Modeling Sex Trafficking and Commercial Sex Work Policy in Massachusetts

Abstract

Introduction. Sex trafficking affects many individuals in the United States, yet severe data scarcity hampers evidence-based policymaking. Commercial sex work (CSW) policy is tightly intertwined with trafficking outcomes, and current policies of criminalization disproportionately harm sellers who are often trafficking victims themselves. This paper investigates how alternative CSW policy regimes affect trafficking in Massachusetts using a system dynamics model.

Approach. System dynamics modeling (SDM) is a type of computational simulation that allows us to capture the causal structure of the system even with scarce data. We developed an SDM of the Massachusetts CSW industry through iterative subject matter expert elicitation and calibrated it against available state-level data estimates. Sensitivity analyses identify the most impactful and policy-relevant parameters.

Results. We compare the outcomes of four potential policy regimes against the default, full criminalization of CSW. We found that full decriminalization increases trafficking, buyers and demand by removing buyer risk. Partial decriminalization and an extension that also increases seller services reduce total and trafficked sex sellers, though both modestly increase trafficker counts. Expungement of seller criminal records produces consistent protective effects across outcomes.

Discussion. The model demonstrates that partial decriminalization consistently outperforms full decriminalization on trafficking-related outcomes which is a counterintuitive finding that, nonetheless, has support from prior empirical and simulation research. Criminal record reform represents a high-leverage, low-disruption policy option. We also demonstrate how the model could be used to investigate non-legislative interventions and future work should prioritize data collection to narrow uncertainty bounds for decision-making.

Introduction

Sex trafficking is a major issue globally and in the United States. There are around 1-2 million individuals being exploited in the commercial sex industry in the US (estimates vary

widely). An analysis of 2021 data from the National Human Trafficking Hotline found that 68% of identified trafficking cases were related to sex or sex and labor. There is firm consensus on policy related to sex trafficking – it is always prosecuted – but it is also inextricably tied to the commercial sex work (CSW) industry, which has many possible (and sometimes competing) policies and interventions. Current policy in nearly all of the US is that of 'criminalization,' wherein both buying and selling sex are illegal and may be prosecuted. The result of criminalization is that the overwhelming majority of prostitution arrests are of sellers, who are frequently experiencing sexual exploitation, rather than of buyers or traffickers (Farrell and Cronin, 2015).

The US federal definition of sex trafficking is the "recruitment, harboring, transportation, provision, obtaining, patronizing, or soliciting of a person for the purpose of a commercial sex act in which a commercial sex act is induced by force, fraud, or coercion, or in which the person induced to perform such act has not attained 18 years of age" (22 U.S.C. § 7102(11)(A)). Force, fraud and coercion are the key indicators in this definition and include physical force (force), faking debt or making false promises of a job/citizenship/etc. (fraud), and threat of physical or sexual violence, withholding documentation, blackmail, or identity disturbance disorder (coercion), among others. Under this definition, all CSW involving a minor is defined as sex trafficking.

A 2019 report from Demand Abolition estimated the annual size of the US commercial sex market at $5.7 billion (Demand Abolition, 2019). Estimates of the number of people involved in the sex trade are extremely rare and unreliable. For example, a 2019 paper claimed there are 1-2 million full-service sex workers in the US, citing a 2012 report from the French organization, Fondation SCELLES, that does not actually include those values (Fondation Scelles and Charpenel, 2012; Sawicki *et al.*, 2019). A later report from Fondation Scelles says "No official national statistics on prostitution, but NGO estimates vary between 500,000 and 1 million prostituted persons," but there is no citation for the "NGO estimates" and we were unable to verify them separately (Fondation SCELLES, 2016, p. 427). A lack of data on the situation makes research much more difficult. Instead of data, we must rely on the experience of subject matter experts.

In this paper, we present a system dynamics model of the commercial sex work industry in Massachusetts (MA), USA. System dynamics modeling (SDM) is a form of computational simulation that allows us to build a model of the system using subject matter expert (SME) knowledge, calibrate with limited data estimates, and produce meaningful insights into systemic behavior under various policy regimes or interventions. SDMs have been applied to a wide variety of applications including human and sex trafficking (Kővári and Pruyt, 2014; King, 2019; Senft *et al.*, 2019; Yow, 2024). Findings from these models emphasize the

futility of reducing the supply of trafficking victims and the need to reduce demand instead (Kővári and Pruyt, 2014; Senft *et al.*, 2019). They also evaluate policy options such as increasing policing, legalization, partial decriminalization and others (Grimes, Dillon and Tinsley, 2011; King, 2019).

There are four major types of policy related to commercial sex work, three of which have been implemented in US states. The first and most widespread policy is *criminalization* wherein CSW is illegal and criminal charges can be brought against anyone involved. The result of this policy, as mentioned above, is that most arrests are of those selling sex, who are often victims of sex trafficking. The second type is *full decriminalization*, which legalizes CSW and eliminates arrests for everyone involved except traffickers. A step further than *full decriminalization* is *legalization*, which introduces regulation into the CSW industry. The US state of Nevada implemented *legalization* that permits CSW in licensed and regulated brothels in counties with fewer than 700,000 residents (Nevada Revised Statute 201.353 and 201.354). A fourth form of policy is *partial decriminalization*, which is also sometimes referred to as the abolition or Nordic model. *Partial decriminalization* legalizes the selling of sex but buying sex remains criminalized. In 2023, Maine adopted this policy model alongside a bill allowing expungement for those with a criminal record of selling sex (AP News, 2023). The *Equality model* is the same general policy as *partial decriminalization*, but includes increased wraparound services for sellers to help trafficking victims leave the system. It has been implemented in Sweden and France. These policies serve as the main analytical focus of this paper, though the simulation, by capturing the system's causal structure, is equally suited to testing many other interventions (e.g. service capacity planning, limiting youth exposure to traffickers, educational programs to change buyer behavior).

A note about terminology. There is a large amount of variation in the terminology related to sex trafficking and CSW among those engaged in the field, law enforcement, researchers, and service providers. The term *commercial sex work* can refer to all types of ways goods and services are traded for sex acts including prostitution, web-camming, phone sex, pornography, and other types of commercial sex acts. For the purpose of this study, we focus solely on prostitution and use simplified terms to maintain consistency and clarity. Sex sellers (SS) refer to individuals providing sex acts and are sometimes called prostituted persons, sex workers, etc., in other settings. Sex traffickers (ST) are individuals causing others to be an SS through force, fraud or coercion, and are sometimes called 'pimps' in other settings. Finally, sex buyers (SB) are individuals buying sex acts from SS and are sometimes called 'Johns.' We also make the distinction between trafficked sex sellers (TSS) and sex sellers in general.

Methods

Subject matter expert elicitation

Because data on sex trafficking and the commercial sex industry in the US is scarce, we turn to subject matter expert (SME) elicitation to build a realistic causal model. Experts in a field often have a highly nuanced mental model of a system informed by personal experience and observations (Ford and Sterman, 1998). In our case, we consulted a SME who is a survivor of sex trafficking, holds a PhD in public policy, and is the executive director of a nonprofit helping support survivors of sexual exploitation.

SME elicitation can take many forms including structured and semi-structured approaches in groups or with individual SMEs (Andersen and Richardson, 1997; Rouwette, Vennix and Mullekom, 2002; Luna-Reyes and Andersen, 2003; Hovmand *et al.*, 2012). In essence, they are facilitated and targeted discussions with SMEs to extract and formalize metal models, identify hidden assumptions, and build consensus. In our case, we used an iterative, semi-structured approach involving a lecture on sex trafficking and commercial sex work, targeted questioning to build an initial sketch of the model, and repeated review meetings as the model was developed. To validate the SME informed model, we conducted a separate literature review and presented the model to another SME for feedback. Through this process, we built a system dynamics model of the commercial sex work industry, focusing on the impacts of CSW on sex trafficking, and calibrated to available data for Massachusetts, USA.

System Dynamics modeling

System dynamics modeling is a form of dynamic simulation modeling in which a system is defined by a set of differential equations and can be simulated through time by iteratively solving the equations. The method was first described by Jay Forrester in the mid-1950s and has been applied to a wide range of applications, from political polarization analysis and climate change predictions to assembly-line optimization and both human- and sex-trafficking (Forrester, 1961; Sterman, 2009; Grimes, Dillon and Tinsley, 2011; Yang, Bukkapatnam and Barajas, 2013; Kővári and Pruyt, 2014; Neely *et al.*, 2019; Egerer *et al.*, 2021; Bertotti and Menale, 2024). The core elements of a system-dynamics model are stocks (quantities that accumulate) and flows (rates of change). In the model presented here, stocks represent quantities of people (e.g. number of trafficked sex sellers) and flows represent people moving to different states (e.g. a sex seller moving to short-term support services).

Sex Trafficking model

A full diagram of the model is shown in Appendix A. The trafficking model was developed in the AnyLogic modeling software version 8.9.3 (https://anylogic.com). In the model, there are three disconnected groups that influence each other. The first group are at risk of becoming, currently, or formerly sex sellers (SS); the second group are individuals engaging in sex trafficking (ST); and the third group are individuals buying sex (SB). The SS model is much more complex than the other two because the purpose of this model is to investigate interventions that affect sex sellers. If this were, instead, a model trying to understand how someone becomes a sex buyer or exploring ways to reduce demand, the SB section would be much more detailed.

Sex Seller model

There are several populations of interest in the SS model: vulnerable individuals (adult and youth populations tracked separately), trafficked sex sellers (adult and youth), non-trafficked sex sellers, and those exiting the CSW system with or without services. There is a complex array of factors that would cause someone to become vulnerable to trafficking. For the sake of parsimony, the vulnerable population in this model is caused by homelessness, poverty, lack of support networks, and childhood violence, and is fixed for the duration of the simulation. These are issues affecting a far larger portion of the population than trafficking, and so the vulnerable population will always dwarf the actively trafficked population. Previous research suggests that, because of this, saving individual trafficking victims has little effect on the overall size of the trafficked population because traffickers will just find another vulnerable person (Neely *et al.*, 2019).

Our SME identified trafficker exposure and geographic CSW normalization as the two main factors that would affect individuals becoming trafficked, besides the market force of traffickers increasing activity to meet demand. These two factors are static during a simulation but could be affected by interventions. Once an individual becomes trafficked, they may become involved with law enforcement and pick up a criminal record based on local law enforcement prosecution culture. Prosecution culture around violence, substance abuse, and commercial sex work can vary greatly, and are all included in the model, but only prosecution culture related to CSW is likely to change with CSW interventions. Trafficked individuals may exit the trafficked system by either becoming a non-trafficked sex seller or by attempting to exit CSW entirely with or without assistance from services. Having a criminal record presents an obstacle for exiting the system, both from CSW to services as well as from 'recovering' to 'recovered'.

There are three types of available services. Emergency services are extremely short-term, anywhere from one minute to three months, and include emergency medical care, homeless shelters, etc. Short-term services include longer term shelters, sobriety programs and other similar programs and can last anywhere from three to 18 months. Finally, long-term services can last indefinitely and include semi-permanent housing and other semi-permanent support. All of these services exhibit extremely high rates of recidivism. According to our SME, long-term services have the least amount with 40-50% recidivism, while emergency services have recidivism rates higher than 80%. There is also a shortage of both short- and long-term services in MA, with especially long waiting lists for any long-term service.

The largest flow out of the 'recovery' stocks is recidivism back into the CSW system, but it is also possible to exit entirely and remain vulnerable or make a full 'recovery.' The youth sex trafficked system mirrors the adult system except in two key ways. First, by definition, youth CSW is always trafficking because they cannot provide consent so there are no non-trafficked SS youth stocks. Second, support services are far more prevalent for youth and recidivism is lower. The percentage of trafficked sex sellers who are youths is currently fixed in the model, but future work could focus on youth sex trafficking and make the relationship more dynamic.

Sex Buyer model

The SB model is much simpler than the SS model, containing only a single stock of sex buyers and incoming and outgoing flow rates. The key factors influencing SB increases are societal CSW acceptance and education on sex trafficking, consistent with the key findings of Demand Abolition's 2019 report (Demand Abolition, 2019). The factors decreasing the number of sex buyers are risk of arrest for buying sex and a generic economic cost-benefit analysis. Buyers have a fixed 'benefit' per transaction while cost is determined by the amount of seller surplus in the system (which is in turn determined by SB demand). The base number of SB in the system is used to calibrate the entire system to values calculated in the Data estimates section, below.

Sex Trafficker model

The ST model shares the same structure as the SB model, with a single trafficker stock and incoming/outgoing flows. As facilitators of the system, the number of traffickers is largely driven by market forces: increased by revenue, decreased by over-supply. The other three factors that increase traffickers are ST recruitment, organized crime prevalence, and overall prosecution level of the system. Most arrests of sex traffickers are due to prostitution statute warrants and law enforcement identifying patterns of trafficking. Increased levels of prosecution identify more patterns of trafficking and lead to increased pressure on

traffickers, therefore an increase in prosecution leads to a decrease in traffickers. ST recruitment and organized crime prevalence also factor heavily into increasing traffickers and could be potential targets for intervention in the future, but current targets focus on the SS and SB systems because they are easier to reach with high level policy options.

Data estimates

As mentioned above, there is a chronic lack of data on the CSW industry in the US. At a minimum, we need to calculate an estimate for the number of SB and SS in Massachusetts and use expert estimates for other parameters to calibrate the model. Table 1 contains our final data estimates, and the following sections describe our calculations for SB and SS.

Sex Buyer estimates

Our SME estimated one in 14 men pay for sex in a year, while the Demand Abolition 2019 report found 6.2% of respondents had paid for sex in the previous 12 months (Demand Abolition, 2019). We will use one in 14 for our calculations as these estimates are similar. The U.S. census estimates a total population in MA for 2025 of 7,154,084 with 51.1% female, leaving 3,498,347 men (U.S. Census Bureau, 2025). If one in 14 men buy sex annually, we estimate 20,823 men per month are buying sex in MA.

Estimating the number of transactions per month is difficult because there are a small minority of buyers who are highly active and engage in a large percentage of transactions. Demand Abolition reports that, of active buyers, 30.8% paid for sex one time in the previous 12 months, 43% paid two to five times, 21.5% paid six to 24 times, and 4.7% paid 25-52+ times. Taking a weighted average using the SB number estimated previously and using the center of each range (except for the highly active group, where we assume 52 transactions per year), we estimate 1,869,617 transactions per year or 155,801 transactions per month and 7.48 transactions per buyer per month.

Sex Seller estimates

As discussion in the introduction, there is no clear data on the number of commercial sex workers in the U.S. The 2016 report from Fondation SCELLES estimates between 500,000 and 1 million prostituted persons, while our SME gave a higher estimate of 1-2 million (Fondation SCELLES, 2016). We will use 1 million trafficked sex sellers as a baseline for our estimates (total sex sellers would be higher than 1 million).

The amount of commercial sex work varies greatly around the U.S. (Dank *et al.*, 2014), so we cannot assume there are sex workers proportional to the population in MA. The National Human Trafficking Hotline publishes statistics by state and year on signals received and cases identified (National Human Trafficking Hotline, 2025). A signal is a

report to the hotline and a case is a confirmed instance of human trafficking. We assume that the number of identified cases is proportional to the number of trafficked sellers in each state. Using data from the National Human Trafficking Hotline as well as population data from the U.S. Census (U.S. Census Bureau, Population Division, 2024) we find the number of cases per person in each state, calculate the percentage of cases per state out of the total number of cases, and multiply the MA value by 1 million to create an estimate for the number of trafficked sex sellers. We average this value calculated from trafficking hotline data in 2022, 2023 and 2024, and find an estimate of 9,529 trafficked SS.

A report from the Urban Institute found a wide variation in number of seller transactions per day, anywhere from four to 15 (Dank *et al.*, 2014), while our SME estimated a similar range. If we assume sellers are completing five transactions per day with five working days per week, we estimate 1,032,256 transactions per month or 108 transactions per seller per month. This estimate is an order of magnitude larger than the estimated number of transactions for buyers. Further research needs to be done to reconcile the difference, but for our study we use the seller value as 'capacity' and the buyer value as 'utilization.'

Table 1: Estimates of key data values used for model calibration.

Name	Value	Source
MA Population	7,154,084	(U.S. Census Bureau, 2025)
MA Male Population	3,498,347	(U.S. Census Bureau, 2025)
Monthly Sex Buyers	20,823	Study estimates
Monthly Sex Buyer Transactions (Demand)	155,801	Study estimates and (Demand Abolition, 2019)
Total U.S. Trafficked Sex Sellers	1-2 million	SME estimate and (Fondation SCELLES, 2016)
MA Trafficked Sex Sellers	9,529	Study estimates and (U.S. Census Bureau, Population Division, 2024; National Human Trafficking Hotline, 2025)
Monthly Sex Seller Transactions	1,032,256	SME and study estimates and (Dank *et al.*, 2014)
Percentage Trafficked of Sex Sellers	85%	SME estimate
Sex Sellers with a Criminal Record	42%	(Polaris, 2023) (N=413)

Calibration

We tuned four parameters to calibrate the model:

- SB base increase rate – the base increasing flow rate for SB before adjustments for CSW acceptance and trafficking education.
- SB base transaction amount – the number of desired transactions per month from SB before adjusting for buyer risk.
- SB transaction risk weight – the impact of buyer risk on the amount of transactions per month desired by buyers.
- SS transactions per month – the capacity of transactions per SS per month.

The outputs of the model after tuning these parameters are presented in Table 2. It is probable that there are parameter combinations that produce a tighter fit to the data, but, because the data values are just estimates, we rely on model dynamics to produce reasonable outputs rather than overfitting the model. For the calibration and all other simulation exercises, we run the model until it detects equilibrium. The model displays equilibrium behavior for specific values of these four calibration parameters (Table 2).

Table 2: Simulated outputs after calibration.

Name	Estimated Value	Simulated Value
Monthly Sex Buyers	20,823	20,697
Monthly Sex Buyer Transactions (Demand)	155,801	200,890
MA Trafficked Sex Sellers	9,529	9,920
Monthly Sex Seller Transactions	1,032,256	991,312
Percentage Trafficked of Sex Sellers	85%	80%
Sex Sellers with a Criminal Record	42%	40%

Sensitivity Analysis

Following the calibration exercise, we ran a sensitivity analysis to determine the strengths of the effects of individual parameters on model behavior. System dynamics models are built around feedback loops and nonlinear relationships, so small parameter perturbations can have outsized and non-obvious effects. Sensitivity analysis makes these dynamics visible and helps distinguish between parameters that are structurally central to the model's behavior and those that are incidental to it.

We conducted a two-step sensitivity analysis. First, we ran simulations while varying parameters one at a time (OAT). The OAT sensitivity analysis characterizes the influence of each parameter in isolation, indicating both how strongly it affects model behavior and whether that influence is proportional across the parameter's range. For each parameter, we specified a plausible range of values and ran simulations at 50 evenly spaced intervals across that range. Figure 1 shows a heatmap of the effect sizes of each parameter on

dependent variables of interest, while Figure 2 shows response curves for each parameter on the number of SB in the system. Response curves for other dependent variables are available in the online supplemental materials. SB benefit, the theoretical utility sex buyers derive from purchasing sex, is the parameter with the greatest influence across dependent variables but is unlikely to be a target for intervention. The second most influential parameter, criminal record obstacle, is more tractable, as the barriers a criminal record creates to exiting the sex trade could plausibly be reduced through policy.

The second step of the sensitivity analysis is a multivariate approach using Latin Hypercube Sampling (LHS) and Partial Rank Correlation Coefficients (PRCC). LHS is a stochastic sampling technique that ensures uniform coverage of the input parameter space (McKay, Beckman and Conover, 1979). We generated 5,000 parameter sets by sampling 44 parameters simultaneously, each drawn uniformly from a ±20% range around its calibrated default value. Each sample was simulated until equilibrium, and PRCC was computed for each input-output pair by rank-transforming all variables, regressing out the effects of all other inputs via ordinary least squares, and computing the Pearson correlation of the resulting residuals (Marino *et al.*, 2008). This partial correlation approach isolates each parameter's independent contribution to output variance, controlling for co-variation among inputs. Statistical significance was assessed using a t-test with $n - 2 - k$ degrees of freedom, where k is the number of covariates ($df = 4{,}954$). Results from this analysis can be used to identify which structural assumptions and parameters most strongly drive outcomes. Figure 3 shows a heatmap of the PRCC for the top twenty inputs against each output metric. Most parameters had non-significant effects, with SB benefit and criminal record obstacle remaining the most powerful.

OAT Sensitivity Heatmap — Signed SI (% change from baseline)
Top 15 parameters by max |SI| across outputs

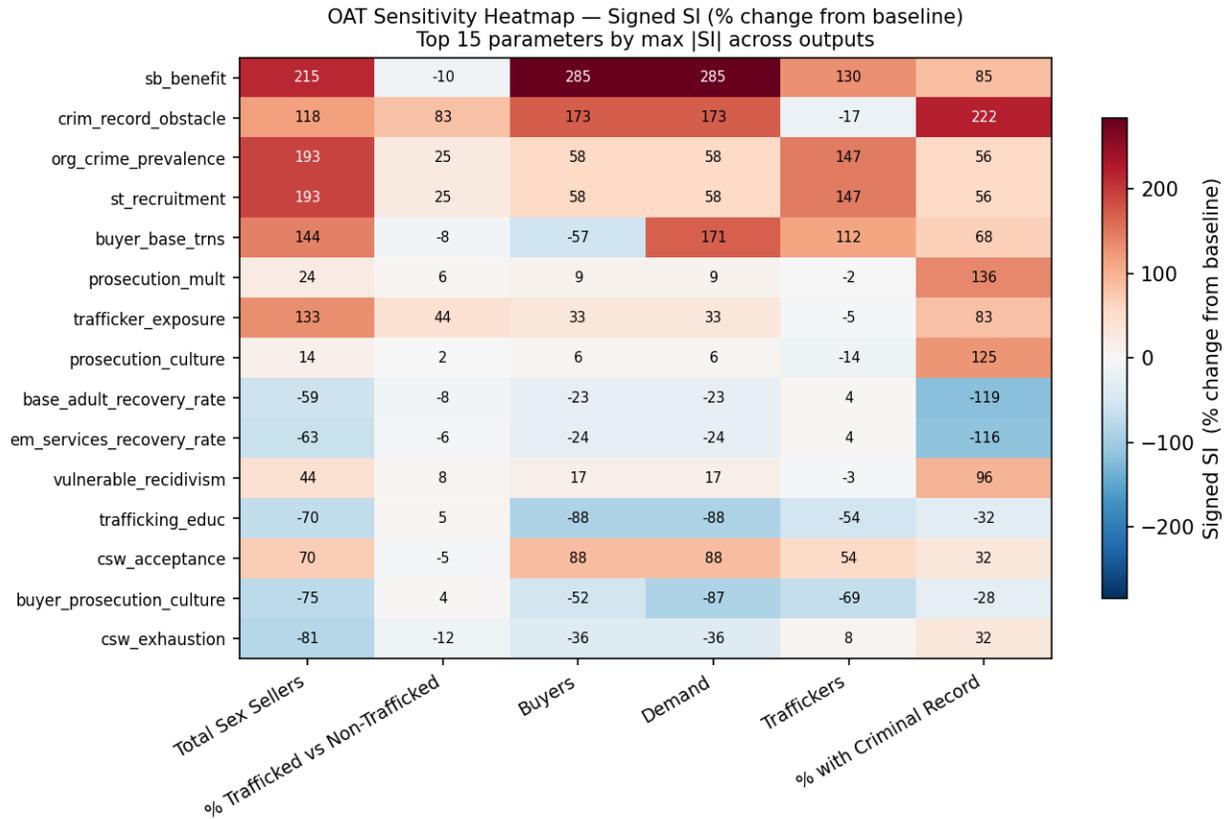| Parameter	Total Sex Sellers	% Trafficked vs Non-Trafficked	Buyers	Demand	Traffickers	% with Criminal Record
sb_benefit	215	-10	285	285	130	85
crim_record_obstacle	118	83	173	173	-17	222
org_crime_prevalence	193	25	58	58	147	56
st_recruitment	193	25	58	58	147	56
buyer_base_trns	144	-8	-57	171	112	68
prosecution_mult	24	6	9	9	-2	136
trafficker_exposure	133	44	33	33	-5	83
prosecution_culture	14	2	6	6	-14	125
base_adult_recovery_rate	-59	-8	-23	-23	4	-119
em_services_recovery_rate	-63	-6	-24	-24	4	-116
vulnerable_recidivism	44	8	17	17	-3	96
trafficking_educ	-70	5	-88	-88	-54	-32
csw_acceptance	70	-5	88	88	54	32
buyer_prosecution_culture	-75	4	-52	-87	-69	-28
csw_exhaustion	-81	-12	-36	-36	8	32

Figure 1: Heatmap from one-at-a-time (OAT) sensitivity analysis. Values are signed sensitivity indices. OAT analyses vary a single parameter in each run while holding all others constant at their default values. The parameter names use abbreviations: sb (sex buyers), crim (criminal), org (organized), st (sex traffickers), trns (transactions), mult (multiplier), em (emergency), educ (education), and csw (commercial sex work).
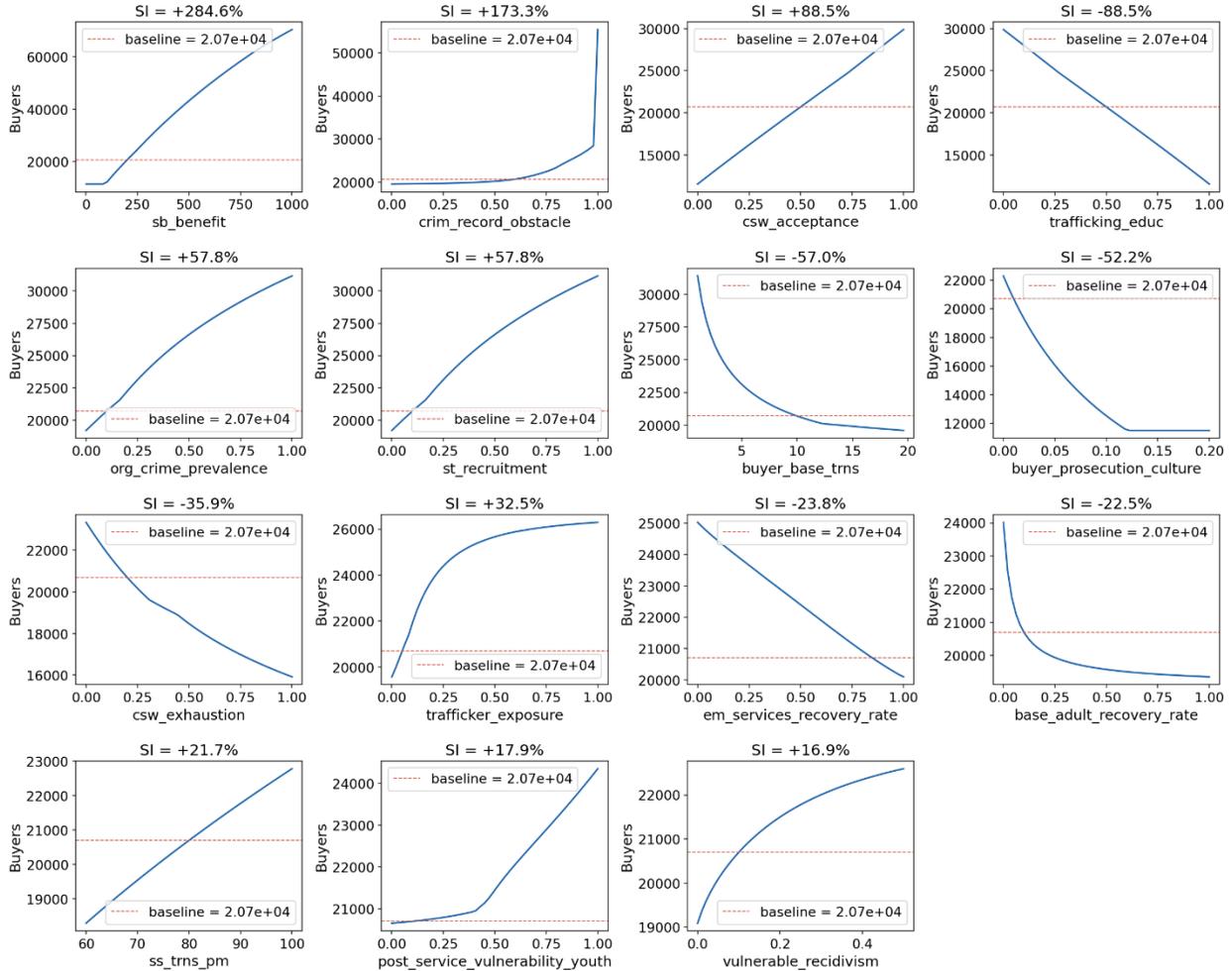
Figure 2: Response curves for number of sex buyers from one-at-a-time (OAT) sensitivity analysis. OAT analyses vary a single parameter in each run while holding all others constant at their default values. Each plot reflects the effect on the number of buyers of varying a single parameter while holder others constant. For example, the plot in the upper left varies "sb_benefit" which is the theoretical utility buyers gain from purchasing sex. The solid line is the response curve across all tested parameter values, while the dashed line is the buyer value at the parameter's default. Refer to the Figure 1 caption for parameter name abbreviation explanations.
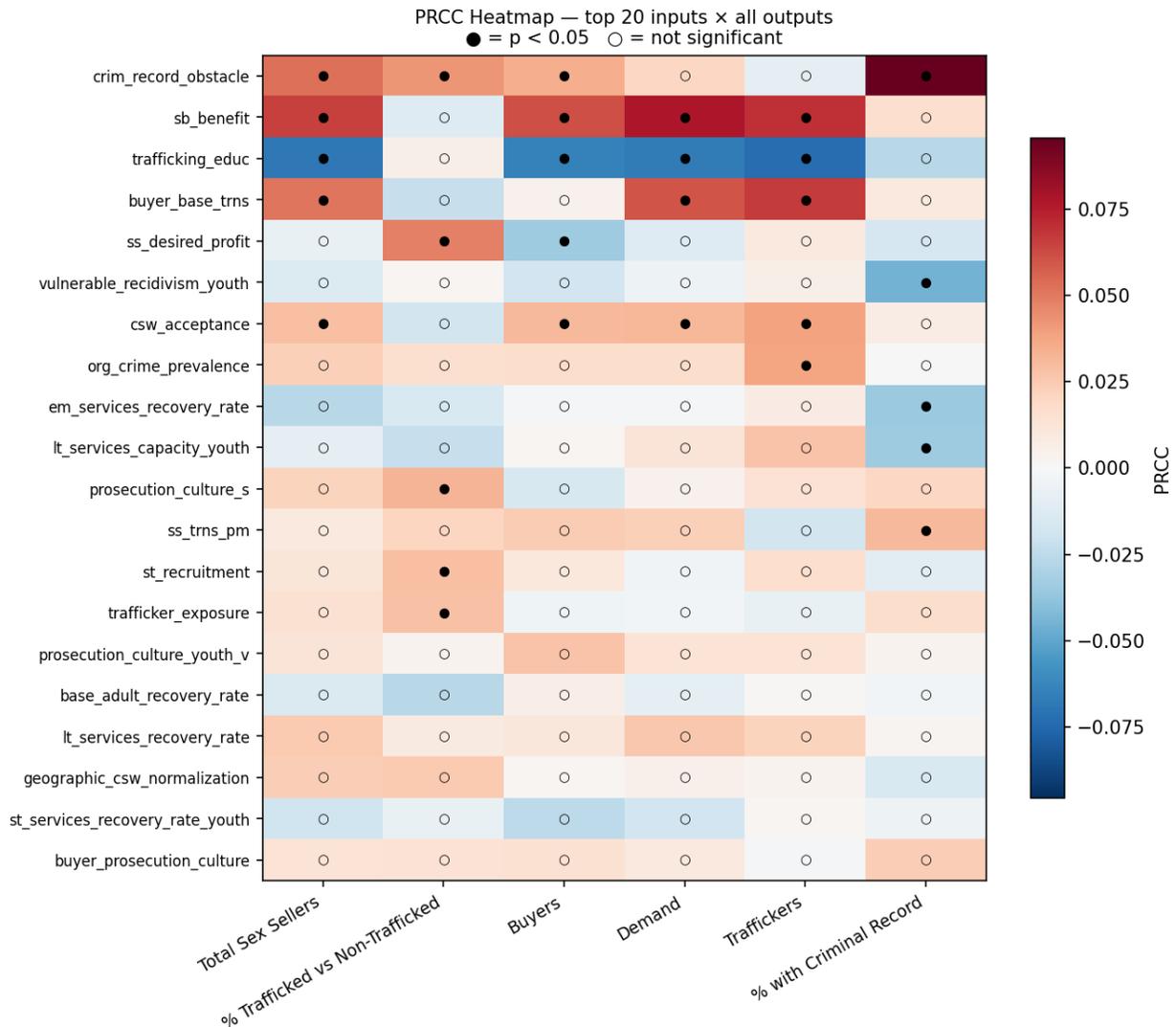
Figure 3: Partial Rank Correlation Coefficients (PRCC) heatmap for multivariate sensitivity analysis. Parameters are significant if their correlation with the output is distinguishable from zero after accounting for all other input parameters simultaneously. PRCC analyses vary all parameters simultaneously using latin hypercube sampling to control for covariation between inputs. Refer to the Figure 1 caption for parameter name abbreviation explanations.

Results

We investigated four policy scenarios besides *criminalization,* the default. Under *full decriminalization,* we set both SS and SB prosecution culture to zero. For *partial decriminalization,* we set only SS prosecution culture to zero. *Equality model,* a variation on *partial decriminalization* sets SS prosecution culture to zero and increases available services. Besides these main policy scenarios, we also test a policy of *expungement,* wherein former sellers with a criminal record are able to have their record sealed to the highest level. At the time of writing, there is a bill passing through the MA legislature

proposing *expungement*. To implement it, we reduce the percentage of former SS with a criminal record by 10%. Table 3 shows the exact parameter changes for each policy scenario.

Table 3: Policy experiment parameter values.

Policy Name	Parameter Values (default)
Full decriminalization	Buyer prosecution culture: 0 (0.01)
	Seller prosecution culture: 0 (0.05)
Partial decriminalization	Seller prosecution culture: 0 (0.05)
Equality Model	Seller prosecution culture: 0 (0.05)
	Short-term services capacity: 750 (250)
	Long-term services capacity: 300 (100)
Expungement	Percent expungement: 10% (0%)

Figure 4 and Figure 5 contain the results from the policy experiments in percent change from baseline and in absolute values respectively. Selected dependent variables are the total number of TSS and overall SS, SB, ST, buyer demand, and the percent of SS that are trafficked vs. non-trafficked.
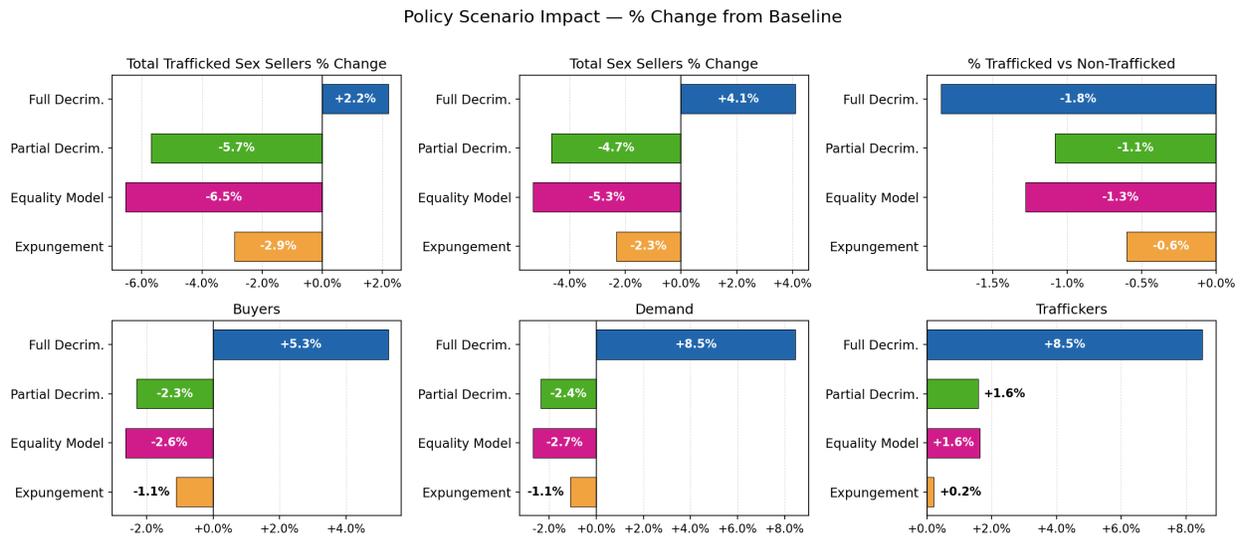

Figure 4: Policy experiment results - percent change from the default (criminalization).
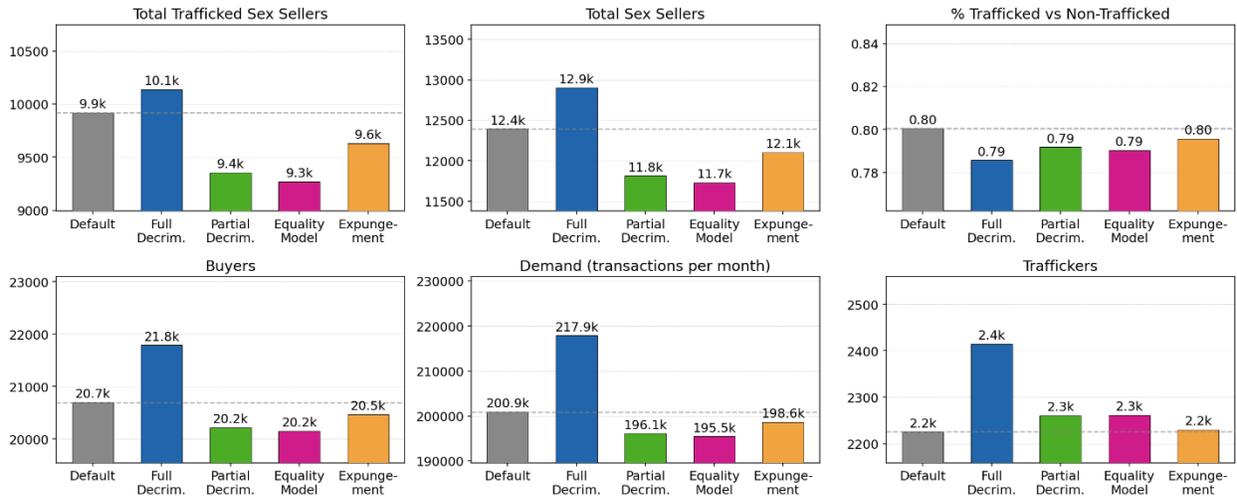
Figure 5: Policy experiment results - absolute values of dependent variables.

We find a stark difference in behavior between the full decriminalization policy and the others. Decriminalizing both buying and selling sex has the effect of increasing all of SS, SB, and ST. Demand is also increased disproportionately to SB increase as buyers buy more frequently with reduced risk. We also see the largest decrease in percent SS who are trafficked vs. non-trafficked. This indicates that full decrim. leads to the largest inflow of voluntary SS of any policy. TSS and ST increasing under this regime show that the inflow of non-trafficked SS is not enough to meet the increased demand and so traffickers increase the number of TSS to make up for the difference.

Partial decriminalization has the effect of reducing SS and TSS, increasing the number of non-trafficked SS in the system, decreasing buyers and demand, and increasing the number of ST. Buyers are decreased in this policy because there is higher buyer risk when there is lower seller risk. Traffickers are increased because, with no seller arrests, the barrier to exit is lower and traffickers must increase activity to make up for increased seller exits. The Equality Model policy, as an extension to partial decrim., has the same behavior but shows that increased services to sellers does have a protective effect.

Lastly, the effects from the expungement policy are in the same direction as the partial decrim. and Equality Model effects, though with a much smaller magnitude. This shows that simply reducing the legal and social barriers to recovery presented by a criminal record can have a protective effect on the whole system.

Discussion

To summarize, the model produces a consistent and interpretable pattern across policy scenarios: partial decrim. and the Equality Model reduce both total sex sellers and trafficked sex sellers, while full decrim. increases both. This finding may be counterintuitive as decriminalization is often seen as a harm-reducing strategy. The expungement finding is particularly noteworthy, both because of the current legislation under consideration in MA and because it highlights how a relatively modest intervention (10% reduction in former sex seller criminal records) produces measurable protective effects across the system. The results suggest that criminal record reform is a high-leverage, low-disruption policy option.

The sensitivity analysis reinforces the policy conclusions by highlighting particularly influential parameters. The model suggests that the obstacle presented by a criminal record is the second most influential parameter across the dependent variables. The analysis also revealed influential parameters that are not within policymaker's reach, such as buyer benefit. The alignment between results from the OAT and PRCC analyses strengthens confidence in these conclusions because both methods identified a very similar small set of high-influence parameters.

Despite the confidence gained from the sensitivity analysis, the scarcity of data is one of the most fundamental problems faced in this research. While the calibration data are defensible and SME estimates draw on extensive experience, both remain approximations rather than empirical measurements. This challenge does not invalidate model findings, but it does change what those findings mean. The value of this model is not in the precision of its outputs – 9,920 simulated TSS versus 9,529 estimated TSS is not a meaningful difference given the uncertainty in the underlying estimate. Rather, the value lies in the model's causal structure and the direction and relative magnitude of policy effects. The model can say, with more confidence, that partial decriminalization consistently outperforms full decriminalization on trafficking-related outcomes. The model cannot say exactly how many people would be affected, or by precisely how much.

Future work should focus on the very difficult problem of data collection in the underground industry of the commercial sex trade. Particularly, data on the number of active sex sellers, transaction frequencies and costs, and service recidivism rates would narrow the uncertainty bounds around these findings. The sensitivity analysis itself serves as a roadmap for where that data collection effort would have the highest return. The estimates presented here, particularly those using the MA trafficking hotline data, are a reasonable workaround in a data-scarce environment but have obvious limitations. It assumes that hotline reports are proportional to actual trafficking prevalence across

states, which may not hold if reporting rates, advocacy infrastructure, or law enforcement practices vary across states.

One finding that warrants attention is the increase in traffickers under partial decriminalization (and all other policy alternatives). The mechanism in the model is straightforward: when seller arrests are eliminated, the barrier to exiting the sex trade is lower, so sellers exit more readily, and traffickers must increase activity to replenish their 'supply.' This is a counterintuitive and potentially controversial result that deserves scrutiny. The Equality Model result is also important here, showing that adding services to the partial decriminalization scenario leads to further reductions in total and trafficked sex sellers. This suggests that seller services act as a complement to legal reform rather than a substitute. It is also worth noting that an increase in the number of traffickers does not necessarily mean an increase in harm if the number of trafficked sex sellers is simultaneously declining. The model shows both happening under partial decriminalization, and the policy question is which effect is stronger and what measure of harm is more important.

The full decriminalization result is also important and somewhat counterintuitive, but consistent with findings from other system dynamics models of trafficking and with empirical evidence from areas that have legalized or fully decriminalized CSW (Cho, Dreher and Neumayer, 2013; Kővári and Pruyt, 2014; Cunningham and Shah, 2018; Senft *et al.*, 2019). The mechanism driving this result is demand. Removing risk for buyers in the CSW system increases the number of buyers and the frequency of transactions, which in turn increases market size and incentivizes more trafficking. The magnitude of the effect should be interpreted cautiously given the data constraints, but model's finding has directional consistency with prior research and the sensitivity analysis gives it reasonable credibility.

In this paper, we present several statewide policy scenarios, but the causal structure captured by the model allows for intervention testing in many domains and scales. For example, the model describes service pathways, capacity and recidivism rates, and reflects a real shortage in MA. The model could be used to test the effectiveness of adding service capacity on recidivism which would be directly useful to nonprofits and government agencies without needing legislative changes. The youth trafficking component is also an area of high interest to nonprofits and stakeholders. The current model focuses on the adult-side of sex trafficking and CSW, but future work could add complexity to the youth-side and open pathways for intervention investigation. Youth sex trafficking has many unique features such as distinct entry points (e.g. foster care involvement, runaway and homeless youth, online recruitment), distinct service needs and

availability, and distinct legal frameworks. A youth-focused extension of this model could help identify leverage points specific to that population.

There are several limitations to this study that could be the focus of future work. First, the model's structure was developed primarily through elicitation with one SME and face-validated by a second. This opens the possibility of elements specific to the primary SME's experience and perspective being embedded in the model's structure in ways that are difficult to detect. Future work could include group model building with a broader range of stakeholders, including active sex sellers, law enforcement, service providers, and advocates from different points on the policy spectrum. Second, the model treats the vulnerable population as fixed, which is a deliberate simplification but limits the model's ability to capture upstream interventions focusing on the drivers of vulnerability such as homelessness and poverty. Third, the model is not spatially aware and does not capture dynamics such as displacement effects, where enforcement in one jurisdiction pushes trafficking activity to neighboring areas. This is a well-documented phenomenon within trafficking research. Finally, all policy experiments are evaluated at equilibrium, which captures long-run steady state dynamics, but not transition dynamics. For example, some policies may produce beneficial long-run outcomes through painful short-run transitions, or vice versa. Future work should involve time path analysis between equilibrium at the default and a new policy equilibrium.

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Appendix A – Full model diagram