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# Prostitution 2.0: The changing face of sex work

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ABSTRACT

The use of Internet technology for solicitation by sex workers has raised important legal and regulatory questions. We provide a description of the new institutions that facilitate prostitution online, and their potential market effects. We then supply some of the first evidence on several key parameters of interest to policymakers. First, we find that workers who solicit online largely represent growth in the overall prostitution market, as opposed to simple displacement of the off-line, street-focused market, although we find sizeable displacement effects among sex workers in their 30s and 40s. Using a newly-implemented survey, we also find that most sex workers who solicit online engage in lower-risk behaviors than traditional street-based workers; however, workers close to the margin for migration from outdoor work bring riskier business and sexual practices with them as they enter the off-street-sector.



## 1. Introduction

The rise of e-commerce over the last 15 years has facilitated the development and growth of markets in all manner of goods and services, including used books, musical recordings, software, and collectibles. Markets for illegal goods and services have not been immune to this retailing revolution – if anything, they have been at the forefront, since Internet commerce is frequently associated with substantial reductions in search costs, which constitute a large share of the total price for goods such as pornographic images, Nazi memorabilia, and black market pharmaceuticals.[1]

In this paper, we focus on the role of the Internet in facilitating the market for prostitution. As one long-time "john" (Roberts, 2007) writes ("provider" here is a synonym for sex worker):

"Not long after computers became an accepted household necessity and the Internet became a popular place to surf, the independent provider and the agencies discovered the potential of the Internet. The independent provider discovered that if she could put together a simple web page, she could reach a massive, upscale male audience not only in her own city, but nationally and internationally, thereby increasing her business exponentially. Before the Internet, escorts advertised in the Adult Services section of the local newspaper or perhaps in the yellow pages."

As this suggests, prostitution was among the first markets to develop online, with the newsgroup alt.sex.services (later renamed alt.sex.prostitution) active as early as the 1980s with advertisements and discussion among sex workers and clients. Given the importance of visual appearance in the prostitution market, the development and spread of graphical browsers in the mid- and late-1990s marked another important step in the development of the online market. The first known website devoted to prostitution was developed by an escort in Dallas in December 1996 (Brooks, 2006). The popularity of the site grew quickly and within a year had experienced 700,000 page views. In August of 1997, the first nationwide online escort advertising service, Eros.com, appeared. In a 2000 article in the online magazine *Slate*, a high-end escort named "Anne-Marie" claimed to have earned a small fortune as a prostitute, thanks largely to the flexibility and profitable advantages offered by the Internet (Shuger, 2000). In the mid-2000s, the growth of large national classified ads sites like craigslist.org – which initially offered free advertising in its "erotic services" section – created opportunities for the advertisement of prostitution services to a much wider audience.[2] The growth in prostitution activity online has naturally drawn the attention of law enforcement agencies and regulators, including a lawsuit brought by the Sheriff of Cook County, Illinois, and additional legal action by a consortium of 40 state attorneys general, against craigslist.[3]

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[1] See Goldsmith and Wu (2006) for other examples of attempts to circumvent prohibitions through the use of the Internet.

[2] Craigslist ads were free until late 2008 when the site began charging $5–10 per ad. Under pressure from law enforcement, craigslist closed the section of its site used by prostitutes in September 2010. Preliminary anecdotal evidence indicates that other sites such as backpage.com may be filling in the resulting gap in the marketplace (see Cunningham and Kendall, 2010a for similar evidence from earlier regulations of craigslist).

[3] The Cook County Sherrif's lawsuit against craigslist alleged that the site was "the single largest source of prostitution in the nation" at the time.

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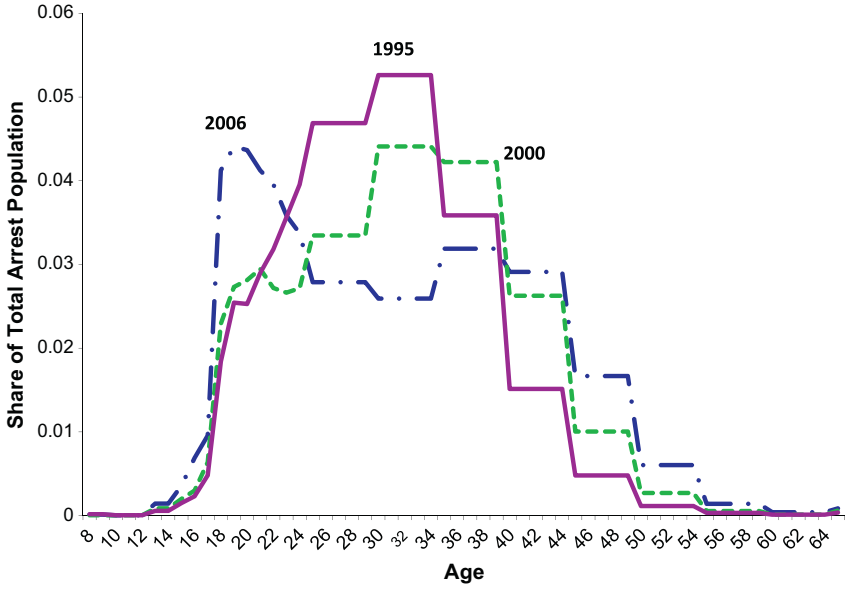


**Fig. 1.** Age distribution of female prostitution arrests, 1995, 2000, and 2006. Source: FBI *Crime in the United States*, various years.

To sharpen the policy-relevance of our research, we focus on two key questions: (1) to what extent is the Internet augmenting the market for prostitution, as opposed to merely displacing older forms of solicitation such as streetwalking? and (2) to what degree have the institutions associated with online solicitation changed sex workers' risk behaviors, potentially reducing the social harms from prostitution?

Focusing on the first question, a sunny perspective on the rise of online prostitution services is that such activity largely replaces older forms of solicitation, such as streetwalking, which more frequently involve serious social problems such as nuisance externalities, disease transmission, and worker exploitation (Weitzer, 2005; Gertler and Shah, 2009). Our empirical results show that, while there is some evidence of the Internet displacing street markets among certain age groups, this perspective is likely too optimistic. Overall, online solicitation appears to represent an augmentation of the prostitution market, not simply a displacement of streetwalkers.

However, we do find substantial streetwalker displacement effects among certain age classes of sex workers. Fig. 1 illustrates the national age distribution of arrested female prostitutes (we show in Section 3 that arrested prostitutes are almost always streetwalkers) in 1995, just before home Internet access became widespread, and in 2000 and 2006. The data illustrate a striking trend towards bimodalism, in which arrests of women ages 25–40 appear to have declined substantially, relative to older and younger workers. In Section 4, we show that, to a large degree, this pattern continues to hold in a more sophisticated analysis that controls for many other factors.

To explain these results, we hypothesize that the rise of online prostitution lowered demand for streetwalking prostitution, while raising demand for indoor prostitution. Overall, street-based sex workers have few good outside job opportunities, and hence, a highly inelastic supply. Thus, there has been relatively little displacement of street prostitution, and an overall augmentation of the prostitution market. However, relative to other subgroups, street prostitutes aged 25–40 may have more elastic labor supply, due to better marriage opportunities, lower rates of drug addiction, fewer psychopathologies that limit non-prostitution work, and greater levels of literacy and technological skill and experience. This may have allowed some sex workers in this age group to employ the Internet and other new technologies in order to take advantage of the changes in relative wages across sectors and move into indoor prostitution.[4] Those remaining on the street include younger workers, which previous survey literature suggests may include a larger share of runaways,[5] exploited women, and women involved in drugs-for-sex exchanges, as well as older workers, who face weaker marriage opportunities and may not have the literacy and technological skill necessary to move into the Internet-focused indoor market.

Turning to our second question regarding the risk behaviors of online prostitutes, as we discuss below, the Internet likely has lowered the probability of arrest and improved the ability of sex workers to advertise and build reputational capital. These changes imply potential improvements in prostitution service "quality", such as stronger incentives to avoid the transmission of disease in order to maintain a reputation and attract repeat clients.[6] On the other hand, prostitution market participants who perceive a lower-risk environment may engage in offsetting higher-risk behaviors. Our results show that those who solicit online in fact do engage less frequently in high-risk behaviors, relative to those involved in street markets; however, online workers still offer a large quantity of transactional sex, and occasionally do not use condoms.

Intersecting these results with our findings on displacement, we also examine specifically the risk behaviors of online sex workers who have previously engaged in street prostitution. Alarmingly, we find that these former streetwalkers appear to carry their risky behaviors with them into the indoor sector, potentially creating new disease vectors where few existed before. This suggests another caveat to the potentially ameliorative impact of streetwalker displacement.

Our findings shed light on a relatively under-researched but growing segment of the prostitution market. Recent theoretical advances (Edlund and Korn, 2002), and empirical studies in economics (e.g., Edlund et al., 2009, Levitt and Venkatesh, 2007,

[4] See Cunningham and Kendall (2010b) for a fuller analysis of the returns to human capital in sex work.

[5] Matthews (1993) and Brannigan and Brunschot (1997) find that runaways turn to prostitution because they have few good alternative options for survival. Potterat et al. (1990) find that the average street prostitute career is 5 years, implying that most of those who entered the industry as runaways would have exited by age 25.

[6] See evidence on the risk behaviors of Internet-mediated prostitutes in Cunningham and Kendall (2010c), and a similar theoretical argument with respect to illegal drugs in Miron and Zweibel (1995).

Arunachalam and Shah, 2008; Gertler et al., 2005; Cameron and Collins, 2003; Rao et al., 2003), have contributed to an already substantial public health and sociological literature.[7] However, most research in economics and elsewhere has focused either on street prostitution markets, or on prostitution in developing markets, with relatively little focus on indoor prostitution, and in particular, the Internet-facilitated indoor market. While estimates of the relative importance of the street and off-street-sectors differ widely, a recent survey piece by Weitzer (2005) finds that street-based prostitution may constitute as little as 20% of the US market for prostitution, while it has attracted upwards of 80% of the academic research.

As many researchers have noted, empirical work on prostitution markets has been limited by a lack of systematic data. In this paper, we marshal the best evidence available on prostitution markets, and examine it through various empirical approaches, while admitting that no dataset on this poorly understood industry can be truly definitive. For our analyses, we combine law enforcement data on prostitution with a proxy for the rise in Internet-facilitated prostitution – counts of customer reviews from a widely used nationwide "mall" for sex workers, TheEroticReview.com ("TER"), which as of August 2008, included detailed data on over 90,000 workers. These data have previously been analyzed by Edlund et al. (2009) and Cunningham and Kendall (2010a,c).[8]

We also implemented a new survey of nearly 700 sex workers who currently use the Internet to solicit clients, asking questions about their history in the profession, and about their last five client transactions. We believe ours is the largest survey of sex workers in a modern economy to date, and is unique for its extensive sampling of indoor workers.

Section 2 describes the institutions associated with online sex work, and theorizes regarding how these institutions have affected the online and off-line markets for prostitution services. Section 3 describes the law enforcement and TER website data. Section 4 presents our results regarding displacement effects, while Section 5 describes the survey data and uses it to examine the risk behaviors of workers who solicit online. Section 6 concludes.

While prostitution is a concern globally, our data focus on markets in the United States, and so may not be applicable elsewhere, especially given the widely varying cultural and legal frameworks in which prostitution operates. Nevertheless, our results are likely to be most relevant for Western countries where modern information technology is widely used, and may be predictive of the experience of developing countries where such technologies are only beginning to see broad adoption.

## 2. Effects of the Internet on prostitution markets

In most large cities, prostitution services have long been available through street "strolls", call operations, and as secondary products of some legal businesses, such as massage parlors. Nevertheless, the Internet has exponentially increased the ability of sex workers to: (a) reach large numbers of potential clients with informative advertising, (b) build reputations for high-quality service, and (c) employ screening methods to reduce the risk of discovery and avoid undesirable clients. In this section, we describe briefly how sex workers and sex buyers employ the Internet to engage in market transactions, and outline the potential effects of these changes on the market for prostitution.

As in other industries, online commerce has revolutionized advertising among certain segments of sex workers. Several researchers have observed segmentation in the market for commercial sex corresponding to both the kinds of women who work in different sectors, and the kinds of services. Reynolds (1986) decomposed all types of prostitution into seven categories: streetwalkers, masseuses, escorts, bar prostitutes, bell captain's list, call girls and brothel inmates. Roberts (2007) notes a similar decomposition, and specifically comments that the Internet uniquely benefited sex workers in the escort and call girl categories, because of those subtypes' unique advertising challenges. Specifically, because these workers provide companionship in addition to sexual services, personality match with the client is a key element driving demand, and Internet technology enables greater pre-assignation communication to facilitate compatible matching.

A number of websites offer advertisement services specifically for sex workers at low (and sometimes zero) cost. The most well-known of these is the classified ads site, craigslist.org, which until recently had local posting boards in most US cities. Before May 2009, each local posting board included a section entitled "Erotic Services", where for a nominal fee,[9] users could post advertisements with essentially an unlimited amount of text and up to four images. Typical postings gave a worker's telephone number or email, and indicated services offered and prices (often using thinly-veiled euphemisms for money, such as "roses"). Some ads appeared to be for sex workers operating independently, while others suggested an escort agency, pimp, or other third-party manager (Kennedy and Taylor, 2010). The number of daily postings on many local boards was extremely high; there were an average of 1690 ads posted each day on the New York City craigslist board in May, 2009 (Cunningham and Kendall, 2010a).[10]

Since the closure of craigslist's prostitution-themed posting boards in September 2010, activity has increased at a number of other sites which offer similar advertisement services, including Backpage.com, CityVibe.com, and Eros.com. All of these sites allow customers to browse and directly compare the characteristics, photographs, and prices of a large number of sex workers in ways that were not possible through older methods of solicitation. As on the street, online prostitution activity tends to agglomerate in key focal locations (websites).[11] Because clients value the existence of a range of choices, there may be increasing returns to scale in market size, and so prostitutes have an incentive to congregate spatially where clients can find them, while clients in turn have an incentive to move to locations where prostitutes are (see, generally, the model in Ellison and Fudenberg, 2003). In addition, if law enforcement budgets are fixed, agglomeration may reduce the probability of arrest for each prostitute (Freeman et al., 1996). This may explain the existence of "strolls" in most cities, where many prostitutes and clients congregate. "Spatial" agglomeration at key sites on the Internet may operate through similar mechanisms, with Craigslist and other sites serving a purpose similar to "strolls" in street prostitution.

While the monetary cost of posting ads at these sites varies, the non-pecuniary time costs that would have been required to reach

[7] See also the pioneering research in the economics of prostitution in Reynolds (1986).

[8] Similar data from other sites have been employed by Moffatt and Peters (2004), Logan and Shah (2009) and Logan (2009).

[9] In November, 2008, a consortium of 40 state attorneys general negotiated with Craigslist to charge advertisers $5 per posting (previously, advertisement was free) and to require the use of a credit card for payment. Later, in May, 2009, actual and threatened legal action by the attorneys general of Connecticut and South Carolina, and the sheriff of Cook County, Illinois, led Craigslist to abolish the erotic services boards entirely, and replace them with more closely-monitored "adult services" sites. A perusal of these sites indicates that they continue to be used for advertisement by sex workers, although ads are generally not as explicit as before.

[10] Similarly calculated figures for San Francisco, Los Angeles, and Chicago during the same month were 770, 670, and 315. Some postings are repeat ads for the same worker, and there is a small amount of "spam," though the latter is limited by the fact that, after November 2008, craigslist was charging advertisers $5 per posting.

[11] See Levitt and Venkatesh (2007) for evidence on geographic agglomeration in US street prostitution markets, Yan (2005) for evidence on the spatial concentration of sex-oriented industries in Hong Kong, Reynolds (1986) for a discussion of traditional "red light districts" and O'Flaherty and Sethi (2010) for a model of the association between race and the spatial concentration of vice crime more generally.

such a wide audience of potential customers through streetwalking clearly is quite high. Moreover, street-based advertising requires a continuous physical presence on the street (of either the prostitute or the pimp or both), while online advertisements do not. In addition, as we discuss below, Internet advertising appears to involve a significantly reduced probability of arrest, a key cost of advertising, relative to streetwalking.

From the perspective of sex buyers, the Internet dramatically reduces the (primarily non-pecuniary) costs of purchasing sex. Instead of time-consuming surreptitious "curb crawling", with its associated arrest risk, customers can browse classified ads and other sites in the comfort of their own homes, identify a subset of potentially good "matches", and talk with these women at some length either through email or telephone, before ever meeting in person or risking arrest and discovery.

Also as in markets for other goods and services, the rise of online commerce has created greater opportunities for seller reputation-building among sex workers. One of the earliest innovations associated with e-commerce was the development of review sites for various products where customers leave feedback about sellers. Such sites have become staples of the electronic economy, and their success has been attributed to the fact that they provide incentives to sellers to provide quality services and avoid fraud (Dellarocas, 2003). In 1999, two major review sites focused on prostitution went live: TheEroticReview.com (initially focused on US sex workers) and Punternet.com (largely focused on UK sex workers). While information sharing between clients was always a feature of the illicit market for commercial sex (see Reynolds, 1986), before such sites, information typically moved only through informal word-of-mouth websites. Rocha et al., 2010 provide further evidence on the popularity of such sites.

Reviewing sites allow sex workers to build and maintain public reputations for quality service, as well as increasing the willingness-to-pay among risk-averse clients, for whom reviews serve as an indication that the worker is unlikely to be dangerous or fraudulent. In their advertisements, sex workers frequently refer potential clients to their reviews on such sites, and various ethnographic interviews we undertook with sex workers consistently revealed the importance workers place on having many positive reviews. We describe the reviewing process on TheEroticReview.com in greater detail in the following section, where we use information from the site as one of our key data sources (see also the more detailed information in the online appendix). Since seller reputation can substitute for explicit contracts with buyers (Klein and Leffler, 1981), such sites have the potential to create stronger incentives for online sex workers to provide higher quality service to customers and to reduce the risk that they pass on sexually transmitted diseases. To the extent market participants perceive lower-risks, these effects may be muted by rational offsetting risk behavior (Philipson and Posner, 1993). Since perceptions in this market may be based on poor or incorrect information, the overall effect on risk behaviors implied by the theory is ambiguous.

Sex buyers can also develop some measure of "reputation" through online "black lists" and "white lists", which simultaneously facilitate screening of customers by sex workers. In addition, there is a fascinating system of worker-to-worker references, by which many sex workers will refuse to see a client unless he can provide evidence that he has seen another worker (see Cunningham et al., 2010d for a formal model of this behavior).[12] This system functions because a sex worker who is contacted by a potential client with a reference can quickly find information about the referring sex worker online and contact her for verification. At the same time, many sex workers indicate that e-mail and the Internet also facilitate more informal screening procedures, including entering the potential client's name or telephone number into search engines, or simply communicating via email for a brief period before arranging an assignation (Brooks, 2009).

Similarly, as described by Holt and Blevins (forthcoming), there are a number of websites where sex buyers communicate with each other to pass along information about available sex workers and strategies for avoiding arrest and discovery. The availability of such information further lowers the cost of market participation, potentially expanding the market.

Law enforcement agencies have not ignored these developments in prostitution markets, though they have faced difficulties in responding effectively. For the most part, declines in the price of advertising and better methods of screening out law enforcement agents have allowed online solicitation to flourish with low probabilities of arrest or punishment. As we show below, nearly all prostitutes who come into contact with police are streetwalkers. This is consistent with evidence presented by Murphy and Venkatesh (2006), who find that "while street-based sex work accounts for only 15% of all prostitution, 85–90% of the women arrested for prostitution work on the street".[13] Reductions in arrest probabilities directly lower the (expected) cost of offering prostitution services due to fewer fines and jail terms, but also lower the likelihood of a sex worker's discovery by friends and family. Della Guista et al. (2009) argue that the risk of discovery and social stigma is a key cost to prostitutes, although see Edlund and Korn (2002) and Edlund et al. (2009) for evidence to the contrary.

The reduced probability of arrest and lower costs of advertising and client screening have potentially raised the supply of prostitution services online, including new entry by sellers who might otherwise not have participated in the market at all, as well as displacement into online work from prostitutes who formerly solicited elsewhere, such as on the street. For customers of prostitutes, the reduced probability of arrest implies an increase in demand, particularly among customers who otherwise would not have participated in the market for fear of reputational loss due to arrest or discovery.[14] The potential for advertising and reviewing sites to strengthen prostitutes' incentives to supply quality service and lower STI transmission risk may have increased demand further. Therefore, the empirical predictions of our discussion for the online prostitution market are a substantial increase in quantity, driven by increases in both supply and demand, and an ambiguous effect on prices.

In the street-based market, some customers who previously purchased prostitution services there may have switched to purchasing service online after Internet solicitation began flourishing. Given that Internet technology is rarely employed by streetwalkers, the cost structure of street work is unlikely to have changed much, and so the reduction in demand should lead to lower prices in the street-sector. To the extent that the supply of streetwalking prostitutes is elastic, quantity may fall noticeably as well, creating a "displacement" effect. In addition, some streetwalking

[12] This is quite common among workers, with 58% in our survey (described in Section 5) indicating that they refuse to see new clients without at least one reference from another worker.

[13] See Chapkis (2000) and Thukral and Ditmore (2003) for further evidence on high rates of arrest among outdoor sex workers. There is also some evidence that the resource cost associated with arresting indoor workers is high. A 2008 analysis by the Cook County sheriff's office estimated that the cost of arresting a worker who advertises and communicates with clients online is $674, not including the opportunity costs of potential increases in other crimes while police officers are occupied in arresting sex workers – a figure presumably higher than the cost of arresting street-based workers, since they claimed damages in a lawsuit based on this calculation.

[14] Evidence from arrested customers of prostitutes indicates that men who visit prostitutes appear to have similar labor force participation, educational background, marital status and other characteristics in comparison with the general population of men. In particular, nearly 40% of offenders appear to be married (Monto and McRee, 2005).

prostitutes may be able to move into indoor work in response to the higher relative wages available there, creating an additional supply-driven displacement effect.

However, there is a substantial literature suggesting that streetwalker labor supply is fairly inelastic. To a degree greater than that of other sex workers, street-based prostitutes appear to struggle with drug addiction and substance abuse (Goldstein, 1979; Potterat et al., 1998; Church et al., 2001), worker exploitation by pimps or other managers (Reynolds, 1986; Weitzer, 2005), and high rates of psychopathology, depression, and antisocial tendencies (Exner et al., 1977, Alegria et al., 1994). In addition, a number of studies document substantial heterogeneity in characteristics, experiences, and risk behaviors between street and off-street workers (see the survey in Weitzer, 2005), which potentially serve as barriers to direct worker movement between these sectors. These factors may make streetwalkers relatively unresponsive to changes in wages.

If streetwalker labor supply is fairly inelastic and stable, then the hope that online solicitation may largely serve to displace the social problems associated with streetwalking may be false. However, it is possible that the streetwalker supply elasticity, while generally low, may vary substantially across different subsegments of workers. Prime-age streetwalkers between 25 and 40 may have the most elastic labor supply, with relatively better opportunities in the legal employment sector and the marriage market which they can pursue when street prices fall. They may also be better able to use Internet technology to move into the online sector in response to higher wages there.

By contrast, sex workers outside this demographic may face more inelastic supply. Survey literature has found that street-based workers in their teens are frequently runaways who enter prostitution for survival purposes, and who have few other good options (McClanahan, et al. 1999, Brannigan and Brunschot, 1997). Older sex workers may face reduced employment and marriage market opportunities, as well as lack the technological skill and experience necessary to operate effectively on the Internet.[15]

## 3. Measuring street and online prostitution activity

In order to examine the degree of displacement caused by the rise of online solicitation, we require measures of both online and street prostitution activity. Our chief proxy for street-level prostitution is the number of arrests for prostitution, while for online activity, we focus on counts of reviews at a popular online reviewing site for sex workers. In this section, we first show that the vast majority of women who come into contact with police are street workers, and we describe the advantages and limitations of law enforcement data. We then describe the reviewing data and present summary statistics.

### 3.1. Measuring street prostitution activity

To examine the locational choices of arrested prostitutes, we first examined data collected by the FBI for the National Incident-Based Reporting System (NIBRS). NIBRS is unique among law enforcement data in that it includes information on the location at which each recorded criminal incident takes place.

**Table 1**
Location of law enforcement-recorded prostitution incidents, 2005. Source: 2005 FBI National Incident-Based Reporting System (NIBRS).

| Location type | Share of incidents (%) |
|---|---|
| Highway/road/alley | 73.43 |
| Other/unknown | 7.33 |
| Hotel/motel/etc. | 6.44 |
| Parking lot/garage | 4.69 |
| Residence/home | 4.29 |
| Field/woods | 0.67 |
| Commercial/office building | 0.56 |
| Bar/nightclub | 0.45 |
| Convenience store | 0.41 |
| Service/gas station | 0.33 |
| Specialty store | 0.31 |
| Government/public building | 0.20 |
| Church/synagogue/temple | 0.17 |
| Jail/prison | 0.14 |
| Grocery/supermarket | 0.10 |
| Bank/savings and loan | 0.09 |
| School/college | 0.09 |
| Drug store/doctor's office/hospital | 0.07 |
| Lake/waterway | 0.06 |
| Air/bus/train terminal | 0.05 |
| Department/discount store | 0.04 |
| Construction site | 0.03 |
| Rental storage facility | 0.03 |
| Liquor store | 0.02 |

Table 1 displays the distribution of arrests across locations in 2005, and shows that the bulk of arrests took place at what are clearly "street" locations, including "highway/road/alley", and "parking lot/garage". Only 10.72% of arrests took place in locations that would normally be associated with off-street workers – "hotel/motel/etc." and "residence/home," though this likely overstates the share of arrests of off-street workers, since it is not uncommon for solicitation to take place on a street, while the actual assignation takes place in a motel or residence. Thus, NIBRS data suggest that outdoor workers remain the vast majority of prostitutes who come into contact with law enforcement, despite the apparent growth in the off-street-sector associated with online solicitation. Cunningham and Kendall (forthcoming a) show that the share of prostitutes arrested at "street"-like locations did not change materially between 1999 and 2005, reflecting the fact that police agencies have faced difficulties in arresting many indoor workers.

While NIBRS data supply information on location of arrest, they are limited in coverage[16]; hence, in our analyses we will proxy for the level of street activity with counts of prostitution arrests from a more comprehensive law enforcement dataset, the FBI's Uniform Crime Reports (UCR). Rantala and Edwards (2000) show that crime patterns track closely between the two data sources. Unlike NIBRS, the vast majority of law enforcement agencies in the US participate in UCR.[17] Since our measure of online activity (described in the following section) focuses on female sex workers, we will focus our offline measures exclusively on female prostitution arrests as well.[18]

### 3.2. Measuring online prostitution activity

To measure online activity by prostitutes, we examined what we believe is the largest dataset currently available on sex workers who use the Internet to solicit and communicate with customers. The data are drawn one of the reviewing websites described in

[15] See Government Accountability Office (2005), which found that older workers identified lack of computer skills as the key hindrance to finding work. See also Fox (2004), who concludes that "Most seniors live lives far removed from the Internet, know few people who use email or surf the Web, and cannot imagine why they would spend money and time learning how to use a computer. Seniors are also more likely than any other age group to be living with some kind of disability, which could hinder their capacity to get to a computer training center or read the small type on many Web sites."

[16] Currently there are only 32 states in which law enforcement agencies record their data for the program, and most of the largest US cities are not included in the data.

[17] The major exceptions include spotty recording by some agencies in Florida and the District of Columbia.

[18] See Logan and Shah (2009) and Logan (2009) for a description of the highly-developed online market for male sex workers.

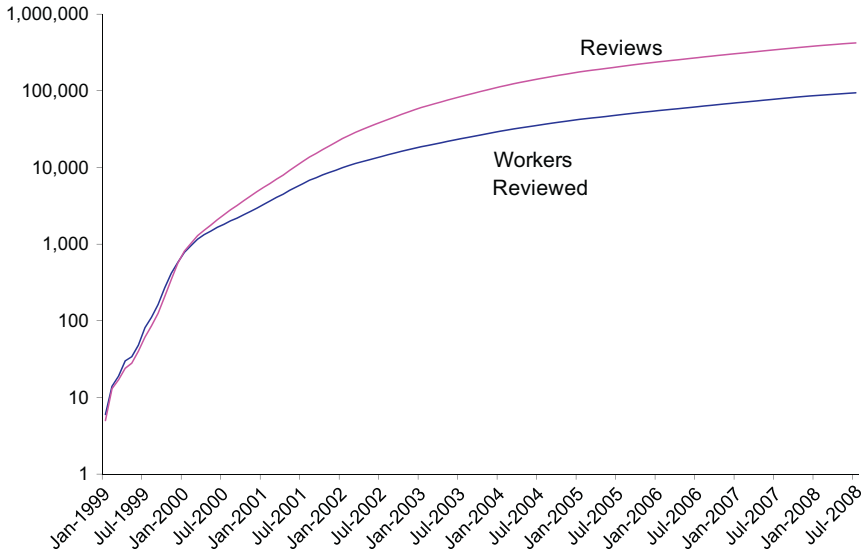


**Fig. 2.** Cumulative number of new sex workers and reviews posted at TheEroticReview.com, 1999–2009. *Notes*: Vertical axis employs logarithmic scale.

the previous section,TheEroticReview.com ("TER"), where clients share reports and reviews of sex workers they have met.[19] TER was established in 1999, and the number of individuals reviewed, as well as the number of reviews, has grown substantially over the last decade as the use of the Internet for advertisement by sex workers has grown. Fig. 2 illustrates, in logarithmic scale, growth in the site's popularity.

A recent estimate indicated that TER receives between 500,000 and 1000000 unique visitors each month (Richtel, 2008). As of August, 2008, when we retrieved the data using a web-crawling PERL script, there were over 500,000 reviews of more than 94,000 sex workers reviewed on the site. Moreover, unlike some other similar sites, TER is national in scope, with reviews categorized by geographic location. We will take as our measure of online prostitution activity the number of individuals receiving at least one new review in a given location in a given time period. We describe the strengths and limitations of these data in further detail in an online appendix.

## 4. Displacement analyses

### 4.1. National trends

Before proceeding to our formal regression analyses, we first examine the evidence regarding displacement at the national level. Fig. 1, discussed previously, shows the age distribution of all female prostitution arrests recorded in UCR in 1995, just before widespread home adoption of the Internet, in 2000, and in 2006. The data illustrate a striking trend towards bimodalism, in which arrests of women ages 25–40 appear to have declined substantially relative to older and younger workers. No similar trend is evident for female prostitution arrests in other crime categories, such as property or violent crimes, nor is there any similar trend among male prostitution arrests.

Fig. 3 illustrates a similar phenomenon in per capita arrest levels. Between 1999 and 2006, arrest rates among women aged 25–39 fell substantially, while other age groups saw either stagnant or even increasing arrest rates. Figs. 1 and 3 are consistent with a hypothesis which will find further support in our formal regression analyses below, that the Internet and other modern technologies are drawing outdoor transactions associated with prime-aged sex workers into the indoor sector, where they rarely encounter law enforcement. Those transactions remaining on the street are associated with very young and inexperienced sex workers, and older workers who lack the human and social capital necessary to convert to indoor work.

### 4.2. Correlational analyses

In this section, we report simple least squares analyses of the relationship between street and online prostitution, proxying for street prostitution activity with female prostitution arrests, and proxying for online activity with the number of sex workers reviewed on TER.

We aggregate our data to the level of the year and state in order to include controls for other factors that might covary with prostitution activity. In doing so, we are forced to drop some geographic locations, since TER data, while national in scope, do not always classify the location of a reviewed worker to a single state.[20] After these culls, we are left with 152 state-year observations.[21] Since UCR data allows us to categorize arrests into age groups, we will be able to analyze not only the overall effect of online activity on arrests, but also the effects on arrests within various age groups, which the national trends presented above suggest may differ.[22]

Most of our analyses in this section will focus on estimating the following regression specification:

$$Arrests^{a}_{it} = \alpha + \beta\ Workers\ reviewed\ per\ capita^{a}_{it} + \gamma X_{it} + \mu_i + \delta_t + \varepsilon_{it}, \quad (1)$$

[19] Data from TER and other sex worker review sites are analyzed by Moffatt and Peters (2004), Logan and Shah (2009), and Edlund et al. (2009).

[20] For instance, one of the geographic categories available to TER reviewers is "Carolinas," which presumably includes both North and South Carolina, and there is no obvious way to distinguish which workers operated in which of the two states.

[21] The states used in our analyses are Arizona, California, Colorado, Georgia, Hawaii, Illinois, Indiana, Louisiana, Massachusetts, Michigan, Minnesota, Nevada, New Jersey, New Mexico, New York, Ohio, Oregon, Pennsylvania, Tennessee, Texas, Utah and Washington. All states have observations for all 8 years, except Hawaii (2006), Georgia, (1999–2002), New Mexico (2000–2006), and New York (1999–2002).

[22] UCR data can also be disaggregated by race (but not by race and age simultaneously). In unreported analyses, we found no significant differences in our estimated relationships between Whites and Blacks, but we did generally find significantly stronger evidence of displacement among Asian prostitutes; however, some evidence suggests arrests are a relatively poor measure of street sector activity among Asians, who nevertheless constitute a very small share of all arrests.

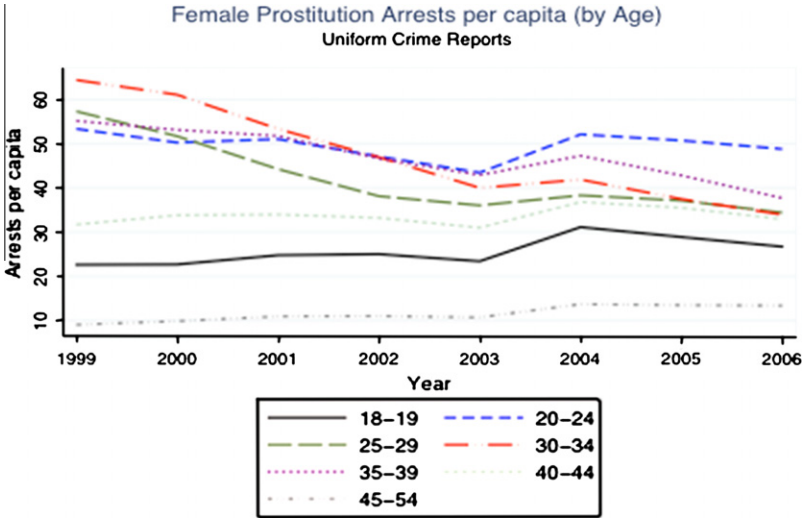


**Fig. 3.** Trends in female prostitution arrests by age category, 1999–2006.

**Table 2**
Summary statistics for state-level displacement analyses.

| Variable | *N* | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| Female prostitution arrests per 100,000 (All Ages) | 152 | 42.039 | 61.529 | 1.222 | 351.940 |
| Female prostitution arrests per 100,000 (18–19) | 152 | 31.584 | 66.179 | 0.408 | 431.934 |
| Female prostitution arrests per 100,000 (20–24) | 152 | 73.187 | 161.947 | 2.001 | 979.677 |
| Female prostitution arrests per 100,000 (25–29) | 152 | 53.774 | 80.189 | 0.634 | 457.597 |
| Female prostitution arrests per 100,000 (30–34) | 152 | 56.487 | 64.715 | 0.840 | 427.225 |
| Female prostitution arrests per 100,000 (35–39) | 152 | 55.598 | 63.576 | 0.530 | 440.125 |
| Female prostitution arrests per 100,000 (40–44) | 152 | 39.351 | 46.529 | 0.236 | 286.138 |
| Female prostitution arrests per 100,000 (45–54) | 152 | 13.259 | 17.017 | 0.142 | 99.050 |
| Workers reviewed per 100,000 (all ages) | 152 | 12.126 | 16.445 | 0.000 | 102.139 |
| Workers reviewed per 100,000 (18–19) | 152 | 7.219 | 10.086 | 0.000 | 69.403 |
| Workers reviewed per 100,000 (20–24) | 152 | 34.574 | 45.473 | 0.000 | 275.664 |
| Workers reviewed per 100,000 (25–29) | 152 | 26.240 | 33.979 | 0.000 | 196.841 |
| Workers reviewed per 100,000 (30–34) | 152 | 15.198 | 21.533 | 0.000 | 127.190 |
| Workers reviewed per 100,000 (35–39) | 152 | 8.491 | 16.403 | 0.000 | 107.824 |
| Workers reviewed per 100,000 (40–44) | 152 | 3.766 | 5.555 | 0.000 | 27.459 |
| Workers reviewed per 100,000 (45–54) | 152 | 1.250 | 1.914 | 0.000 | 9.034 |
| Percent of homes with residential broadband lines | 152 | 19.585 | 15.321 | 0.789 | 60.734 |
| Meth price (per pure gram) | 152 | $673.19 | 447.66 | $186.86 | $2979.30 |
| Meth purity | 152 | 41.77 | 16.89 | 10.62 | 98.18 |
| Cocaine price (per pure gram) | 152 | 62.35 | 7.22 | 47.11 | 82.41 |
| Cocaine purity | 152 | 62.35 | 7.22 | 47.11 | 82.41 |
| Heroin price (per pure gram) | 152 | $484.61 | 200.74 | $103.90 | $1677.29 |
| Heroin purity | 152 | 42.20 | 11.72 | 18.74 | 73.06 |
| Police per 100,000 residents ($t-1$) | 152 | 352.87 | 339.635 | 20.50 | 4376.51 |
| Prisoners per 100,000 residents ($t-1$) | 152 | 411.98 | 164.65 | 117.89 | 823.07 |
| Population density (land area/population) $\times$ 100 | 152 | 1.543 | 1.682 | 0.086 | 6.665 |
| Unemployment rate | 152 | 5.026 | 1.075 | 2.5 | 8.2 |
| Poverty rate | 152 | 11.981 | 3.051 | 5.7 | 20.3 |
| Personal income per capita | 152 | $29,834.55 | 4186.45 | $22,143 | $40,779 |

*Notes*: Data are based on 152 state-year observations. Methodology for calculating drug prices and purity described in the online appendix.

where $Arrests_{it}^{a}$ represents the number of arrests in age group $a$ in state $i$ and year $t$, $X_{it}$ is a matrix of state-year covariates, and $\mu_i$ and $\delta_t$ are state- and year-fixed effects, respectively, used to control for national secular trends in online and street activity.[23]

Table 2 presents summary statistics on the relevant variables for our analyses. The set of state-year covariates includes law enforcement controls, such as police presence and imprisonment rates (lagged one year to avoid simultaneity issues); income measures such as per capita real income and the unemployment rate;[24] and local average prices and purity levels for key illegal drugs.[25]

[23] In unreported analyses, we also considered the inclusion of census region-specific and state-specific trends. Our results are robust to the inclusion of census-specific trends, maintaining both precision and sign for both our correlational and casual analyses. The inclusion of state-specific trends, however, eliminates most of the variation used to identify effects, particularly in our casual analyses. Therefore, it appears that our results are robust to controls for regional trends, but we are unable to distinguish our findings from state-specific secular trends. These results are available from the authors upon request.

[24] A sizeable literature suggests economic considerations are key in the decision to offer prostitution services (see, e.g., Rosen and Venkatesh, 2009).

[25] Since a substantial criminological literature suggests a connection between street prostitution and drug use (see, e.g., Inciardi et al., 1991), the inclusion of these drug variables allows us to control for a possibly important omitted variable relating street and off-street solicitation. See the online appendix for the methodology used to construct drug price and purity measures.

**Table 3**
OLS estimates of effect of online prostitution on prostitution arrests. Dependent variable: female prostitution arrests in specified age category.

| | All ages | 18–19 | 20–24 | 25–29 | 30–34 | 35–39 | 40–44 | 45–54 |
|---|---|---|---|---|---|---|---|---|
| *Panel A: Fixed effects only* | | | | | | | | |
| Reviewed sex workers per 100,000 | −0.309** | 1.523 | 0.794 | −0.253*** | −1.477*** | −1.784*** | −1.702** | 0.172 |
| | (0.128) | (1.094) | (0.533) | (0.072) | (0.473) | (0.265) | (0.654) | (0.491) |
| Observations | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 |
| *R*-squared | 0.977 | 0.891 | 0.963 | 0.965 | 0.928 | 0.938 | 0.944 | 0.957 |
| *Panel B: Fixed effects and time-varying covariates* | | | | | | | | |
| Reviewed sex workers per 100,000 | −0.218 | 0.021 | 0.421 | −0.184 | −0.712*** | −0.803*** | −0.382 | 0.348 |
| | (0.221) | (0.54) | (0.43) | (0.13) | (0.19) | (0.23) | (0.27) | (0.62) |
| Meth purity | −0.139 | −0.383 | −0.586 | −0.067 | 0.117 | −0.082 | −0.137 | −0.063 |
| | (0.188) | (0.407) | (0.593) | (0.276) | (0.325) | (0.350) | (0.177) | (0.048) |
| Meth price | −0.000 | −0.009 | −0.011 | 0.003 | 0.005 | 0.005 | 0.003 | 0.001 |
| | (0.002) | (0.008) | (0.011) | (0.002) | (0.004) | (0.005) | (0.003) | (0.001) |
| Cocaine purity | −1.441 | 3.147 | 2.281 | −2.732 | −3.020 | −2.980 | −2.112 | −0.722 |
| | (2.819) | (6.544) | (9.440) | (3.260) | (3.762) | (3.211) | (1.746) | (0.864) |
| Cocaine price | −0.071 | 0.233 | 0.164 | −0.096 | −0.183 | −0.229 | −0.168 | −0.058 |
| | (0.165) | (0.284) | (0.421) | (0.207) | (0.207) | (0.174) | (0.100) | (0.043) |
| Heroin purity | −0.454 | −0.065 | −1.973 | −0.726 | 0.011 | −0.306 | −0.162 | −0.164 |
| | (0.391) | (0.357) | (1.539) | (0.564) | (0.349) | (0.601) | (0.235) | (0.113) |
| Heroin price | −0.006 | 0.004 | −0.053 | −0.017 | 0.008 | 0.006 | 0.001 | 0.000 |
| | (0.012) | (0.014) | (0.057) | (0.019) | (0.012) | (0.013) | (0.009) | (0.004) |
| Ln(Police per capita) [$t-1$] | −0.002** | −0.001 | −0.001 | −0.002 | −0.006*** | −0.005*** | −0.003*** | −0.001*** |
| | (0.001) | (0.001) | (0.002) | (0.002) | (0.002) | (0.001) | (0.001) | (0.000) |
| Ln(prisoners per capita) [$t-1$] | 0.057 | −0.151 | 0.052 | 0.123* | 0.241** | 0.186** | 0.075 | −0.005 |
| | (0.043) | (0.100) | (0.155) | (0.064) | (0.105) | (0.081) | (0.051) | (0.023) |
| Population density | 7.630 | −133.585*** | −115.126*** | 10.010 | 89.075*** | 100.963*** | 54.665*** | 6.954*** |
| | (12.405) | (35.533) | (39.231) | (19.929) | (18.003) | (24.789) | (7.010) | (1.949) |
| Real income | 0.001 | 0.003 | 0.005 | 0.003 | −0.002 | −0.001 | −0.003 | −0.001 |
| | (0.001) | (0.004) | (0.005) | (0.003) | (0.004) | (0.002) | (0.004) | (0.001) |
| Unemployment rate | −3.143 | −6.185 | −9.069 | −2.801 | 3.299 | −3.563 | −4.335 | −1.381 |
| | (3.910) | (6.306) | (12.048) | (6.750) | (3.982) | (4.257) | (3.293) | (1.080) |
| Observations | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 |
| *R*-squared | 0.979 | 0.944 | 0.971 | 0.968 | 0.957 | 0.960 | 0.960 | 0.963 |

*Notes*: Cluster robust standard errors in parentheses. All regressions based on 152 state-year observations.
* Indicates significance at 10% level.
** Indicates significance at 5% level.
*** Indicates significance at 1% level.

Despite the inclusion of these covariates, there are a number of remaining factors that could bias our estimates of Eq. (1). First, if consumers perceive street prostitution and online prostitution as near substitutes, then a temporal and location-specific increase in overall demand for prostitution could lead to a spurious positive correlation between street and off-street activity. For instance, a large convention attracting many potential customers from out-of-town could raise the demand for both street and off-street prostitutes simultaneously (Cunningham and Kendall, 2008). Similarly, temporal increases in levels of police enforcement against all forms of prostitution or changes in economic conditions that drive women to offer prostitution services both online and off-line could imply a spurious positive correlation in the estimation of Eq. (1). Similarly, it is possible that greater growth in online markets could lead law enforcement to shift resources either to or away from street markets, potentially biasing our estimates.[26] We will attempt to control for these factors using an instrumental variables approach in the following subsection; however, it seems likely our correlational results will be biased against finding a displacement effect. Moreover, since we can estimate Eq. (1) on an age-specific basis, we can also draw some conclusions from the pattern of estimates across various ages, so long as biases such as those discussed above operate similarly across ages.

Table 3 presents the results from estimating Eq. (1) using least squares. Heteroskedasticity-robust standard errors, clustered at the state-level, are presented in parentheses below each coefficient.[27] In the first column, both the dependent and independent variables include all ages, while the other columns estimate Eq. (1) using data on each age group separately. In panel A of Table 3, no covariates except year and state-fixed effects are included in the regressions, while panel B includes time-varying covariates.

The results in Table 3 suggest a robust displacement effect among sex workers aged 30–39, while apparent displacement effects for other age groups are either not present or are not robust to the inclusion of covariates. The coefficient on the 35–39 age group in panel B of Table 3 can be interpreted to mean a unit increase in the number of TER workers reviewed per 100,000 females aged 35–39 is associated with a 0.8 reduction in arrests among that age group. Thus, we estimate that a one standard deviation increase (16.40 reviewed women per 100,000 residents) in online prostitution activity is associated with a 23.7% reduction in arrests at the mean, around 1/5 of a standard deviation decrease in arrests among 35–39 year old women. Other coefficients in the table can be interpreted similarly.

The raw data in Fig. 1 and the regression analysis without covariates in Panel A show potential displacement effects over the 25–45 range; however, the inclusion of covariates in Panel B reduces both the size and significance of the estimates, with the result for the 25–30 range becoming statistically insignificant. In unreported analysis, sensitivity testing showed that the key

[26] If law enforcement officials face a fixed budget, then the growth of Internet-mediated prostitution may lead them to expend less effort on street-based prostitution. Alternatively, and as documented by Murphy and Venkatesh (2006) and Bernstein (2007), if police largely respond to the demands of property owners whose concern with prostitution relates to its public nuisance aspect, police may expend more effort on street-based prostitution precisely because of the larger opportunity for displacement.

[27] By clustering at the state level, we assume the disturbance term to be a stochastic value correlated within state-age cells over time.

covariate causing this change is population density. It appears (perhaps unsurprisingly) that both TER activity and arrests are positively correlated with population density.

For the aggregate of all ages in column 1, we find no statistically significant displacement of arrests from online prostitution activity (at least, once we include covariates), although the point estimate is negative. Overall, we cannot reject the hypothesis of no displacement, and therefore, that the rise in online solicitation represents an expansion of the market. However, consistent with the evidence presented in the national trends above, these simple correlations do suggest a focused displacement effect among women in the middle of the age distribution. Since TER may not be an ideal proxy for all online activity, we are disinclined to interpret our findings structurally (and even less inclined to assume a globally linear effect); however, the estimated 23.7% decline in arrests among 35–39 year old women associated with a standard deviation increase in TER activity is quite large, given that over the 1999–2006 period, arrest rates in this age group declined by 27%.

### 4.3. Causational analyses

The previous subsection estimated correlations between proxies for online and off-line prostitution activity. However, as discussed above, there are many temporal location-specific shocks that might bias these correlations, such as the temporary presence of a convention bringing many out-of-town visitors, a short-term police crack-down, or simply omitted variables that we cannot observe and account for, including changing consumer preferences or cultural norms. In this section, we examine the relationship between online and off-line prostitution activity, using only variation in online activity that is correlated with a plausibly exogenous factor, the growth in residential high-speed Internet access.

The period from 1999 to 2006 was one of tremendous growth in residential broadband. Fig. 4 plots the share of US households with broadband access, by year, using data from the Federal Communications Commission (e.g., FCC, 2009). Broadband subscription in the United States grew from fewer than three million lines in 1999 to over 60 million lines in 2006 with most residential subscribers choosing cable models or DSL lines (Prieger and Hu, 2008). The increased availability of broadband Internet connections facilitates online prostitution activity by connecting buyers with sellers, and by widening the population who can access, at high-speeds, the institutions that facilitate online solicitation described in Section 2. Since much of the value in these new forms of advertisement and communication is visual, the availability of broadband, which vastly increases download speeds for images, has special importance beyond simple Internet access. Older forms of Internet access, such as "dial-up", are unlikely to have had the same impact, since one of the primary benefits to consumers of online solicitation is the ability to compare images and other information from many potential prostitutes quickly.

A valid instrument must have two characteristics: it must be excludable from Eq. (1) and it must be relevant for explaining variation in our endogenous repressor, growth in online solicitation activity.[28]

One prominent way that broadband may directly affect street prostitution, and thus, not be excludable from Eq. (1), is if it facilitates access to online pornography, which might be either a substitute or a complement for prostitution services, including street prostitution. While we cannot fully exclude this possibility, there are both theoretical and empirical indications that substitution towards pornography does not seriously invalidate our identification strategy. From the standpoint of theory, as noted in the previous sub-sections (and confirmed below), our findings indicate a strong displacement effect only among prime-aged workers. However, the rise of the Internet has primarily increased access to pornography among younger consumers, who faced legal and social restrictions in accessing pre-internet sources of pornography, such as magazines or adult theaters. Similarly, in our survey (described in the following section), we find that the average age among clients who purchase services from sex workers who advertise on the Internet is 43.[29]

A second criterion for a valid instrument, besides excludability from Eq. (1), is that it is relevant for explaining changes in the endogenous variable. As in all instrumental variables-based research, "weak" instruments can result in large standard errors with poor asymptotic approximation of confidence intervals. As the first-stage *F*-statistic gets smaller (i.e., as the instrument becomes weak), the bias of the 2SLS estimator converges to the biased OLS estimator. Stock and Yogo (2001) therefore recommend as a diagnostic test an *F*-statistic larger than 10. But while this is a widely used standard for 2SLS estimators, this threshold is only appropriate in situations when the disturbance term is homoskedastic and i.i.d. Less is known of situations when the disturbance term is heteroskedastic and/or serially correlated within state/age cells, for instance. Nevertheless, we report robust *F*-statistics for all our 2SLS estimates.

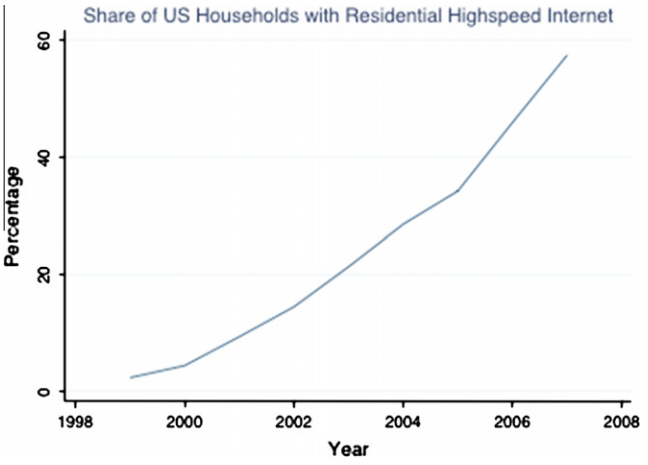


**Fig. 4.** Trends in share of US households with residential high-speed internet access, 1999–2007. Source: Data on Residential High-Speed Internet Access available from Federal Communications Commission (http://www.fcc.gov/wcb/iatd/comp.html).

[28] Recent studies on broadband diffusion find that in addition to income, factors related to market structure explain the growth in broadband in states. Prieger and Hu (2008) shows that, in states with more competition from suppliers, broadband grew faster. Prieger and Hu (2008) also find that service quality, affected by population density and residential sorting, can reduce demand for broadband, particularly among Black households which more commonly live far from broadband provider central offices, causing decay in signal quality. All of our models control for two moments in the income distribution: real state income per capita and the state poverty rate. State-fixed effects capture all other time-invariant state and state-age level heterogeneity.

[29] A second possible means by which broadband access could directly affect street prostitution would be if access to the Internet allowed clients of street prostitutes to better avoid arrest. Holt and Blevins (2009) show that there is, in fact, considerable sharing of information among street prostitute clients regarding which streets are frequent targets of police sting operations, tips to avoid getting caught in stings, and so on. As an empirical check on the potential excludability of broadband penetration from Eq. (1), we considered adding it directly to our correlational regression model, as described in the previous subsection. If broadband penetration was independently correlated with arrests, controlling for our proxy of online activity, this would suggest that it may not be excludable from Eq. (1). In unreported analysis, we found that broadband penetration is not separately correlated with arrests for all age groups together, or for any age group separately, except for the 45–54 age group, when time-varying controls are included. These results do not prove with certainty the validity of broadband as an instrument, but they are an empirical indication consistent with a valid identification strategy.

**Table 4**
First stage coefficients from 2SLS estimates of effects of online prostitution on prostitution arrests. Dependent variable: reviewed sex workers per 100,000.

| | All Ages | 18–19 | 20–24 | 25–29 | 30–34 | 35–39 | 40–44 | 45–54 |
|---|---|---|---|---|---|---|---|---|
| *Panel A: Fixed effects only* | | | | | | | | |
| % Households with Broadband access | 1.317*** | 0.934*** | 4.391*** | 2.744*** | 1.308** | 1.033 | 0.404** | 0.084 |
| | (0.452) | (0.242) | (1.032) | (0.893) | (0.495) | (0.639) | (0.184) | (0.060) |
| Observations | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 |
| *R*-squared | 0.207 | 0.276 | 0.289 | 0.220 | 0.127 | 0.087 | 0.136 | 0.045 |
| *Panel B: Fixed effects and time-varying covariates* | | | | | | | | |
| % Households with Broadband access | 1.244*** | 0.962*** | 3.911*** | 2.598*** | 1.486*** | 0.908** | 0.353** | 0.081** |
| | (0.249) | (0.195) | (0.592) | (0.557) | (0.331) | (0.340) | (0.133) | (0.038) |
| Observations | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 |
| *R*-squared | 0.287 | 0.206 | 0.339 | 0.264 | 0.209 | 0.115 | 0.129 | 0.042 |
| *Panel C: Fixed effects and time-varying covariates, excluding NY and CA* | | | | | | | | |
| % Households with Broadband access | 1.276*** | 0.905*** | 3.978*** | 2.848*** | 1.583*** | 0.944** | 0.336** | 0.068 |
| | (0.318) | (0.226) | (0.791) | (0.768) | (0.450) | (0.465) | (0.180) | (0.045) |
| Observations | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 |
| *R*-squared | 0.276 | 0.644 | 0.850 | 0.834 | 0.829 | 0.801 | 0.740 | 0.571 |

*Notes*: Cluster robust errors in parentheses. All regressions based on 152 state-year observations. All time-varying covariates were partialed out from all the other variables because the number of clusters was less than the number of exogenous regressors plus the number of excluded instruments.

* Indicates significance at 10% level.
** Indicates significance at 5% level.
*** Indicates significance at 1% level.

Weak instruments also result in size distortions such that the estimator has a null distribution poorly approximated by a standard normal (Nelson and Startz, 1990). As a result, conventional IV tests will have spuriously high null rejection rates, even in large samples. There are, however, several tests available for linear instrumental variable models that have the correct size even when instruments are weak. For just-identified models such as ours, the Anderson–Rubin test is optimal (Moreira, 2009). Because of concerns regarding serial correlation, as well as the apparent presence of weak instruments (as defined by the *F*-statistic threshold of 10) for some of our results, we display both traditional *t*-statistics, as well as *p*-values from a chi-squared Anderson-Rubin (AR) test with all our 2SLS results.

In Tables 4 and 5, we replicate the analyses we performed using OLS in the previous subsection, but instead of estimating Eq. (1) through correlation, we implement a two-stage least squares procedure, using broadband penetration as an instrument for per capita TER workers reviewed. Table 4 presents the first-stage estimation of Eq. (2), while Table 5 presents the associated structural estimates of Eq. (1). The first-stage results in Table 4 show a strong association between broadband access and online prostitution activity overall, and across most age subgroups.[30] Since these regressions control for state and time fixed effects, the results strongly suggest that broadband access is an important factor driving the online prostitution market.

The results in Table 5 are qualitatively similar for all ages to our correlational findings in Table 3; however, in Table 5, we find a larger effect for ages 35–39 and 40–44, but a smaller effect for ages 30–34. For the 35–44 year olds, when we control for time-varying state covariates in panel B, the strength of the first-stage increases by two to three fold over the fixed effects model, but the instruments are still weak according to traditional *F*-tests. Both AR tests, however, indicate that the statistical significance of these results is robust to weak instruments.

The qualitative differences between the coefficients in Tables 3 and 5 may indicate that the omitted variables biases discussed earlier primarily act to lower the estimated relationship between online and off-line activity among 35–44 year olds. Alternatively, the results in Table 5 may represent a local average treatment effect (commonly known as a "LATE", see Imbens and Angrist, 1994) among a subset of transactions where the adoption of broadband was key to the displacement effect. For instance, because most of the variation in our sample occurs during the mid- and late-2000s, the key variation used to identify displacement effects in Table 5 is likely to be TER activity among relatively late technology adopters. Later adopters of Internet technology tend to be older households (Gant et al., 2010), and there is some evidence of age-matching between sex workers and their clients.[31] Therefore, when we focus on the subset of TER activity that is correlated with broadband adoption, this may lead us to find relatively smaller and less statistically significant effects for the relatively younger age groups.[32]

Panel C in Table 5 displays results for a similar analysis, including all time-varying state controls, but excluding two high-density states with large urban street markets, New York and California. When New York and California are excluded, we find a sizeable overall displacement effect, and for each age group between 25 and 54 separately. This is our strongest evidence of large displacement effects.

We speculate that the stronger apparent displacement effects outside New York and California may be attributable to the fact that New York City, Los Angeles, and San Francisco have long had very active off-street prostitution markets, before the widespread adoption of Internet technology, including through advertisements in newspapers and specialized publications. Therefore, the rise in online solicitation may have had relatively little impact in these cities. In other locations, search costs for off-street prostitution were much higher absent the Internet, and markets were thin; the rise of sites that reduce these costs, such as TER, therefore may have had a much larger impact outside New York and California. However, in the absence of better evidence to substantiate this speculation, our best estimate is that displacement effects are only

[30] Because the number of clusters is less than the number of regressors and excluded instruments, the coefficients in this table were calculated through the Frisch–Waugh–Lovell procedure.

[31] In our survey of online sex workers (described in the following section) we find that sex workers over age 45 are nearly twice as likely to see a client over age 45 relative to sex workers aged 20–24.

[32] Alternatively, the results may represent a LATE focused on White sex workers and clients (Prieger and Hu (2008) shows that broadband adoption to date has focused primarily on whites). In unreported analysis, we estimated a multinomial logit model on the relative risk that a TER-reviewed worker was White. We found that a one standard deviation increase in the share of all households with broadband access was associated with a 46% increase in the probability that a worker was White relative to Black. These results are available from the authors upon request.

**Table 5**
2SLS estimates of effect of online prostitution on prostitution arrests. Dependent variable: female prostitution arrests in specified age category.

| | All ages | 18–19 | 20–24 | 25–29 | 30–34 | 35–39 | 40–44 | 45–54 |
|---|---|---|---|---|---|---|---|---|
| *Panel A: Fixed effects only* | | | | | | | | |
| Reviewed sex workers per 100,000 | −0.340 | 1.163 | 0.267 | −0.193 | −1.310* | −1.878*** | −2.302** | −1.803 |
| | (0.280) | (1.34) | (0.45) | (0.17) | (0.69) | (0.41) | (0.99) | (1.36) |
| Anderson-Rubin *p*-value | 0.231 | 0.451 | 0.580 | 0.26 | 0.169 | 0.121 | 0.098 | 0.119 |
| First stage *F*-stat | 8.50 | 14.89 | 18.11 | 9.45 | 7.00 | 2.62 | 4.85 | 1.91 |
| Time-varying covariates? | No | No | No | No | No | No | No | No |
| Observations | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 |
| *Panel B: Fixed effects and time-varying covariates* | | | | | | | | |
| Reviewed sex workers per 100,000 | −0.358 | 0.163 | 0.000 | −0.190 | −0.394 | −1.447*** | −2.133* | −3.527 |
| | (0.331) | (0.908) | (0.392) | (0.214) | (0.341) | (0.546) | (1.137) | (2.159) |
| Anderson-Rubin *p*-value | 0.266 | 0.860 | 0.999 | 0.386 | 0.300 | 0.028 | 0.030 | 0.012 |
| First stage *F*-stat | 24.86 | 24.40 | 43.6 | 21.79 | 20.13 | 7.12 | 7.06 | 4.60 |
| Time-varying covariates? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 |
| *Panel C: Fixed effects and time-varying covariates, excluding NY and CA* | | | | | | | | |
| Reviewed sex workers per 100,000 | −0.569** | −0.408 | −0.163 | −0.321* | −0.584* | −1.536*** | −2.309* | −4.798 |
| | (0.289) | (0.939) | (0.374) | (0.174) | (0.338) | (0.594) | (1.326) | (3.196) |
| Anderson-Rubin *p*-value | 0.041 | 0.656 | 0.652 | 0.067 | 0.159 | 0.039 | 0.054 | 0.011 |
| First stage *F*-stat | 16.08 | 16.11 | 25.31 | 13.73 | 12.37 | 4.13 | 3.51 | 2.28 |
| Time-varying covariates? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 |

*Notes*: Cluster robust standard errors in parentheses. All regressions based on 152 state-year observations.
* Indicates significance at 10% level.
** Indicates significance at 5% level.
*** Indicates significance at 1% level.

substantial among sex workers in their 30s and 40s, and that the rise in online solicitation has likely augmented the market in other age groups.

## 5. Risk behaviors of sex workers who solicit online

In this section, we examine the business and sexual practices of workers who currently solicit online. Given the results in the previous section showing displacement effects for some age groups of sex workers, we are also able to specifically examine individuals who have previously worked in the outdoor sector, and thus may be close to the margin for displacement and possibly most responsive to policies targeting the sector.

### 5.1. Survey methodology

Our analyses are derived from a survey of sex workers implemented by the authors between August 2008 and June 2009, known as the Survey of Adult Service Providers (SASP). Previous surveys have largely focused on street-based prostitutes, in part due to the lower cost of contacting workers who operate in public places. Sampling methods in such studies, therefore, frequently suffer from selection biases by focusing disproportionately on a high-risk group and extrapolating to the broader prostitution population. SASP represents the most comprehensive sampling of indoor workers to date, and by correcting for the inverse probability of appearing in the survey, it is unique in the literature in its efforts to address selection bias.

The online appendix lists all survey questions and describes the survey procedure in more detail, but to summarize briefly, SASP was implemented by sending requests to all valid email addresses among TER-reviewed workers, supplemented with a sample of sex workers who advertise on a popular national site for escort ads, Eros.com. In the email, respondents were asked to click on a link that led them to the survey, hosted on Baylor University servers. Each email sent was associated with a randomly-generated string of characters, which allowed us to prevent multiple responses from the same email, while at the same time maintaining the anonymity of the survey, which we found to be a key factor driving participation.[33] Throughout the survey process, we continually worked to build trust with respondents, answering numerous emails and telephone calls from those who received our survey. Endorsement of SASP by the Las Vegas Sex Workers Outreach Project (SWOP), a major support and advocacy group, helped tremendously.

In total, we attempted to contact 26,189 individuals to participate in SASP. 13,333 of these emails were successfully delivered to an address and did not "bounce back". Some share of the accounts receiving these emails, although nominally open for incoming mail, are likely unused or rarely checked, especially since our population of TER-reviewed workers stretches back to 1999. Thus, 13,333 is likely an upper bound on the pool of potential respondents, and the "true" response rate is likely much higher as a result. Nevertheless, 685 respondents answered our request to take the survey, giving a lower bound response rate of 5.14%.

While this figure is low by traditional survey standards, we believe the survey results are of value, given the general difficulty previous research has faced in reaching this population, and the hesitancy among sex workers to answer questions related to work in illicit activity. In an attempt to make the survey as representative as possible, we adjusted the responses for the most serious potential selection biases on the part of respondents, as described below. Nevertheless, the results must be interpreted with some care.

In order to facilitate extrapolations to the population of sex workers who solicit online, we adjusted SASP responses using probability weights constructed from the distribution of age and race characteristics of all TER-reviewed workers and SASP respondents. Specifically, we calculated the share of individuals reviewed on TER in each age-race category, and divided that share by the similarly-calculated share of SASP respondents in that same category. This process allows us to present estimates of population means and linearized standard errors using these probability weights.

[33] Respondents were also allowed to answer survey questions by telephone with the authors or their research assistants.

**Table 6**
Weighted means of key characteristics and practices among sex workers who solicit on the Internet.

| Variable | Mean | Linearized SD | N |
|---|---|---|---|
| *Panel A: Worker-level characteristics* | | | |
| Weekly earnings | $2576.69 | 404.497 | 442 |
| Any clients (0/1) | 0.760 | 0.028 | 630 |
| Total # clients | 5.422 | 0.949 | 600 |
| # "Regular" clients | 2.941 | 0.563 | 597 |
| # First-time clients | 2.474 | 0.419 | 597 |
| Years since entry into prostitution | 5.457 | 0.256 | 601 |
| Have solicited on street | 0.130 | 0.022 | 602 |
| Independent/own boss | 0.926 | 0.019 | 603 |
| Have health insurance | 0.449 | 0.035 | 598 |
| Have second job | 0.429 | 0.035 | 599 |
| College graduate | 0.406 | 0.030 | 604 |
| Married/cohabitating with partner | 0.128 | 0.018 | 605 |
| BMI | 23.096 | 0.386 | 591 |
| Age | 28.294 | 0.323 | 608 |
| Any children (0/1) | 0.377 | 0.036 | 604 |
| White race | 0.610 | 0.040 | 608 |
| Black race | 0.111 | 0.025 | 608 |
| Hispanic race | 0.121 | 0.043 | 608 |
| Asian race | 0.086 | 0.023 | 608 |
| *Panel B: Transaction-level characteristics* | | | |
| Compensation paid | $486.51 | 22.925 | 2416 |
| Length of session (mins) | 120.786 | 9.488 | 2478 |
| Massage given | 0.367 | 0.017 | 2487 |
| Fellatio with condom | 0.316 | 0.018 | 2401 |
| Fellatio without condom | 0.508 | 0.018 | 2401 |
| Vaginal sex with condom | 0.696 | 0.015 | 2432 |
| Vaginal sex without condom | 0.052 | 0.009 | 2432 |
| Anal sex with condom | 0.052 | 0.006 | 2457 |
| Anal sex without condom | 0.011 | 0.003 | 2457 |
| Group sex | 0.057 | 0.007 | 2490 |
| Age of client | 43.033 | 0.408 | 2369 |
| Client white race | 0.803 | 0.015 | 2414 |
| Client black race | 0.052 | 0.007 | 2414 |
| Client Hispanic race | 0.035 | 0.007 | 2414 |
| Client Asian race | 0.073 | 0.012 | 2414 |

*Notes*: Data are drawn from Survey of Adult Service Providers (SASP). Survey means and standard errors are weighted by population means within each age-race cell, taking all TER-reviewed workers as the population.

### 5.2. Business and sexual practices of online sex workers

The SASP data has two files – a worker-level file based on responses to questions about personal characteristics and general practices, and a transaction-level file with observations that vary across clients for a given sex worker. The latter is based on a sequence of questions asked in the survey regarding each respondent's five most recent client-session transactions. Table 6 shows estimates of population means for key variables from each file, with linearized standard errors.

Based on the information in Table 6, we estimate that the typical sex worker who solicits for clients online sees 5.4 clients per week, and of these, 54.2% (=2.94/5.42) are "regulars" – that is, repeat customers. By contrast, Levitt and Venkatesh's (2007) analysis of streetwalking prostitutes in Chicago found a mean of 7.2 clients per week, with 47.4% of these being regulars.

We estimate that the average technology-facilitated sex worker has been involved in the industry for around 5.5 years, and nearly 93% are "independents", who do not operate under third-party management, such as by a pimp or agency. The latter result may partially reflect the greater difficulty we faced in receiving responses from those without their own advertised email address, including some workers in brothels or under pimp management; nevertheless, it appears that a very sizeable share of those who solicit online are independents. By contrast, studies of streetwalking prostitutes generally find between 40% and 80% work under pimp management (Giobbe, 1993; Norton-Hawk, 2004).

The mean body mass index (BMI) is 23.1, a value that falls into the range generally considered normal and healthy. 45% of those surveyed have private health insurance. However, 11% of online sex workers reported BMI values below 18.5, indicating underweight (by comparison, 2.6% of US males and females aged 20–39 were underweight in the 2003–2006 National Health and Nutrition Examination Survey). Insofar as low BMI measurements are indicative of malnutrition associated with drug use and eating disorders, this suggests a relatively low frequency of such behaviors among online prostitutes, though the share is considerably higher than the national average.

Our survey results suggest that 13% of workers are married or cohabitating with a partner, 38% have children, and 41% are college graduates. We are unaware of any previous studies examining such questions among streetwalking prostitutes; however, these findings suggest that online workers are drawn from those with relatively traditional backgrounds and family situations, relative to common perceptions of prostitutes in the street-sector, and relative to the low quality-of-life suggested by the ethnographic literature on streetwalking (e.g., Rosen and Venkatesh, 2009).

We can also compare the age and race characteristics estimated for sex workers who solicit online with those of arrested prostitutes, which we have shown above appear to be largely constituted of street-sector workers. Among online workers, the average age is 28.3, and 61% are white, 11.1% are black, and 8.6% are Asian. Based on the FBI's 2005 NIBRS data, the average age of female prostitute offenders is 33.5 and 59.8% are white, 37.5% are black, and 2.1% are Asian. Online sex workers therefore appear to be younger, and to include a smaller share of Black workers.

Turning to the transaction-level file, panel B in Table 6 presents the population frequency of various risky sexual acts among transactions associated with sex workers who solicit online. Fellatio appears to be the most common sexual practice, with 50.4% of all transactions involving unprotected fellatio, and another 31.2% involving fellatio with a condom. Vaginal sex is common as well, and anal sex less frequent, but only 6.1% of all transactions involved unprotected vaginal or anal sex. By comparison, in Levitt and Venkatesh's (2007) survey of streetwalking prostitutes, oral and vaginal sex were much less common (45.8% and 17.2% of all transactions, respectively), while anal sex was more common (9.4%); however, they report 79.4% of all transactions were unprotected, with that share rising to nearly 97% in some subsamples. The results in Table 6 suggest a substantially lower degree of risk-taking among online sex workers.

Overall, we conclude from the means provided in Table 6 that sex workers who use the Internet to solicit for customers represent a population behaviorally and demographically different from street-based workers. They see lower volume of clients, more repeat clients, and engage in high-risk sexual activities less frequently. However, they do see multiple clients per week, and occasionally engage in unprotected penetrative sex; therefore, if as suggested above, the rise in online solicitation represents augmentation of the market for prostitution, such behaviors are of concern.

### 5.3. Behaviors of sex workers on the margin of displacement

Given our earlier focus on displacement between outdoor and Internet-facilitated solicitation, we can also ask how these risk behaviors differ among those on the margin of displacement and who might plausibly be most affected by policies focused on prostitution.[34] In particular, a series of questions in the survey listed

[34] Since our survey focuses on sex workers, we have little to say about the equally-important question regarding the behaviors of customers of prostitutes who are on the margin between buying street-based and online-based services.

**Table 7**
Estimated differences between online sex workers with street solicitation experience and others business and insurance practices.

| | Any clients (0/1) | # Total clients | # Regular clients | # New clients | Ln(weekly earnings) | Have second job (0/1) | Have health insurance (0/1) | Enrolled in medicaid (0/1) |
|---|---|---|---|---|---|---|---|---|
| Street experience | −0.066 | 4.315** | 1.327** | 1.620** | 0.736** | −0.422** | −0.226* | 0.043 |
| | (0.091) | (1.166) | (0.594) | (0.509) | (0.206) | (0.066) | (0.093) | (0.054) |
| Worker characteristics | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Client characteristics | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Sex act controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| State and month fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Obs. | 513 | 401 | 398 | 398 | 395 | 521 | 513 | 446 |
| Model specification | Probit | Neg. Binomial | Neg. Binomial | Neg. Binomial | OLS | Probit | Probit | Probit |

*Notes*: Regressions based on analysis of SASP worker-level data, with observations weighted to represent population of sex workers who solicit online. Probit and Negative Binomial coefficients are represented as marginal effects. Standard errors in parentheses.
* Indicates statistical significance at 5% level.
** Indicates significance at 1% level.

under the heading of "Historical Experience Questions" asked about respondents' employment history in sex work. Relevant for our analyses, we asked: "Have you ever solicited your customers from a public place, like a street, alley, highway, or parking lot?" We coded those who responded affirmatively to have had "street experience". As indicated in Table 6, we estimate that 13% of the population of workers who currently solicit online have street experience.[35]

Table 7 correlates this street experience variable with several worker-level characteristics, including whether the worker saw any clients during the past week, the number of clients (broken out among "new" clients and "regulars"), total weekly earnings, whether the worker held a second (non-prostitution) job, and the worker's insurance and Medicaid status. In addition to our usual set of controls, we include fixed effects for all unmeasured observables associated with the worker's primary state of residence, and with the month in which the worker was surveyed; and all regressions are population-weighted using the procedure described above.

The results in the first column of Table 7 indicate that workers with street experience are not significantly different from others who solicit online in terms of the likelihood of working at all in a given week. However, columns 2–4, which are expressed as marginal effects derived from negative binomial count models, imply that former street workers see more clients in a week, including both more "new" clients and more "regulars". It is largely this higher volume that accounts for the fact that these workers see 73.6% higher weekly earnings (conditional on working at all), as noted in column 5. Workers with street experience are also 42.2% less likely to hold a second job outside of sex work, and are 22.6% less likely to have private medical insurance, but no more or less likely to be enrolled in Medicaid.

Table 8 presents additional evidence on the behaviors of workers with street experience, using the transaction-level file to examine typical length of sessions and calculated hourly wages. The results in Table 8 suggest that sex workers near the margin of displacement provide shorter sessions (20.6% shorter in length, and 14.7% more likely to be less than the mode, 60 min). These findings are consistent with other studies (Lever and Dolnick, 2010) that find streetwalkers specializing in more transitory sexual encounters with strangers, when compared to indoor workers. The last column of Table 8 shows that, on average, sex workers with street experience see 3.8% lower hourly wages.[36]

**Table 8**
Estimated differences between online sex workers with street solicitation experience and others session length and calculated hourly wage.

| | Dependent variable | | |
|---|---|---|---|
| | Ln(Length) | Indicator for less than 60 min | Ln(Wage) |
| Street experience | −0.206* | 0.147* | −0.038 |
| | (0.09) | (0.068) | (0.079) |
| Worker characteristics | Yes | Yes | Yes |
| Client characteristics | Yes | Yes | Yes |
| Sex act controls | Yes | Yes | Yes |
| State and month fixed effects | Yes | Yes | Yes |
| Obs. | 1649 | 1598 | 1649 |
| *R*-squared | 0.291 | 0.386 | 0.406 |

*Notes*: All regressions based on SASP transaction-level data, including most recent (up to) five sessions for 685 sex workers who solicit online.

The findings in Tables 7 and 8 suggest that workers with street experience, who are potentially on the margin for displacement, tend to be associated with high-volume activity, tend to be full-time sex workers, as opposed to "moonlighters", and to face limitations in their ability to access medical resources.

Finally, in Table 9 we use transaction-level data to examine how the sexual practices of workers with street experience differ from other sex workers who solicit online. Each column presents the results of a regression in which the dependent variable is an indicator for whether a particular sex act occurred during a transaction. The first three columns indicate that those with street experience differ little with other sex workers who solicit online regarding the provision of, and condom usage during, fellatio. Columns 4 and 5, however, indicate that those with former street experience are 13.6% more likely to provide vaginal sex, and 4.7% more likely to provide anal sex in any given transaction. The last column in Table 9 indicates that these former street workers are 2.8% more

[35] Note that street experience only refers to workers who have ever solicited from a public location, like a street. There may be other workers who would have entered prostitution as a street worker, but due to technological change, entered indoors instead; thus, those with street experience in our survey are a subsample of those on the margin of displacement.

[36] For women with sessions shorter than the modal 60-min session, there is a 27.1% penalty ($p$-value of 0.038). We find no statistically significant penalty for sessions lasting 60 min or longer. One interpretation of these results is that street experience sorts into shorter sessions, involving less companionship and other non-sexual activity, and that these shorter sessions involve a sizeable wage penalty. It may be that these workers have high subjective time discount rates, leading them to specialize in low-cost high-volume service.

**Table 9**
Estimated differences between online sex workers with street solicitation experience and others sexual practices.

| | No oral sex | Oral sex w/condom | Oral sex w/o condom | No vaginal sex | Vaginal sex w/condom | No anal sex | Anal sex w/condom | Vaginal or anal sex w/o condom |
|---|---|---|---|---|---|---|---|---|
| Street experience | −0.029 | −0.004 | 0.027 | −0.136** | 0.157** | −0.047+ | 0.001 | 0.028* |
| | (0.04) | (0.07) | (0.09) | (0.03) | (0.05) | (0.03) | (0.01) | (0.02) |
| Worker characteristics | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Client characteristics | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Other sex act controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| State and month fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Obs. | 1792 | 1721 | 1790 | 1790 | 1785 | 1758 | 1745 | 1201 |
| *R*-squared | 0.296 | 0.218 | 0.219 | 0.272 | 0.263 | 0.224 | 0.194 | 0.493 |

*Notes*: Results based on analysis of SASP transaction-level data, including most recent (up to) five sessions for 685 sex workers who solicit online. Each column represents a regression in which the dependent variable is an indicator for whether the specified sex act took place during the session. Each model corrects for within-provider correlation in disturbances.

likely to engage in some form of receptive vaginal or anal sex without a condom.[37] According to Varghese et al. (2002), for a heterosexual woman who has receptive vaginal sex without a condom with a partner of unknown HIV serostatus and an HIV prevalence of 1%, the risk of HIV transmission in a single sex act would be ten times higher than is associated with receptive fellatio without a condom.

Overall, the results from the survey suggest that most sex workers who solicit online engage less frequently in high-risk sexual practices than has been found among street-level prostitutes. However, the segment of workers who are close to the margin of displacement between street and off-street activity engage in higher volume and higher-risk behaviors, which more closely match those of street workers.

## 6. Conclusion

We consider the main contribution of this paper to shed further light on the market for prostitution, and particularly on the modern, technology-facilitated segment, which has received little empirical attention by researchers, but which has fomented significant concern and calls for changes in policing and public health measures. We have developed economic hypotheses linking the growth in online solicitation to activity in the street prostitution market, and to risk behaviors of prostitutes, and we have provided preliminary evidence on key parameters for policymakers, estimating the degree of displacement between new and old technologies for solicitation and the frequency of risky behaviors among those who use new technologies.

A sunny perspective on the rise of online solicitation among prostitutes is that such activity largely displaces streetwalking, with its associated nuisance externalities and worker exploitation, and that the new market institutions associated with online activity incentivize reputation-building and screening, which reduce the risks and social externalities of prostitution. Our results suggest that, while there is some evidence for such effects, this perspective is likely too optimistic. In fact, it appears that overall, online solicitation represents an augmentation of the prostitution market, with large displacement effects only among some age groups of sex workers. This conclusion is not inconsistent with available survey evidence from the General Social Survey, in which the share of individuals who admit to having paid for, or received pay for, sex during the past year increased from 0.54% in 1998 to 0.79% in 2008.

Moreover, we also find that, while it is true that those who solicit online generally engage in less high-risk behavior than those involved in street markets, they still offer a large quantity of transactional sex, and moreover, those sex workers who appear to have been displaced from the street-sector mostly carry their risky behaviors with them into the off-street-sector, potentially creating new disease vectors where few existed before. This differentiates our findings from those of Gertler and Shah (2009), who find that displacement of sex workers from the outdoor to the indoor sector in Ecuador led to declines in STI incidence, although more research is needed to fully understand whether the growth in online sex work has had any effect on STI incidence and prevalence.

While we believe our evidence is based on the best available data, we recognize serious limitations in the scope of these data, and so we conclude with a call for more substantial data collection on business and sexual practices in this industry.

[37] There are a small number of cases of unprotected anal sex, but not enough to estimate the effects of street experience on these separately from unprotected vaginal sex.

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## Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jue.2010.12.001.

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