Prostitution and Human Trafficking: A model-based exploration and policy analysis

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Abstract

The meeting of the oldest profession with modern slavery is the topic of this paper. After a brief introduction to prostitution and prostitution-related human trafficking, this paper focuses on the Dutch policy debate. A System Dynamics simulation model related to the Dutch situation developed to explore and provide insights related to the effects of proposed policies is presented in this paper. Using the simulation model, a 'quick and dirty' policy analysis is first of all performed, and preliminary conclusions are drawn. These preliminary conclusions are further tested under uncertainty, using two different but relatively similar simulation models. The main conclusions are that demand side measures are necessary, but not sufficient. The topic is so complex and uncertain that simple (combinations of) basic policies will not hold in all circumstances, which is why this topic requires further exploration and policy testing under deep uncertainty.

Keywords: Prostitution, Human Trafficking, Swedish model, EMA, ESDMA

1. Introduction

Selling sex for money is generally acknowledged as the oldest profession. According to the 2011 Global Risk report it has a 190 billion $ global market size [1], being listed as the 2nd largest among the illicit goods. Time and again it emerged as a hot topic for debate and went through cycles of criminalization-tolerance-legalization. Countries over the world have very different legislations for it today (see Figure 1). In most places all forms are illegal, rejecting the profession itself on various moral grounds and punishing prostitutes. Others tolerate it but prohibit the organized forms in order to restrict it. In either case, many countries now face a booming tendency of human trafficking which is highly linked to the sex industry. Since 2000 prostitution is legal and regulated in the Netherlands, where 75% of the population accepts it as a normal profession [2]. Regulation in this country wasn't only a response to the strong voice of women's rights activists, but intended to be a means of lifting the business out of the illicit trade area. However, it never became the happy, clean and free business that was dreamed of. It is still plagued by many facets of criminality: human trafficking, corruption, hard drugs, and murders. Meanwhile, Scandinavia took another path since 1999. First Sweden, then Norway, Iceland and Finland followed suit: punishing the act of buying sex in order to reduce demand. There the discussion was approached from a gender equality perspective and prostitution was banned. Prostitution is viewed there as violence against women and against gender equality, therefore being punishable. The first signs in Sweden show promising results in fighting human trafficking. Many other countries including the US are now considering adopting the Swedish model, however its possible success in other countries and cultures is highly debated.

The purpose of this paper is to analyze the link between prostitution and human trafficking using an exploratory System Dynamics approach in order to provide a better understanding of prostitution and its link to the socio-economical-criminal system. It also helps to explore effects of uncertainties and to analyze effects of different policies in order to support policy-making.

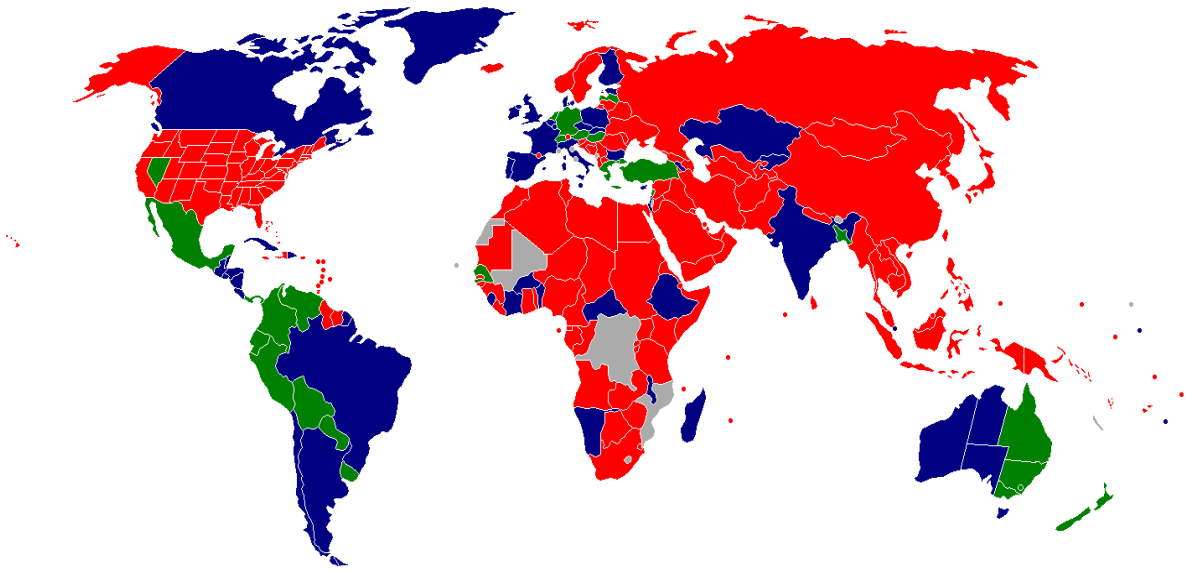

Figure 1. Legal stances on prostitution: red=illegal, blue=organized forms illegal, green=legal and regulated

The rest of this paper is organized as follows. The problem field is specified in more details, discussing boundaries, assumptions and intended applicability in section 2. A first SD model and its behavior are presented in section 3. Possible policy-interventions are explored and discussed in section 4. Policy robustness is tested under deep uncertainty in section 5. Section 6 presents concluding remarks and the current and future research. Appendix 1 contains a 'hot case' based on the model presented in this paper, used at Delft University of Technology for teaching and testing the introductory System Dynamics course.

2. The Problem

2.1 Why Model Problems Related to Prostitution and Human Trafficking?

In its 2011 edition, the Global Risks report of the World Economic Forum presents experts' view on the highest risk clusters in today's global economy [1]. One of them is the illegal economy nexus, in which the strong link between corruption, organized crime and illicit trade is discussed. The report lists the estimated market sizes of various illicit goods, like drugs, counterfeit electronics, and pharmaceutics, etc. If the market size of human trafficking is added to prostitution, together they become first on the list with an estimated 220 billion USD[1]. Exploring and tackling them was the motivation behind the choice of the topic for this study.

It has to be noted at this point that – perhaps understandably – there is a lot of disagreement on the issue and data related to prostitution and trafficking in persons. This has several reasons. Self-reporting is often unreliable due to feared stigmatization, criminal records do not tell how many cases of trafficking actually occurred and the public opinion is not always representative because the criminal activities are mostly hidden [3, 4]. This gives room for many uncertainties that are under

[1] Havocscope – the source cited in the Global Risks report – lists illegal gambling as the biggest market (500 billion USD), but it is not explained why is it completely left out of the Global Risks report.

exploration (see section 5). The data used are at best 'informed estimates', based on several sources.

2.2 Problems Related to Prostitution in the Netherlands

Not only prostitution and human trafficking, but all the illegal economies are strongly interlinked. They also manifest themselves differently for rich or developing regions and in different religious or social contexts. In this paper the Dutch case has been studied and the system representation is described below (see Figure 2.)

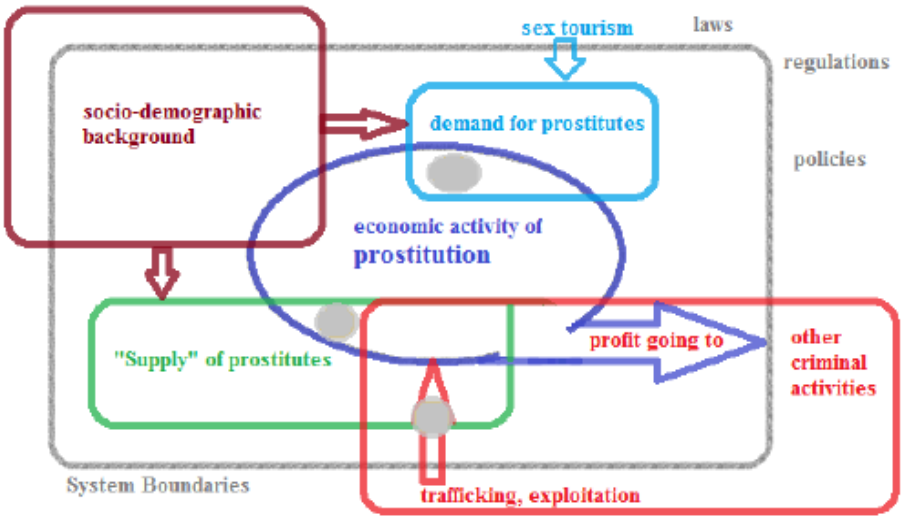

Figure 2: Conceptual model of prostitution in the Netherlands

The Netherlands is an economically developed region, where prostitution is legal, while human trafficking not. Free choice is sacred and tolerance is a high virtue [2]. This makes an interesting case to explore the blurred area where legal fades into illegal. Prostitution is represented as an economic activity. Part of the supply and demand is backed by the country's population, but the attracted tourists also add to the demand. Organized crime has a strong grip on the supply side: most of the prostitutes are enslaved, coerced into this activity, many times trafficked across country borders [5]. The problem is that huge amount of the profit goes into the hands of mafias, criminals, who either reinvest by enslaving more people or sustain other illegal markets. Hence this activity supplies money for corrupt and organized criminal activities.

Job Cohen, the former mayor of Amsterdam said: "We've realized this is no longer about small-scale entrepreneurs, but that big crime organizations are involved here in trafficking women, drugs, killings and other criminal activities"[6]. The goal is now to restrict and reduce prostitution as much as possible in order to cut the financial supply for other criminal activities. For this purpose, various policy options (P1 to P4) were proposed by different actors. These possible intervention points are represented in the model (see Figure 3):

P1: Strengthen the anti-human-trafficking law and enforce with usual police work

P2: Raise the protection of trafficking victims, build rehabilitation centers, help the social reintegration of those who want to escape from prostitution, make the choice for this profession really 'free'.

P3: Ban prostitution, prosecute prostitutes, brothels and other organized forms

P4: ban the purchase of sex (the Swedish model). This makes sense of course only if you ban prostitution too, but the difference is that prostitutes are not punished but protected and helped instead to escape from their profession.

The discussion about what measures to take is highly politicized. All these policy options would have their merits but not all the proponents understand the limitations and possible side-effects that these interventions could have.

3. A Simulation Model: Structure and Behavior

In the previous section the choice of exploring the Dutch prostitution case was discussed. This section presents a quantitative SD simulation model based on the conceptual model presented in the previous section. Table 1 shows the data used in this model for the 'base case' scenario. The initial conditions refer to data from around the year 2000. The first 12 years' behavior should then be confirmed by (estimated) historical data.

Initial number of children	4,000,000	person
Initial number of sexually active adults	9,500,000	person
Initial number of prostitutes	25,000	person
Initial fraction of new adults considering entering business	0.2	%
Level of child sexual abuse	0.5	%
Average age entering prostitution	14	years
Birth rate	0.02	
Age of consent	18	years
Average sexually active period	45	years
Fraction becoming prostitute if abused as child	10	%
Normal percentage of Johns	10	%
Number of clients per prostitute	30	
Potential tourist demand growth	500	person/year
Initial naked costs of sex services	20	€
Potential annually trafficked prostitutes	1500	person/year
Average time spent in prostitution	12	years
Average frequency of prostitute visits	24	service/person/year

Table 1. Constants and initial values in the model. Estimations based on [5-13]

3.1 The Model

Figure 3 presents the stock-flow diagram of the first simulation model. The rest of this subsection is a detailed explanation of the model's structure, equations and assumptions.

The **population structure** is represented by a simple ageing chain with *children* and *sexually active adults*. The data on *birth rate, age of consent* and *average sexually active period* are such that there will be a slightly decreasing and ageing population.

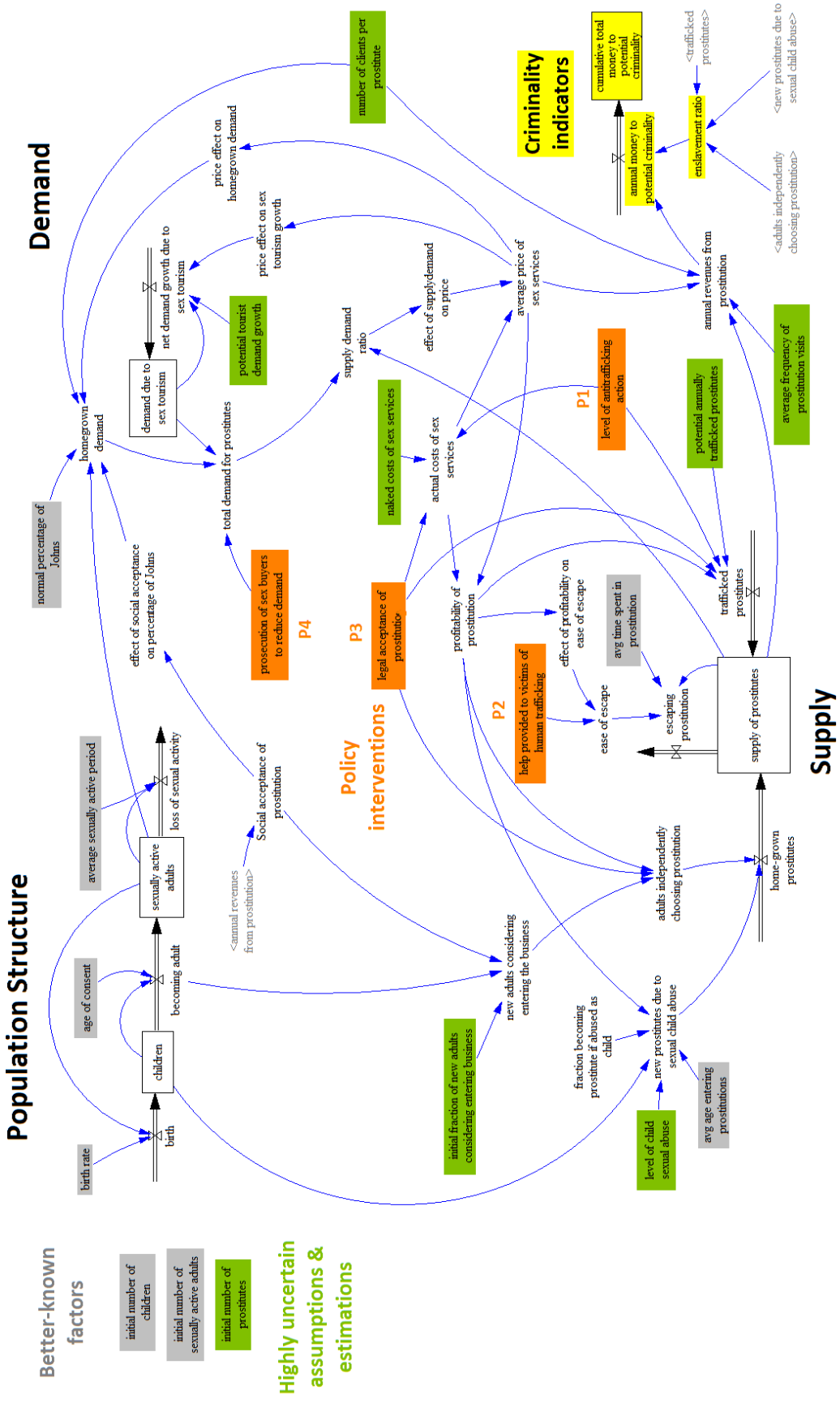

Figure 3. Stock-Flow Diagram of the simulation model presented in section 3

Supply. The *Supply of prostitutes* can increase through the *home-grown prostitutes (*those originally Dutch) or by *trafficked prostitutes (*those brought to the country to be exploited as sex workers). The annual number of *home-grown prostitutes i*s equal to the sum of the *new prostitutes due to sexual child abuse a*nd the *adults independently choosing prostitution.* Children, who were sexually abused, are more likely to become prostitutes at a young age. They are more likely to fall victim to 'loverboys' who seduce young women and later force them into prostitution [3, 8]. Hence, the *new prostitutes due to sexual child abuse* equals the product of the number of *children,* the *level of child sexual abuse*, the *fraction becoming prostitute if abused as child* and the *profitability of prostitution* divided by the *average age entering prostitution*. This *profitability* also has an influence on the *adults independently choosing prostitution* [3]. It is assumed that the final number of adults independently becoming prostitutes drops by half if the *legal acceptance of prostitution* is 0. "Independently" becoming a prostitute means choosing this profession by free will and above the *age of consent*, hence it is driven by the *becoming adult* flow from the population structure. The s*ocial acceptance of prostitution* is assumed to have a positive influence on the annual number of *new adults considering entering the business,* which will thus be equal to (*becoming adult/2*) ** initial fraction of new adults considering entering business * social acceptance of prostitution.*

The *anti-trafficking action* prevents the number of *trafficked prostitutes* reaching its potential maximum [5]. It is assumed for this model version that the legalization of prostitution in a region makes the business more attractive and accessible, hence increasing trafficking of women. Prostitutes leave their profession after an average of approximately 12 years (valid for women [9]), but this also depends on the *ease of escape*. Many NGOs are there to assist women who want to leave prostitution, but they generally lack funding and they can only reach a small fraction of those in need [10]. Higher *profitability of prostitution* has a negative effect on the *ease of escape* either because of financial dependence or because of pimps exerting higher control on their exploited women.

Demand. The *total demand for prostitution* expresses the number of prostitutes demanded in the country for a given *number of clients per prostitute*. Clients – also known as "Johns"- can be either Dutch or tourists. The *home-grown demand* then equals (*sexually active adults/2*) ** normal percentage of Johns * effect of social acceptance on percentage of Johns * price effect on homegrown demand / number of clients per prostitute*. Since lifting the ban from brothels, sex tourism accounts for a growing demand for prostitution in the Netherlands. However, the *net demand growth due to sex tourism* can become negative if the *average price of sex services* becomes too high*. Prosecution of sex buyers* is a simplistic representation of the P4 policy option (see section 2.2) supposed to reduce the total demand if this policy option is activated (a multiplier between 0 and 1).

Economic behavior. There are some *naked costs of sex services* assumed [12] which is then influenced by the actual policies in place. Criminalizing the act of prostitution (especially the prosecution of prostitutes) and hunting down traffickers' businesses can causes a huge increase the *actual costs of sex services* [13]. According to the double of the costs and the actual *supply demand ratio* the *average price of sex services* will then emerge with a delay of 1 year. The *profitability of prostitution* is then the (*average price of sex services – actual costs of sex services*) / *actual costs of sex services.*

Criminality indicators. The *enslavement ratio* shows the fraction of those being in the business against their own free will. The exact definition of this ratio is subjective. Victims of child sexual abuse might not identify themselves as slaves, but what happened to them was generally against their will [5]. Many of the trafficked prostitutes also can't identify themselves as victims. In the model an extreme definition is taken: all the trafficked women and the sexually abused ones positively contribute to the enslavement ratio. The *annual revenues from prostitution* is equal to the *average price of sex services * supply of prostitutes * number of clients per prostitute *average frequency of prostitution visits.* This annual revenue multiplied by the *enslavement ratio* gives an estimate of how much money goes annually to potential criminal hands. This *annual money to potential criminality* is assumed to fuel organized crime, which is perceived by the population, hence (in this model) it serves as a proxy for decreasing the overall *social acceptance of prostitution*.

Policy interventions in the base case scenario are set to reflect the actual situation since 2000 as follows. *Legal acceptance of prostitution*: the value close to 1 means that almost all forms of prostitution are legal, brothels can be licensed, prostitutes can work with a valid residence permit. A value close to 0 would mean criminalizing all forms of prostitution. *Level of anti-trafficking action* (scale of 0 to 1): shows the legal and organizational infrastructure provided to fight modern slavery as well as the activity's efficiency. Although the Netherlands adheres to the legislative standard of the Palermo Trafficking Protocol [14], reports and personal accounts of police officers show that enforcement is still very inefficient [5, 10]. An initial level of 0.2 is given; increasing it would involve considerable efforts. *Help provided to victims of human trafficking* (scale of 0 to 1): shows the efforts to help those who want to escape prostitution. Again, although the laws are there, help doesn't efficiently reach those who mostly need it (the base case level is thus 0.1). *Prosecution of sex buyers to reduce demand* is also represented on a scale of 0 to 1 (the base case level is 0).

3.2 Model Behavior – Base Case and Separate Basic Policies

Simulating the base case scenario shows what would happen if nothing would change in terms of the highlighted policy instruments: growing number of prostitutes, growing demand, increasing annual revenues for criminals, slightly growing prices due to decline in supply-demand ratio and a high enslavement ratio (around 90%). All these tendencies can be confirmed by estimated data [5,6,7] for the period 2000-2011 (see Figure 4).

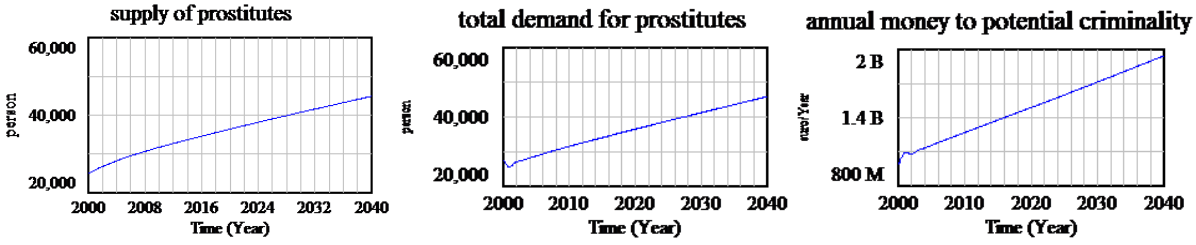

Figure 4. Base case behavior

Although the base-case does not show interesting dynamic behavior, exploring the effects of possible policy interventions does lead to interesting dynamics. Sketching the individual effects of each policy intervention also helps to better understand the system's influences and behavior.

Policy interventions were gradually applied (modeled as ramps, see figure 5) because reaching higher levels of help, anti-trafficking action or demand reduction are changes that need a lot of

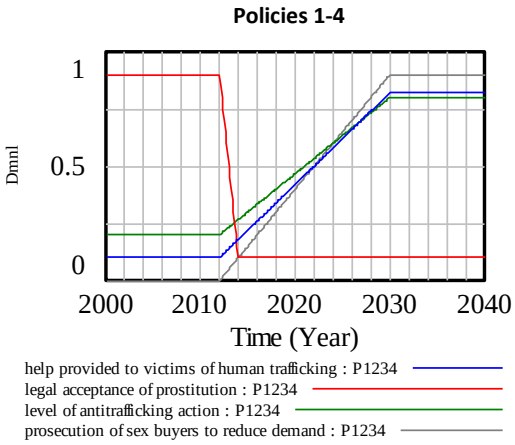

Figure 5. Activation of policy options

financial and other efforts. Only *legal level of acceptance* (P3) is such that it can be relatively quickly changed. The Netherlands committed itself to fighting human trafficking and it can be expected that it will gradually increase its efforts to wipe it out from the country [5, 14]. Activating this policy leads to the behavior presented in figure 6 with blue. Trafficking goes down, hence the number of prostitutes stops growing so fast. Demand is also moderated because prices go up. However, the annual money flow to potential criminality will become higher than in the base case because of the increased prices.

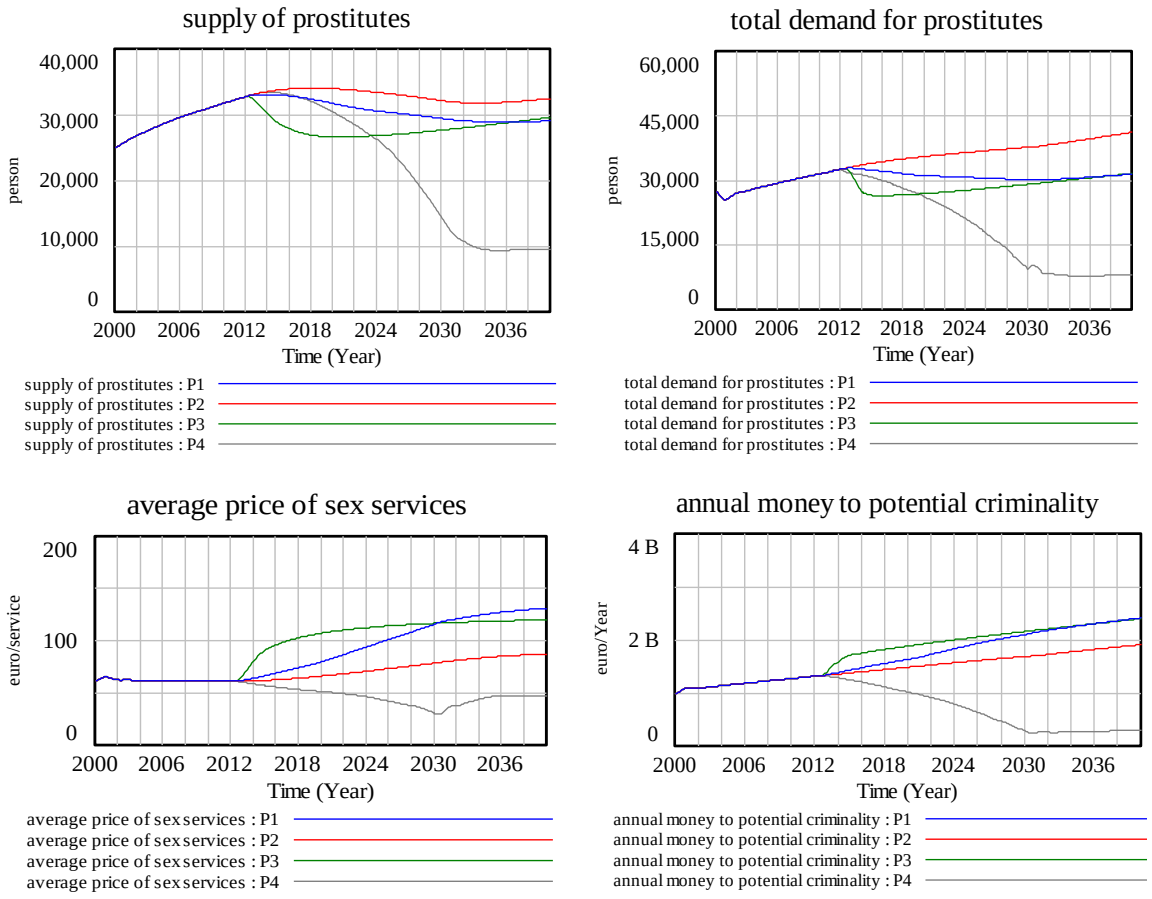

Figure 6. The individual effects of the possible policy interventions

Providing more efficient and extensive help to escape prostitution (P2, red line) is a possibility to decrease the number of prostitutes. Indeed, if pursuing this policy starting from 2012, the number of prostitutes starts falling after 2018. This creates scarcity increasing average price, thus slightly moderating demand, but it does not seem to be an effective way of stopping the annual money flow growth. Declaring prostitution illegal can be done in a short time and has more immediate impact (P3, green line). It sets some limit to growth by reducing the attractiveness of the country for both traffickers and sex tourists (via the growing prices). Direct demand reduction (P4, grey) with a

hypothetical 90% over 20 years brings out the best results on all the above indicators. However P4 alone hardly has any practical meaning and the 90% level is probably overly optimistic.

Figure 5 shows a strongly aggregated causal loop diagram (CLD) of the system on which the above discussed effects of the policy interventions can be followed. The preliminary results show that the anti-trafficking action as well as the criminalization not only reduces the number of prostitutes, but the price is also so much increased, that the market remains profitable, possibly even generating more revenues than under initial conditions.

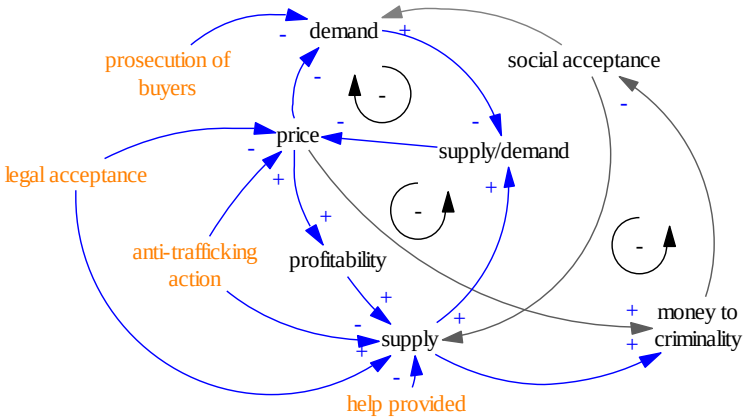

Figure 7. Causal Loop Diagram of the system

4. Combined Policies and Interpretation

4.1 Combined Policies

While sketching the behavior of the system under different interventions, one could learn about the effectiveness of each policy. Before giving away advice on policies, their combined effect should be analyzed. Also, their effect in different scenarios could be explored, since there are many uncertainties in the 'base case' model.

In this section, we will start with combined policy effects. Figure 8 shows the behavior of the system under some combinations of policies in the base case scenario.

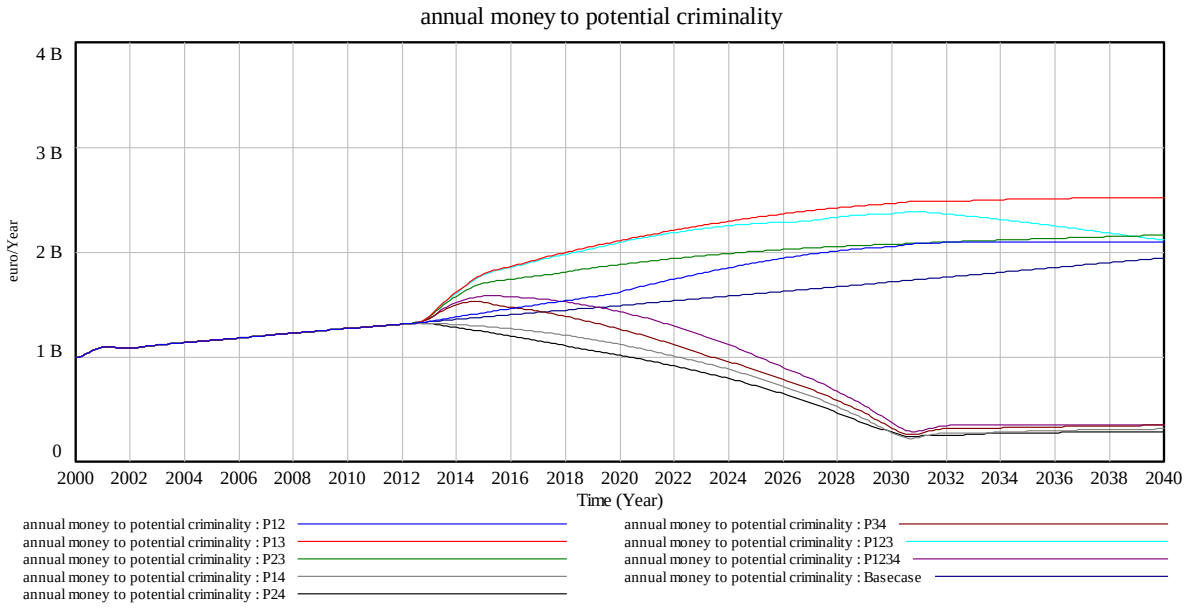

Figure 8. Behavior of combinations of policies in the base case scenario

Two modes of behavior can be distinguished that are defined by whether P4 is implemented or not. It turned out that P2 has very little influence if P4 also features in the combination of policies, which is why those combinations featuring both were removed from the figure. The two modes of behavior are not so clearly distinguishable on other indicators such as the supply of prostitutes, the enslavement ratio or the average prices.

As a next step, the behavior of the system is explored for a rather bad scenario. In this second scenario, some of those variables which are highly uncertain were changed. The level of sexual abuse of children was set to 0.1%, but the maximum potential trafficked prostitutes were increased from 1500 to 6000 (towards the higher ends of estimated intervals in literature [5]). The effectiveness of P4 was also reduced to 50% at its maximum. Now the two modes of behavior are not so different but still distinguishable: those including P4 give more desirable results than those without.

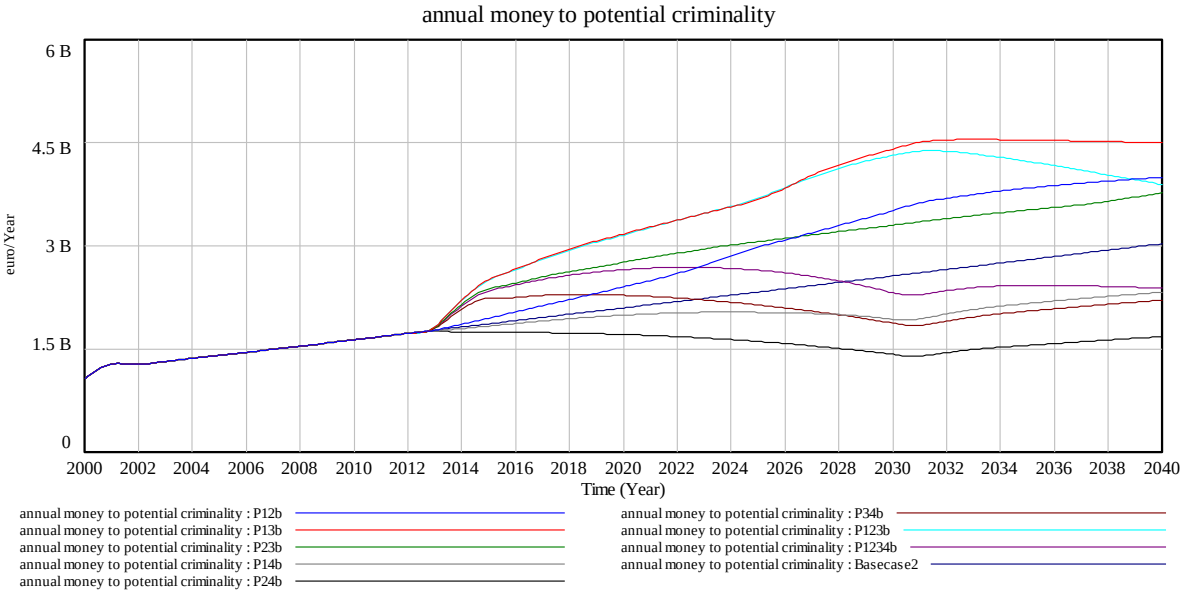

Figure 9. Behavior of combinations of policies under the pessimistic scenario

The same combinations of policies were plotted in Figure 9 to assess their behaviour under less favorable conditions. From this graph, it could be concluded that although there is a significant numeric difference, the ranking of the policy combinations based on these two criteria remains similar.

4.2 Interpretation

Above, various consistent combinations of policy interventions were evaluated under two different scenarios. The main evaluation criterion was the *annual money to potential criminality.* Other possibly important criteria could be the actual number of prostitutes, the annually trafficked prostitutes and the enslavement ratio. In view of these criteria and the obtained results with this model, it is not enough to fight trafficking or to provide extensive help for escape. The most effective way to reduce the market size of this activity seems to be making it illegal and trying to reduce

demand. The demand is such a strong driving force, that attention should be paid to finding ways to voluntarily reduce it [15]. All alternative policies would involve considerable financial and organizational efforts, while the criminalization of prostitution and punishment of sex buyers also needs a rather big change in views, principles and norms.

In the Dutch context it is a bit problematic to come up with the above policy advice. In October, 2011, Lodewijk Asscher, Amsterdam council executive gave voice to this problem: “people who criticize or object to prostitution are often dismissed as being 'too proper' or 'prudish'. But talking about human trafficking has nothing to do with being prudish,” he said. “It is a national mistake to think that the way we deal with prostitution should be considered part of our tradition of freedom, happiness and tolerance. That is not the reality.”[16]

Indeed, criminalizing prostitution might be unimaginable in the short term, but there is a nice precedent close to the Netherlands and Dutch culture, i.e. Sweden. After being legalized and regulated for 30 years, prostitution in Sweden became illegal in 1999 and it is now viewed as violence against women. Ironically, this was the result of a hard fight and strong voice of the women’s rights activists in Sweden. Men trying to pay for sex face severe punishments, but prostitutes are viewed as victims and they cannot be persecuted. Instead, huge funds were allocated to build up extensive programs and services helping them reintegrate into the society. Even in Sweden this system did not yield good results, until the whole police department was re-educated about how to handle the cases. This ensured the efficiency of law enforcement. This shift in paradigm probably did not yet happen even among the women’s rights activists in the Netherlands, but the governments or city councils might want to adopt it sooner [16].

However, before headlong adopting this or any other policy, it makes sense to test its robustness, i.e. its efficacy under deep uncertainty (i.e. using different simulation models and sweeping large multidimensional uncertainty spaces) as well as to closely monitor the real-world Swedish experiment – not only in terms of the effect on human trafficking and prostitution as we know it now, but also in terms of the effects on other forms of human trafficking and prostitution, and first and second order effects on organized crime. The former is pursued in the following section.

5. Testing policy robustness under deep uncertainty

5.1 Policies

Table 2 displays seven consistent policy sets based on the four policies discussed above. The Dutch policy situation is assumed to be reasonably similar to activating Policy1 and Policy2. The Swedish situation is represented by the combined implementation of Policy1, Policy2 and Policy4. The policy set consisting of Policy1, Policy2 and Policy3 represents the future USA policy set. And Pol1234 is a combination of all policies, illegalizing both demand and supply of paid sex services.

	NoPolicies	Pol1	Pol2	Pol3	Dutch	Sweden	FutureUSA	Pol1234
Policy1	0	1	0	0	1	1	1	1
Policy2	0	0	1	0	1	1	1	1
Policy3	0	0	0	1	0	0	1	1
Policy4	0	0	0	0	0	1	0	1

Table 2. Policy sets tested under deep uncertainty

5.2 Uncertainties

Parameter	Uncertainty interval	
average frequency of prostitution visits	12	52
average age entering prostitutions	17	21
average time spent in prostitution	6	14
delay of price adaptation	0.2	2
fraction becoming prostitute if abused as child	0.01	0.3
initial fraction of new adults considering entering business	0.0001	0.04
initial number of prostitutes	15000	60000
law indifferent human trafficking level	0.05	0.5
level of child sexual abuse	0.0005	0.05
naked costs per sex service	5	40
normal percentage of Johns	0.01	0.25
number of clients per prostitute	5	100
potential annually trafficked prostitutes	500	3000
potential tourist demand growth	50	2000
initial demand due to sex tourism	50	2000
percentage reduction demand due to illegality	0.1	0.5
price increase factor due to more human trafficking enforcement	0.5	4
price increase factor if illegal	0.5	4
nuisance factor (influencing social acceptance)	1bln	10bln
desired profit margin sex services	1.2	3.2
percentage reduction of social acceptance due to illegalization	0.1	0.9

Table 3. Parameter uncertainties and their ranges

These policies are first of all simulated and their effectiveness is tested and compared under deep uncertainty. In order to do so, we added parametric uncertainty using uniform distributions (see Table 3), categorical uncertainty for switches, orders of delays, and lookup functions (see Table 4), and model uncertainty, i.e. different simulation models (see Figures 10 and 11). The effects of the policy sets presented in subsection 5.1 were also implemented differently in the two models: the policies affect model 1 gradually and model 2 abruptly with different degrees of effectiveness.

Variable	Uncertainty
switch price elasticity of demand	Short- or long run
order delay of price adaptation	1, 3, 10
lookup home price effect	[(0,4),(40,1.5),(80,1),(200,0.5),(400,0.2),(800,0.1),(1200,0.1)]
	[(0,2),(40,1.5),(80,1.1),(200,0.5),(400,0.3),(800,0.2),(4000,0.01)]
	[(0,3),(40,1.5),(80,0.8),(200,0.3),(400,0.1),(800,0.05),(1200,0.01),(4000,0)]
lookup tourist price effect	[(0,4),(50,1.5),(200,0),(500,-1.5),(800,-2.5),(3000,-5)]
	[(0,4),(50,1),(100,0),(300,-1.5),(800,-3),(4000,-10)]
	[(0,4),(50,1.5),(150,0),(500,-1.2),(800,-2),(4000,-5)]
lookup supply/demand on price	[(0,10),(0.2,4),(0.5,2),(1,1),(1.5,0.75),(2,0.5),(3,0),(5,0.2)]
	[(0,10),(0.3,5),(0.5,3),(1,1),(1.5,0.6),(2,0.5),(3,0.4),(5,0.2)]
	[(0,10),(0.3,4),(0.5,2),(1,1),(1.5,0.4),(2,0.3),(5,0.2)]
	[(0,5),(0.05,3),(0.25,2),(1,1),(2,0.75),(3,0.6),(5,0.5)]
lookup profitability on escape	[[(-1,2),(-0.5,1.6),(0,1),(0.8,-0.2),(1.6,-0.95),(2,-1),(4,-1)]
	[(-1,2),(-0.75,1.95),(-0.3,1.8),(0,1),(0.2,-0.2),(0.7,-0.8),(1.2,-0.95),(2,-1),(4,-1)]
	[(-1,2),(-0.75,1.9),(-0.5,1.7),(0,1),(0.5,-0.2),(1,-0.8),(1.5,-0.95),(2,-1),(4,-1)]
lookup effect of social acceptance	[(0,0.5),(0.25,0.6),(0.5,1),(0.7,1.3),(1,1.5)]
	[(0,0),(1,4)]
	[(0,0),(0.25,0.6),(0.5,1),(0.7,1.3),(0.9,2),(1,3)]
	[(0,0.5),(0.25,0.55),(0.75,1),(1,1.2)]

Table 4. Categorical uncertainties and their categories (e.g. different lookup functions)

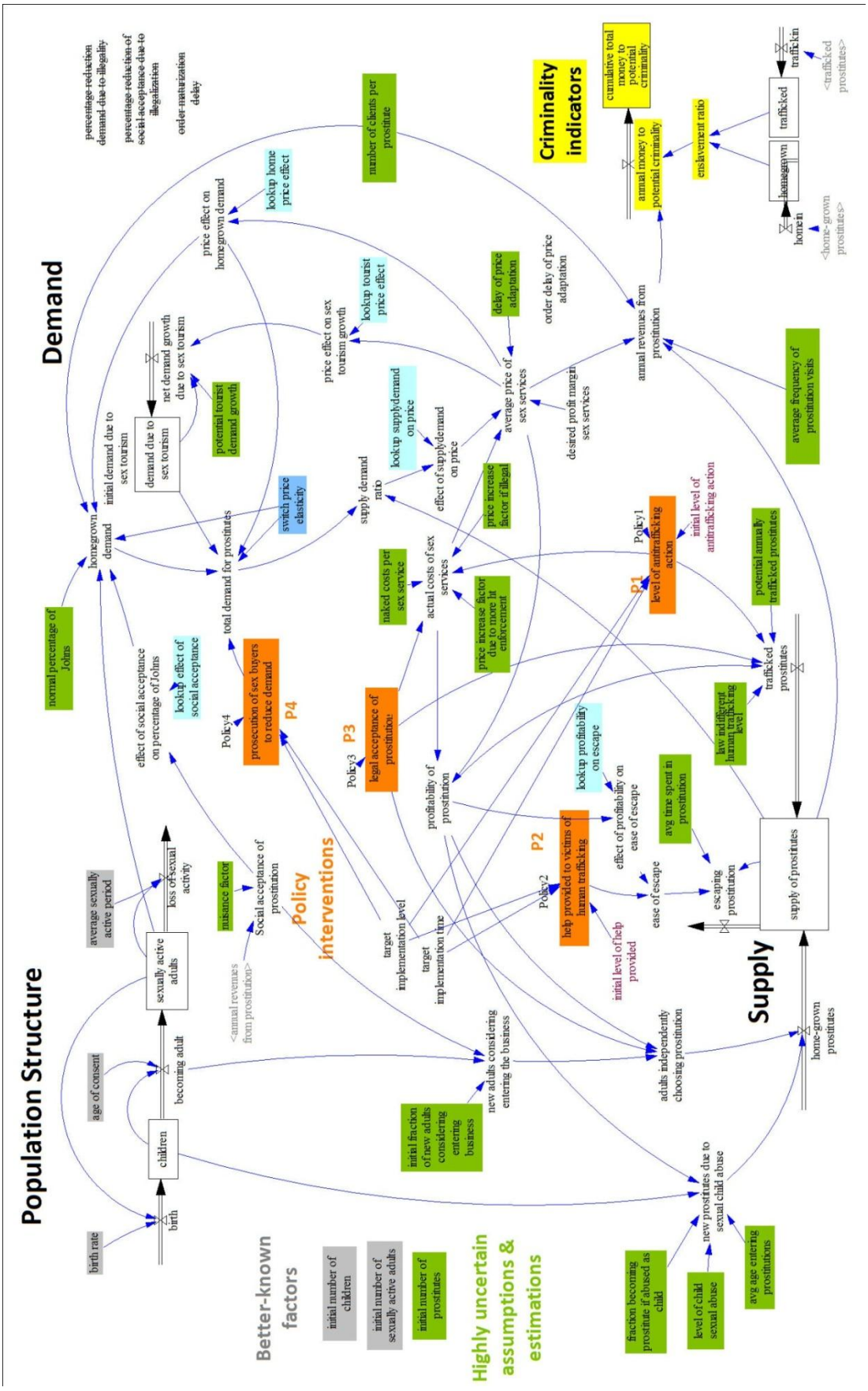

Figure 10. model 1 (slight extension of the model presented in section 3)

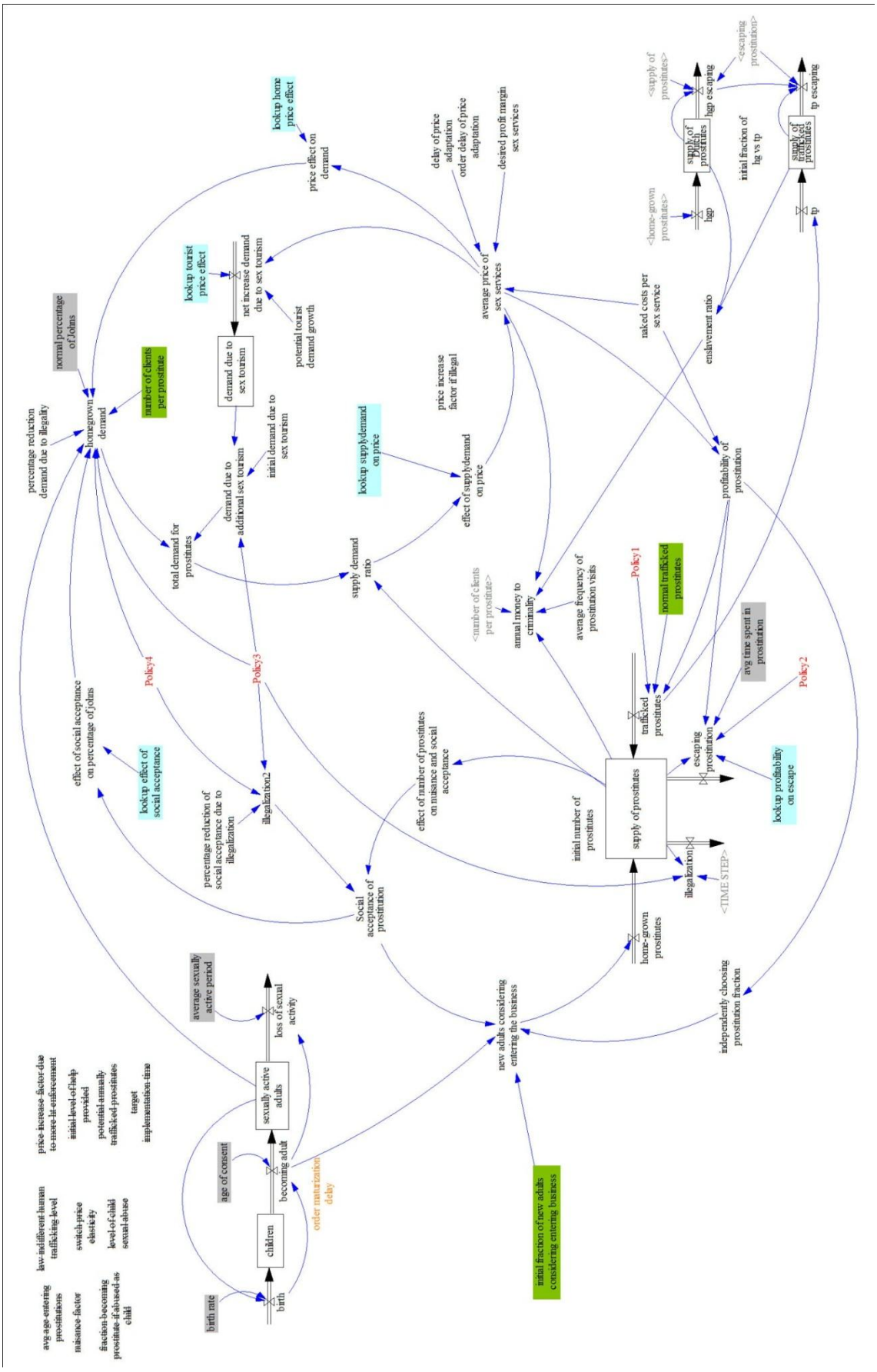

Figure 11. model 2 (extension of the case model (see appendix) which was based on the model presented in section 3)

5.3 Policies under deep uncertainty

Figure 12 shows the envelopes and end-state Kernel Density Estimates (KDEs) [17] of the results obtained by applying the same Latin Hypercube sampling plan for both models and each of the 8 policies, i.e. 2 x 8 x 100 runs in total. The models react slightly differently to the policies activated in 2012 and 2013, which should not come as a surprise since both the models and the implementation of the policies differ. Note however that Figure 12 only shows the envelopes and end state KDEs of a very small number of runs (100 per policy per model). These runs were first and foremost generated to test the policies over different models and uncertainties; the model output comparison in Figure 12 helps to understand the different reactions of these models to these policies.

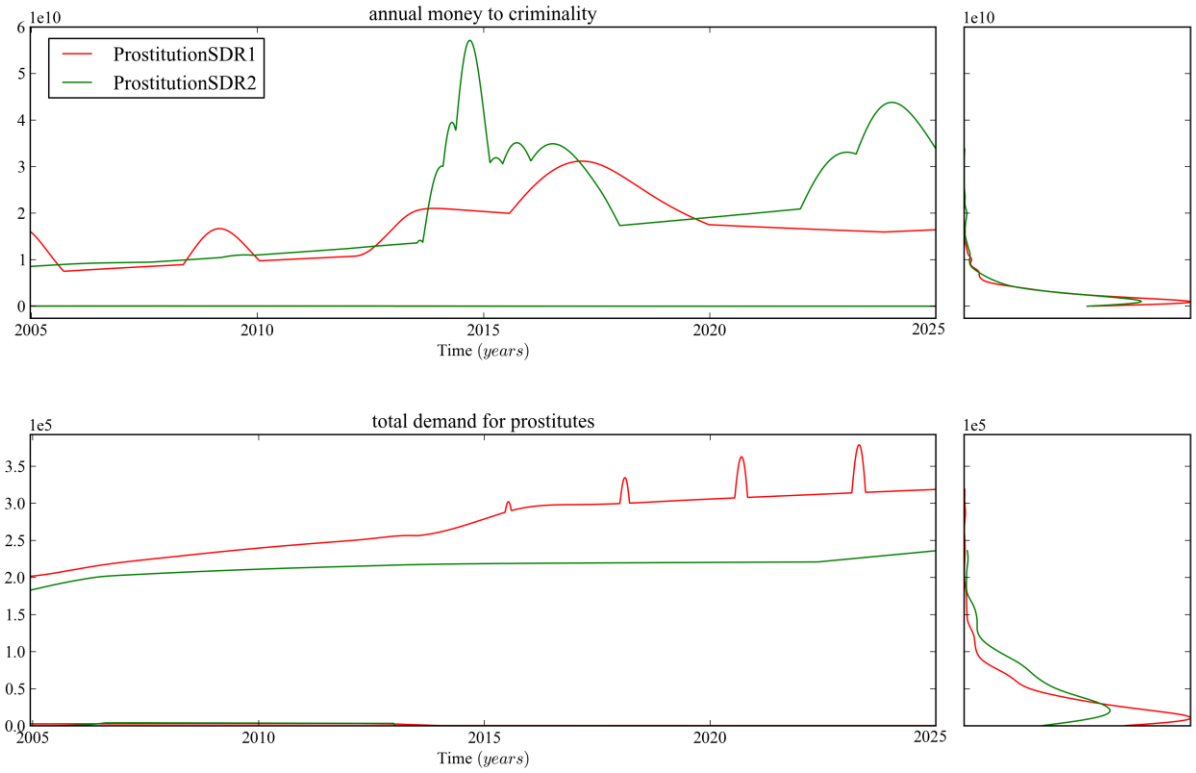

Figure 12. Envelopes and KDEs of Two KPIs for 2x8x100 runs visualized per ESDMA model

Figure 13 shows plots of the trajectories of the same runs, but now for each of the 8 policies (2 x 100 runs per policy) for all key performance indicators (KPIs). Pol1234 seems to outperform the other policies in terms of profitability of prostitution, demand for prostitutes, and annual money to criminality, in other words the KPIs related to big crime, but not the enslavement ratio and the average price of sex services. The graph displaying the dynamics of the enslavement ratio is rather interesting: it seems like the sudden increase in prices and profitability caused by a sudden illegalization, causes a significant increase in homegrown supply of prostitution and decrease in enslavement ratio, until the delayed increase of foreign supply of prostitutes depresses the prices, making the then illegal profession less interesting for locals offering sex services, hence, raising the enslavement ratio, et cetera.

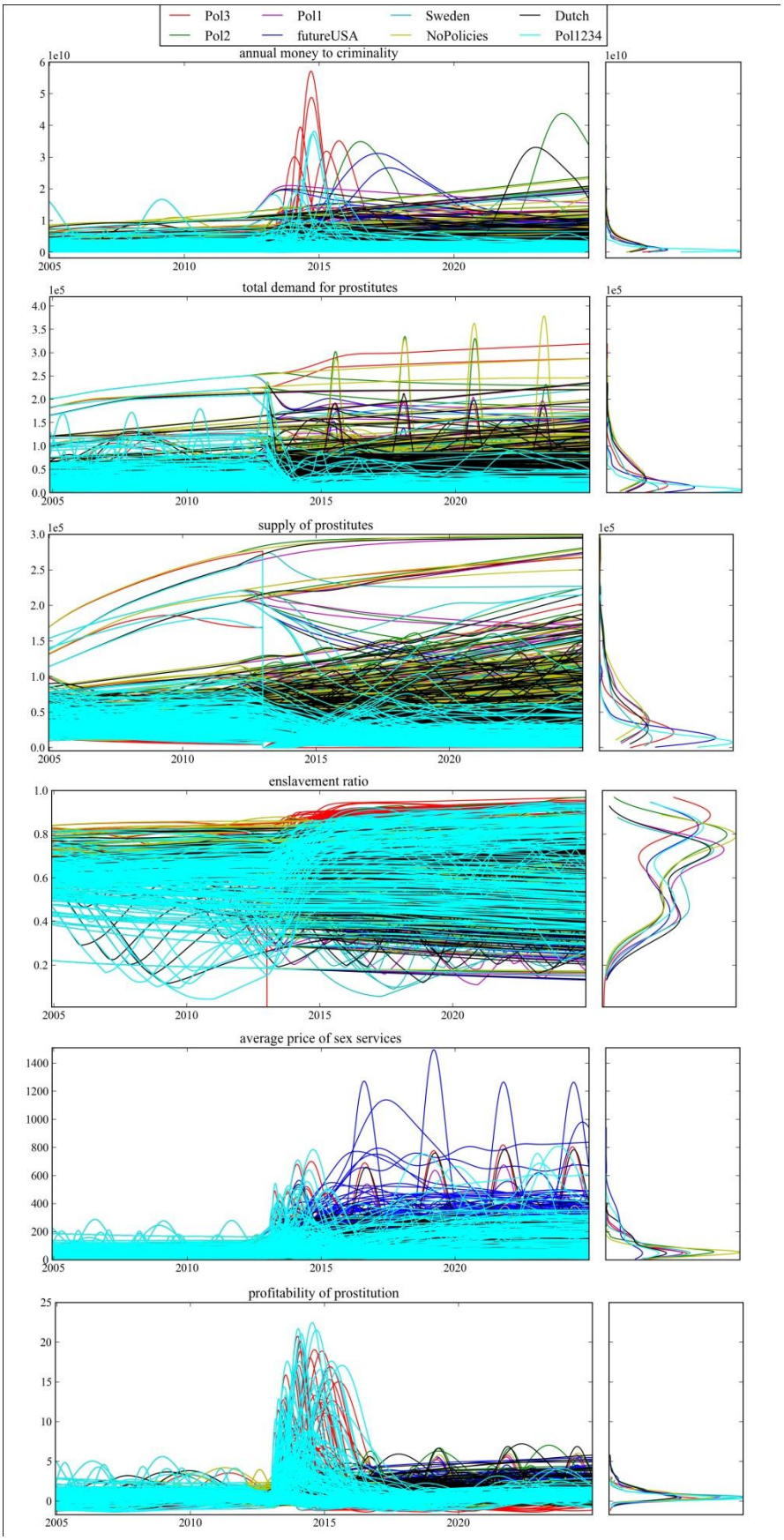

Figure 13. Lines and KDEs of six KPIs for 2x8x100 runs visualized per model

5.3 Policy1234 under deep uncertainty

Since Pol1234 seems to outperform the other policies, we used a Latin Hypercube sampling plan of 1000 cases to generate 2x1000 runs for Pol1234, i.e. 1000 runs per model. Table 5 shows a ranking of the individual uncertainties using a random forest [18] feature selection algorithm in terms of their relative contribution to an underlying classification (…> 5B >…> 4B >…> 3B >…> 2B >…> 1B >…) of the maximum value of the KPI 'annual money to criminality' over a run. Note that the 'model' uncertainty, i.e. whether model 1 or model 2 was used, does not rank high: its overall effect is relatively modest because the model structures are rather similar. However, this ranking based on the Random Forest algorithm does not take dependencies and combinations of uncertainties into account.

Uncertainties	Relative score Random Forest Feature Selection
average frequency of prostitution visits	**3.20**
normal percentage of Johns	2.14
number of clients per prostitute	**1.87**
desired profit margin sex services	1.30
naked costs per sex service	0.86
potential tourist demand growth	**0.66**
percentage reduction of social acceptance…	0.58
lookup effect of social acceptance	**0.51**
lookup supply/demand on price	**0.50**
lookup tourist price effect	**0.44**
lookup home price effect	**0.43**
nuisance factor	0.31
model	**0.31**
initial fraction of new adults … entering business	0.27
avg time spent in prostitution	0.26
percentage reduction demand due to illegality	0.24
level of child sexual abuse	0.24
law indifferent human trafficking level	0.20
initial number of prostitutes	0.18
fraction becoming prostitute if abused as child	0.17
potential annually trafficked prostitutes	0.17

Table 5. Relative importance of uncertainties according to a random forest feature selection algorithm based on a classification in terms of the maximum 'annual money to criminality' (…>5B>…>4B>…>3B>…>2B>…>1B>…) – in bold: set of uncertainties that according to the PRIM algorithm determine about 40 percent of all runs with an 'annual money to criminality' above 1B

Another algorithm, PRIM [19, 20], is more useful to identify combinations of uncertainties that jointly have very (un)desirable effects on particular KPIs. Applying PRIM in search of relatively large PRIM boxes (boxes that contain more than 5% of all runs, of which more than 50% have an 'annual money to criminality' end value of more than 1B), results in just one box, displayed in Figure 14, containing 5.9% of all runs of which 56% are undesirable. This box is entirely made up of combinations of lookup functions: i.e. the second function of the 'Lookup home price effect', the first function of the 'Lookup tourist price effect', *not* the third function of the 'Lookup supply

demand on price', and *not* the third function of the 'Lookup profitability on escape'. These undesirable scenarios in this particular PRIM box are runs in which the P1234 policy fails in terms of 'annual money to criminality' mainly because of a failing economic pricing mechanism (demand is insensitive to price increases, et cetera). The underlying economic pricing mechanism should in these cases not be relied upon. These scenarios require measures, not directly or indirectly addressing the demand for prostitution through the underlying pricing mechanism, that complement P1234. This is not a general conclusion though: it only holds for 11% of all undesirable cases.

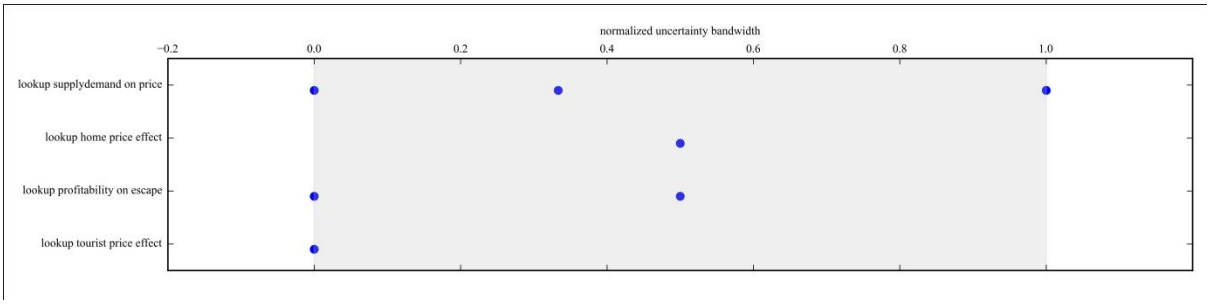

Figure 14. PRIM box (mass = 0.059; density = 0.56; coverage = 0.11)

Since this is the only relatively large PRIM box, we continued the search for smaller boxes. The –mainly structural– uncertainties displayed in bold in Table 5 jointly cause many more small boxes, i.e. multi-dimensional subspaces in uncertainty space, with relatively moderate concentrations of undesirable behavior on the KPI 'annual money to criminality'[2]. Comparing the uncertainties that according to the PRIM algorithm jointly cause undesirable behaviors on this KPI with the set of uncertainties that according to the Random Forest algorithm influence the same KPI, and knowing that 17 boxes together only contain about 40% of all undesirable cases, leads to the conclusion that many undesirable cases *are not* caused by particular sets of uncertainties. The undesirable outcomes are, in other words, caused by diverse sets and combinations of uncertainty values, and are not sufficiently concentrated in the multi-dimensional uncertainty space to be targeted with dedicated policies addressing a small set of uncertainties. In other words: even with such simple System Dynamics models is the prostitution-based human trafficking a very complex policy issue that requires more advanced policies and much more (policy) research.

6. Conclusions

6.1 Concluding remarks

The first objective of this study was to model the problem of prostitution and prostitution-related human trafficking in The Netherlands in view of performing a preliminary policy analysis. The model is based on data from the Netherlands and focuses on female prostitution[3]. Its structure is nevertheless rather generic: it can be tuned to other developed countries by changing initial

[2] 17 boxes each containing slightly more than 1% of all the runs, for which more than 50% of the runs have end state values for 'annual money to criminality' exceeding 1B

[3] 90% of prostitutes in the Netherlands are women, 5% men, 5% transvestites. [5]

conditions and the values of some external factors. More restructuring and rather big changes in effect functions would be needed to apply it to other, dissimilar, countries.

The aim of this 'quick and dirty' policy analysis was to evaluate policy effects on prostitution-related money flows to organized crime and the position of prostitutes. Understanding how (combined) policies reduce these money flows is important for policymaking related to prostitution.

An important element of any effective policy set seems to be the reduction of the demand since demand partly determines the supply. But even the combination of all measures tested in this paper does not necessarily lead to acceptable outcomes in terms of money flows to organized crime and 'enslavement' of prostitutes. It may even lead –unless demand is tackled– to totally undesirable outcomes: illegalizing prostitution may push the entire sector into the grip of organized crime and may deteriorate work conditions in prostitution.

The complexity of prostitution-related human trafficking and prostitution exceeds the power of a 'quick and dirty' policy analysis, of simple policies, and/or simplistic and 'certain' representations of fundamental systems. The models presented in this paper were first approximations. And the policies studied here were implemented rather simplistically in these simulation models. And although policies were also tested under uncertainty, it was not fully embraced.

6.2 Current and Future Research

Hence, the preliminary research described in this paper will be broadened and deepened, and deep uncertainty will be fully embraced.

The models presented in this paper are obviously just two out of many plausible models about the dynamics of prostitution related human trafficking. More plausible models and uncertainties will therefore be included in the analysis. Alternative models will be developed together with important stakeholders (the police, organizations representing or helping prostitutes, et cetera) or representing stakeholders that are hard to involve (e.g. organized crime).

These alternative models will be used together with the models described in this paper as scenario generators for an extended analysis combining System Dynamics and Exploratory Modeling and Analysis (EMA) [21, 22, 23, 24]. EMA is a methodology for exploring deeply uncertain issues, generating a very large scenario space, analyzing the scenario and corresponding uncertainty space, identifying potential basic policies and uncertainty space areas that require specific policies, and testing and comparing the robustness of policies across the uncertainty/scenario space. The combination of System Dynamics modeling and EMA is also referred to as 'ESDMA'. Although ESDMA is relatively new, it has already been applied successfully to many complex uncertain issues, ranging from acute pandemic shocks [25] to long term material scarcity [26].

The boundaries of the research will also be broadened in some of these models to include related illicit markets and related forms of organized crime, such as drug trade, arms trade, and illicit goods trafficking – in a first stage on the national level, and in a second stage on the transnational level.

A broad set of plausible models and a plethora of uncertainties will then be used to generate a large ensemble of plausible scenarios. More realistic and detailed policies will subsequently be tested over all plausible scenarios generated with these models. The most promising sets of policies will then be turned into adaptive robust policies as in [27, 28].

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APPENDIX A: HOT TEACHING & TESTING CASE ON PROSTITUTION RELATED HUMAN TRAFFICKING

The teaching & testing case included in this appendix was based on the model described in this paper. It was developed to evaluate the modeling skills of 2nd year undergraduate students at the end of their Introductory System Dynamics course at Delft University of Technology. The case is discussed and related multiple choice questions are provided in [29].

A Case Description: Prostitution in the Netherlands (/25)

For centuries, prostitution has been highly cyclic but also amazingly constant. In the 17th century, brothels were openly present in Dutch cities. Between 1806 and 1911 Dutch brothels were regulated and registered. But Christian campaigns lead to the illegalization of Dutch brothels in 1911. Some cities went even further by forbidding any form of prostitution (window prostitution and streetwalking). From the 1970s on, Dutch governments started to recognize that repression of prostitution does not make prostitution disappear. This gradual recognition lead to different policies across different cities, from tolerance to fierce prosecution. The ambiguous status of prostitution in the Netherlands was resolved on 1 October 2000 by the abolishment of the general Dutch brothel prohibition. From 2000 on, prostitutes of age and of their own free will are allowed to work under strict conditions. Although the abolishment of the brothel prohibition partly brought prostitution back to the straight world, it did not end the underlying human trafficking and organized crime. Lodewijk Asscher, Martijn Roessingh and Perdiep Ramesar claim that even in the legalized and regulated business more than half of the women work against their own will and are exploited, and do not use the rights reserved to them. For a few years, several communes and the national government are again more restrictive in view of fighting the underlying human trafficking and organized crime.

Suppose the Dutch government asks you to build and use an explorative SD model in order to investigate the possible consequences of new policies, measures, and actions. Closely follow the description below when constructing your model.

A.1 The Population

The *demand for prostitutes* emanates from the group of *sexually active adults*, initially equal to 12 million: suppose thus that there is no sex tourism. Suppose that this group –that is to say the group of *sexually active adults*– only increases through a flow *from minor to adult* and decreases through a an outflow *loss of sexual activity* after an average *sexual lifetime* of about 45 years. Set the flow variable *from minor to adult* for now equal to the *children* divided by the *age of consent* of 18 years. The number of *children*, initially equal to 4 million, only increases through *births*, equal to the number of *sexually active adults* times the *birth rate* of 0.017 children per person per year.

> 1.(/2) Model the above description. And make both a detailed and an aggregated causal loop diagram of this model.

A.2 Demand for and supply of commercial sex services

The *demand for prostitutes* is the product of half the *sexually active adults*, the *normal percentage of Johns*, the *effect of societal acceptation on the percentage of Johns*, and the *price effect on the demand for prostitution*, divided by an average of 50 *clients per prostitute*. The *normal percentage of Johns* in the Netherlands amounts to 12% (in other words: 12% of Dutch men frequent prostitutes). The *price effect on the demand for prostitution* is a function of the *average price of sex services* connecting following couples: (0, 4), (50, 1.5), (100, 1), (200, 0.5), (400, 0.2), (800, 0.1), and (1200, 0.1). In other words, the *price effect on the demand for prostitution* is equal to 1 if the *average price of sex services* is €100, et cetera. The *average price of sex services* could be modeled as a third order delay of (2 * *naked costs per sex service* * *supply demand effect on the price of sex services*), with a delay time of a year, and an initial value equal to (2 * *naked costs per sex service*). The average *naked costs per sex service* amount to €20.

The *supply demand effect on the price of sex services* is equal to 5 if the *supply demand ratio* equals 0, the *supply demand effect on the price of sex services* is equal to 3 if the *supply demand ratio* equals 0.05, the *supply demand effect on the price of sex services* is equal to 2 if the *supply demand ratio* equals 0.25, the *supply demand effect on the price of sex services* is equal to 1 if the *supply demand ratio* equals 1, the *supply demand effect on the price of sex services* is equal to 0.6 if the *supply demand ratio* equals 2, the *supply demand effect on the price of sex services* is equal to 0.5 if the *supply demand ratio* equals 3. De *supply demand ratio* calculates the *supply of prostitutes* divided by the *demand for prostitutes*.

Suppose that the *effect of societal acceptation on the percentage of Johns* equals (0.5 + *societal acceptation of prostitution*/1.5), with the *societal acceptation of prostitution* equal to a third order delay of the function (1 - *supply of prostitutes*/100000), with an average delay time of 3 years. In other words, societal nuisance increases and societal acceptation decreases from 0 to 100000 prostitutes. And from 100000

prostitutes on, nuisance is so big that societal acceptation is 0. Model the *societal acceptation of prostitution* such that it is always between 0 and 1.

In the year 2000, there were 28254 prostitutes in the Netherlands –in other words, the *supply of prostitutes* was equal to 28254 prostitutes. The *supply of prostitutes* increases through *new Dutch prostitutes* as well as through *new foreign prostitutes*, and decreases through the *prostitution outflow*. Suppose the nonnegative flow of *new Dutch prostitutes* equals the product of half the flow *from underage to adult from underage to adult*, de *normal fraction of young Dutch adults open for a job in prostitution*, the *profitability of prostitution*, and the *societal acceptability of prostitution*. Suppose that the *normal fraction of young Dutch adults open for a job in prostitution* –that is, if the circumstances are favorable– equals 1 in 1000.

The *prostitution outflow* is equal to the *supply of prostitutes* divided by an *average lifetime in prostitution* of 10 years. The *expected gap between demand and supply* then equals the sum of the *demand for prostitutes* and the *prostitution outflow* minus the *supply of prostitutes*. Model the nonnegative number of *new foreign prostitutes* as the product of the *expected gap between demand and supply* and the *profitability of prostitution*. Foreign prostitutes are likely to be 'supplied' by traffickers. The average '*delivery time*' in women trafficking is on average about a year. And the *profitability of prostitution* is close to the difference between the *average price of sex services* and the *naked costs per sex service*, divided by the *naked costs per sex service.*

Total annual prostitution revenues are then the product of the *supply of prostitutes*, the average *frequency of prostitution visit* per client, the number of *clients per prostitute*, and the *average price of sex services*. Suppose that clients have an average *frequency of prostitution visit* of 24 times per year.

1. (/6) Create a SD simulation model based on the above description. [Note that MC questions are used to automate the correction of this question. See [16].]

2. (/1) Simulate the model from 2000 to 2040 and answer the following MC question. [Note that a MC question is used to automate the correction of this question. See [16].]

3. (/1) Change the flow variable *from minor to adult* now so that reach majority exactly 18 years after having been born. Use an initial value equal to 222222 persons per year for this flow *from minor to adult*. Save the model. [Note that a MC question is used to automate the correction of this question. See [16].]

4. (/2) According to Asscher cs, the Netherlands should consider a ban on prostitution if the situation does not improve with the new prostitution law. Suppose the government asks you to simulate what would happen if the *supply of prostitution* is made completely illegal (not the demand as in Sweden and requested by Asscher) on 1 January 2013. Add therefore two variables: an outflow variable *reduction of supply through illegalization* in order to completely empty the *supply of prostitutes* early 2013; and a variable '*influence of illegalization on the societal acceptability of prostitution* which equals 1 till early 2013, after which it suddenly falls to, and stays, 0.7. Multiply this last variable with the formula (1 - *supply of prostitutes* / 100000) in the *societal acceptability of prostitution*. Model this. [Note that MC questions are used to automate the correction of this question. See [16].]

5. (/2) Verify the model. [Note that MC questions are used to automate the correction of this question.]

6. (/2) Validate the model: cite two different suitable validation tests (different from sensitivity analysis), perform them, draw the necessary conclusions, and describe them briefly.

7. (/2) Simulate the validated model, save your results, and draw the correct model behavior of the following variables: (1) the *demand for prostitutes* and the *supply of prostitutes*, (2) the *average price of sex services*, and (3) the *total annual prostitution revenues*.

8. (/1) Interpret this dynamic: What are the implications for organized crime, trafficking, and victims of trafficking?

9. (/3) Make an extremely aggregated causal loop diagram (CLD) of this model with this policy. Explain the relationship between structure and behavior of this model with this policy using this causal loop diagram.

10. (/2) Perform the necessary sensitivity analysis: test the sensitivity of model and policy for two important assumptions or parameters. Describe briefly (which factors or parameters, what conclusions).

11. (/1) Suppose you advice against this policy: propose an effective policy to address especially the trafficking and serious crime related to prostitution? Describe your policy, its effect, and the robustness thereof.