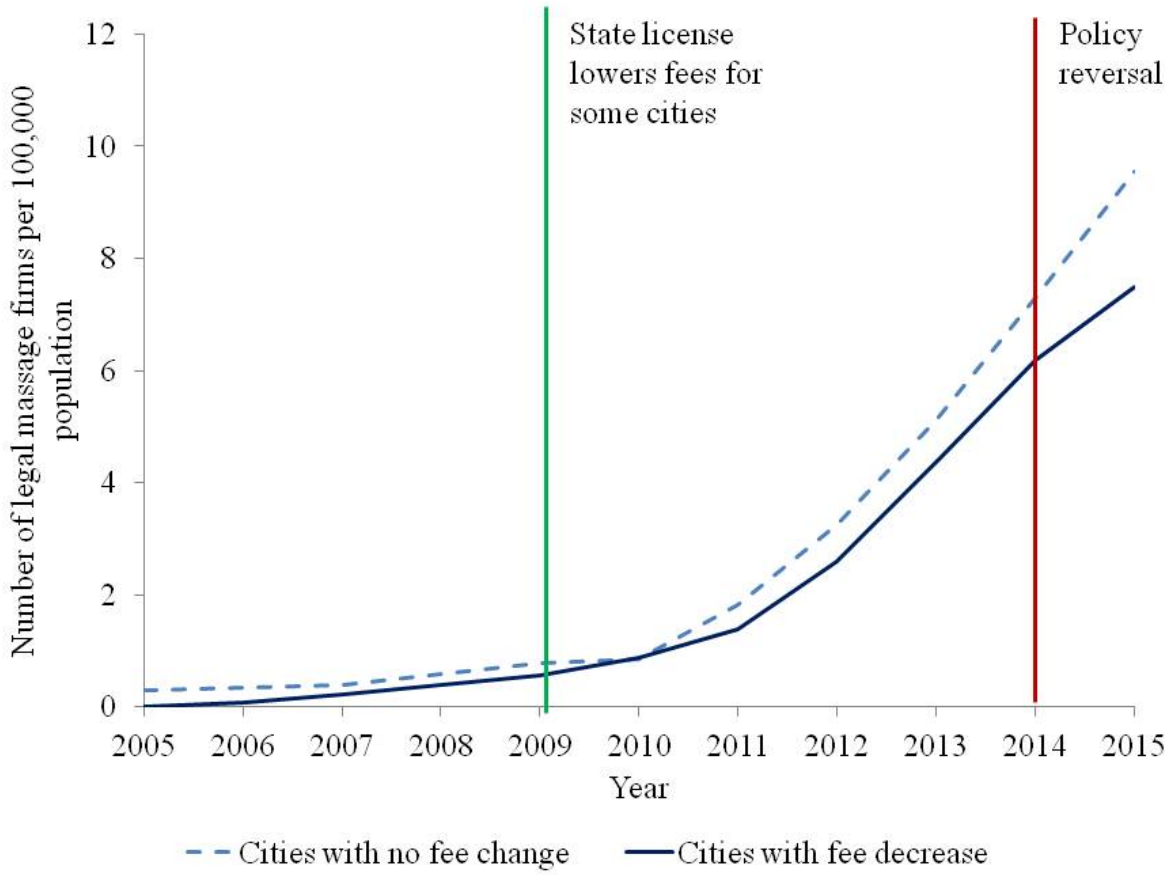
Note: Massage fee data hand collected from city government officials (business license division, planning department, police or sheriff's department, public health department, etc.). Shows distribution for $\frac{(MassageFee_{2008} - MassageFee_{2012})}{(MassageFee_{2008})} \times 100\%$

Figure 4: City-level massage licensing fees in California over time, 2005-2015



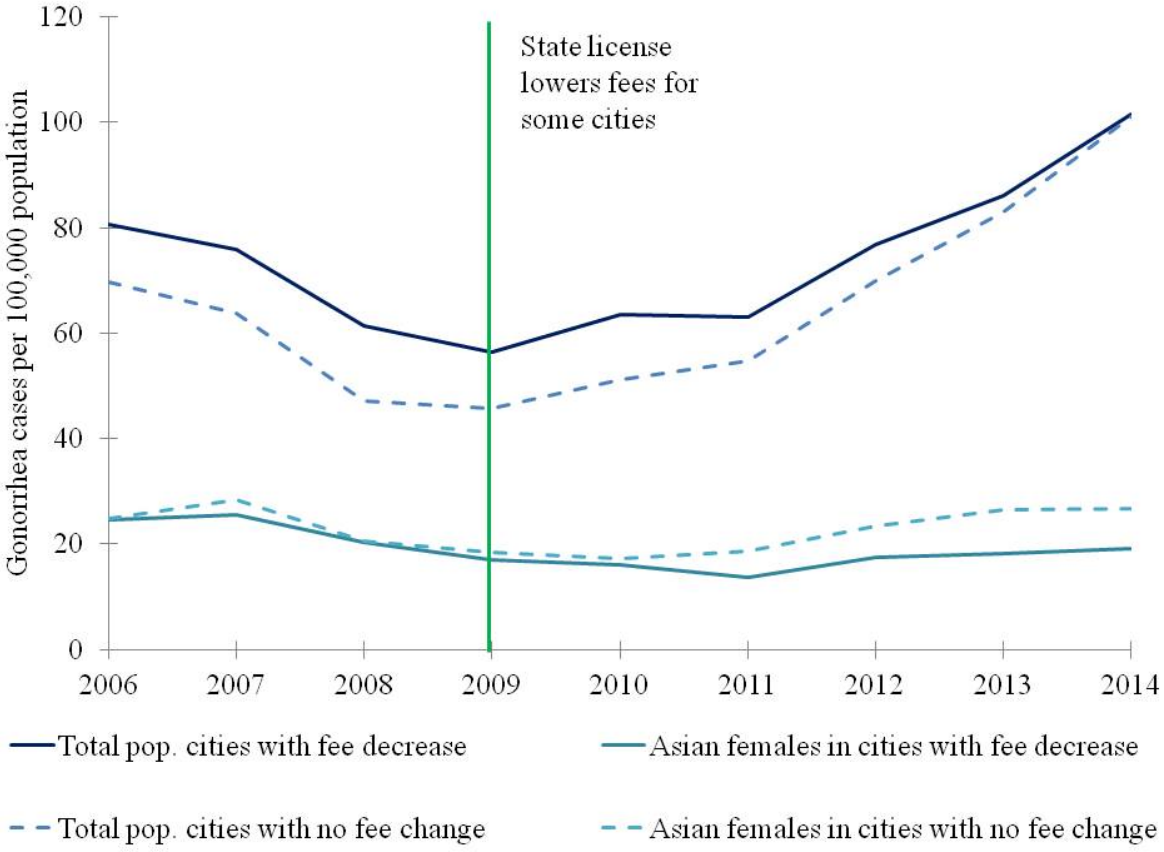
Note: Massage fee data hand collected from city government officials. State law active from 2009-2014 effectively lowered fees for some cities. State law policy reversal active in 2015. Cities affected by state law are cities for which fees in 2008 are higher than the state license fee. Cities unaffected by state law are cities for which fees in 2008 are lower than or equal to the state license fee.

Figure 5: New data on legal massage firms in California, 2005-2015



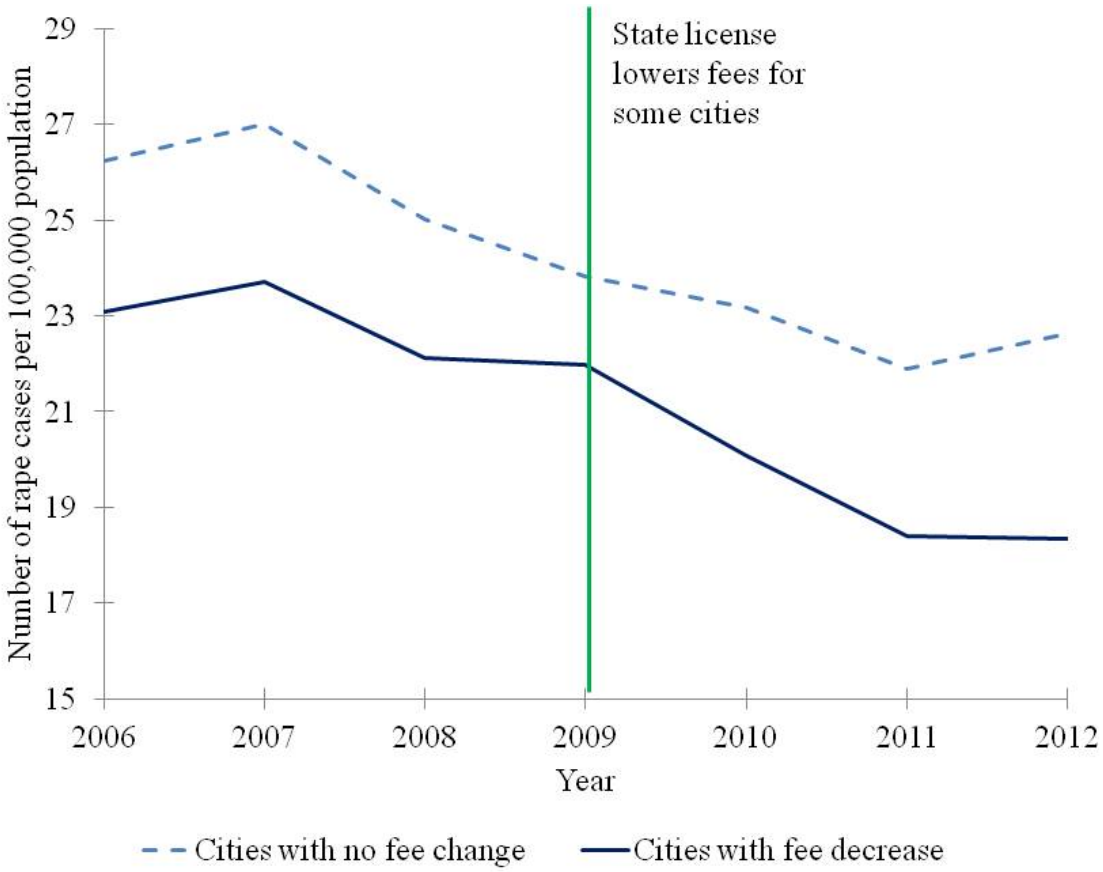
Note: Number of legal massage firms measured by massage parlors scraped from Yelp.com "massage" business search and cross-checked with Rubmaps.com quasi-legal listings. Population data from the Census. State law active from 2009-2014 effectively lowered fees for some cities. State law policy reversal active in 2015. Cities affected by state law are cities for which fees in 2008 are higher than the state license fee. Cities unaffected by state law are cities for which fees in 2008 are lower than or equal to the state license fee.

Figure 6: Gonorrhea rates in California, 2006-2014



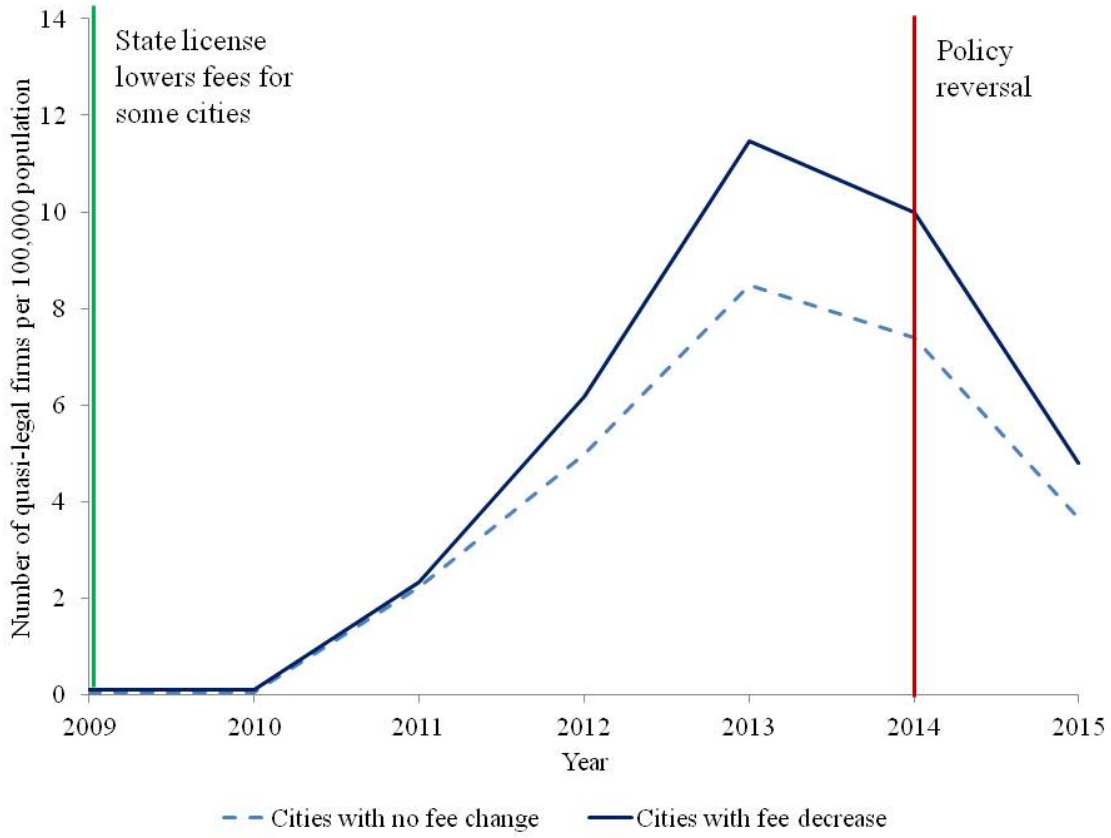
Note: Gonorrhea data from the California Department of Public Health. State law active from 2009-2014 effectively lowered fees for some cities. State law policy reversal active in 2015. Cities affected by state law are cities for which fees in 2008 are higher than the state license fee. Cities unaffected by state law are cities for which fees in 2008 are lower than or equal to the state license fee.

Figure 7: Rape rates in California, 2006-2012



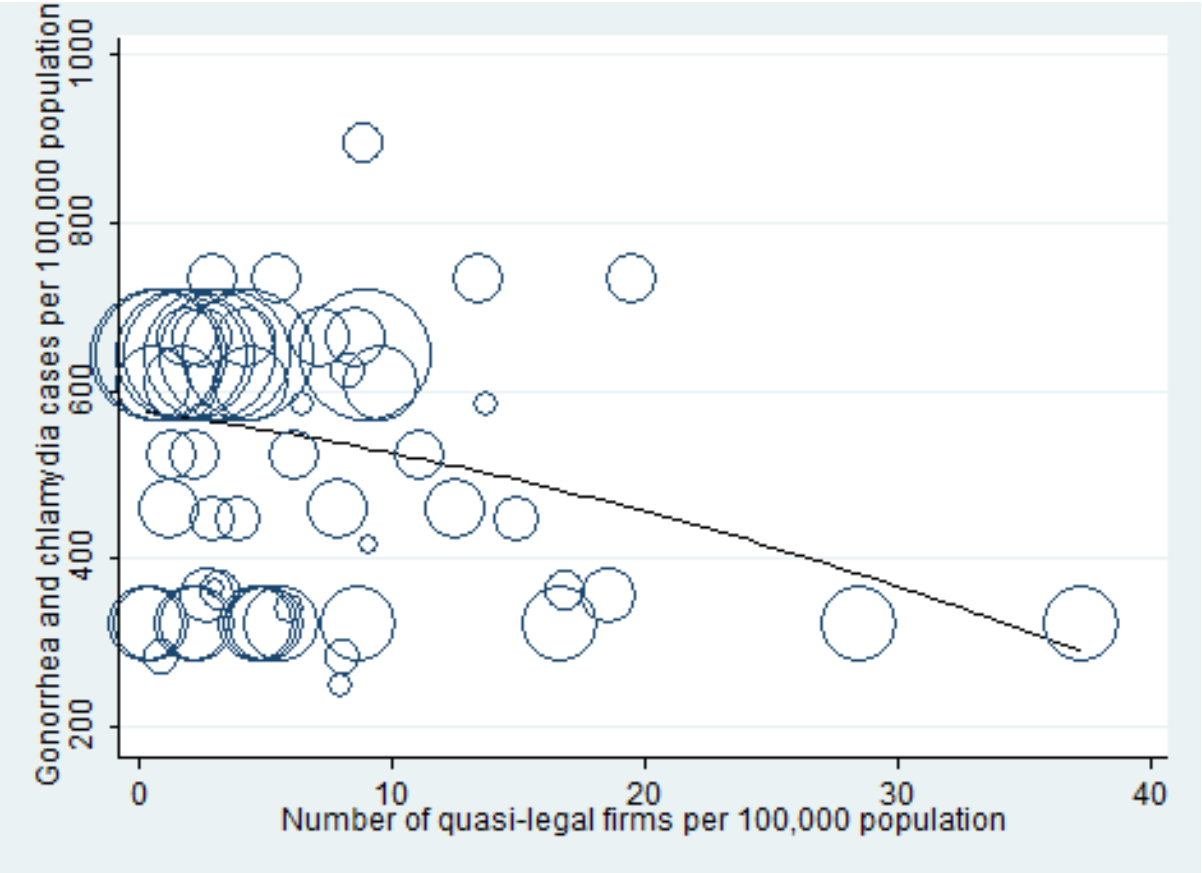
Note: Rape data from FBI Uniform Crime Report. State law active from 2009-2014 effectively lowered fees for some cities. State law policy reversal active in 2015. Cities affected by state law are cities for which fees in 2008 are higher than the state license fee. Cities unaffected by state law are cities for which fees in 2008 are lower than or equal to the state license fee.

Figure 8: New data on quasi-legal prostitution firms in California, 2006-2015



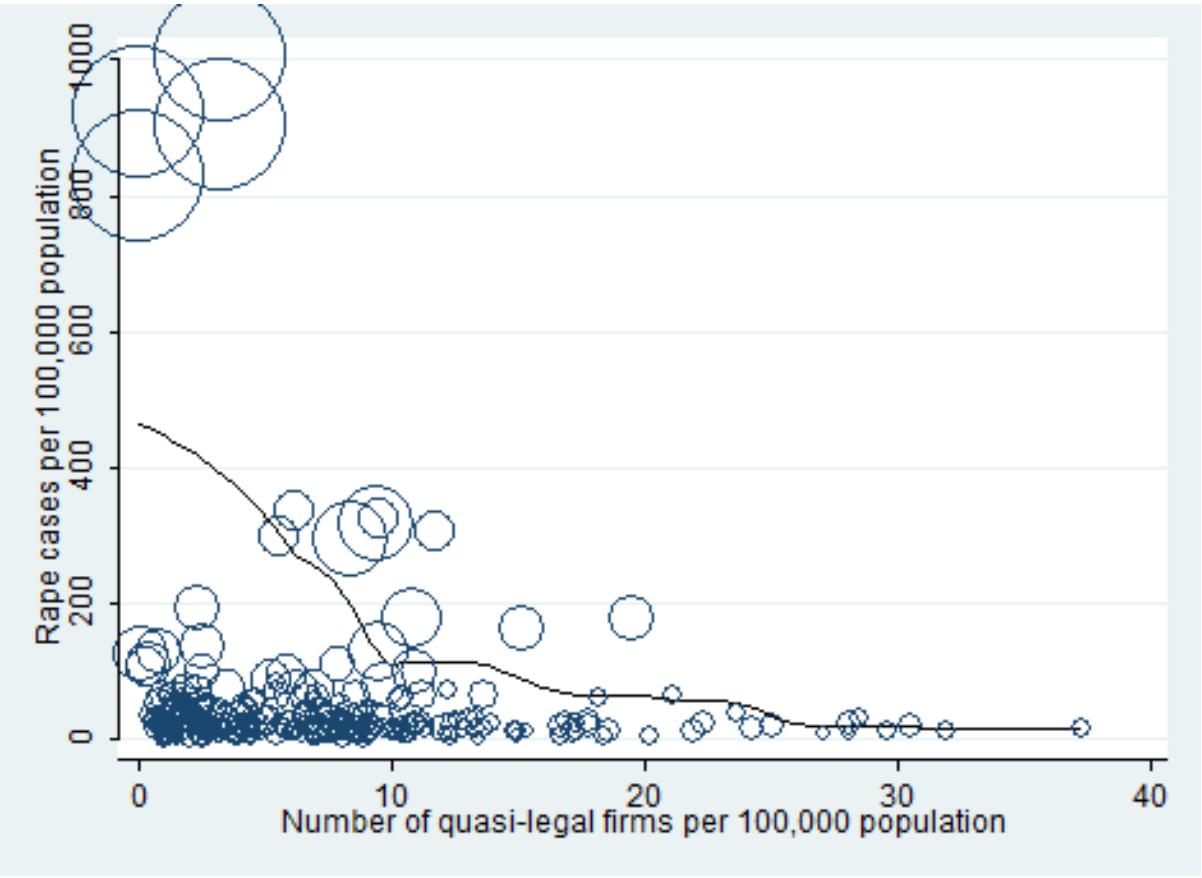
Note: Number of quasi-legal prostitution firms measured by erotic massage parlors scraped from Rubmaps.com. Population data from the Census. State law active from 2009-2014 effectively lowered fees for some cities. State law policy reversal active in 2015. Cities affected by state law are cities for which fees in 2008 are higher than the state license fee. Cities unaffected by state law are cities for which fees in 2008 are lower than or equal to the state license fee.

Figure 9: STI rates vs. size of quasi-legal sector



Note: Gonorrhea and chlamydia data from the California Department of Public Health. Quasi-legal data from Rubmaps. City-level size of quasi-legal sector weighted by city population. Quadratic fitted line shown.

Figure 10: Rape rates vs. size of quasi-legal sector



Note: Rape data from FBI Uniform Crime Report. Quasi-legal data from Rubmaps. City-level size of quasi-legal sector weighted by city population. Nonparametric fitted line shown.

1.10.2 Data Appendix

Illegal prostitution (escort) data

Data on escorts was scraped from TheEroticReview.com from May through July 2015. TheEroticReview.com is a website that allows escorts to list their businesses online and buyers to post ratings and transaction reviews. The website is able to operate legally through a disclaimer that the information provided is "fantasy" and fictional, despite anecdotal evidence to the contrary. Each individual provider's page was scraped for information on location, services offered, price, and number of reviews. Further location information was scraped from the main search results page for providers. The data reflects individual service providers, who may or may not be working for a pimp or escort agency.

The data reflects all escorts listed on the website at the time of scraping. Generally, provider listings appear to remain on TheEroticReview.com for quite some time, despite inactivity. To construct a measure of the escort market over time, I use the date of the earliest review as a proxy for the year of entry in the market. For years prior to 2015, I use the date the provider's page was last modified (i.e. reviewed or updated by the provider) as a proxy for the year of exit in the market. If the year of last modification is 2015, I assume that the provider is still operating. I then aggregate the number of listings active in a given year at the city level.

Since escorts are not typically tied to a brick-and-mortar location (as erotic massage parlors are), I created indicator variables for an escort's "coverage" of each city in California. To estimate the size of the escort market in each city, I sum all of the values of this indicator variable for each city. It is possible for the same escort to cover more than one city. Coverage in a given city is first proxied by the location labels assigned to the provider's page. This is clear and straightforward for the labels that contain city or regional names. However, other locations only provide a general region, e.g. "Inland Empire," and a non-specific label such as "My hotel." In this case, location is proxied by the area code's corresponding cities, if the area code falls within the general region. If

there is not a match, i.e. the provider's phone number is for an out-of-town area code, then the provider's ad website URLs are searched for any location information, e.g. Long Beach Craigslist. If the location information cannot be determined in this way, then the observation is dropped from the sample.

Quasi-legal prostitution (erotic massage) data

Data on erotic massage parlors was scraped from Rubmaps.com from December 2014 through January 2015 and again in July 2015. Rubmaps.com is a website that allows erotic massage parlors to list their businesses online and buyers to verify the parlor's involvement in prostitution, as well as post transaction reviews. Like TheEroticReview.com, Rubmaps.com is able to operate legally through a fictional disclaimer. Each massage parlor's page was scraped for information on location, listed prices, and number of reviews. For each massage parlor, the individual reviews were also scraped for transaction-level data on specific services sold, actual prices paid, and sex worker demographics.

The data reflects all erotic massage parlors listed on the website at the time of scraping. Rubmaps.com indicates when a massage parlor is closed, so these firms are observed in the dataset. I construct a measure of the erotic massage parlor market over time in a similar manner as for TheEroticReview.com. I use the date the business was added to Rubmaps.com as a proxy for entry in the market. I use the date of the last review as a proxy for exit in the market. Massage parlors with reviews in 2015 are assumed to still be in operation.

Location data is an exact address, so I match Rubmaps information with the cities for which I have fee data. In the case where many Rubmaps neighborhoods use the same fee, I sum the number of business listings for a given city, e.g. many neighborhoods in Los Angeles are distinguished from each other on Rubmaps.com but fall under the same municipality regulation.

Legal massage data

Data on legitimate massage parlors was scraped from Yelp.com from January to July 2015. Yelp.com is a website that allows providers to list their businesses online and buyers to post ratings and reviews. Business listings can be merchant-verified and Yelp.com employs an algorithm to filter out inappropriate reviews, including discussion of illegal market activity. I scraped information for all businesses listed under the search term "massage" for each city in California. Duplicate URLs in the data are dropped (as many firms appear multiple times in the search for nearby cities).

The data reflects all massage businesses listed on the website at the time of scraping. Yelp.com indicates when a business is closed, so these firms are observed to some degree in the dataset, although there is a margin for error as these businesses do not always appear in the current searches. I construct a measure of the legitimate massage market over time in the same manner as for Rubmaps.com. I use the year of the first review as a proxy for entry in the market and the year of closing as a proxy exit. Due to the limitations of current searches, the data is a more accurate representation of massage businesses that have survived through 2015. I am able to see the number of businesses that had their Yelp page deleted between time of scraping and July 2015; however, I am not able to determine the date of entry.

To create a sample of legitimate massage parlors, I restrict the sample by Yelp.com's categorization of the businesses. For the most narrow definition, I eliminate all service categories except for those including "Massage Therapy." I run sensitivity checks applying other categories such as "Massage Parlors" and dropping observations that match store names listed on Rubmaps.com.

CHAPTER 2

Product differentiation by legal status: estimating the demand for commercial sex

2.1 Introduction

Very little is understood regarding the market structure of illegal industries, despite their significant size and influence on social welfare and other economic outcomes. Accurately measuring quantity and prices alone has been historically challenging; however, the rapidly increasing scope of online activity provides new and promising means for observing illicit market activity. This chapter exploits the recent technological transformation of the U.S. commercial sex market in order to empirically estimate the demand for illegal goods and services when differentiated by both product characteristics as well as regulatory legal status.

Using quantity and price data from customer-review websites for sex workers, I estimate the demand for two horizontally differentiated types of commercial sex: quasi-legal massage prostitution and illegal escort prostitution. Buyers in the commercial sex market can be characterized as having subjectively different preferences, irrespective of quality. By choosing the mode of solicitation, the buyer selects on attributes such as the type of service, the appearance of the sex worker, the length of time spent with the sex worker, as well as the relative risk of infectious disease and law enforcement. Consequently, sex workers differentiate themselves on these dimensions. Some specialize in massage and manual stimulation, while others offer a full range of services to those willing to pay. As the online data supports, the quasi-legal sector trades heavily in these less risky services, while the illegal sector is primarily characterized by higher risk activity such as unpro-

tected sex.[1] Furthermore, in addition to heterogeneity in the types of services offered, the regulatory climate can also impact the two sectors differentially. In particular, I focus on the market in California, where quasi-legal massage prostitution is subject to occupational licensing, but illegal escort prostitution still operates completely informally. As a result, the two sectors have significantly different regulatory costs.

Given this framework of discrete consumer choice across two differentiated products, I employ a Logit model to estimate the own-price elasticity of demand for quasi-legal prostitution and the cross-price elasticity of demand with respect to illegal prostitution. Due to simultaneous equations bias, ordinary least squares regression analysis suffers from endogeneity. Prices will be correlated with sector-city-year specific demand shocks, and consequently correlated with the unobservables in the econometric model. Thus, I instrument for prices using marginal cost variables that vary across both city and time: massage licensing fees and their interaction with the adult Asian population. To check the validity of these instruments, I also separately estimate the model using the standard price instruments outlined in the previous literature by Hausman et al. (1994); Hausman and Leonard (1996); Nevo (2001) and compare elasticity estimates.

Under my preferred specification, I estimate the mean price elasticity of demand for quasi-legal prostitution to be -9.99. The demand for quasi-legal prostitution is highly elastic with respect to price. Furthermore, I confirm that quasi-legal prostitution and illegal prostitution are substitutes, with an estimated mean cross-price elasticity of 0.02. These are the first estimates of own- and cross-price elasticity of demand for the commercial sex market. From a policy standpoint, these estimates can be used to calculate the optimal penalty fines for solicitation. Moreover, this work contributes to the empirical literature on differentiated demand systems by estimating the demand for an illegal industry where products are differentiated by regulatory status.[2]

The rest of the chapter is organized as follows. Section 2.2 describes the organization

[1] See Table 1.4 of the previous chapter.

[2] Berry et al. (1995); Hausman et al. (1994); Hausman and Leonard (1996); McFadden et al. (2000); Nevo (2000, 2001)

of the Internet-based, indoor commercial sex industry and Section 2.3 outlines a basic model of supply and demand. Section 2.4 discusses the data, estimation procedure, and instruments, while Section 2.5 gives the estimation results. Section 2.6 concludes.

2.2 Background

Given my data sources and the recent rapid industry growth, I focus on the indoor, Internet-based commercial sex market in the U.S., which can be broadly categorized into two differentiated products: erotic massage parlors (i.e., quasi-legal prostitution) and escorts (i.e., illegal prostitution). These two sectors are horizontally differentiated along two key dimensions: (1) how they are regulated, and (2) the types of services offered.

Differentiation on legal status matters to buyers, as they face a relatively lower risk of arrest visiting a quasi-legal sex worker rather than an illegal sex worker. Due to the organizational structure of quasi-legal firms, reverse sting operations are difficult to successfully implement. Occupational licensing also lends a sense of legitimacy to the profession. In contrast, illegal sex workers operate without any formal license and law enforcement can easily set up false escort advertisements in order to arrest buyers.

Quasi-legal and illegal prostitution are also differentiated in terms of product characteristics, i.e. the services offered by sex workers. Sex workers in the illegal sector are much more likely to offer vaginal and anal intercourse, oral sex, and unprotected sex; meanwhile, sex workers in the quasi-legal sector are much more likely to offer massage and manual genital stimulation.[3] Consumer preferences across these types of services is highly subjective. Very risk-averse buyers may favor the quasi-legal sector for its low risk of arrest and disease transmission. In contrast, buyers with a strong disutility for condom use may prefer the illegal sector, despite the added risks.

The consumer ultimately weighs these differences in legal risk and product characteristics when deciding which type of sex worker to visit. In the following section, I present

[3]For more detailed discussion of the industry, please refer to Section 1.2.1.

a simple discrete choice model for this differentiated product demand system.

2.3 Model

The following section presents a Logit discrete choice model for differentiated demand systems. I follow the standard approach outlined by Berry et al. (1995); Nevo (2001) and the subsequent literature.

2.3.1 Supply

Suppose there are F firms, each of which produces some subset of the two sectors of indoor prostitution. The profits of firm f are given as:

$$\Pi_f = (P^{ql} - MC^{ql})(M)S^{ql}(P) + (P^{il} - MC^{il})(M)S^{il}(P) - C_f \tag{2.1}$$

where P^{ql}, P^{il}, MC^{ql}, and MC^{il} are the price and marginal cost of the quasi-legal and illegal sectors, $S^{ql}(P)$ is the market share of the quasi-legal sector, $S^{il}(P)$ is the market share of the illegal sector, M is the size of the indoor prostitution market, and C_f is the fixed cost of production for the firm.

Under the assumptions of strictly positive prices and the existence of a pure strategy Bertrand-Nash equilibrium, prices in each sector will satisfy the following first order conditions:

$$S^{ql}(P) + (P^{il} - MC^{il})\frac{\partial S^{il}(P)}{\partial P^{ql}} = 0 \tag{2.2}$$

$$S^{il}(P) + (P^{ql} - MC^{ql})\frac{\partial S^{ql}(P)}{\partial P^{il}} = 0 \tag{2.3}$$

2.3.2 Demand

Consumer i makes a discrete choice over quasi-legal and illegal prostitution in order to maximize utility, as given by:

$$U_i^{ql} = \delta_{ql} + \epsilon_i^{ql} \tag{2.4}$$

$$U_i^{il} = \delta_{il} + \epsilon_i^{il} \tag{2.5}$$

where $\mathcal{E}$ is independent and identically distributed with a Type I extreme-value distribution. Consumers have the same taste for sector quality δ_j, but idiosyncratic preferences for bundles of product characteristics, ϵ.

We also decompose product quality into observable product characteristics X^j and an unobservable component:

$$\delta_{ql} = X_{ql}\beta - \alpha P^{ql} + \mathcal{E}^{ql} \tag{2.6}$$

Normalizing the value of the outside good to zero, we can express the aggregate shares in the following closed form expression for estimation:

$$Pr(U_i^{ql} \geq U_i^{il}) = \frac{exp(\delta_{ql})}{1 + exp(\delta^{il})} \tag{2.7}$$

$$Pr(U_i^{il} \geq U_i^{ql}) = \frac{exp(\delta_{il})}{1 + exp(\delta^{ql})} \tag{2.8}$$

2.4 Estimation

The following section presents the new data measuring illegal and quasi-legal market shares and prices, estimation procedure, and instruments discussion.

2.4.1 Data

To estimate demand for the differentiated indoor prostitution market, I combine transactional review data scraped from the dedicated customer review websites, Rubmaps.com and TheEroticReview.com, with Census data on demographics and government data on massage licensing fees.

As previously described in Section 1.5.3, I construct a city-level panel that tracks the indoor, Internet-based commercial sex market in California from 2005 to 2015. I proxy

for the quantity demanded of quasi-legal prostitution using the number of reviews in a given city and year on Rubmaps.com. Similarly, I proxy for the quantity demanded of illegal prostitution using the number of reviews in a given city and year on TheEroticReview.com.

To measure market share S_t^j for sector j and year t, I divide the number of reviewed visits by the total potential number of visits in a city in a year. I assume the total potential market to be one visit per adult male capita per year. I define the market share of the outside good as:

$$S_{0t} = 1 - S_t^{ql} - S_t^{il} \tag{2.9}$$

where sector ql represents the quasi-legal prostitution sector and il represents the illegal prostitution sector.

The transactional data contains detailed information on prices and product characteristics for both sectors. Table 2.7.1 reports summary statistics for the variables used in the estimation. For the quasi-legal price, I use the total price paid: house price plus tip. For the illegal price, I use hourly price. I also observe the type of sexual services offered for each transaction, and thus construct sector-city-year level measures for the proportion of the market offering each service. These variables capture observed product characteristics for the quasi-legal and illegal prostitution sectors.

To instrument for prices, I utilize the massage licensing fees from Section 1.5.1 and city-level data on the the Asian population from the U.S. Census. I also use city-level demographic data on population, education, age, and income from the Census. For further details on the data collection, see the Data Appendix 1.10.2.

2.4.2 Logit model estimation

To estimate the parameters of demand, I can use the decomposition in equation 2.6 to rewrite equation 2.7 linearly:

$$ln(S_{it}^{ql}) - ln(S_{0it}) = X_{it}^{ql}\beta - \alpha P_{it}^{ql} + \mathcal{E}_{it}^{ql} \tag{2.10}$$

where S_{it}^{ql} is the market share of the quasi-legal sector in city i at time t, P_{it}^{ql} and P_{it}^{il} are the city-level average price for quasi-legal and illegal commercial sex services, respectively, and X_{it} is a vector of city-year covariates.

The own-price and cross-price elasticities of demand are as follows:

$$\eta_{ql,ql} = -\alpha P^{ql}(1 - S^{ql}) \tag{2.11}$$

$$\eta_{ql,il} = \alpha P^{il} S^{il} \tag{2.12}$$

The primary obstacle to identifying these own- and cross-price elasticities is the issue of simultaneity. Estimating equation 2.10 using ordinary least squares regression would yield biased results, as both prices are simultaneously determined with market share. Consequently, I use marginal cost variables as instruments for the prices of quasi-legal and illegal prostitution.

2.4.3 Marginal Cost Instruments

To instrument for prices, I estimate the following first stage:

$$P_{it}^{j} = \theta^{j} MassageFee_{it} + \omega^{j}(MassageFee \times Asian)_{it} + W_{it}\psi + \nu_{it} \tag{2.13}$$

where $j = ql$, il and W_{it} is a vector of exogenous city-year covariates.

As discussed at length in Section 1.7.2, massage licensing fees are a substantial cost for quasi-legal firms. Changes in massage licensing fees can significantly shift quasi-legal supply, thereby impacting both quasi-legal and illegal prostitution prices (the latter through general equilibrium effects).

In addition to massage licensing fees, I also instrument for prices using the interaction between licensing fees and the adult Asian population. According to Rubmaps.com and TheEroticReview.com, Asian women make up 94.3% of the quasi-legal sector and only 17.5% of the illegal sector. Based on the demographics of the quasi-legal sector in my

sample, the adult Asian population serves as a good proxy for potential quasi-legal labor supply. The interaction with massage licensing fees provides additional variation in the impact of regulatory cost changes over time.

2.5 Results

The results of the first stage are reported in Table 2.2. As expected, higher regulatory costs in the form of massage licensing fees reduces supply and increases quasi-legal prices. This relationship is attenuated for cities with larger adult Asian populations and therefore larger potential quasi-legal labor supply. In all specifications, the instruments are sufficiently strong. Further discussion of the instruments' relevance in predicting price can be found in Section 1.7.2.

Table 2.3 reports the results of the estimation. Columns 1-4 estimate equation 2.10 using OLS for comparison. Columns 5-8 estimate equation 2.10 using licensing fees and the Asian adult population as instrumental variables. Each column adds controls for sector-specific product characteristics, "brand" (i.e., sector) fixed effects, and city demographics. However, the magnitude of the estimates change most significantly when moving from OLS to IV, underlining the importance of addressing simultaneity when estimating elasticities of demand.

Plugging the two-stage least squares estimates into equations 2.11 and 2.12, Table 2.4 summarizes the mean estimated own-price and cross-price elasticities of demand. Under my preferred specification, I estimate the mean price elasticity of demand for quasi-legal prostitution to be -9.99. The demand for quasi-legal prostitution is highly elastic with respect to price, although still less elastic than the demand for illegal sex work, which has an estimated mean price elasticity of -22.18. These findings are consistent with the descriptive evidence on the availability of substitutes for quasi-legal and illegal sex work.

2.5.1 Robustness check: Hausman instruments

In addition to instrument relevance, the key identifying assumption is instrument exogeneity, i.e. $Corr(LicensingFees_{it}, S_{it}^{ql}) = 0$. This could be violated if commercial sex buyers experienced a change in their preferences due to entry and exit related to the licensing fees. Including demographic variables helps, but to provide an additional robustness check, I also estimate the Logit model using a different set of instruments: the price of the same type of goods in other geographic markets. In order to account for the endogeneity of quasi-legal price in city i in year t, I use the quasi-legal prices in cities $k = 1, ...N - 1$ in year t as instruments.

Given the panel structure of the data, I am able to use these price instruments in the spirit of Hausman et al. (1994); Hausman and Leonard (1996); Nevo (2001). The key identifying assumption is that city-specific valuations are independent across cities, controlling for demographics and "brand"-specific means. Under this assumption, the prices of quasi-legal and illegal prostitution in other cities are valid instruments for the prices of quasi-legal and illegal prostitution within a given city.

The independence assumption would be violated if there is an aggregate demand shock that impacts the unobserved valuation of quasi-legal prostitution in all cities. For example, if the passage of the CAMTC law in the state of California also shifts the demand for quasi-legal prostitution by signalling more lenient law enforcement of buyers. To examine the validity of my instruments in both specifications, I compare the IV estimates from the marginal cost instruments to the IV estimates from the Hausman instruments.

Table 2.5 reports the results. The Hausman instruments are sufficiently strong, as indicated by the first stage. For each specification, including product characteristics, brand fixed effects, and market demographics, the coefficients are very similar across the two sets of instruments. This supports the use of licensing fees and the interaction with the adult Asian population as valid instruments for price, as I find similar magnitudes for the coefficients.

2.6 Conclusion

Modeling the indoor, Internet-based prostitution industry as a differentiated products market, I find that demand for quasi-legal massage prostitution is very elastic, with an estimated mean price elasticity of -9.99. The responsivenes of prostitution demand to price suggests that public policy can have a significant impact on the consumption of prostitution. Policymakers can use these price elasticity of demand estimates to help set optimal fees for solicitation arrests and John schools. Moreover, as "End Demand" law enforcement programs become increasingly more popular in the U.S., it may be useful to consider designing a market-based approach with this framework in mind. Future work should also attempt to incorporate more rich sources of consumer data, in order to interact product characteristics with consumer characteristics.

2.7 Appendix

2.7.1 Tables and Figures

Table 1: Summary statistics for quasi-legal and illegal prostitution

	Mean	Std. Dev.
Quasi-legal price	91.38	34.10
Illegal price	203.09	100.07
Number of quasi-legal reviews	3.16	32.19
Number of illegal reviews	100.30	838.72
Quasi-legal market share	0.01	0.03
Illegal market share	0.10	0.20
Quasi-legal % offering intercourse	0.24	0.27
Illegal % offering intercourse	0.80	0.31
Quasi-legal % offering oral sex	0.29	0.27
Illegal % offering oral sex	0.62	0.36
Massage licensing fee	171.15	535.44
Asian population	34385	75694
N	7149	

City-year means. See Data Appendix 1.10.2 for further details.

Table 2: First stage results instrumenting for quasi-legal price

	(1)	(2)	(3)
Massage licensing fee	0.881**	0.912**	0.581**
	(0.0656)	(0.0621)	(0.115)
Massage licensing fee × Asian population	0.00000119*	0.00000104	-0.000000421
	(0.000000676)	(0.000000639)	(0.00000247)
% Asian sex workers	22.55	-2.433	-1.567
	(17.43)	(16.95)	(17.70)
% offer intercourse	71.13**	35.18**	37.01**
	(10.91)	(11.87)	(11.86)
% offer oral sex	45.63**	41.80**	37.76**
	(12.76)	(12.06)	(12.00)
Total population			0.0000242
			(0.0000323)
Mean family income			0.000395**
			(0.000169)
Male population over 25 with bachelor's or higher			-0.395
			(0.359)
R^2	0.890	0.903	0.907
F-test	113.11	133.35	12.73
Brand dummies included	–	X	X

Dependent variable is city-average price of quasi-legal prostitution. City-level regressions based on 7,149 observations. Columns 2 and 4 include "brand" dummy variables for sex work sector. Standard errors in parentheses. $^{+}$ $p < 0.15$, * $p < 0.10$, ** $p < 0.05$.

Table 3: Logit demand estimation for commercial sex: marginal cost instruments

	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) IV	(6) IV
Price	-0.0125**	-0.0122**	-0.00328**	-0.101**	-0.0983**	-0.109**
	(0.00126)	(0.00132)	(0.00104)	(0.00716)	(0.00635)	(0.0220)
% Asian sex workers	3.140**	3.178**	3.278**	5.086**	2.032	2.248
	(0.513)	(0.515)	(0.381)	(1.875)	(1.761)	(1.926)
% offer intercourse	-3.283**	-3.001**	-1.363**	7.150**	2.796**	3.207*
	(0.535)	(0.629)	(0.458)	(1.411)	(1.317)	(1.690)
% off oral sex	-3.986**	-3.962**	-1.992**	2.018	1.473	2.008
	(0.567)	(0.568)	(0.417)	(1.519)	(1.366)	(1.658)
Total population			0.000000294**			0.00000320**
			(0.000000128)			(0.00000119)
Mean family income			-0.0000942**			0.00000205
			(0.00000456)			(0.0000250)
Male population over 25 with bachelor's degree or higher			0.115**			-0.00654
			(0.0104)			(0.0428)
First stage F-test				113.11	133.35	12.73
Brand dummies included	–	X	X	–	X	X

Dependent variable is $\ln(S_{it}^{ql}) - \ln(S_{0it})$. Based on 7,149 observations. City-level regressions using total number of reviews and average city-level prices from 1999 to 2015. Columns 2, 4, 6, and 7 include "brand" dummy variables for sex work sector. In columns 4-7, prices are instrumented with massage licensing fees and the interaction between fees and the city's Asian population. Standard errors in parentheses. $^{+}$ $p < 0.15$, * $p < 0.10$, ** $p < 0.05$

Table 4: Mean own-price and cross-price elasticity of demand estimates

	Quasi-legal	Illegal
Quasi-legal	-9.99054	0.00098
Illegal	0.02231	-22.18299

Using specification in column 6 from Table 2.3 at mean price and share values.

Table 5: Logit demand estimation for commercial sex: Hausman instruments

	(1) IV	(2) IV	(3) IV
Price	-0.146**	-0.103**	-0.149**
	(0.0359)	(0.0160)	(0.0306)
% Asian sex workers	4.660**	3.204**	2.209
	(1.962)	(1.310)	(1.848)
% offer intercourse	20.26**	4.824**	6.795**
	(6.604)	(2.093)	(3.156)
% off oral sex	1.464	-1.158	1.901
	(2.574)	(1.524)	(2.398)
Total population			0.00000440**
			(0.00000108)
First stage F-test	13.42	66.25	18.71
Brand dummies included		X	X

Dependent variable is $\ln(S_{it}^{ql}) - \ln(S_{0it})$. Based on 7,149 observations. City-level regressions using total number of reviews and average city-level prices from 1999 to 2015. Columns 2 and 3 include "brand" dummy variables for sex work sector. Prices are instrumented with the prices for the same sector in other cities.
Standard errors in parentheses. $^{+}$ $p < 0.15$, * $p < 0.10$, ** $p < 0.05$

CHAPTER 3

Reducing the risk premium for unprotected sex through community-based HIV prevention: evidence from India and Ecuador

with Manisha Shah

3.1 Introduction

Commercial sex workers and their clients are a key population in prevention efforts against the spread of HIV/AIDS and other sexually transmitted infections (STIs).[1] This population is particularly important in developing countries at the frontier of the epidemic, such as India and Ecuador, where prevalence is relatively concentrated but growing among female sex workers (FSW) and men who have sex with men (MSM). In addition to playing a significant role in transmission dynamics, the commercial sex market also presents an interesting population for study, as sex workers' behavioral incentives also align with their economic incentives.

The existence of a risk premium for unprotected sex in the commercial sex market has been well documented in both developed and developing countries.[2] Gertler et al. (2005) show that commercial sex workers receive higher prices for unprotected sex as a compensating wage differential for the increased risk of HIV and STI transmission. Fur-

[1]International AIDS Conference (2014), Dandona et al. (2005), Gutiérrez et al. (2006), Gutierrez et al. (2010), Gutierrez and Atienzo (2012), Gutiérrez et al. (2013)

[2]Nguyen (2015a), Gertler et al. (2005), Jakubowski et al. (2016)

thermore, Jakubowski et al. (2016) suggest that these large risk premiums pose significant challenges to behavioral HIV prevention programs. Despite condom promotion efforts, commercial sex workers may still respond to these economic incentives, especially when poverty levels are high. Consequently, it is important to understand the determinants of the risk premium for unprotected sex, and how the premium may evolve in response to environmental changes such as a community-based public health interventions.

We utilize individual survey data from the Frontiers Prevention Program (FPP) in India and Ecuador to examine changes in the risk premium for unprotected sex from the baseline in 2003 to the endline in 2007. The intervention provided large-scale, community-based outreach in order to strengthen clinical capacity and quality of voluntary counseling and testing services, as well as build community solidarity through peer support. The goal of the intervention was to educate and mobilize key populations to utilize prevention commodities and services, reduce risky behaviors, and consequently reduce HIV and STI prevalence. We focus on both FSW as well as MSM – including male sex workers as well as their male clients – in India and Ecuador. For each sample, we analyze transactional data for a panel of sex workers (2,926 women and 2,713 men in Ecuador, and 6,704 women and 6,693 men in India) and estimate the risk premium for unprotected sex before and after the intervention. We estimate transaction-level price regressions with sex worker fixed effects as outlined in Gertler et al. (2005), and document a decrease in the risk premia across all samples. After the FPP intervention, the risk premium for unprotected sex requested by clients declined from 2.6% to -1.6% for female sex workers and from 1.6% to -3.0% for male sex workers in India. Similarly, the premium declined from 2.4% to -48.7% for female sex workers and from 4.9% to 1.5% for male sex workers in Ecuador.

To examine the role that the intervention may have played in this decline, we employ an intent-to-treat analysis, exploiting the randomization in roll out of FPP services across geographic sites. We pool each sample across baseline and endline surveys and interact FPP with the change in risk premium. We find that the risk premia declines for

sex workers from the treatment sites across all samples except for FSW in India.[3] For Indian male sex workers, the risk premium was 7.4 percentage points lower in FPP treatment sites. Likewise, the risk premium was 45 percentage points lower for Ecuadorean female sex workers and 8.1 percentage points lower for Ecuadorean male sex workers from the treatment group. Furthermore, the decline was significantly stronger in treatment locations with higher local STI prevalence.

To explore the mechanisms through which this decline occurs, we examine the effect of the FPP intervention on sex worker behavior. In order to account for possible contamination of the control sites, we use a difference-in-differences framework. Overall, we find evidence that the community-based intervention effectively increased preventative behavior amongst sex workers. Facing lower wage premia, treated sex workers had less incentive to engage in unprotected sexual activity at the suggestion of their clients. Consequently, we find that condom use increased by as much as 25 percentage points, and the incidence of syphilis decreased by as much as 5 percentage points for treated sex workers. Moreover, treated sex workers were not only more likely to use condoms, but also more likely to bring their own condoms and suggest condom use. We also find that treated MSM in Ecuador were 11 percentage points more likely to successfully convince their clients to use condoms, suggesting that the intervention also helped improve sex workers' bargaining power. By reducing stigma in the general community and promoting condom use, the program reduced risky health behavior while also empowering sex workers to effectively negotiate safer working conditions.

We also consider alternative mechanisms through which the risk premium could decline, namely through an income effect. If income levels are also rising as a result of the intervention, then sex workers may be less responsive to the risk premia and adjust their behavior accordingly. We employ the same difference-in-differences framework to examine the impact of the FPP intervention on sex work income as well as secondary income and do not find significant treatment effects in the India samples. This suggests that

[3]However, we that find the premium significantly declines for FSW in India after accounting for the local disease environment.

the behavioral channel is the primary mechanism through which the premium responds to community-based prevention programs, although we also find evidence of potential income effects in Ecuador.

The rest of the chapter proceeds as follows. Section 3.2 gives background on the commercial sex market in each country and the FPP intervention. Section 3.3 describes the data, while Section 3.4 outlines the empirical model. Section 3.5 presents a discussion of the key findings and Section 3.6 explores the possible mechanisms for the results. Section 3.7 concludes.

3.2 Background

The spread of HIV/AIDS and other STIs is a significant concern in both India and Ecuador. Recent estimates from UNAIDS and the World Bank put adult HIV prevalence at approximately 0.3% in both India and Ecuador.[4] However, the incidence of HIV/AIDS and other STIs is much greater for high risk populations like FSW and MSM. Studies report HIV prevalence rates up to a 17% for MSM in Ecuador, 15% for MSM in India, and 2.6% for FSW in India.[5] Moreover, sexual activity remains the most common source of transmission, accounting for 87.4% of reported HIV cases in India.[6] Consequently, sex workers form a key population that is epidemiologically critical to HIV and STI prevention efforts.[7]

Though prostitution is still heavily stigmatized, there are legal sectors of commercial sex work in both India and Ecuador. In India, brothels, pimping, and public solicitation are illegal, but commercial sex work within a private residence is allowed.[8] In Ecuador, commercial sex work, including brothels, is legal and regulated through licens-

[4]The World Bank (2012); UNAIDS (2014)

[5]Bautista et al. (2004); The World Bank (2012)

[6]The World Bank (2012)

[7]Jakubowski et al. (2016)

[8]India Central Government Act (1956)

ing.[9] Nonetheless in both countries, illegal or unregulated prostitution persists, and sex workers experience varying degrees of social acceptance and support. This in turn may impact sex workers' decision making and health behaviors. For instance, previous work analyzing the same dataset has found that official permission to engage in sex work is a positive correlate of condom use among MSM in Ecuador.[10] Consequently, community-based outreach programs are an especially important method of HIV prevention for stigmatized and vulnerable populations such as sex workers.

3.2.1 Randomized control trial: the Frontiers Prevention Program (FPP)

The Frontiers Prevention Program (FPP) targeted relatively low-prevalence countries where the HIV epidemic was still concentrated in high risk populations. The ultimate goal of the program was to target these key populations before the epidemic spread, thereby reducing HIV prevalence in the national population. Prior evaluations of the FPP intervention have found that the community-based programs successfully increased condom use and lowered the incidence of syphilis and herpes in India and Ecuador.[11]

To achieve this, the FPP focused on five primary goals: (1) individually focused health promotion, (2) scaling-up, targeting, and improving service and commodity delivery, (3) mobilization of key populations, (4) advocacy, policy change, and community awareness, and (5) NGO capacity building to support program implementation. For example, the FPP implemented peer outreach and skills building activities to build mutual support among FSW and MSM, as well as reduce stigma in the general public. The intervention also strengthened clinical capacity and quality of voluntary counseling and testing services.[12] To evaluate the program's effectiveness, the implementation was randomized across geographic participatory sites.

[9] U.S. Department of State (2006)

[10] Gutiérrez et al. (2006)

[11] Gutierrez and Atienzo (2012); Gutierrez et al. (2010)

[12] International HIV/AIDS Alliance (2003)

However, the comparison group was contaminated due coordination issues and the introduction of prevention activities in all participatory sites. In India, the Bill and Melinda Gates Foundation and the AP State AIDS Control Society scaled up Avahan, a targeted HIV prevention program, shortly after the baseline survey. However, as discussed in the previous literature, the FPP intervention had a greater degree of community participation – hence, the focus on evaluating the community-based features that differentiate the FPP from Avahan.[13] Additionally, in Ecuador, the randomization suffered from disjointed implementation and control group contamination from a Female Sex Worker Network that spanned across comparison sites. To address these issues, the previous literature augments the treatment assignment with measures of treatment intensity.[14] Given the focus of our work, we choose to utilize an intent-to-treat analysis and account for possible control group contamination using econometric methods.

3.3 Data

We utilize baseline and endline survey data for sex workers in India and Ecuador, totaling four different samples. From India, our sample includes FSW and MSM – including male sex workers and their male clients – from Andhra Pradesh, the state with the highest HIV prevalence rate in India.[15] The baseline survey was collected in 2003 and the endline survey in 2007, covering 24 sites in Andhra Pradesh. At baseline, the sample covered 6,704 FSW and 6,693 MSM in India. From Ecuador, our sample again includes FSW and MSM – including male sex workers and their male clients – from eight cities in Ecuador. The baseline survey was collected in 2003 and the endline survey in 2007, covering 2,926 FSW and 2,713 MSM in Ecuador.

To analyze the effects of condom use on prices, we create a panel of sex workers for each survey, tracking their behavior in the last three commercial sex transactions. While the

[13]Gutiérrez et al. (2013)

[14]Gutierrez et al. (2010)

[15]The World Bank (2012)

survey design does not follow individual sex workers from baseline to endline, we are able to analyze the program's effect on transactions taking place within the treatment sites as a group. Assuming there is no significant migration between the baseline and endline surveys, we can compare the surveyed populations over the course of the intervention across participatory sites. For each transaction, we observe both information on the services provided as well as client characteristics. Table 3.1 provides summary statistics of these transaction-level variables for each sample.

As done in the previous literature by Gertler et al. (2005), we categorize each transaction based on who suggested condom or no condom use. This illicits information on clients' and sex workers' preferences in determining the risk premium for unprotected sex. In differentiating between reasons for no condom use, we categorize cases of ignorance regarding the existence, effectiveness, and availability of condoms under client requests. In contrast, we categorize unintended no condom use (e.g. ran out or store was closed) as unprotected sex due to not having a condom. In the MSM samples, we also observe both sex workers and their clients. As a result, our analysis considers transactions reported by sex workers as well as buyers, and we control for buyer status in all of our specifications.

In addition to transactional information, the data also includes variables on health outcomes, namely blood and urine test results for syphilis, chlamydia, herpes simplex virus 2, and HIV. We create more general measures for the incidence of any STI; however, the only outcome consistetly measured across all samples and time periods is syphilis.[16] From this information, we also construct measures of the local disease rate by generating the prevalence within a given site, excluding the sex worker's own status. We use this measure of local STI prevalence in order to examine the effect of FPP on treatment sites.

[16]However, we do not include syphilis for FSW in India in our analysis because of data quality issues.

3.4 Empirical model

To estimate the risk premia for unprotected sex, we follow the model of commercial sex transactions presented by Gertler et al. (2005). That is, the price P_{ij} for transaction i and sex worker j can be represented by the following:

$$P_{ij} = \lambda + \sum_k \phi_k X_{ik} + \sum_l \delta_l S_{ijl} + \rho(\beta_i, \gamma_j) C_{ij} + \theta_j + \epsilon_{ij} \tag{3.1}$$

where

$$\rho(\beta_i, \gamma_j) = -[(1-\alpha)\beta_i + \alpha\gamma_i)] \tag{3.2}$$

and X_{ik} are client characteristics, S_{ijl} are services provided in the transaction, C_{ij} is an indicator for whether or not the sex worker used a condom with the client, θ_j is a sex worker fixed effect, and ϵ_{ij} is a zero mean random disturbance. The coefficient on condom use, ρ, is a function of the client's disutility from using a condom β_i, the sex worker's disutility from risking infection with unprotected sex γ_i, and the relative bargaining power of the client and sex worker α and $(1-\alpha)$, respectively. The sex worker will use a condom when the disutility from condom use outweighs the disutility from disease risk, i.e. $\beta_i \leq \gamma_i$. When $\beta_i > 0$ and $\gamma_i > 0$, the risk premium on unprotected sex is positive.

The intervention could impact the parameters of this model in the following ways:

(i) Client disutility from condom use, β_i, decreases or becomes negative. The FPP empowers sex workers to educate the client on the health risks of unprotected sex, causing the client to care about infection risks and gain utility from condom use.

(ii) Sex worker disutility from unprotected sex, γ_i, increases. The FPP educates the sex worker on the effectiveness of condoms, where to access free condoms, and how to correctly use condoms, increasing sex worker utility for condoms and consequently, the number of transactions where a condom is used.

(iii) Sex worker bargaining power, $(1-\alpha)$, increases (and client bargaining power α decreases). The FPP reduces stigma associated with sex work and empowers the

sex worker, increasing the sex worker's relative bargaining power.

A negative premium for unprotected sex implies two mechanisms: (1) the sex workers accepting client requests for unprotected sex are receiving less money, and (2) the sex workers suggesting condom use are receiving more money. The first mechanism could be the result of a large decline in the number of sex workers agreeing to unprotected sex, due to an increase in γ and/or decrease in β. This could leave only risk-loving sex workers, for whom $\gamma < 0$, in the sample of no condom transactions. The second mechanism could be the result of an increase in $(1 - \alpha)$, as empowered sex workers can not only negotiate more condom use, but also higher prices with condom use.

Taking equation 3.1 to the data, we first estimate the premia for unprotected sex separately at baseline and endline using the following econometric model with sex worker fixed effects:

$$ln(P)_{ij} = \lambda + \sum_k \phi_k X_{ik} + \sum_l \delta_l S_{ijl} + \sum_k \rho_k C_{kij} + \theta_j + \epsilon_{ij} \tag{3.3}$$

where C_k represents an indicator variable for the following categories: client requested condom, client requested no condom, sex worker requested no condom, and no condom available. The excluded group for comparison is sex worker requested condom.

Second, to directly test the impact of the intervention on the premia, we pool the baseline and endline data and estimate the following:

$$ln(P)_{ij} = \lambda + \sum_k \phi_k X_{ik} + \sum_l \delta_l S_{ijl} + \rho_1 C_{ij} + \rho_2 (C \times Endline \times FPP)_{ij} + \theta_j + \epsilon_{ij} \tag{3.4}$$

$$ln(P)_{ij} = \lambda + \sum_k \phi_k X_{ik} + \sum_l \delta_l S_{ijl} + \rho_1 C_{ij} + \rho_2 (C \times Endline \times FPP \times STI)_{ij} + \theta_j + \epsilon_{ij} \tag{3.5}$$

where $Endline$ represents an indicator variable for post-intervention, FPP represents an indicator variable for treatment site, and STI is the local STI prevalence rate. Equation 3.4 allows us to estimate the change in risk premia due to FPP treatment, while equation 3.4 allows for heterogeneity in the change in risk premia across disease environments. The

expectation is that if local STI rates are high, then the changes in γ and β will be even greater, contributing to a larger decline in risk premia for FPP-treated sites.

Lastly, we check for a change in sex worker behaviors that signal a change in β, γ, and α. In particular, we are interested in determining whether or not FPP influenced sex workers' decisions to bring a condom, suggest a condom, use a condom, and convince a client to use a condom. To do so, we do not rely on the randomization of FPP treatment sites, since the comparison group contamination may bias our results. Instead, we employ a difference-in-differences analysis to estimate the treatment effect on health and behavioral outcomes:

$$Y_{it} = \psi + \omega(FPP \times Endline)_{it} + \zeta FPP_i + \eta Endline_t + \sum_k \phi_k X_{ik} + \sum_l \delta_l S_{ijl} + \nu_{it} \quad (3.6)$$

where, under the assumption of common group trends over time, $\hat{\omega}$ is our unbiased difference-in-differences estimator of the average treatment effect. The identifying assumption could be violated if the FPP contamination grows differentially than the treated sites; however, given the scale of the contamination and the initial randomization of intent-to-treat, we do not believe this to be a significant concern.

3.5 Results

We estimate the log price regression model in equation 3.3 with sex worker fixed effects for the baseline and endline surveys. Table 3.2 reports the results and Figure 3.1 summarizes the changes in risk premia for each sample. After the intervention, the risk premium for unprotected sex requested by clients declined from 2.6% to -1.6% for female sex workers and from 1.6% to -3.0% for male sex workers in India. Similarly, the premium declined from 2.4% to -48.7% for female sex workers and from 4.9% to 1.5% for male sex workers in Ecuador. While the magnitudes vary and some of the declines are not statistically significant, the consistent direction across all samples suggests that the risk premium parameters responded to the program in some capacity.

To take a closer look at this pattern, we pool each sample over the intervention period and estimate equations 3.4 and 3.4. Columns 1, 3, 5, and 7 of Table 3.3 correspond to equation 3.4. The results suggest that, without conditioning on local disease prevalence, the risk premia declines in FPP sites for all samples except FSW in India. For MSM in India, the risk premium decreased by 7.4 percentage points in FPP treatment sites. Likewise, the risk premium was 45 percentage points lower for Ecuadorean female sex workers and 8.1 percentage points lower for Ecuadorean male sex workers from the treatment group. Columns 2, 4, 6, and 8 estimate equation 3.4 and allow for heterogeneity across local STI prevalence. After accounting for the local disease environment, we find that the risk premia falls for treated sex workers in all samples, including FSW in India. Previous literature has documented a decrease in syphilis infection for FSW in India during this time.[17] This may explain why it initially appears that FPP increases the premium – as it would in an environment with falling disease prevalence – but the premium then declines after controlling for local STI rates. We conclude that the introduction of FPP caused the risk premium to decline in all samples, and this decline was larger in treatment locations with higher local disease prevalence.

Facing lower wage premia, treated sex workers may have felt less incentive to engage in unprotected sexual activity at the suggestion of their clients. Consequently, we estimate equation 3.6 for condom use and the local syphilis rate. Table 3.4 reports the results. We find that rates of condom use increase across all samples, with a 4.5% increase for FSW India, a 5.6% increase for MSM in India, a 3.7% increase for FSW in Ecuador, and a 71.3% increase for MSM in Ecuador. As a result, we find that local syphilis rates also decrease significantly in treated sites, with a 23.3% decline for MSM in India, a 44.1% decline for FSW in Ecuador, and a 28.4% decline for MSM in Ecuador. These findings are consistent with the previous literature's evaluation of the FPP intervention.[18]

[17] Gutierrez and Atienzo (2012)

[18] Gutiérrez et al. (2013); Gutierrez et al. (2010)

3.6 Possible mechanisms for the decline in risk premium

In this section, we explore two possible causes of the decline in the risk premium. The first is the community-based intervention, which focused on providing health knowledge and community outreach. The second is a response to changes in income over time.

3.6.0.1 Health knowledge and community outreach

Tables 3.5 and 3.6 present the results of the difference-in-differences regressions on sex worker behavior. Overall, we find evidence that treated sex workers were more likely to bring a condom, more likely to suggest condom use, and more likely to convince their clients of condom use.

Condom promotion efforts were aimed at educating sex workers on the proper use, efficacy, and availability of condoms. After the intervention, treated sex workers were more likely to carry condoms and provide them in a transaction. The probability of the sex worker providing the condom increased across all samples, with an 8.2% increase for FSW India, a 12% increase for MSM in India, a 2.5% increase for FSW in Ecuador, and a 110% increase for MSM in Ecuador. Meanwhile, the probability of having unprotected sex due to not having a condom decreased by 9.1% for FSW in Ecuador and by 27.2% for MSM in Ecuador.

In addition to helping sex workers access prevention resources, the FPP intervention also worked to build community support and reduce stigma against sex workers. Consequently, we find that the probability of the sex worker suggesting a condom increased by 7.2% for FSW in India, 4.5% for FSW in Ecuador, and 103.5% for MSM in Ecuador. This could reflect an increase in both γ_i and $(1 - \alpha)$, as the program may have helped empower sex workers to ask for condom use. Furthermore, the probability of the sex worker successfully convincing the client to use a condom increased by 150.7% for MSM in Ecuador. This implies a large increase in sex worker bargaining power, with peer support and education efforts helping sex workers more effectively negotiate condom use

We conclude that the intervention increased condom use suggested by sex workers by reducing the number of sex workers accepting client requests for unprotected sex, as well as reducing the number of sex workers going into transactions unprepared. By reducing stigma in the general community and promoting condom use, the program reduced risky health behavior while also empowering sex workers to ask for safer working conditions.

3.6.0.2 Income

We now consider alternative mechanisms through which the risk premium could also decline. As previous literature suggests, income and poverty levels may impact sex workers' responsiveness to the risk premium for unprotected sex.[19] If the intervention causes sex workers' incomes to rise, unrelated to their health behaviors, then the premium for high risk activity may also evolve as unprotected sex becomes relatively less valuable. We check whether or not income is increasing as a result of the FPP intervention, employing the same difference-in-differences framework in equation 3.6.

Table 3.7 reports the results. We estimate the treatment effect for both sex work income, as well as secondary income. For FSW and MSM in India, we do not find any significant treatment effects, providing evidence that neither measures of income changed as a result of the intervention. This suggests that the behavioral channel is the primary mechanism through which the premium responds to community-based prevention programs in India. However, we do find evidence of potential income effects in Ecuador, particularly among FSW. Moreover, this is consistent with FSW in Ecuador experiencing a significantly larger decline in the risk premium relative to the other groups sampled. Thus, the behavioral changes coupled with rising incomes could both be contributing to the dramatic change in risk premium observed among treated FSW in Ecuador.

[19] Jakubowski et al. (2016)

3.7 Conclusion

We find that the risk premium and incidence of high-risk behavior falls when sex workers are exposed to community-based prevention programs. Improved peer support and health education reduces the value of no condom use relative to condom use, thus eroding the compensating wage differential for unprotected sex.

As the risk premium declines, this change in economic incentives could promote future condom use long after the intervention. Future work should test the persistence of these premia declines and assess the long term impact on health behavior and infectious disease. It would also be useful to study this phenomena in other contexts, such as developing countries with higher HIV prevalence (e.g., sub-Saharan Africa), developed countries (e.g., MSM in the U.S.), and countries with different legal regimes (e.g. illegal prostitution in the U.S.). More evidence across different settings is necessary in order to evaluate the relative importance of the behavioral channel vis-à-vis other channels, such as income.

3.8 Appendix

3.8.1 Tables and Figures

Table 1: Transaction-level summary statistics

	FSW India		MSM India		FSW Ecuador		MSM Ecuador	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Price	104.788	(113.262)	30.478	(42.463)	8.018	(10.039)	20.058	(60.284)
Condom used	0.657	(0.475)	0.534	(0.499)	0.895	(0.307)	0.462	(0.499)
No condom: client suggested	0.035	(0.185)	0.036	(0.185)	0.033	(0.178)	0.153	(0.360)
No condom: sex worker suggested	0.031	(0.173)	0.118	(0.322)	0.042	(0.200)	0.210	(0.407)
No condom: did not have one	0.159	(0.365)	0.078	(0.268)	0.038	(0.191)	0.082	(0.275)
Condom used: sex worker suggested	0.489	(0.500)	0.649	(0.473)	0.821	(0.338)	0.454	(0.500)
Condom used: client suggested	0.286	(0.452)	0.119	(0.324)	0.066	(0.248)	0.103	(0.304)
Vaginal sex	0.729	(0.444)			0.982	(0.131)		
Anal sex	0.003	(0.053)	0.884	(0.321)	0.474	(0.499)	0.705	(0.456)
Married client	0.554	(0.627)	0.418	(0.493)	0.504	(0.500)		
Wealthy client	0.457	(0.498)	1.843	(0.818)	0.079	(0.270)	0.073	(0.259)
Young client	0.437	(0.496)	1.595	(0.538)	0.368	(0.482)	0.949	(0.713)
Regular client	0.309	(0.462)	0.394	(0.489)	0.453	(0.498)	0.658	(0.475)
Drunk client	0.838	(0.368)			0.118	(0.323)	0.166	(0.373)
Forward caste	0.086	(0.280)	0.121	(0.326)				
Trucker client	0.105	(0.307)						
Tourist client					0.038	(0.191)	0.038	(0.194)
Sex worker thinks client has HIV	0.029	(0.167)	0.004	(0.061)	0.065	(0.247)	0.026	(0.159)
Sex worker thinks client has STI	0.064	(0.245)	0.008	(0.091)	0.084	(0.278)	0.034	(0.182)
N	27075		26120		16611		15702	

Observations pooled across baseline and endline surveys.

Table 2: Log price regressions, before and after FPP intervention

	FSW India		MSM India		FSW Ecuador		MSM Ecuador	
	Baseline (1)	Endline (2)	Baseline (3)	Endline (4)	Baseline (5)	Endline (6)	Baseline (7)	Endline (8)
No condom used:								
Client suggested (=1)	0.0260*	-0.0328	0.0157	-0.0297	0.0238	-0.487**	0.0490	0.0152
	(0.0139)	(0.0626)	(0.0530)	(0.0905)	(0.0418)	(0.160)	(0.0889)	(0.104)
Sex worker suggested (=1)	0.0638	-0.352**	-0.0587	-0.140	0.000305	0.506**	0.231*	-0.315**
	(0.0574)	(0.144)	(0.0851)	(0.178)	(0.0322)	(0.217)	(0.119)	(0.146)
Did not have one (=1)	-0.00678	0.300**	-0.0317	0.00628	-0.0626	-0.387**	0.179**	-0.121
	(0.0163)	(0.110)	(0.0404)	(0.133)	(0.0495)	(0.113)	(0.0827)	(0.610)
Condom used: client suggested (=1)	0.0236**	-0.000585	0.0479	-0.0404	0.0301	0.172**	0.0239	0.0755
	(0.00798)	(0.0119)	(0.0363)	(0.0329)	(0.0259)	(0.0496)	(0.0806)	(0.0700)
Services provided by sex worker:								
Vaginal sex (=1)	0.104**	0.0110			0.121**	0.00999		
	(0.0275)	(0.00824)			(0.0472)	(0.0106)		
Anal sex (=1)	0.0639	0.0751	0.161**	0.185			0.0781	-0.0908
	(0.0988)	(0.0518)	(0.0411)	(0.113)			(0.0729)	(0.0934)
Client characteristics:								
Married (=1)	0.00879	0.180**			0.0230**	0.0262**		
	(0.00622)	(0.00622)			(0.0113)	(0.0124)		
Trucker (=1)	-0.0209**	-0.0125						
	(0.0104)	(0.0131)						
Wealthy (=1)	-0.0140**	0.0738**	-0.0390**	-0.0295	-0.0503**	0.0770**	0.209**	0.304**
	(0.00601)	(0.0101)	(0.0156)	(0.0246)	(0.0207)	(0.0179)	(0.0813)	(0.0909)
Young (=1)	0.00782	0.0303**	0.0255	0.0362	0.0137	-0.0303**		
	(0.00581)	(0.00968)	(0.0167)	(0.0243)	(0.00983)	(0.00912)		
Forward caste (=1)	0.0420**	0.0125	-0.0133	0.0282				
	(0.0114)	(0.0135)	(0.0338)	(0.0319)				
Regular (=1)			-0.0292	-0.0813**	-0.00468	0.000917	0.0182	0.0347
			(0.0235)	(0.0325)	(0.0128)	(0.0116)	(0.0445)	(0.0595)
Tourist (=1)					0.0592*	0.0324	0.0895	0.0484
					(0.0335)	(0.0281)	(0.0613)	(0.0906)
Drunk (=1)					-0.0430**	0.0226		
					(0.0184)	(0.0182)		
Other:								
Sex worker thinks client has HIV (=1)	-0.132	0.0345	-0.0942	-0.172	-0.0160	-0.0185		
	(0.103)	(0.0214)	(0.164)	(0.143)	(0.0619)	(0.0733)		
Sex worker thinks client has STI (=1)	0.0434	-0.0408**	-0.207**	-0.120	-0.0349	0.00978		
	(0.0743)	(0.0151)	(0.101)	(0.164)	(0.0387)	(0.0478)		
Buyer-reported transaction (=1)			-0.337**	-0.0373			-0.318*	-0.208
			(0.112)	(0.0545)			(0.164)	(0.189)
Constant	3.978**	4.806**	3.284**	3.812**	1.620**	1.910**	2.093**	2.691**
	(0.0278)	(0.0128)	(0.0701)	(0.133)	(0.0468)	(0.0152)	(0.0892)	(0.108)
Mean price	71.16	187.87	36.04	26.25	6.97	9.25	20.14	19.91
Number of observations	17479	7083	4593	2833	4483	4306	1191	853
Within R^2	0.005	0.159	0.018	0.012	0.011	0.027	0.036	0.054

Dependent variable is the log of the price charged to the client by the sex worker. Transaction-level regressions with sex worker fixed effects. Excluded group for condom use is condom used: sex worker suggested. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$.

Table 3: Pooled log price regressions with FPP treatment interaction

	FSW India		MSM India		FSW Ecuador		MSM Ecuador	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
No condom used:								
Client suggested (=1)	0.000576	0.000596	0.00714	0.00111	-0.00177	-0.00213	-0.0497	-0.0425
	(0.0162)	(0.0162)	(0.0500)	(0.0491)	(0.0445)	(0.0445)	(0.0858)	(0.0853)
(Client suggested)×(Endline)	0.0568	0.423*	-0.0740		-0.449**		-0.0811	
×(FPP) (=1)	(0.0671)	(0.227)	(0.114)		(0.193)		(0.137)	
(Client suggested)×(Endline)		-1.184*		-0.626		-4.534**		-0.818
×(FPP)×(Local STI rate)		(0.700)		(1.281)		(1.977)		(1.095)
Sex worker suggested (=1)	-0.0179	-0.0218	-0.0784	-0.0783	0.00999	0.0101	-0.0317	-0.0318
	(0.0606)	(0.0606)	(0.0757)	(0.0758)	(0.0348)	(0.0348)	(0.0895)	(0.0894)
Did not have one (=1)	-0.00978	-0.0100	-0.0487	-0.0498	-0.0870*	-0.0870*	0.184**	0.184**
	(0.0138)	(0.0138)	(0.0363)	(0.0363)	(0.0494)	(0.0494)	(0.0829)	(0.0829)
Condom used: client	0.00940	0.00942	0.00240	0.000361	0.0624**	0.0624**	0.0608	0.0610
suggested (=1)	(0.00728)	(0.00728)	(0.0245)	(0.0245)	(0.0261)	(0.0261)	(0.0544)	(0.0544)
Services provided by sex worker:								
Vaginal sex (=1)	0.0161**	0.0161**	0.0670	0.0671				
	(0.00684)	(0.00684)	(0.0536)	(0.0536)				
Anal sex (=1)	0.0472	0.0472	0.165**	0.164**	-0.120**	-0.120**	0.0791	0.0790
	(0.0416)	(0.0416)	(0.0379)	(0.0381)	(0.0470)	(0.0470)	(0.0614)	(0.0613)
Client characteristics:								
Married (=1)	0.123**	0.123**			0.0196**	0.0196**		
	(0.00433)	(0.00433)			(0.01000)	(0.01000)		
Trucker (=1)	-0.0219**	-0.0217**						
	(0.00835)	(0.00835)						
Wealthy (=1)	0.0149**	0.0150**	-0.0394**	-0.0387**	0.0155	0.0155	0.368**	0.369**
	(0.00554)	(0.00554)	(0.0131)	(0.0131)	(0.0169)	(0.0169)	(0.0755)	(0.0755)
Young (=1)	0.0346**	0.0347**	0.0287**	0.0293**	-0.00658	-0.00658		
	(0.00530)	(0.00530)	(0.0137)	(0.0138)	(0.00846)	(0.00846)		
Forward caste (=1)	0.0292**	0.0295**	0.00856	0.00649				
	(0.00876)	(0.00876)	(0.0233)	(0.0233)				
Regular (=1)			-0.0451**	-0.0435**	0.00837	0.00839	0.0787**	0.0791**
			(0.0189)	(0.0189)	(0.0108)	(0.0108)	(0.0384)	(0.0384)
Tourist (=1)					0.0597**	0.0599**	0.0377	0.0378
					(0.0290)	(0.0290)	(0.0665)	(0.0665)
Drunk (=1)					-0.00881	-0.00881		
					(0.0155)	(0.0155)		
Other:								
Sex worker thinks client	0.0294	0.0293	-0.125	-0.124	-0.0167	-0.0167		
has HIV (=1)	(0.0180)	(0.0180)	(0.108)	(0.108)	(0.0515)	(0.0515)		
Sex worker thinks client	-0.0381**	-0.0379**	-0.180**	-0.181**	-0.0281	-0.0281		
has STI (=1)	(0.0127)	(0.0127)	(0.0853)	(0.0853)	(0.0343)	(0.0343)		
Buyer-reported transaction			-0.105**	-0.129**			-0.587**	-0.587**
(=1)			(0.0496)	(0.0504)			(0.0878)	(0.0877)
Constant	4.260**	4.260**	3.466**	3.470**	1.729**	1.729**	2.355**	2.354**
	(0.00879)	(0.00879)	(0.0568)	(0.0569)	(0.0601)	(0.0601)	(0.0800)	(0.0800)
Mean price	71.16	71.16	36.04	36.04	6.97	6.97	20.14	20.14
Number of observations	22357	22357	7426	7390	5996	5996	1831	1831
Within R^2	0.055	0.055	0.013	0.014	0.009	0.009	0.123	0.124

Dependent variable is the log of the price charged to the client by the sex worker. Transaction-level regressions with sex worker fixed effects. Excluded group for condom use is condom used: sex worker suggested. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$.

Table 4: Effect of FPP intervention on condom use and STI prevalence

	Condom use (=1)				Local syphilis prevalence		
	FSW India (1)	MSM India (2)	FSW Ecuador (3)	MSM Ecuador (4)	MSM India (5)	FSW Ecuador (6)	MSM Ecuador (7)
DD treatment effect:							
(FPP)×(Endline) (=1)	0.0247*	0.0295	0.0315**	0.248**	-0.0493**	-0.0119**	-0.0165**
	(0.0140)	(0.0201)	(0.0157)	(0.0226)	(0.00806)	(0.00156)	(0.00220)
FPP (=1)	0.0745**	-0.0616**	-0.0560**	-0.0535**	0.0160**	0.00836**	-0.0254**
	(0.00793)	(0.00660)	(0.0111)	(0.0134)	(0.00261)	(0.00104)	(0.00153)
Endline (=1)	0.205**	0.331**	0.142**	0.175**	0.00989	0.0365**	0.0227**
	(0.0138)	(0.0134)	(0.0114)	(0.0182)	(0.00740)	(0.00126)	(0.00192)
Services provided by sex worker:							
Vaginal sex (=1)	0.0886**		0.505**				
	(0.0116)		(0.0359)				
Anal sex (=1)	-0.00132	0.323**		0.0877**			
	(0.0582)	(0.0566)		(0.0116)			
Sex worker characteristics:							
Age	-0.00664**		-0.00260**				
	(0.000541)		(0.000504)				
Client characteristics:							
Married (=1)	-0.0243**		0.0256**				
	(0.00532)	(0.00807)					
Trucker (=1)	-0.0387**						
	(0.0102)						
Wealthy (=1)	0.0242**	0.0148**	0.0561**	0.0831**			
	(0.00651)	(0.00365)	(0.0156)	(0.0207)			
Young (=1)	0.0508**	0.0111**	0.0290**				
	(0.00687)	(0.00534)	(0.00822)				
Forward caste (=1)	-0.0212*	0.0289**					
	(0.0111)	(0.00888)					
Regular (=1)		-0.0388**	-0.0372**	-0.101**			
		(0.00613)	(0.00817)	(0.0108)			
Tourist (=1)			-0.0362*	-0.0238			
			(0.0214)	(0.0302)			
Drunk (=1)			-0.0466**				
			(0.0131)				
Other:							
Sex worker thinks client has HIV (=1)	-0.180**		0.0615**				
	(0.0210)		(0.0213)				
Sex worker thinks client has STI (=1)	-0.0866**		-0.0461**				
	(0.0145)		(0.0185)				
Buyer-reported transaction (=1)		0.0627**		0.249**			
		(0.0105)		(0.0174)			
Constant	0.403**	0.170**	0.400**	0.306**	0.205**	0.0217**	0.0773**
	(0.0208)	(0.0151)	(0.0397)	(0.0172)	(0.00175)	(0.000837)	(0.00135)
Mean dependent variable	0.544	0.531	0.850	0.348	0.212	0.027	0.058
Number of observations	22442	25672	6098	8127	8643	5162	4677
R^2	0.042	0.155	0.122	0.174	0.018	0.234	0.193

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$. Columns 1-4 are transaction-level regressions on the probability of condom use for any reason. Columns 5-7 are sex-worker level regressions. The local syphilis rate is measured by the prevalence within a site, excluding the responding sex worker.

Table 5: Effect of FPP intervention on sex worker empowerment and bargaining power

	Sex worker suggested condom use (=1)			Convinced client to use condom (=1)
	FSW India (1)	FSW Ecuador (2)	MSM Ecuador (3)	MSM Ecuador (4)
DD treatment effect:				
(FPP)×(Endline) (=1)	0.0247*	0.0347**	0.202**	0.110**
	(0.0140)	(0.0163)	(0.0178)	(0.0119)
FPP (=1)	0.0745**	-0.0826**	-0.0379**	-0.0242**
	(0.00793)	(0.0119)	(0.0119)	(0.00797)
Endline (=1)	0.205**	0.108**	-0.0332**	-0.0364**
	(0.0138)	(0.0119)	(0.0145)	(0.00970)
Services provided by sex worker:				
Vaginal sex (=1)	0.0886**	0.303**		
	(0.0116)	(0.0385)		
Anal sex (=1)	-0.00132		0.0885**	0.0365**
	(0.0582)		(0.00943)	(0.00632)
Sex worker characteristics:				
Age	-0.00664**	-0.00133**		
	(0.000541)	(0.000525)		
Client characteristics:				
Married (=1)	-0.0243**	0.0596**		
	(0.00532)	(0.00831)		
Trucker (=1)	-0.0387**			
	(0.0102)			
Wealthy (=1)	0.0242**		-0.00448	0.0370**
	(0.00651)		(0.0167)	(0.0112)
Young (=1)	0.0508**	0.0534**		
	(0.00687)	(0.00851)		
Forward caste (=1)	-0.0212*			
	(0.0111)			
Regular (=1)		-0.0202**	-0.0550**	-0.0290**
		(0.00845)	(0.00878)	(0.00589)
Tourist (=1)		-0.0328	-0.0101	-0.0224
		(0.0227)	(0.0247)	(0.0165)
Drunk (=1)		-0.130**		
		(0.0126)		
Other:				
Sex worker thinks client has HIV (=1)	-0.180**			
	(0.0210)			
Sex worker thinks client has STI (=1)	-0.0866**			
	(0.0145)			
Buyer-reported transaction (=1)			0.0545**	0.00517
			(0.0143)	(0.00955)
Constant	0.403**	0.474**	0.169**	0.0728**
	(0.0208)	(0.0422)	(0.0145)	(0.00971)
Mean dependent variable	0.342	0.765	0.195	0.073
Number of observations	22442	9832	9706	9706
R^2	0.042	0.055	0.052	0.026

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$. Transaction-level regressions. Dependent variables are the probability of suggesting condom use and the probability of convincing client to use a condom.

Table 6: Effect of FPP intervention on sex worker resource access and utilization

	Sex worker provided condom (=1)				No condom used because did not have one (=1)	
	FSW India (1)	MSM India (2)	FSW Ecuador (3)	MSM Ecuador (4)	FSW Ecuador (5)	MSM Ecuador
DD treatment effect:						
(FPP)×(Endline) (=1)	0.0309**	0.0384*	0.0196	0.230**	-0.00594	-0.0433**
	(0.0136)	(0.0201)	(0.0183)	(0.0185)	(0.00808)	(0.0128)
FPP (=1)	0.0814**	-0.0574**	-0.0883**	-0.0578**	0.0109*	0.0482**
	(0.00771)	(0.00660)	(0.0129)	(0.0124)	(0.00594)	(0.00853)
Endline(=1)	0.420**	0.276**	0.163**	0.0171	-0.0713**	-0.140**
	(0.0134)	(0.0187)	(0.0133)	(0.0151)	(0.00592)	(0.0104)
Services provided by sex worker:						
Vaginal sex (=1)	0.127**		0.443**		-0.0141	
	(0.0113)		(0.0422)		(0.0190)	
Anal sex (=1)	0.0301	0.308**		0.0873**		-0.0204**
	(0.0566)	(0.00909)		(0.00981)		(0.00676)
Sex worker characteristics:						
Age	-0.00646**		-0.00283**		0.000722**	
	(0.000525)		(0.000587)		(0.000260)	
Client characteristics:						
Married (=1)	-0.0421**		0.0161*		-0.0110**	
	(0.00517)		(0.00940)		(0.00413)	
Trucker (=1)	0.0208**					
	(0.00993)					
Wealthy (=1)	0.00929	0.0221**		-0.0133	-0.0137*	-0.0228*
	(0.00633)	(0.00366)		(0.0174)	(0.00768)	(0.0120)
Young (=1)	0.0385**	0.00940*	0.0157		-0.00896**	
	(0.00668)	(0.00534)	(0.00958)		(0.00423)	
Forward caste (=1)	-0.0161	0.0154*				
	(0.0108)	(0.00889)				
Regular (=1)		-0.0492**	-0.0418**	-0.0616**	0.0149**	0.00640
		(0.00614)	(0.00954)	(0.00914)	(0.00419)	(0.00630)
Tourist (=1)				0.0531**		0.00605
				(0.0257)		(0.0177)
Drunk (=1)			-0.0840**			
			(0.0154)			
Other:						
Sex worker thinks client has HIV (=1)	0.0260	0.0325	0.0562**			
	(0.0204)	(0.0496)	(0.0249)			
Sex worker thinks client has STI (=1)	0.0244*	0.0688**	-0.0636**			
	(0.0141)	(0.0337)	(0.0215)			
Buyer-reported transaction		0.0260**		0.0368**		-0.0565**
		(0.0105)		(0.0148)		(0.0102)
Constant	0.416**	0.0549**	0.445**	0.195**	0.0738**	0.158**
	(0.0203)	(0.0151)	(0.0465)	(0.0151)	(0.0207)	(0.0104)
Mean dependent variable	0.376	0.320	0.788	0.209	0.065	0.159
Number of observations	22442	25672	6199	9706	9753	9706
R^2	0.126	0.128	0.104	0.077	0.038	0.089

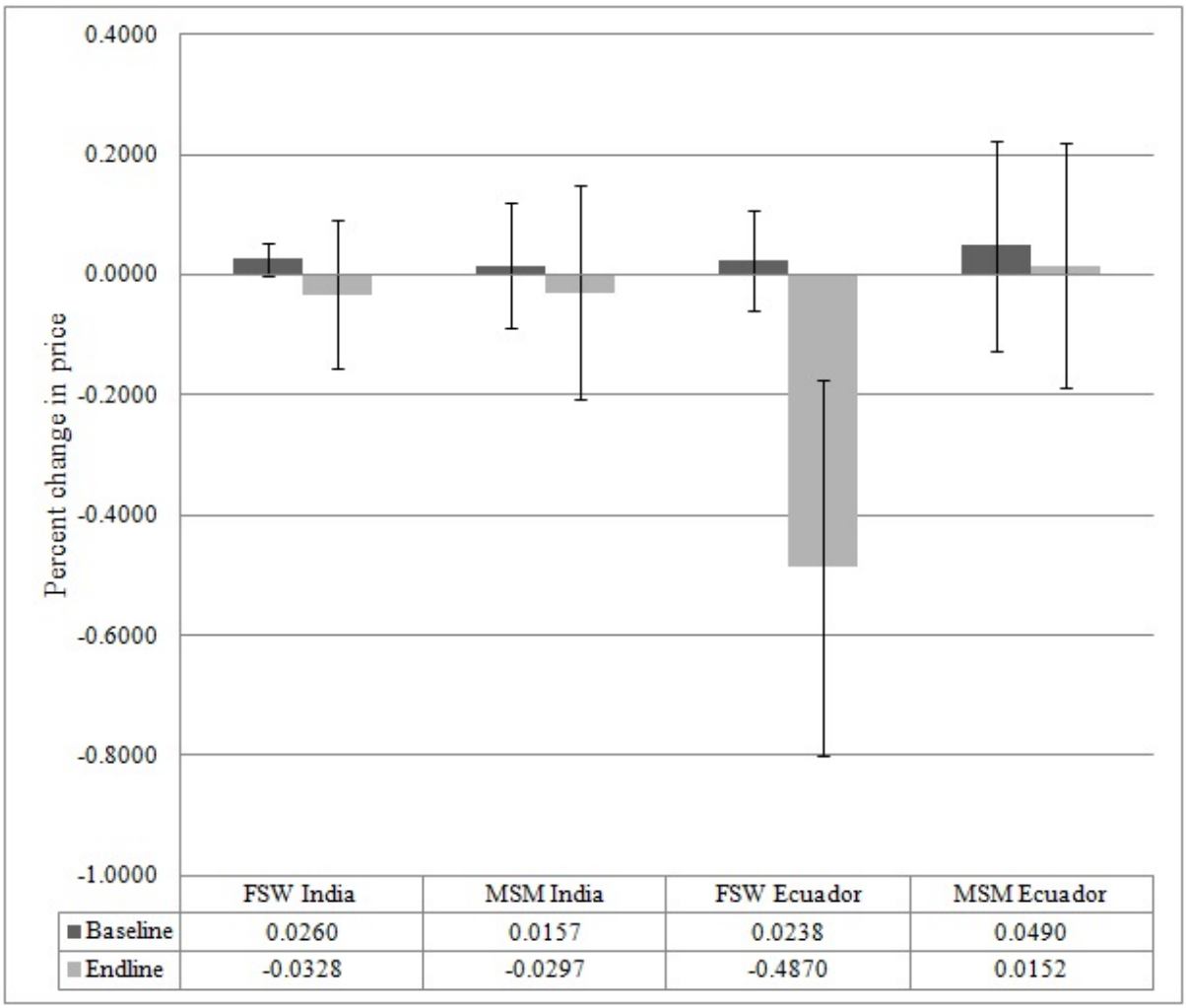
Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$. Transaction-level regressions. Dependent variables are the probability of providing the condom used and the probability of no-condom use due to not having a condom.

Table 7: Effect of FPP intervention on sex worker income

	Weekly income from sex work				Secondary income			
	FSW India	MSM India	FSW Ecuador	MSM Ecuador	FSW India	MSM India	FSW Ecuador	MSM Ecuador
DD treatment effect:								
(FPP)×(Endline) (=1)	-50.38	-30.29	23.63**	218.1**	405.0	1280.5	38.71**	3.455
	(51.11)	(40.83)	(6.201)	(83.69)	(944.2)	(1059.1)	(11.11)	(6.884)
FPP (=1)	17.57	16.42	-14.92**	-76.48	-262.9	-796.5**	-17.93**	0.463
	(27.69)	(18.88)	(4.120)	(51.74)	(503.8)	(344.6)	(7.724)	(4.067)
Endline (=1)	1068.8**	258.4**	36.61**	-89.99	-697.9	-873.3	-22.33**	-0.341
	(38.98)	(35.78)	(4.446)	(68.68)	(708.6)	(973.3)	(7.640)	(5.686)
Constant	475.7**	478.5**	118.6**	144.9**	1069.1**	1860.6**	77.94**	15.42**
	(21.48)	(12.40)	(2.930)	(42.15)	(386.8)	(231.0)	(4.778)	(3.358)
Mean dependent variable	499.70	511.79	112.63	110.98	1168.16	1502.66	66.21	17.43
Number of observations	24624	4994	10992	933	11676	26024	1650	1082
R^2	0.065	0.045	0.023	0.010	0.000	0.000	0.008	0.001

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$. MSM samples restricted to sex workers.

Figure 1: Risk premia for unprotected sex before and after FPP intervention



	FSW India	MSM India	FSW Ecuador	MSM Ecuador
Baseline	0.0260	0.0157	0.0238	0.0490
Endline	-0.0328	-0.0297	-0.4870	0.0152

Note: Figure graphs coefficient on "No condom: client suggested" before and after FPP intervention. 95% confidence interval bars shown.

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