Investigating the Long-Term Impact of the Police Reform: A Case Study of Denmark

A System Dynamics analysis of the police department and criminal activity after the implementation of a new police reform

By

Sunniva Austjord Slyngstad

Thesis submitted in partial fulfillment of the requirements of the Master of Philosophy in System from University of Bergen, Master of Philosophy in System Dynamics from Università degli Studi di Palermo, and Master of Science in Business Administration from Radboud Universiteit Nijmegen

Supervised by Christina Gkini

Joint European Master´s in System Dynamics

Department of Geography

University of Bergen

June 2022

Acknowledgments

Without the assistance and advice of my thesis supervisor Christina Gkini from the University of Bergen, this thesis would not have been feasible. She has provided insightful information on writing a master thesis and on the use of system dynamics as a method. She has also helped motivate me throughout the process of writing my master´s thesis.

I also want to show my gratitude to Professor Birgit Kopainsky, who has been an inspiration through this process, teaching me the wonders of system dynamics. I am extending my gratitude to my friend and former teaching assistant, Jefferson Rajah, who has been able to teach system dynamics understandably and sensibly when we were struggling the most. Without you, I would still be unable to explain what system dynamics is, let alone create a functioning system dynamics model.

I'd also like to thank my colleagues, with whom I've spent a significant amount of time working through the obstacles of modeling a system dynamics model and understanding systems thinking. A special mention to my friends though out this master's program, Knut Ognøy, Henri Contor, and Pepe Bellin. Thank you for the intellectual challenges, wonderful talks, emotional support, and an unlimited supply of coffee. It has been a privilege studying with you.

And as a last recognition to my close family and friends, Gunhild, Svein, June, and Ida. If it was not for the love and support you have shown throughout the years, I would not be where I am today, and I am forever grateful for every one of you.

Abstract

In 2006, Denmark implemented a police reform focusing on efficiency, fast response times, local police, and a unified organization across districts (Holmberg, 2019). The reform was necessary due to increased organized crime, rising crime across borders, technology advancements, and public demand for better service (Holmberg, 2014). However, trust and safety decreased in the coming years after the reform and slowly recovered over time, but local policing never recovered (Holmberg, 2014, 2019).

The goal of this thesis is to assess the long-term effects of the new policies that came with the police reform in Denmark and to understand the impact of the police reform on dark figures, visibility, reporting, convictions, and trust. I will use a literature review as a method to investigate the Danish police reform and its effect. I will also use system dynamics to present a simulated model of the police reforms implementations and how it affects the dark figures, visibility, reporting, convictions, and trust, which provides important information through feedback loops. The literature review will also be used to find the data needed to model this system.

In this study, I have found that an increase in competence, which affects the police detection rate and intervening rate directly, leads to increased convictions, detection, trust, and reports. And the increase in competence will reduce dark figures. With the removal of police stations, as an implementation of the reform, police visibility and police capacity will decrease. This reduces detection rates, convictions, and trust and will increase the dark figures. The increase in competence does show positive behavior but is unable to compensate for the effects that the loss of police stations has on visibility. The importance of visibility should be accounted for when implementing such policies.

The study further discusses the model-based insights that can help create new policy implementations, to enhance the outcomes of the dark figures, visibility, reporting, convictions, and trust. The policies are tested by increasing or decreasing them percentwise, so eventually, new policy implementation can be based on the accessibility they have to change the different policy options found in the study.

Table of content

List of Abbreviations

B	Balancing feedback loop
CLD	Causal Loop Diagram
R	Reinforcing Feedback loop
SD	System Dynamics

List of figures

List of Tables

1. Introduction

In 2006 Denmark implemented a new police reform. The change in the police institution that came with the reform in Denmark included a focus on efficiency, fast response time, local police, and a unified organization across districts (Holmberg, 2019). There are several reasons as to why the reform took place. Reorganization was required because of greater issues with organized crime, rising crime across borders, technology advancements, more mobility of both people and offenders, and public desire for better service and quality from police (Holmberg, 2014). There was also a need for police accountability, that would be reached through measurements of their performance, that could help them in increasing the police ability to prevent crime, and with a new reform focusing on community policing there would be an increased feeling of safety in communities (Holmberg, 2014). The first years after the reform that happened in 2006, there was a drastically decrease in trust and the feeling of safety (Holmberg, 2014, 2019). Although investigation and respond time increased. Satisfaction and trust was on its way back to normal, but local policing never recovered, and the public was overall dissatisfied with the police department (Holmberg, 2014).

All the improvements that Denmark did to improve the police institution are in theory good ways to improve the police department, however, the lack of a local police and visibility creates uncertainty (Blesse & Diegmann, 2022; Holmberg, 2014; Maxson et al., 2003, 2003) and a possibility for a growth of criminal behavior (Blesse & Diegmann, 2022; Bun et al., 2020). When the level of trust decrease, the number of people reporting will also decrease (Boateng, 2018; Goudriaan et al., 2006; Levitt, 1998a; Tolsma et al., 2012) as the perception that the police will solve their reporting issue will decrease. Even though the focus of competence is increasing, it might not compensate for the loss of community policing.

In an extreme condition, where the police are nowhere to be seen, it would not improve the situation by having a police force that it is super-efficient, has a high competence and low response time. This is a problem that affect, not just crime levels, but the safety of all in the country.

Both Norway and Sweden had similar implementations as Denmark (Holmberg et al., 2017), but the long-term effect of the reform is hard to measure as Denmark is the only country that has implemented it for a longer time period. Therefore, I will focus on Denmark in my

system dynamics review. There have been several articles discussing the effects that the reform will have, but no one, to my knowledge, has studied how the reform can influence the dark figures of crime, which I am mostly interested in. For this thesis I will use system dynamics to visualize and model the different scenarios.

1.1. Visualization of the problem

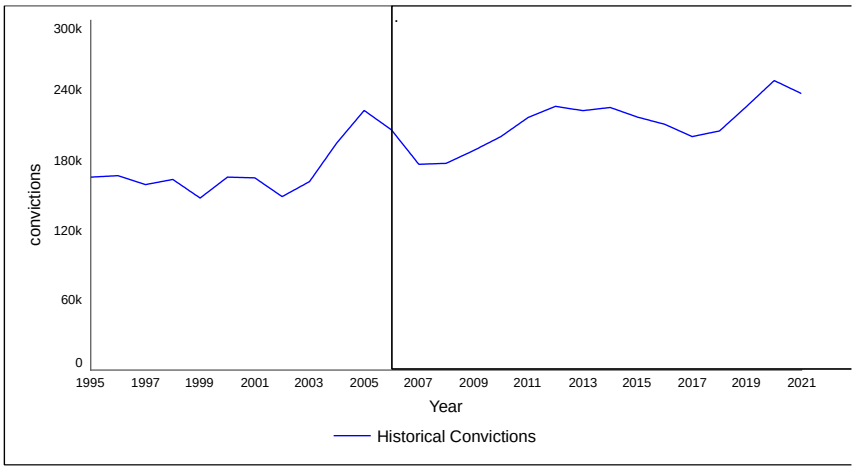


Figure 1.1 Historical convictions Denmark

In figure 1.1 we can see the historical behavior of the convictions in Denmark. Where the black line dividing the graph is the year 2006, to clearly see the behaviors before and after the reform's implementations. Now the conviction In the Danish statistical bank is everyone who is processed by the legal system in Denmark, and is either guilty or not guilty (Statistics Denmark, 2023d). This also includes smaller crimes such as property crime or traffic violations. We can see an increase after 2006, which is a positive behavior, meaning they convict more criminals compared to before 2006.

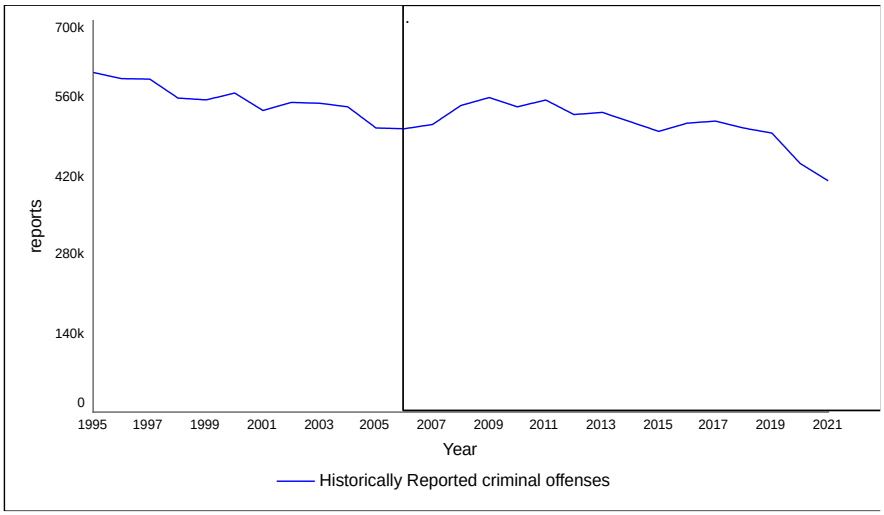


Figure 1.2 Historical reported criminal offences Denmark

In Figure 1.1 we can see that the convictions are clearly increasing. But what we see in figure 1.2 is that the number of reports is decreasing (Statistics Denmark, 2023f). The fact that the number of convictions is increasing, is signaling that there is positive change happening. However, as the number of reports is going down, it can either indicate that the crime rates are going down, therefor no need to report. Or people lack the moivation to report the incidents.

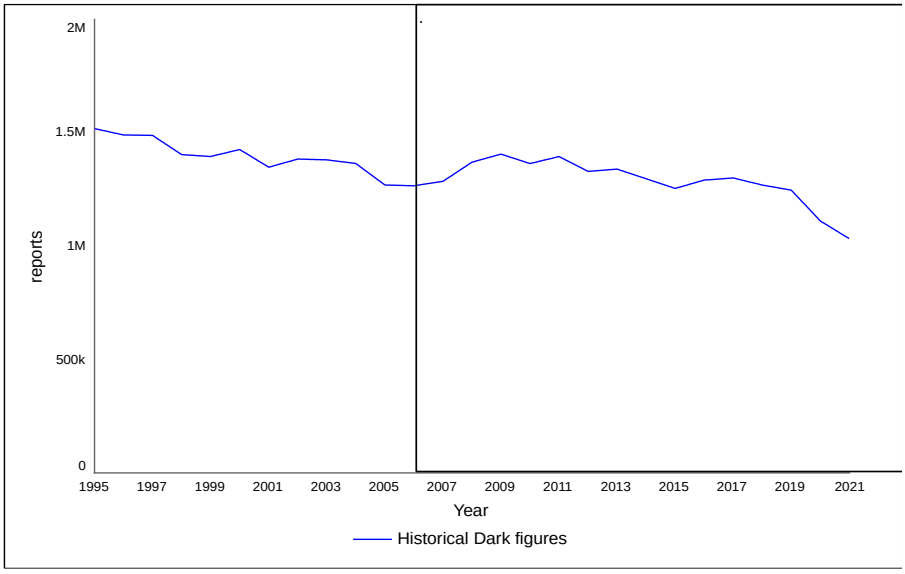


Figure 1.3 Approximated historical dark figures Denmark.

One of the more important factors relating to crime is the dark figures. Dark figures are the undiscovered, unreported crime. Which is not accounted for in statistics. However, it is hard to measure it. Studies found that the crime reported to police is only around 40% of all crime (Baumer, 2002; Buil-Gil et al., 2021; Goudriaan et al., 2006; Skogan, 1977). So, to attempt to

approximate the dark figures, I have been using the number of reports (Statistics Denmark, 2023f) and adding the 60% that is missing. We can estimate the historical dark figures, where 40 percent of the dark figures becomes “known crime”, as around 40 percent of it is reported to police.

The reason why I have attempted to capture the dark figures is that if we look at the reported crimes, or crimes that are discovered by police, this is only the discovered crime. There is a lot of crime that goes undetected, and this I believe is the more important factor in the search for the actual impacts of the reform.

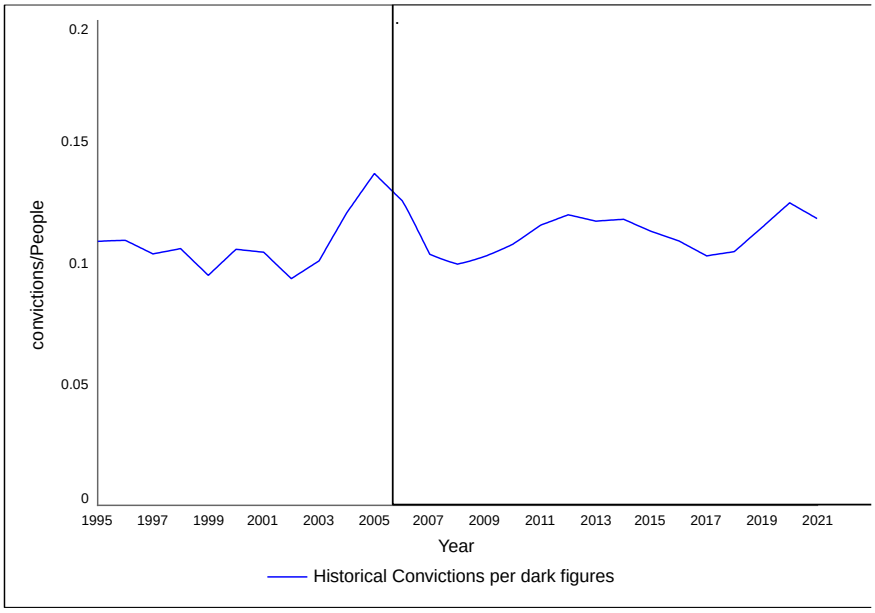


Figure 1.4 Approximated historical convictions per dark figures Denmark

As the dark numbers are the “true” indication of the crime levels in a country, I have used this to estimate the actual level of convictions in Denmark, based on the dark figures. If we look at convictions alone, this can tell us that the growth is good because they are able to convict more criminals. But by measuring it towards the dark figures, we can see how much of the total crime they are able to capture, discover or convict. The convicted relevant to dark figures is very stable and lies around 12%.

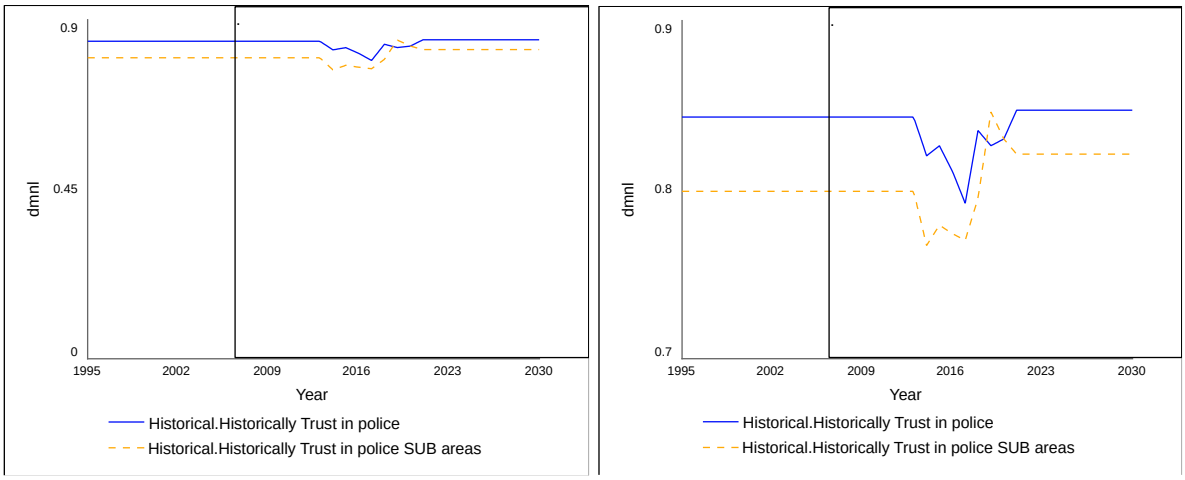


Figure 1.5 Historical trust in police total and SUB areas

Trust in police will also be an important component in this thesis. Trust indicates people's perception of the police and can be an indicator as to if people report crime. The graph to the left uses the values of 0 to 0.9 on the Y axis and the graph to the right uses the values of 0.7 to 0.9 on the Y axis to have a closer look at the behavior. We only have data from 2013 to 2021. The blue line is representing the total level of trust in the population. The dotted orange line in the graph represents the trust in police in SUB areas, which is residential areas that are particularly exposed to crime (Justitsministeriets, 2022). There are a total of 37 areas that are accounted for when they do the surveys for trust, where 19 of these areas are SUB areas (Justitsministeriets, 2022).

My hypothesis of this problem is that the number of dark figures will increase with the new reform policies, making the SUB areas to also increase. An important indicator for this is that the police visibility decreases (Hawdon et al., 2003), which causes people to have a lower level of trust in the police (Maxson et al., 2003) and the accessibility to commit crime increases (Blesse & Diegmann, 2022). We can also see in the historical graph that the report is decreasing, while the convicted increases. This might indicate that trust is changing and effecting the number of reports.

1.2 Research purpose

The aim of this study is to investigate the effect that the new police reform has on the criminal activity in Denmark. I chose this topic, as it appears that the visibility of the police was underestimated when this reform was launched. I anticipate that the new measures will have a negative impact on the country's crime rate and public trust in the police. Both of these elements

are critical in sustaining a secure community that cooperates with the police. As a result, this makes an intriguing study to investigate. This will be done with System dynamics as a method to visualize and capture the complex system. It provides a unique insight to the criminal system and the new police reform that has taken place in Denmark.

1.3 Research objectives and questions

The goal of this thesis was (1) to assess the long-term effects of the new policies that came with the police reform in Denmark. It was also (2) to understand the impact of the police reform on dark figures, visibility, reporting, convictions, and trust. The research questions of the paper are (1) what is the long-term impacts of the police reform on the dark figures? And (2) what is the long-term impacts of the reform on police visibility, trust, and competence. And as a follow up to the latter question (2.1) Can competence compensate for the loss of community policing (visibility) in terms of crime prevention and detection?

1.4 Research methods

For this master's thesis I have chosen to do a literature review and use system dynamics to model the police reform system.

1.4.1 Literature review

A literature review allows you to investigate and integrate existing information and research on the topic at hand. A review allows me to discover and assess the relevant theories, concepts, and empirical data around the reform. Where the current literature serves as a solid foundation for research and assistance in situating my topic within the larger academic conversation (Robson & McCartan, 2016).

A literature review assists in identifying gaps or opportunities for further research. It might uncover unsolved problems, contradictory findings, or areas that demand additional in-depth investigation by evaluating the existing literature. It offers an opportunity to get new ideas and knowledge about the Danish police reform and its implications for society.

An examination of the literature can help to conceptualize and frame research objectives and questions (Robson & McCartan, 2016). It aids in the refinement of the study focus, the identification of key variables and concepts, and the development of a coherent research framework. It can ensure the relevance and quality of the research by building on current

literature and developing a well-informed and theoretically based strategy to investigating police reform in Denmark.

Finally, using a literature review as a research approach in a master's thesis on the Police reform in Denmark in 2006 provides various advantages. It allows us to obtain a thorough awareness of the subject matter, uncover research gaps, outline the research objectives, and boost the credibility of the work. It can contribute to existing knowledge and provide useful insights into police reform and its impact by using this method.

Some disadvantages when doing a literature review is that the research is reliant on existing literature. By focusing on trending perspectives, which can be biased when other perspectives of the topic are not researched. It's a time-consuming method, that requires a large quantity of literature. Where the chances of finding the trending literature will be easier than more uncommonly research on a topic. This kind of review is also an analysis of excising evidence, it may lack the in-depth insight as it does not have a primary data collection.

1.4.2 System dynamics

System dynamics (SD) captures the dynamic interactions and feedback loops among numerous components to provide knowledge of the system. Criminal development is a heterogeneous subject driven by a variety of interconnected factors such as societal conditions, laws, and human conduct. In this paper, I will discuss the police, their visibility, public trust, and their competence, all influencing crime. Using system dynamics, we may create a model that incorporates these variables, allowing us to evaluate their complicated relationships and gain a greater understanding of the system's behavior over time (Bala et al., 2017; Sterman, 2000).

System dynamics enhances dynamic analysis by allowing us to simulate and visualize the system's behavior. It can identify significant factors, their interdependencies, and related patterns and trends through the development of causal loop diagrams and stock-and-flow diagrams (Sterman, 2000). This study aids in identifying underlying causes and appropriate intervention spaces. We can, for example, investigate the consequences of various policy actions. Scenario testing is supported by system dynamics, allowing us to investigate the effects of various policy choices and actions. We can run simulations of different scenarios, modifying variables and parameters in the model to see how they affect criminal development. This aids in assessing the efficacy of various solutions and offering evidence-based suggestions to policymakers.

System dynamics promotes an interdisciplinary approach, which is advantageous for dealing with complicated societal concerns such as criminal behavior. It allows for the synthesis of knowledge from other domains such as criminology, sociology, psychology, and public policy, resulting in a more comprehensive analysis and a more informed thesis. SD improves communication and visualization of complicated concepts and discoveries. We may effectively communicate the structure, behavior, and implications of the system to both academic and non-academic audiences by using diagrams, graphs, and simulation data (Bala et al., 2017; Sterman, 2000). This clarity and accessibility increase the impact and reach of the research.

In conclusion, system dynamics is a great tool to use in a master's thesis, especially when dealing with troublesome behaviors such as criminal development. It provides a comprehensive grasp of complex systems.

Some disadvantages when using system dynamics is that it can make complex systems too simple, where the actual driver of a behavior is not captured in the system, as its simplified. It also relies only on data available. Both qualitative and quantitative can be used. But when using qualitative research, where there is no hard data, the actual value of parameters, variables or effects can be speculative.

2. Dynamic hypothesis

To capture my dynamic hypothesis, I have made mental models of the reform policies and a CLD of the system I have modelled to capture the behavior of the system I am investigating. To capture the relationship between parameters and variables I use red lines with a plus sign and blue lines with a minus sign. The red ones with a + is a visualization of a positive relationship A→+B, beaning if A increases, B will also increase. But if A decreases, so will B. If it's a blue line with -, it symbolizes a negative relationship A→-B, if A increases, B will decrease. If A decreases, B will increase.

2.1Mental model of the reform

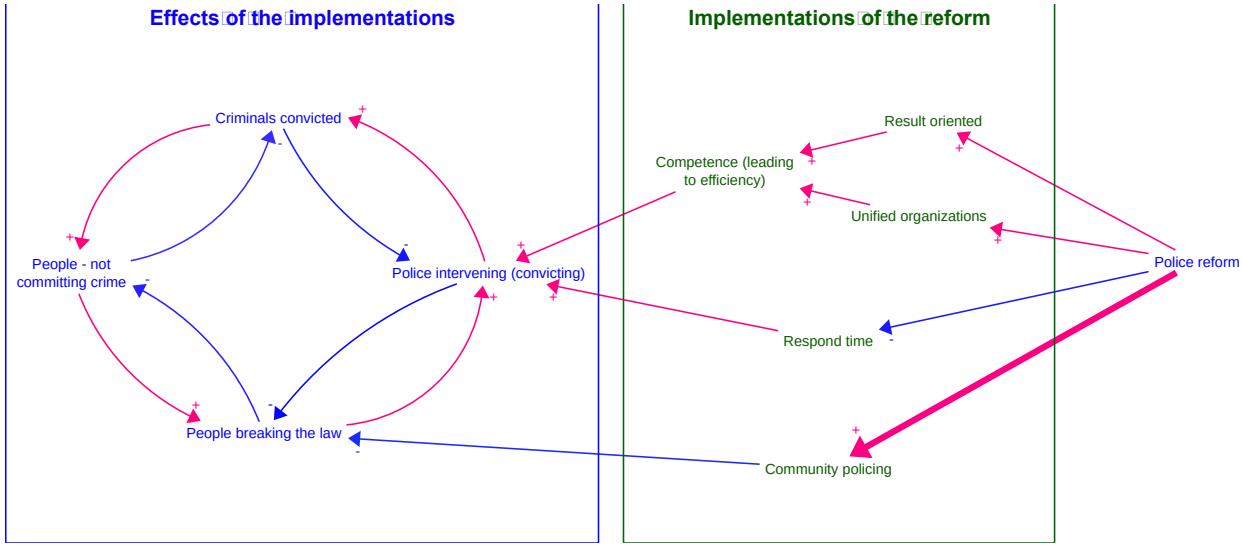


Figure 2.1 The original implentations of the Danish reforms

This is the mental model of the decision makers meant to integrate into the police department. Where the police reform was meant to reduce respond time, focus on results and improve the unified organizations that would lead to a higher competence, and efficiency within the police (Holmberg, 2019, 2021; Holmberg et al., 2017). And a focus on the community policing.

The respond time would increase the police intervening (Holmberg, 2014). The competence would increase the police intervening, as there is more efficiency and competence (Holmberg, 2014). And the community policing would decrease crime, as the visibility increases, and the availability of doing crime decreases (Blesse & Diegmann, 2022). When the police

intervening increases, the crime reduces as the risk of being caught increases (Levitt, 1998b; Rouse, 1985).

The new reform itself is a great idea in reducing crime and increasing the arrests relevant to crime. But we will take a closer look at how the reform took place, and my hypothesis.

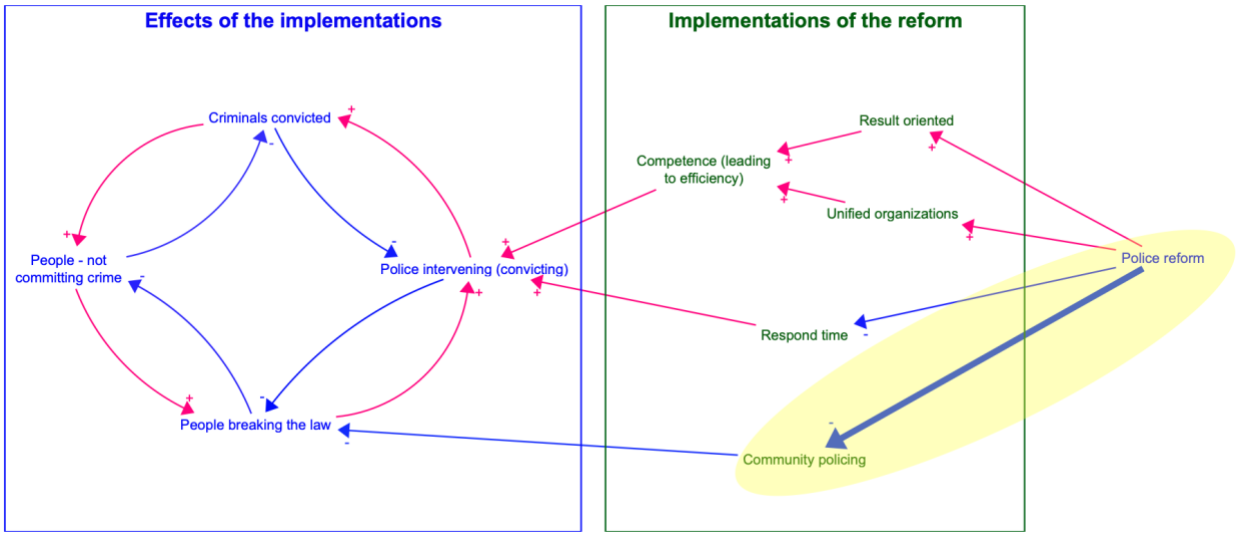


Figure 2.2 The actual implementations of the Danish reforms

In the original plan of the reform, there was a positive relationship between the police reform and community policing (Holmberg, 2019). Meaning that they wanted to increase or focus on community policing. This has not been accomplished. In fact, the community policing has decreased (Holmberg, 2021), with the removal of 63 police stations, and decreasing police surveillance in smaller communities (this relationship is represented by the thick blue negative arrow from “Police reform” to “Community policing” marked in yellow). By decreasing community policing, they have removed a direct effect to decrease crime, and rather promoted a weaker community police, that could eventually increase crime.

2.2 Causal Loop Diagram

We will look at the hybrid Causal Loop Diagram (CLD) that is able to capture the stock and flow system. We use the term R when there is a reinforcing feedback loop. A reinforcing feedback loop is when a change in a system amplifies and reinforces itself, leading to changes in the system, in the same direction as the change (Sterman, 2000). A→(+)B →(+)A, if A increases, B also increases, increasing A. If A decreases, B also decreases, decreasing A. Where they go in a loop, reinforcing themselves.

When we use B, there is a balancing feedback loop. They balance the change, seeking balance and equilibrium (Sterman, 2000). A→(-)B →(+)A, if A increases, B will decrease, making A decrease, which increases B. Balancing the changes in the system.

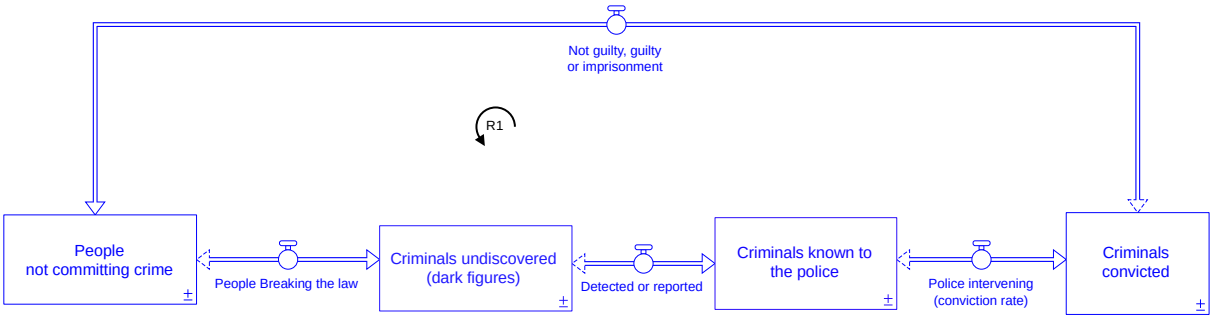


Figure 2.3 R1 Stock and flow system of the population committing crime.

This is R1 and is the first reinforcing feedback loop in the system. It is the main process of the criminal activity. Where if people not committing crime increases the people breaking the law will also increase, due to a percent of the people not committing crime, breaking the law every year though the People breaking the law flow. They then enter the Detected or reported, that is determined by a report and detection rate, that increases the Criminals known to the police. Police intervening (conviction rate) depletes the criminals known to the police stock, and increases the Criminals convicted, dependent on a conviction rate. The flow Not guilty, guilty or imprisonment depletes the Criminals convicted stock and increases People not committing crime.

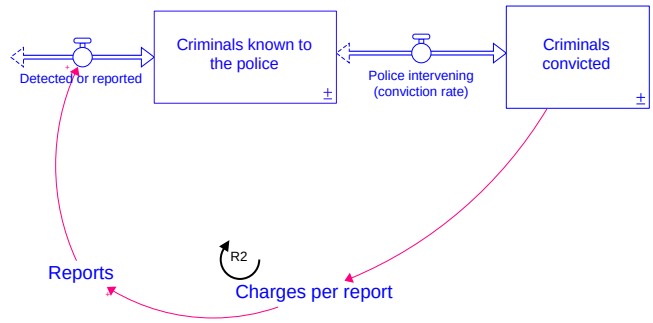


Figure 2.4 R2 Crime Reporting Impact Factor

This is R2, our second reinforcing feedback loop. When the criminals convicted increases, so will the Charges per report. Charges per report, is the conviction rate for the reported, which indicated if the police could convict or intervene in the reported crime. If the Charges per report increases, so will the reports. As the police´s ability to charge the reported, gives an indicator to the public if their effort in reporting crime is "necessary" (Boateng, 2018;

Goudriaan et al., 2006). If the reported were never charged, there would be no necessity in reporting the crime. But if the charges per report does increase, would perceive reporting crime as imperative. Increasing the reporting rate, and crime known to police.

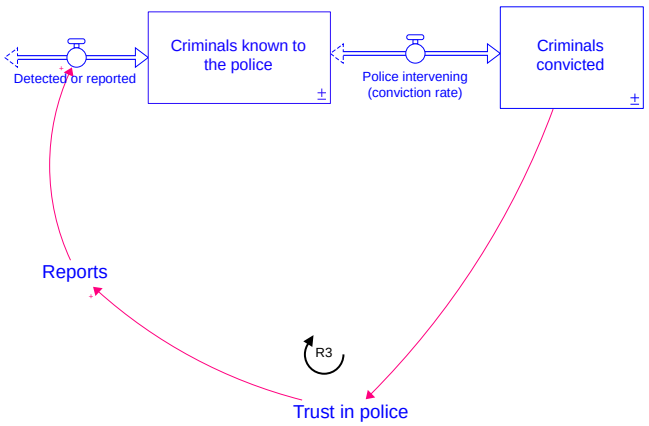


Figure 2.5 Trust-Driven Reporting

This is R3, our third reinforcing feedback loop. When the Criminals convicted increases, so does the Trust in police. The reason for this is that the higher rate of convicted gives a sense of "community policing" as people perceive the arrest rate in the country, increasing the trust when the rate of conviction increases (Hawdon et al., 2003; Maxson et al., 2003; Sindall & Sturgis, 2013; Yesberg et al., 2021). An increase in the trust, will increase the reporting, as people perceive the police as trust worthy, and therefor capable of "solving" their issue, when facing crime (Baumer, 2002; Boateng, 2018; Goudriaan et al., 2006; Levitt, 1998a; Tolsma et al., 2012).

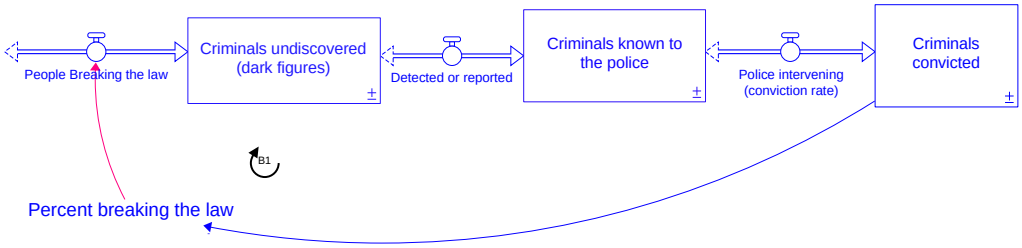


Figure 2.6 B1 crime deterrence by intervening.

This is B1 and is the first balancing feedback loop in the system. When there is an increase in the people breaking the law, the Criminals undiscovered (dark figures) also increases, which causes an increase in Criminals known to the police. This will increase the Police intervening (conviction). When the Police intervening (conviction) increases, the people breaking the law will decrease. This happens because the availability of doing crime decreases,

or the perception people have of getting caught by police when breaking the law increases when the level of convicted increases (Bun et al., 2020; Jackson et al., 2012; Levitt, 1998b). Making the increase in convictions, a decrease in Percent breaking the law.

2.2.1 Exogenous factors in the Causal Loop Diagram

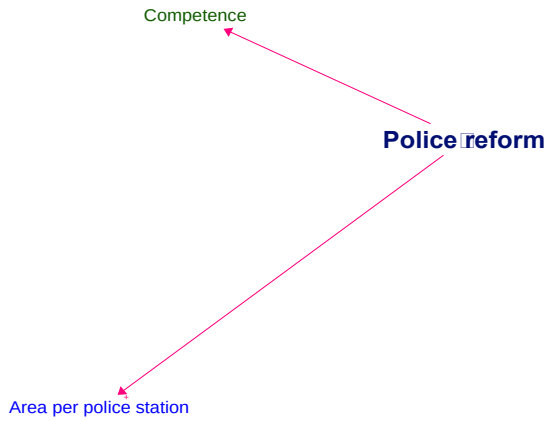


Figure 2.7 Implementations of the reform

These are exogenous factors in the CLD and was implementations of the new reform in Demark. The new focus on competence led the reform to increase the competence in the police force (Holmberg, 2014). It also lead to an increase in the area per police station, as the new reform removed many of the police stations (Justitsministeriet, 2017).

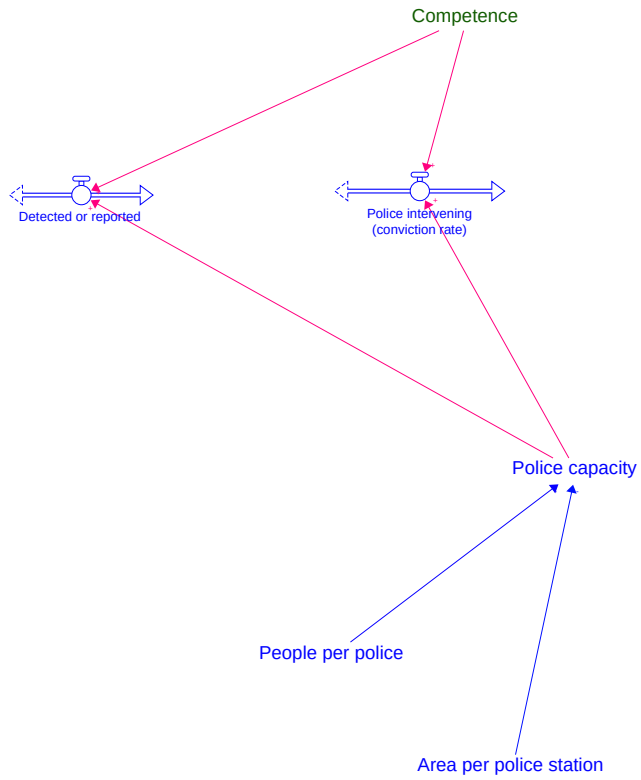


Figure 2.8 Police capacity on Crime known to the police and Police intervening.

The area per police station and people per police have a negative relationship to the Police capacity. An increase in area per police station and people per police leads to a decrease in capacity. In this system the police capacity is determined by the number of police and number of police stations. Where a decrease in police or police stations lead to a decrease in the police capacity. When the police capacity decreases this will decrease the detected rate, as the resources they have to detect crime decreases with the capacity. A decrease in capacity will also lead to a decrease in Police intervening (conviction rate), as there are less resources to convict crime.

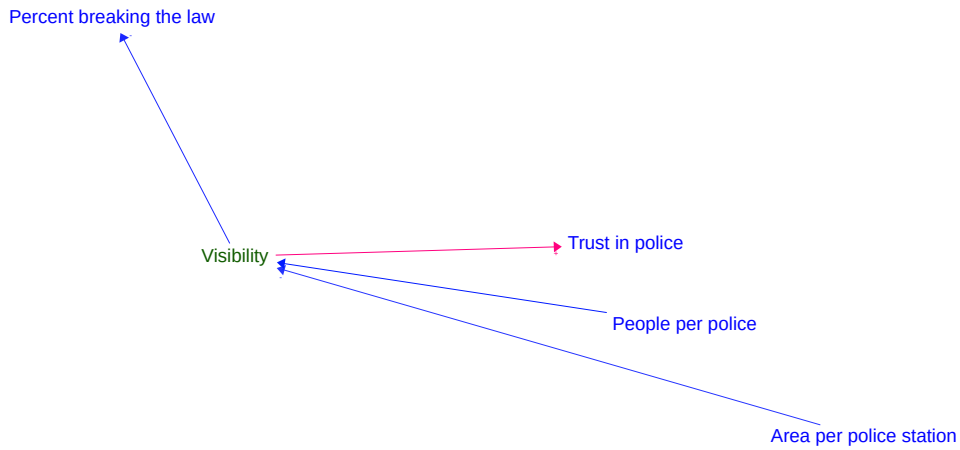


Figure 2.9 Area per police station and People per police on Visibility

If the Area per police station or the People per police increases, there will be a decrease in visibility, this is because the reduction in police will make them less visible in the community, as there are less police. A reduction in police stations will also lead to a reduction in visibility, as they remove an important visual aspect of the police (Yesberg et al., 2021). When there is a decrease in visibility the People breaking the law will increase, due to a decrease in the risk of being detected or caught by police (Bun et al., 2020; Jackson et al., 2012; Rouse, 1985; Sindall & Sturgis, 2013). A decrease in visibility will also lead to a decrease in the Trust in police, because the communities are determining a lot of their trust in police in the frequency of contact, or how their encounter with the police is experienced (Maxson et al., 2003; Yesberg et al., 2021).

2.2.1 Causal Loop Diagram of the modelled police reform

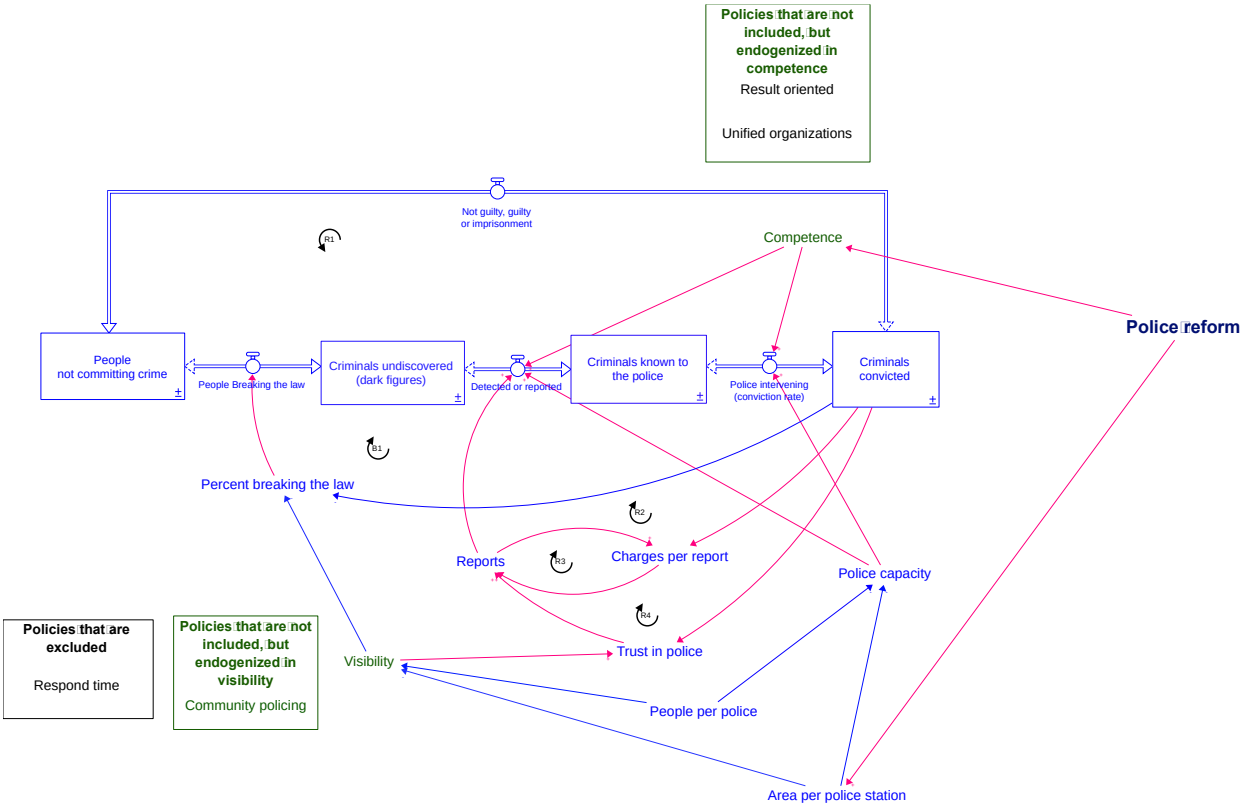


Figure 2.10 CLD of the police reform and its effects.

Figure 2.10 is a CLD of the full CLD. The respond time is not included in this system, as it is difficult to measure, and difficult to incorporate in the model. The policy of being result oriented and a unified organization has been exogenies in competence, as competence is an exogenous stock in the model. Community policing is represented as visibility. For an explanation of the full model structure see *3.2 Structure* tests.

This CLD is a simplified visualization of the model created to capture this system that I am investigating. But as we see in this CLD is that there will be an increase in competence with the police reform, that can increase the performance rate of the police, and help them convict higher rates of criminals. But it also shows a reduction in area per police station (as they remove police stations), which can cause a lot of friction. This will reduce their visibility (Blesse & Diegmann, 2022), that will increase the availability to commit crime and a reduction in trust in police 2.

3. Model structure & validation

The dynamic hypothesis, which was covered in the previous chapter, has been modelled into a simulation model that aids in the visualization of the system, the exploration of future trajectories, and the testing of potential policy solutions. We must put the model through model validation testing to see if it can accurately depict real-world behavior to show realistic findings and evaluate policies. And to build confidence in the model (Homer, 2012; Sterman, 2000). I will in this chapter report Partial model testing, Structure test; that includes boundary adequacy, structure assessment, dimensional consistency, parameter assessment and extreme condition testing. And Behavioral tests that includes integrational error and behavioral reproduction.

3.1 Partial model tests

In this section, we perform a partial model testing. To see if the "decision rules in my model are intendedly rational" (Sterman, 2000, p. 605). To do this test, I have made all the variables that is affecting the main stock and flow system exogenous. Where I have used the historical data as inputs, instead of the simulated once, that have been created. The historical data is only to the year 2021, therefore there will be a constant number after the year 2021, and there will be no change in the behavior.

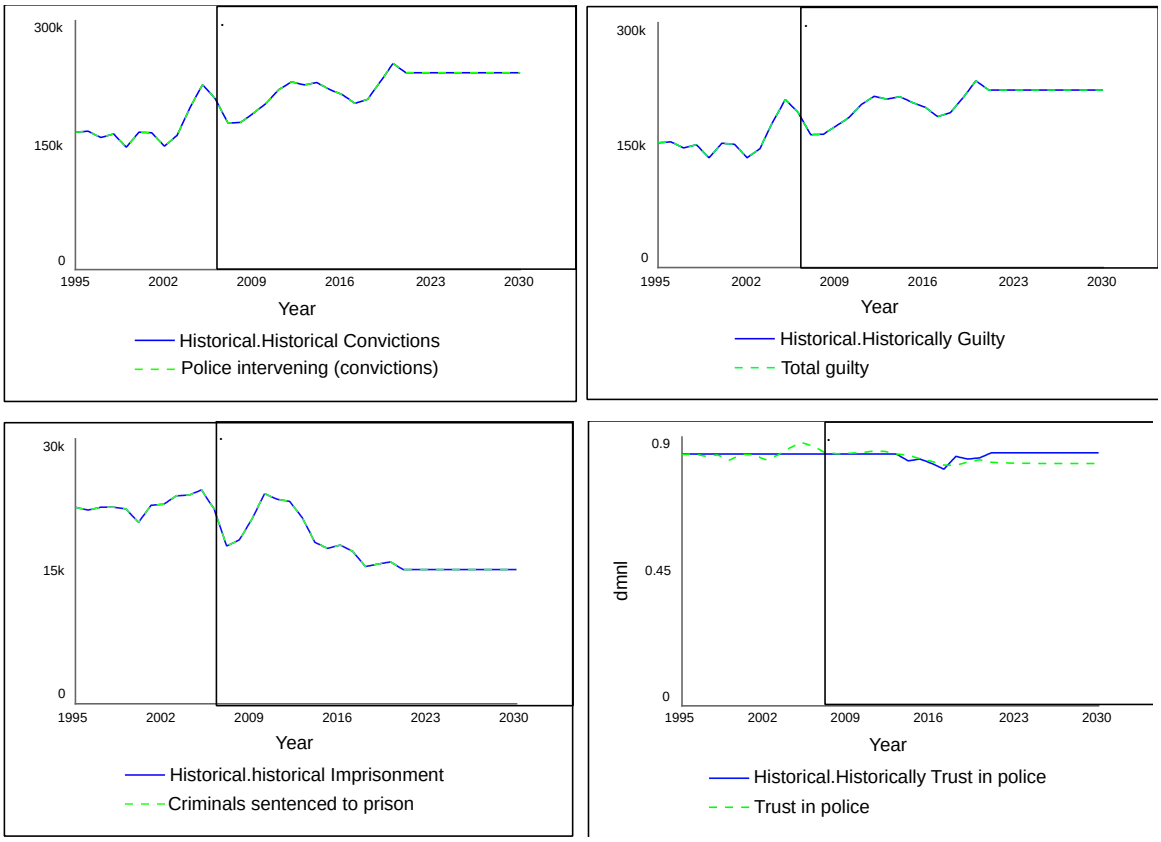


Figure 3.1 Exogenous data inputs: Simulation VS Historical data

For this partial test, we focus on the main stock and flow structure of convictions, guilty and imprisonment. To test this structure, we drive its flows with exogenous inputs, namely the historical data of reported, convictions, the guilty, not guilty, and imprisoned. We observe that the simulated behavior of the stocks matches the historical behavior. Since it does match the behavior, we can verify that the equations used in the stock and flow system does match the real-world behavior of the criminal system.

The trust in this situation is very interesting. Trust is modelled with qualitative data found through literature review. The trust has not been replaced by the historical data, as there is little data on trust. This finds confident that the assumptions are correct about how trust is affected by the system. It does not match the historical data perfectly, but we can see the same increasing and decreasing behavior. We only have data on the trust from 2013 till 2021. The reason for this behavior, is that the Police intervening flow is increasing, making the effect of intervening on trust to increase with it. The decreases we see is determined by the Visibility sector, where visibility decreases with the reform SWITCH in 2006.

3.2 Structure tests

3.2.1 Boundary adequacy

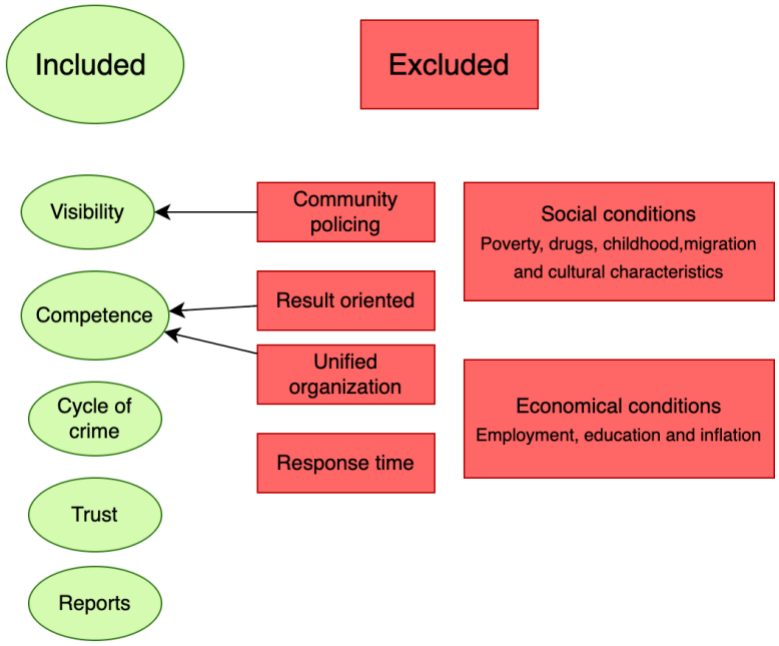


Figure 3.2 Boundary diagram

To assess the boundary adequacy, we need to see if we have the structure necessary to satisfy the models purpose (Bala et al., 2017) and if the level of aggregation and boundaries are justified (Sterman, 2000).

The purpose of the model is to represent the new police reform in Denmark. I have focused on the Danish system, as Denmark was the first country to implement the reform in Scandinavia. The new focus of the reform included “efficiency, fast response time, uniform organization across districts and management by results” (Holmberg, 2019).

The needed structure to invest the relevant subjects of the paper, is the cycle of people breaking the law and is justified through data and literature. The report- and charge sector is justified through literature and data. We have the sector of population and police sector, that is built on historical data, except the police capacity. The visibility-, breaking the law-, police intervening and trust sector is justified through literature.

Competence sector is very unpredictable, this is a focus that came with the reform, were they want to focus on police training and gaining efficiency. It is unpredictable as there is no reference value as to how high the competence can go, how many years it takes for them to reach

certain levels. It is mostly based on assumptions on how competence work, but the effects coming from competence are justified through literature. But the actual level of competence, and time to acquire this competence is assumed, as this is something that the new reform wanted to increase. I have therefore not looked into how other parts of this system can eventually effect competence.

Now, these are the included variables in the model I have created. There are several other, important, factors that play a role in the criminal activity in a country. This model only captures the police department´s influence on crime. Where community policing has been represented in visibility. Result oriented police institution and a unified organization has been exogenized in competence. Response time has not been included at all, because it is difficult to capture in the system I have created, and therefore not included. We have several social- and economic conditions that are very important for the level of crime in a country (Loureiro et al., 2009; Simons & Burt, 2011), that has not been included. This is because in this thesis I am focusing on the police´s influence on the criminal activity in a country and the impact of the police reform.

3.2.2 Structure assessment

Structure assessment is done to ensure that the model follows the real-life behavior, or structure of the system, to validate the structure of the model (Barlas, 1996; Rahmandad & Sterman, 2012).

3.2.2.1 Population and police sector

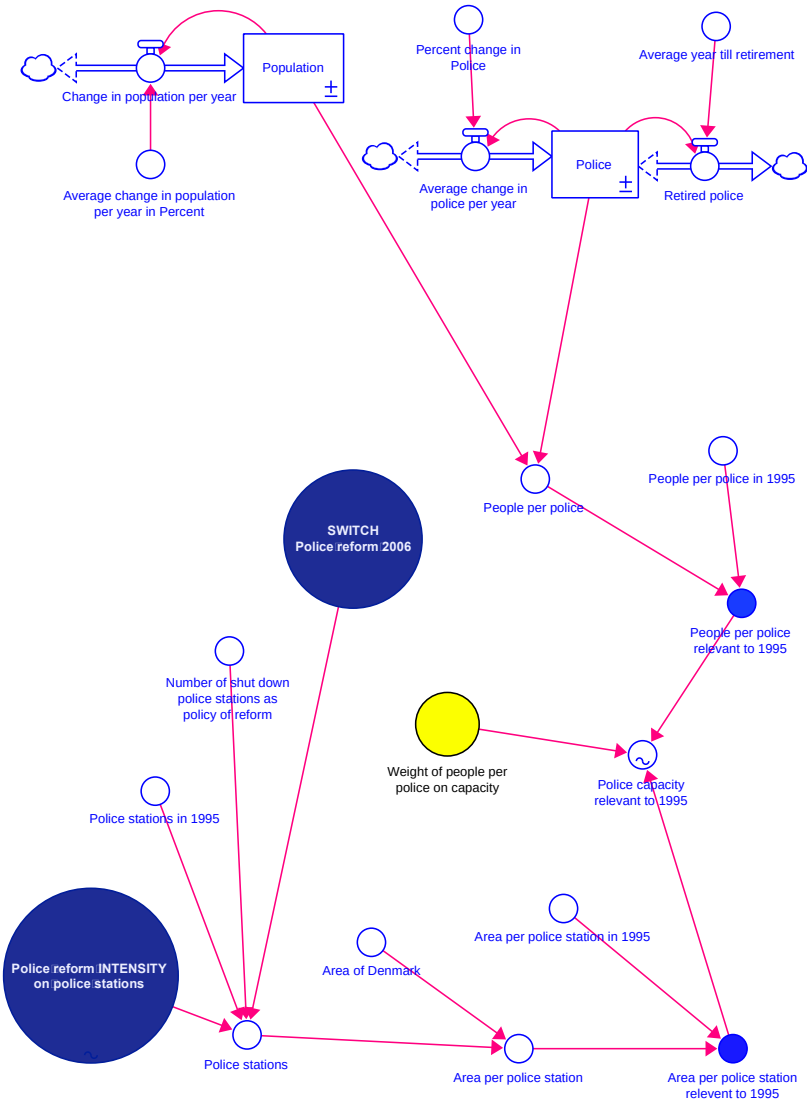


Figure 3.3 Population and police sector

The population and police sector represents the change in population (Statistics Denmark, 2023e), police (Rigspolitiet, 2022), and police station (Justitsministeriet, 2017) each year. This is based on data from Denmark and does match the historical behavior. We use the variables of People per police and Area per police station to measure the relative differences from 1995 until simulated time.

The SWITCH represents the police reform. If this is turned to 0 there is no police reform happening in 2006, if its 1 then the reform is happening in 2006 and the reduction of police stations are implemented in this sector. Based on the policies of the reform.

3.2.2.2 *Visibility sector*

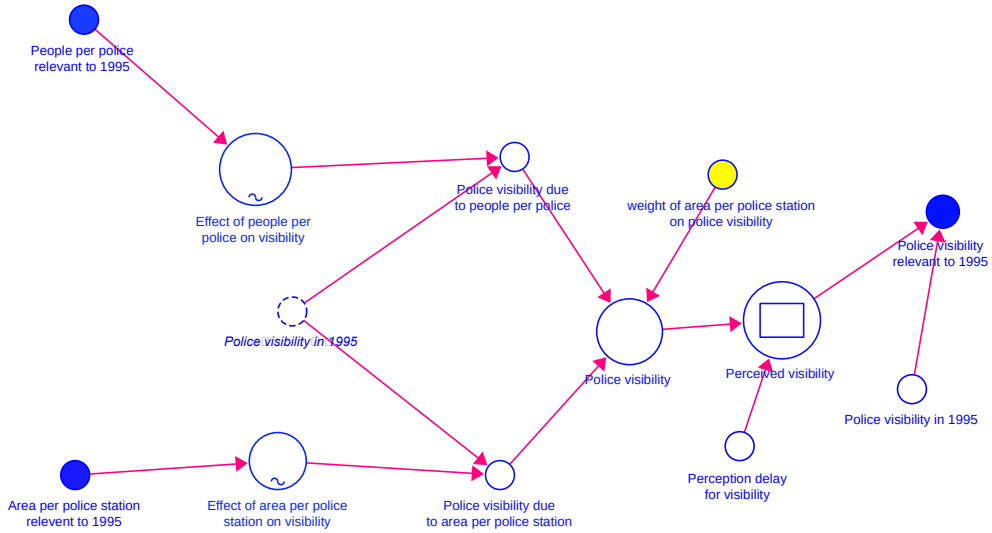


Figure 3.4 Visibility sector

We have two graphical functions, the "effect of people per police on visibility, and is influenced by the "people per police relative to 1995". When people per police increases, the visibility decreases (Levitt, 1998b) as there are relatively less police officers. We also have the "effect of area per police station on visibility" that is influenced by the "area per police station relevant to 1995". Where if the area per police station increases, the visibility decreases (Blesse & Diegmann, 2022) as there are bigger areas to cover per police station. And by removing police station, you also remove a visible policed area. They both influence the police visibility that is based off Norwegian statistics of how many have been in contact with the police (either seen them or interfered with them) (Politidirektoratet, 2023), since there was no data on this for Denmark. We also have perceived visibility as it takes time for them to perceive the visibility, where there is a delay set to 2 years. The assumption of a 2-year delay in the perception of visibility is based on an understanding that outcomes, or changes often require time to be noticed and perceived by the individual. A change in visibility is something that does not happen instantaneously, but rather slowly, and takes time to notice.

3.2.2.3 *Breaking the law sector*

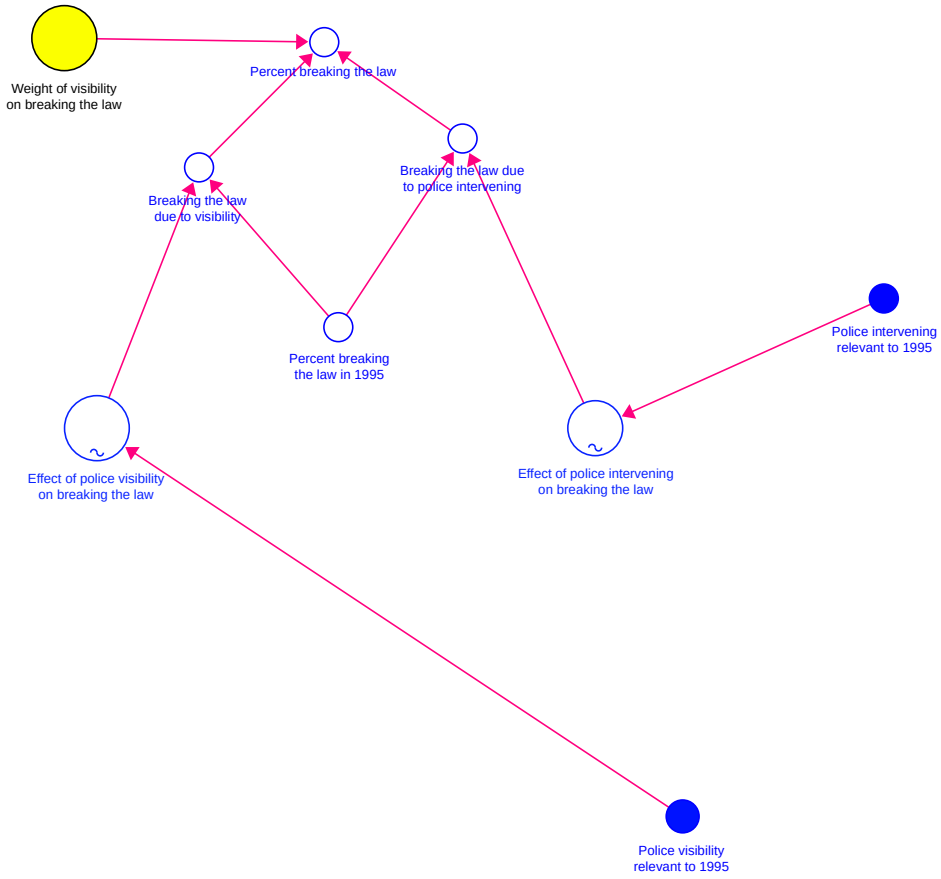


Figure 3.5 Breaking the law sector

This is the breaking the law sector. We have two graphical functions where the "effect of police visibility on breaking the law" is influenced by the "police visibility relevant to 1995". When visibility decreases, the crime rate will increase (Klick & Tabarrok, 2005) as the availability for doing crime increases. The other graphical function is the "effect of police intervening on breaking the law" that is influenced by the" police intervening" flow (Figure 3.6). When police intervening is decreasing, the crime increases, as the consequences for doing crime will be perceived as non-existing (at an extremely low level) (Rouse, 1985). They both influence the "Percent breaking the law" variable.

3.2.2.4 Police intervening sector.

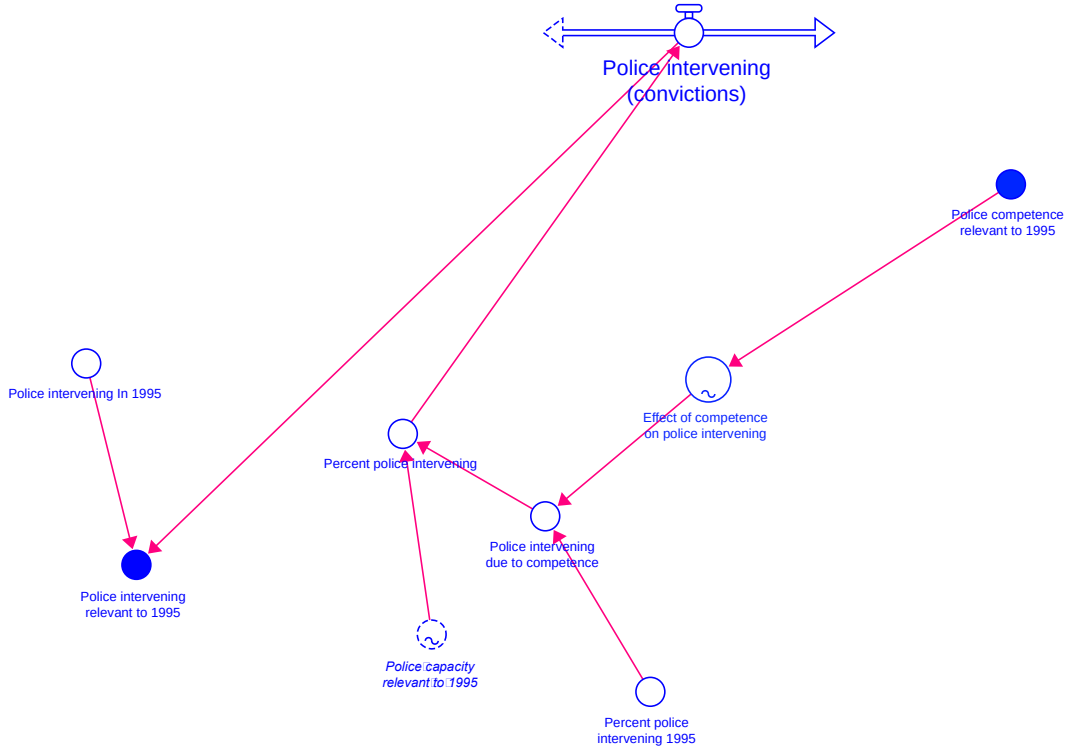


Figure 3.6 Police intervening sector.

The percent police intervening is influenced by the “Police capacity relevant to 1995” (Figure 3.3) when police capacity increases so does the percent police intervening, as the capacity is higher. The intervening is also influenced by “effect of competence on police intervening”, where the intervening increases if competence is higher (Bennell et al., 2022).

3.2.2.5 *Trust sector*

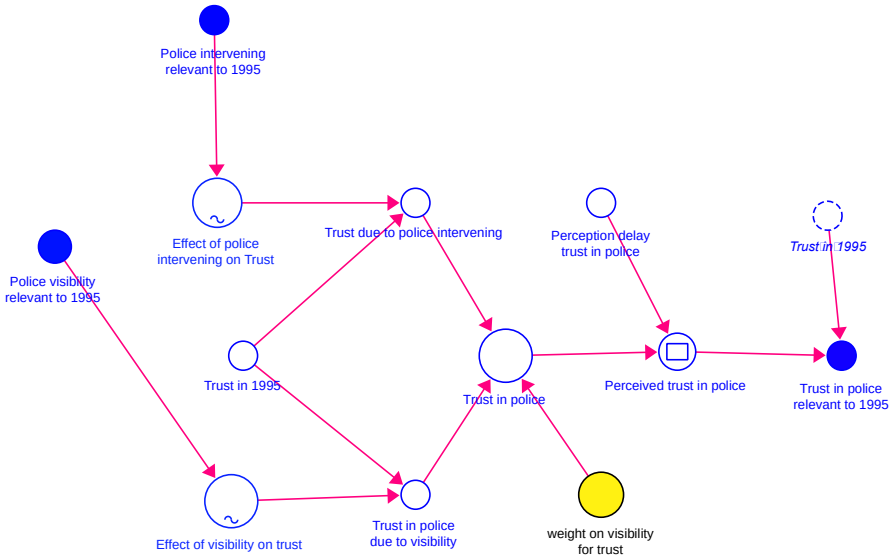


Figure 3.7 Trust sector

There are two graphical functions that influence the "trust in police" variable. The "effect of police intervening on trust" that is influenced by the "police intervening relevant to 1995". If the intervening increases, the trust will also increase (Hawdon et al., 2003). Competence also influences the trust indirectly, through the Police intervening. As an increase in competence, leads to an increase in the intervening rate, making trust to increase. The "effect of visibility on trust" is influence by the "police visibility relevant to 1995", where if visibility increases, so does the trust (Hawdon et al., 2003; Maxson et al., 2003). The trust in Denmark is set at 84.3% (Justitsministeriets, 2022). We then have perceived trust, as it takes time to gain or lose trust, and the delay is set at 2 years. As with visibility, the assumption of a 2-year delay in the perception of trust is based on an understanding that outcomes, or changes often require time to be noticed and perceived by the individual. A change in trust is something that does not happen instantaneously, but rather slowly, and takes time to notice.

3.2.2.6 Charges sector

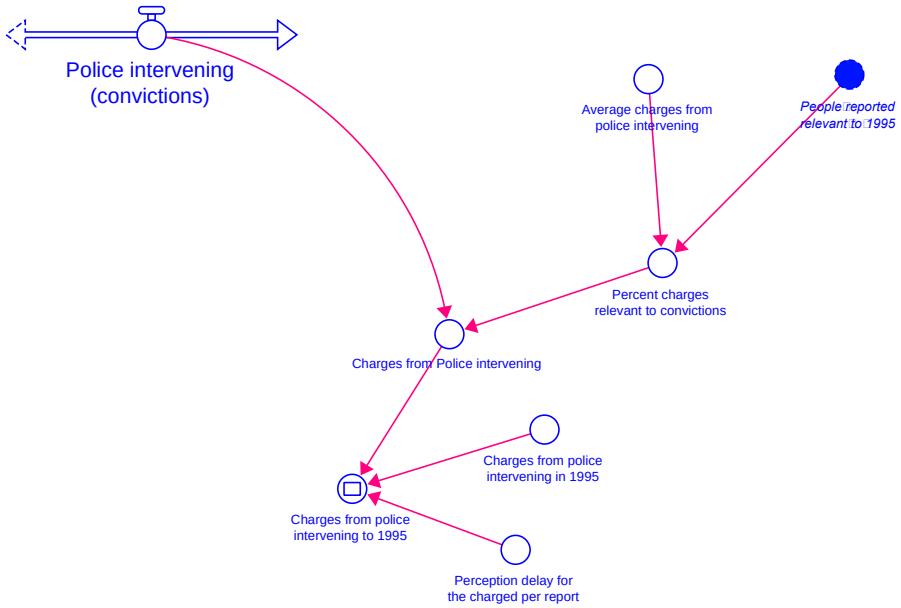


Figure 3.8 Charges sector

Charges is the number of convicted because of a report. Charges is calculated by the percentage of charges from police intervening (Statistics Denmark, 2023f) based off the "people reported relevant to 1995". Where we get the "charges from police intervening", that is also affected by the "police intervening flow". Where the number of charges is finally calculated in the "charges from police intervening to 1995", where there is a perception delay set as 2-years. As it takes time for the people to perceive that the reported has been charged. This is an assumption, as with the visibility and trust. A change in perception of charges is something that does not happen instantaneously, but rather slowly, and takes time to notice.

3.2.2.7 Report sector

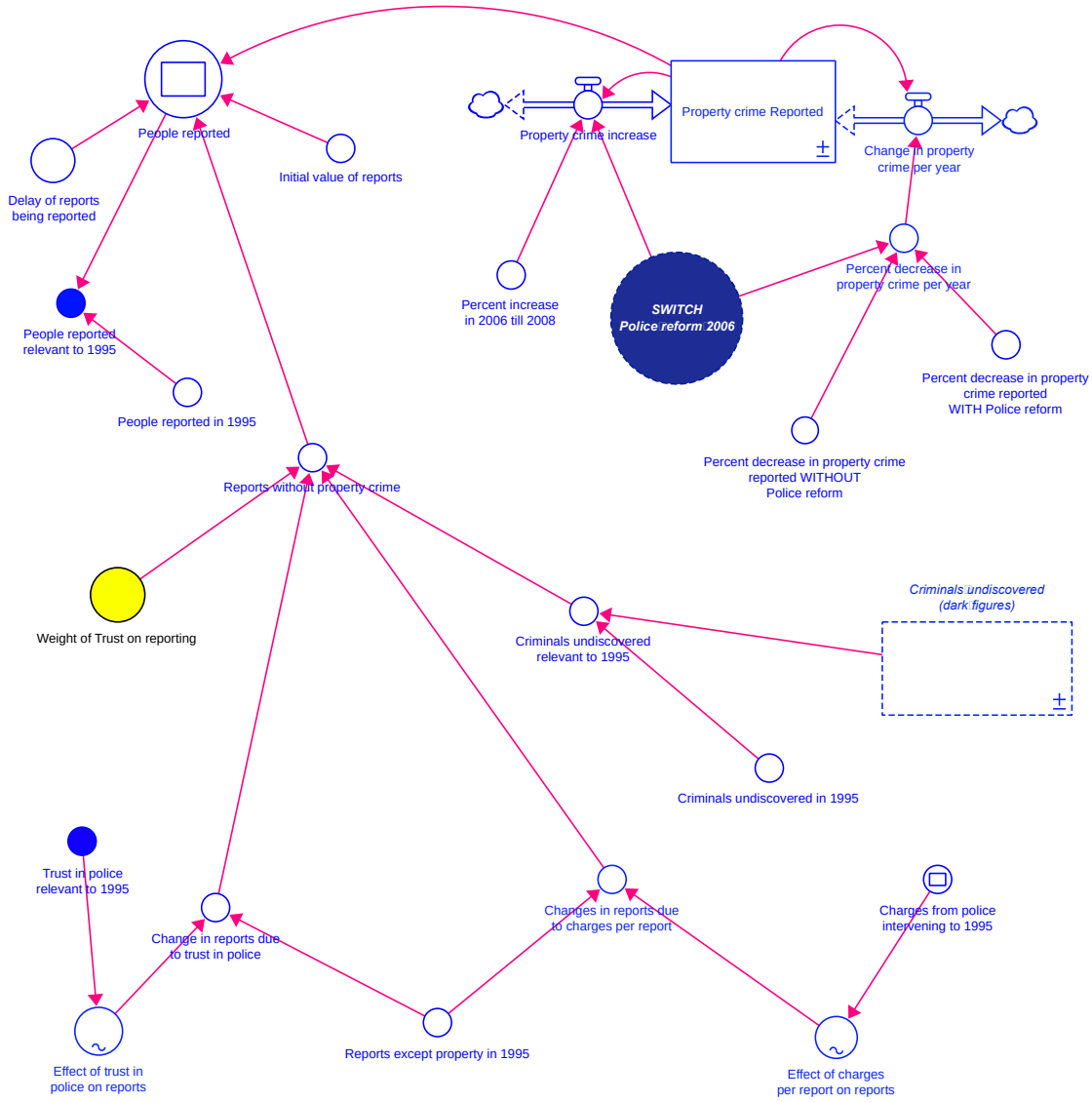


Figure 3.9 Report sector

The report sector is split in two categories of crime: Property crime and reports without property crime. The reason for this is that Property crime is a large proportion of the total number of reported crime and has been decreasing a lot over the years (Statistics Denmark, 2023f) and may be controlled by reasons beyond those represented in the model, and is exogenous. I have found some literature that can indicate that the reason for this is that property crime is not "serious enough" for people to report when visibility or community policing is decreasing (Buil-Gil et al., 2021), or when the neighborhoods safety levels are low, I would need a lot of different structures to be able to visualize the behavior of the property crime. So, the

property crime is exogenized and is replicating the behavior of the historical property crime reporting (Statistics Denmark, 2023f).

We do see some changes in the “reports without property”, coming from two graphical effects and the “criminals undiscovered relevant to 1995”. The “reports without property” increases if “effect of trust in police on reporting” is increasing, as an increase in trust leads to a belief that police will help if a crime is reported (Buil-Gil et al., 2021). The “reports without property” increases if the “effect of charges per report in reports” increases, as this will increase the success rate for reporting a crime and increase the perception we have of the effect of reporting.

3.2.2.8 Police competence sector

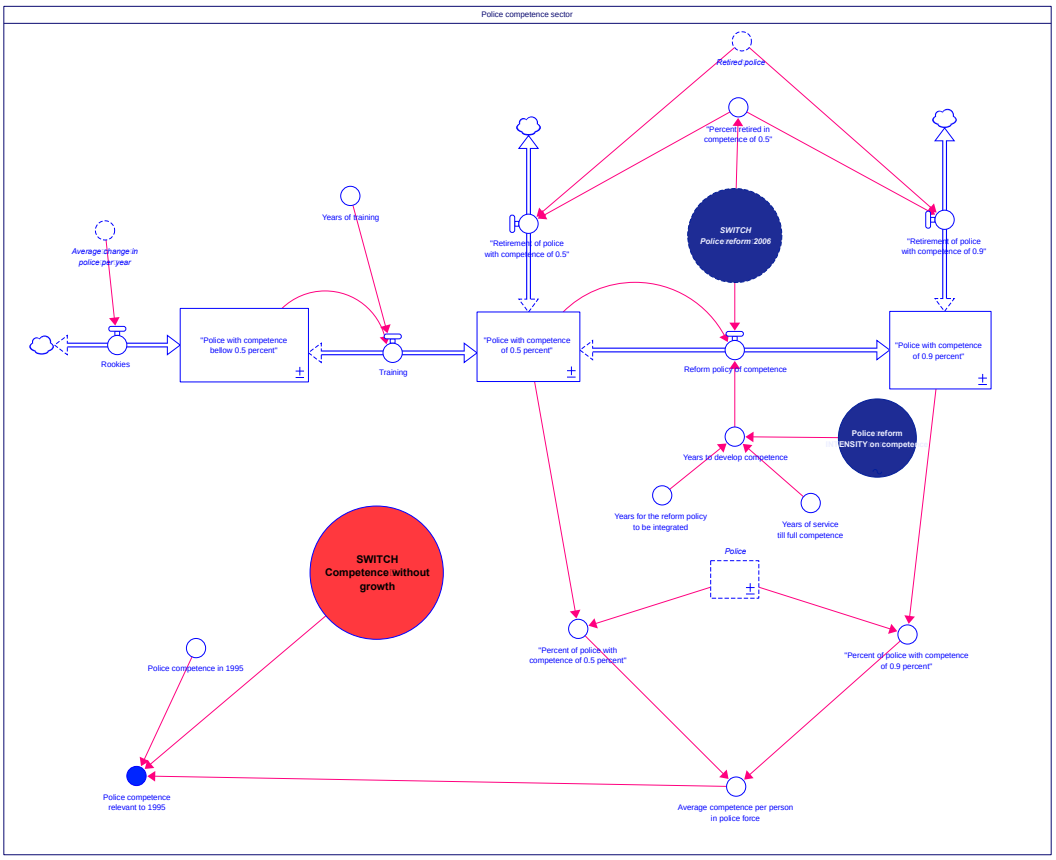


Figure 3.10 Police competence sector

The police competence sector is an assumption. As a policy for the reform, they wanted to focus on the competence of the police. The competence increases after people have been in training or working in the field for X number of years. But because of the reform, extra training takes place, as they are focusing on the knowledge the police obtain. All the new police start off

in the “rookies” flow. Where they enter “Police with competence bellow 0.5” stock. They then enter the flow of “training”, where there is a delay of 3 years. As it takes about 3 years for the to reach the competence of 0.5. This is because it takes time for them to get experience in the field. I have assumed that all police officers will reach 0.5 in competence, even without the reform. Where some proportion of the people in the stock of 0.5 in competence will retire. When the “switch” is set to 1 (meaning the reform happens in 2006), the people in the stock of “Police with competence of 0.5” will enter the “reform policy of competence” flow. Where after time that is decided by the “years to develop competence” variable, they will enter the “Police with competence of 0.9”. Where they also retire from this stock. The “average competence per person in police force” calculates the competence, so it can be compared to 1995. I also have a SWITCH for the competence without growth. This is to see the potential behavior of the system if the competence stayed the same as it was in 1995.

3.2.2.9 Stock and flow of criminal

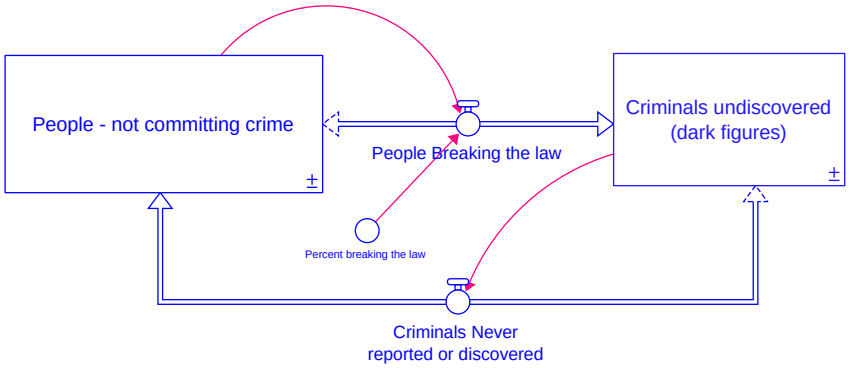


Figure 3.11 Breaking the law flow

The people breaking the law is determined by “percent breaking the law” that is calibrated and calculated based on dark figures (Buil-Gil et al., 2021). See the Breaking the law sector for a further explanation on the “Percent breaking the law”.

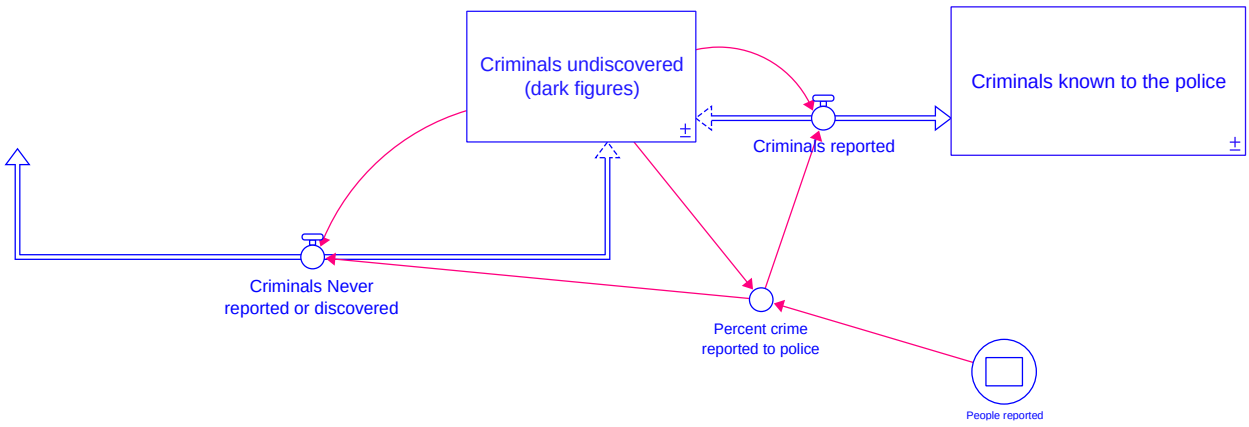


Figure 3.12 Crime reported flow

The "percent crime reported to police" is affected by the People reporting relevant to 1995 (Statistics Denmark, 2023f) and is deciding the present of Criminals reported and Criminals never reported or discovered. See the Report sector for a in depth explanation of the People reported.

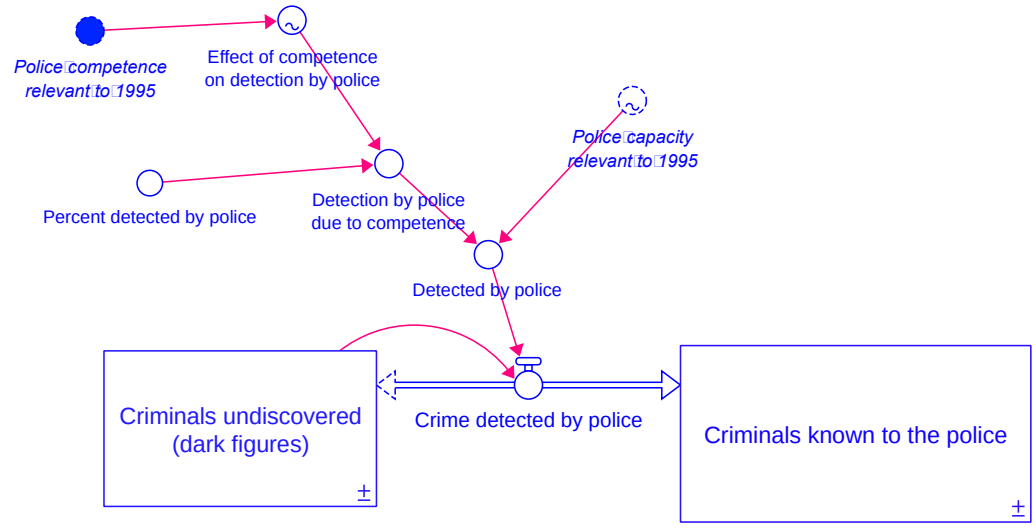


Figure 3.13 Crime detected flow

The detected by police is determined by the Police Competence relevant to 1995, Percent detected by police and the Police capacity. Where an increase in competence or capacity will increase the detection, due to the increase in tools to detect crime (Blesse & Diegmann, 2022). For a further explanation of the percent detected by the police see Documentation: Criminal activity sector. For a further explanation of the competence see Police competence sector, or for the capacity see Population and police sector.

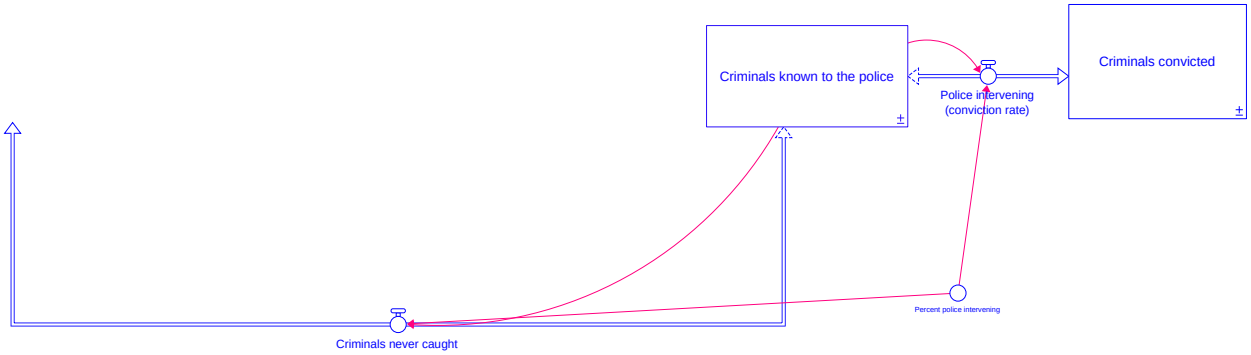


Figure 3.14 Police intervening flow

The police intervening (convictions) flow is determined by the Police intervening (Statistics Denmark, 2023d). Where an increase in the intervening will lead to a higher fraction going into the Police intervening (conviction) flow, and less in the Criminals never caught flow. For a further explanation of the Percent police intervening see the Police intervening sector.

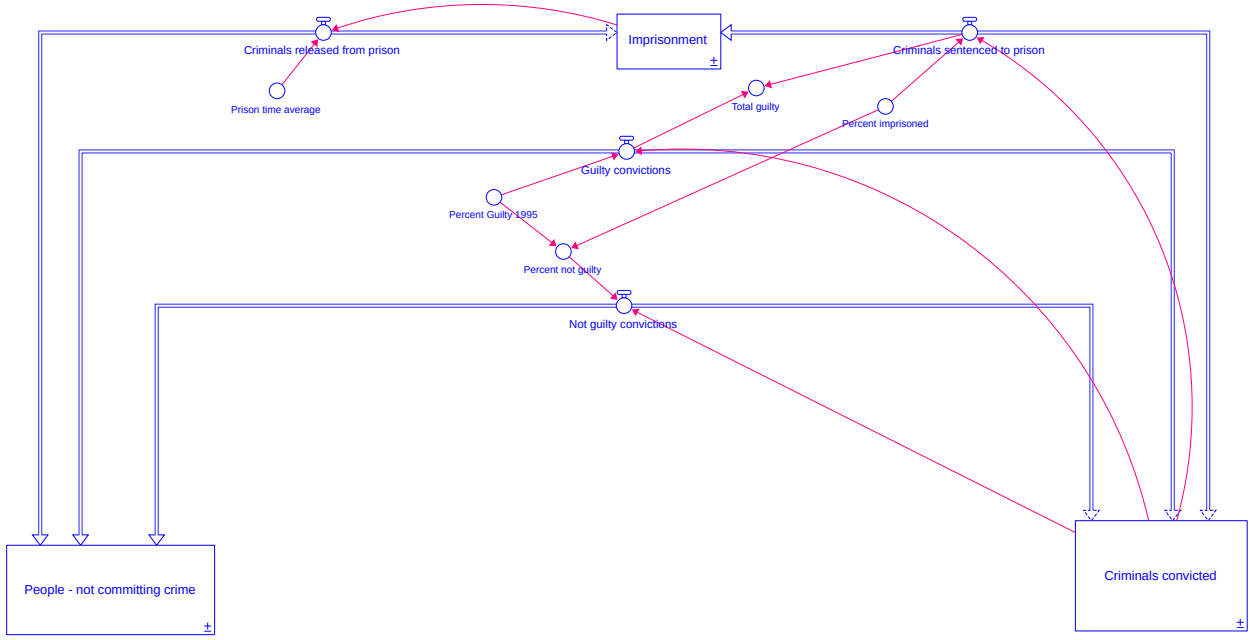


Figure 3.15 Guilty, Not guilty and prison flow

All the fractions of imprisonment, guilty and not guilty decisions are also based off data from Denmark (Statistics Denmark, 2023d). None of them are affected by any other variable in the system. The outflow of Imprisonment, Criminals released from prison, has a delay time of 0.6, as the average time for people to be in prison is a bit over 6 months.

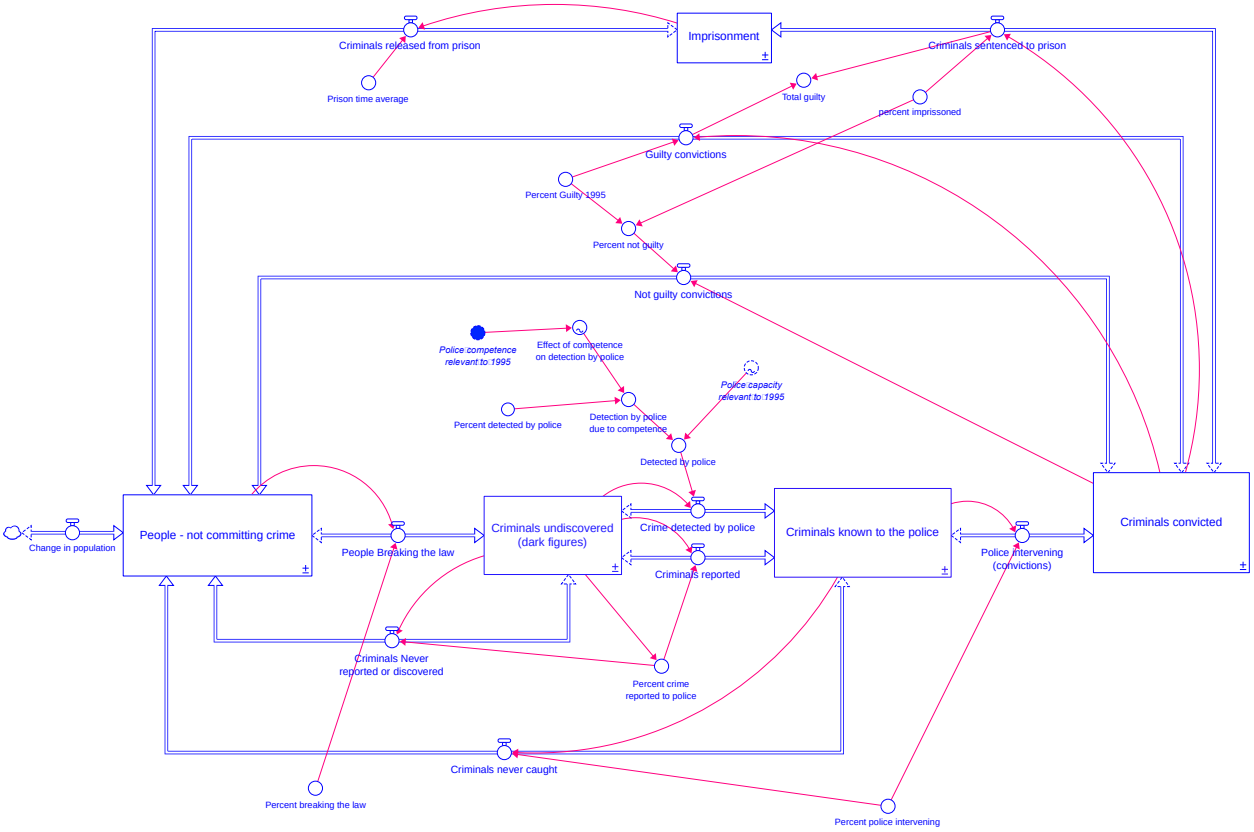


Figure 3.16 Stock and flow of criminals

To finalize this section, we have the full stock and flow of the criminal sector. Where the system is based off the criminal cycle of breaking the law, being discovered, reported, or never reported or discovered. Being convicted or never caught. And then getting a sentence of guilty, not guilty or imprisonment. And then end up in the People – not committing crime stock.

3.2.3 Dimensional consistency

All the parameters, variables, stocks and flows is dimensionally consistent, where they all have "real world" meaning and are mathematically consistent (Sterman, 2000). There are no unit errors that was detected by the modelling software (Stella Architect 3.2). See II. Model Documentation for further explanation of each variable.

3.2.4 Parameter assessment

The parameter assessments is to ensure that the parameter values are "consistent with relevant descriptive and numerical knowledge about the system (Sterman, 2000, p.859). Most of the parameters are based on historical data or calculated by the average change per year in the

historical data (Statistics Denmark, 2023d, 2023f, 2023e, 2023b, 2023c, 2023a). The assumed parameters are the delays, weights, and the parameters in the competence sector.

More details can be found in the I. Sensitivity Analysis and II. Model Documentation.

3.2.5 Extreme conditions

I have performed extreme condition testing to ensure that my model is showing the expected behavior, when affected by extreme conditions (Forrester & Senge, 1980). The use of MAX and MIN functions have been used to ensure that the quantity of the flows is not exceeding the stocks. Through the Police capacity, there has also been assured that with no police, there will be no crime detected by police, and no police intervening (conviction rate). With these measures there has been no errors detected when extreme condition testing. The MIN function has also been used in the visibility and trust, to ensure it can't become more than 1 (100 percent).

Parameter	**Sector**	**Extreme condition**
Percent change in Police	Population and police sector	0

Table 3.1 Extreme conditions Percent change in police

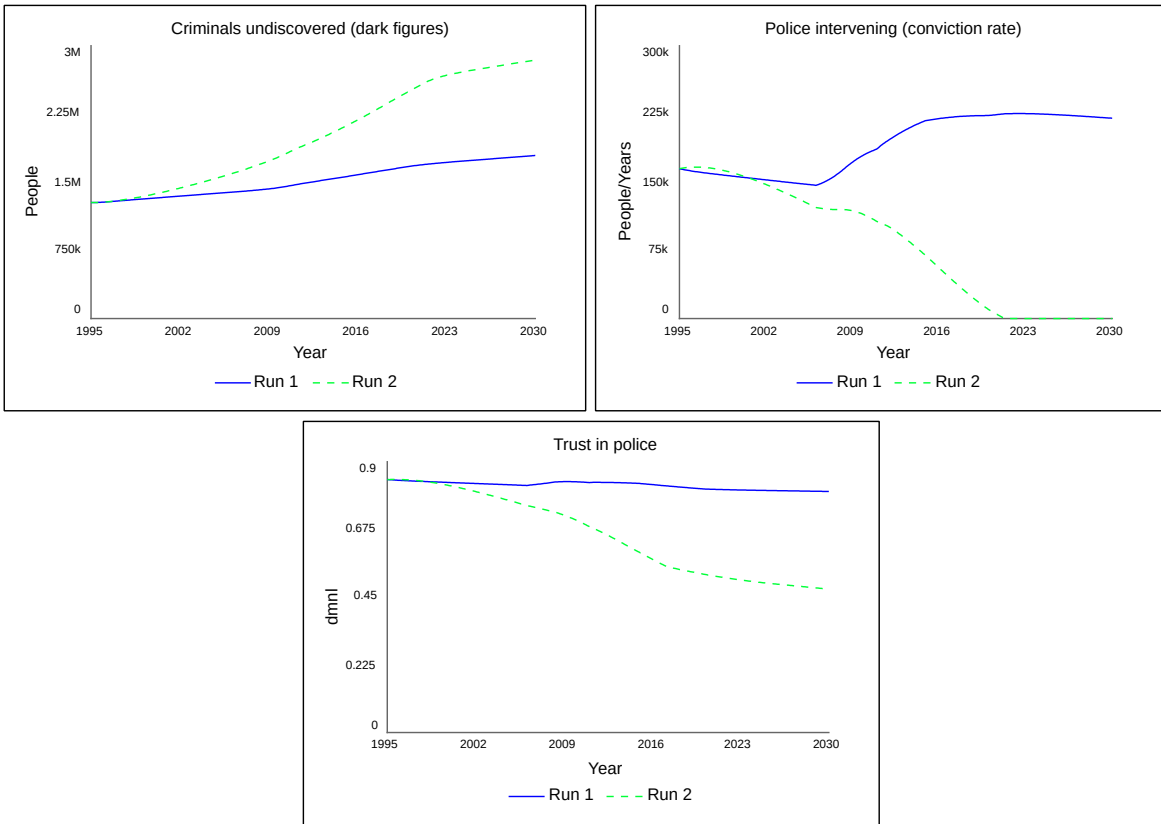


Figure 3.17 Behavior under extreme conditions: Police

We can see that when the Percent change in police is reduced to 0, the conviction rate is decreasing to 0 as the police capacity is too low for the police to intervene, and convict. And with the reduction in police, the Criminals undiscovered (dark figures) increases, and the visibility will decrease, creating the decrease in trust.

Parameter	Sector	Extreme condition
Percent change in Police	Population and police sector	0.35
Number of shut down police stations as policy of the reform	Population and police sector	150

Table 3.2 Extreme conditions for Police and Police stations

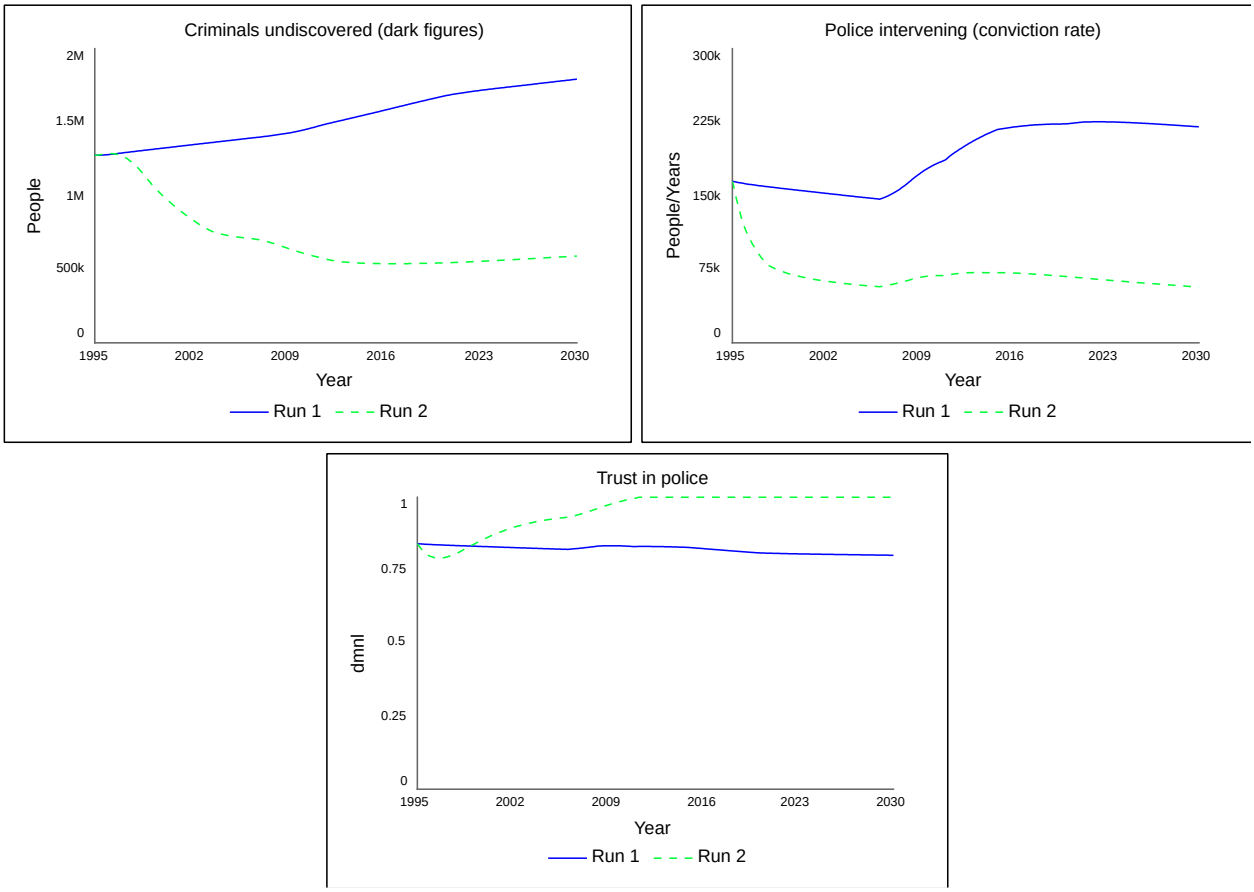


Figure 3.18 Behavior under extreme conditions: Police and police stations

Run 1 is the baseline and Run 2 is the extreme conditions tested. If we increase the Percent change in Police and the Number of shut down police stations as policy of the reform from -63 to +150, the trust will reach 1, but not exceed 1. And the dark figures, and police

intervening (conviction rate) will decrease, as the visibility is relatively high, causing the dark figures to decrease drastically and therefore the decrease in people to convict.

3.3 Behavior tests

3.3.1 Integration error

Integration error testing is to test if the model is sensitive to the change in either the integration interval or the integration method (Sterman, 2000). I am using Euler as integration method and changing it to others like RK2 or RK4 does not show any difference. I am using 1/32 years as the integration interval. To test if the choice of interval and method is consistent with the model, I have cut the interval time in half and doubled it (Sterman, 2000) (1/16 years and 1/64 years), with both Euler and RK4, and RK2 and there is no difference in the behaviors.

3.3.2 Behavior reproduction

Testing the behavior reproduction, is to see how well the model can reproduce the historical behavior (Sterman, 2000). The historical behavior and the simulated behavior are not punctually matching but has the same looking behaviors. The simulated model is not complex enough to capture the yearly changes, but to capture the average changes in historical behavior. We will take a further look at this in the chapter 4 Analysis of Simulation results.

4. Analysis of Simulation results

In this chapter we will look at the simulated behavior compared to the historical, to see if the behaviors are matching. This is to validate that the model has real life consistency and can reproduce real life behaviors. We will then take a further look at the policy options for the current situation, to improve the situation.

4.1 Historical reproduction

4.1.1 Testing the Criminals convicted

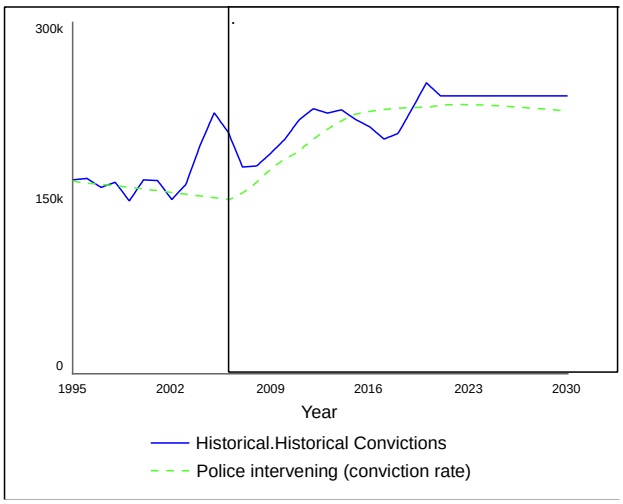


Figure 4.1 Criminals convicted: Simulated vs historical.

The simulated behavior (dotted green line) is not identical to the historical line (blue, solid line). But it does follow the same behavior. The system I have created only focuses on a simplified police institution, how this operates and effect criminal behaviors.

The main drivers of Criminals convicted is closing of police stations, that effects the visibility, making the Percent breaking the law to increase, this makes the Criminals undiscovered to increase, increasing the number of convicted criminals. And the Competence that effects the percent police intervening when the competence increases, as it does after 2006, the percent of police intervening also increases, creating an increase in the Criminals convicted stock.

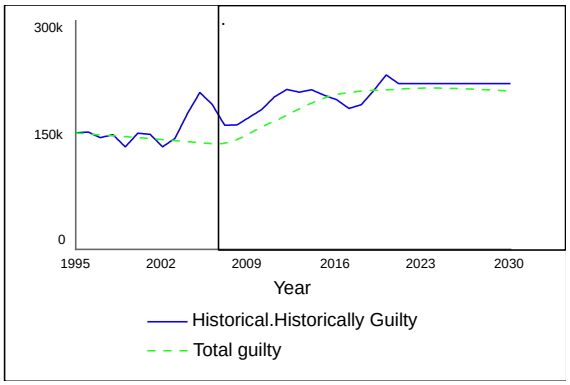


Figure 4.2 Guilty convictions: Simulated vs historical

The total guilty convictions are controlled by two parameters that have been calculated based on historical data. Those parameters are the percent guilty, and the percent imprisoned. Percent imprisoned is 13.4 percent and percent guilty is 78.8 percent. Making the guilty 92.2 percent in total (Statistics Denmark, 2023d).

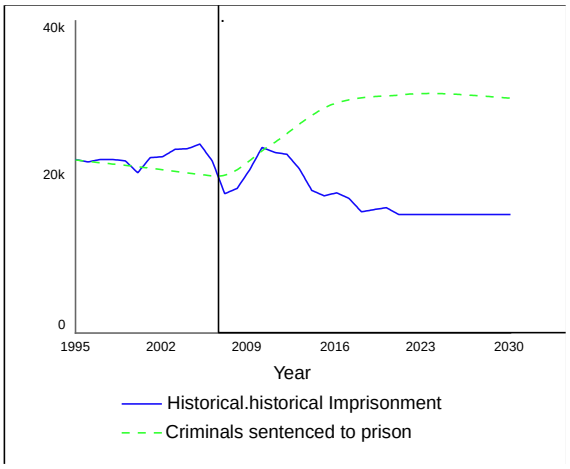


Figure 4.3 Imprisonment: Simulated vs historical

The simulated behavior of the imprisoned is based on a set fraction of 13.4 percent. The fraction is calculated based on the average percent of imprisoned (Statistics Denmark, 2023d). The historical fraction does change a lot, and in my model, I have not made anything effect the fraction of guilty, not guilty and imprisonments. This has not been a focus, and the small changes in these fraction does not affect the model, as the range of imprisoned is at the lowest 0.065 and highest is at 0.14 in the historical data. The only place it makes a change is in the number of Criminals sentenced to prison, and the difference from the historical background as you see here. But the fraction of imprisoned is small, compared to the total guilty.

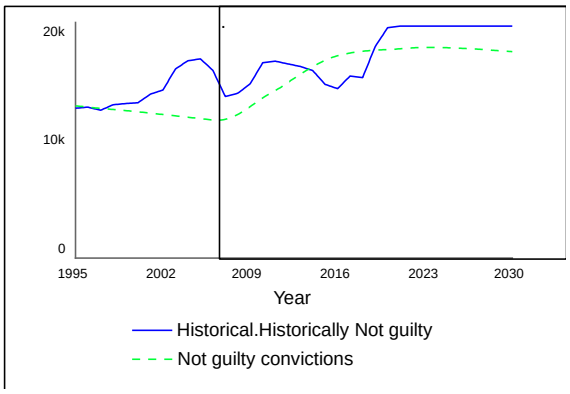


Figure 4.4 Not guilty convictions: Simulated vs historical

The not guilty convictions are decided by a parameter where the fraction is based on 1- the imprisoned fraction and guilty fraction, which is calculated to 7.8 percent (Statistics Denmark, 2023d).

4.1.2 Testing the Trust in police

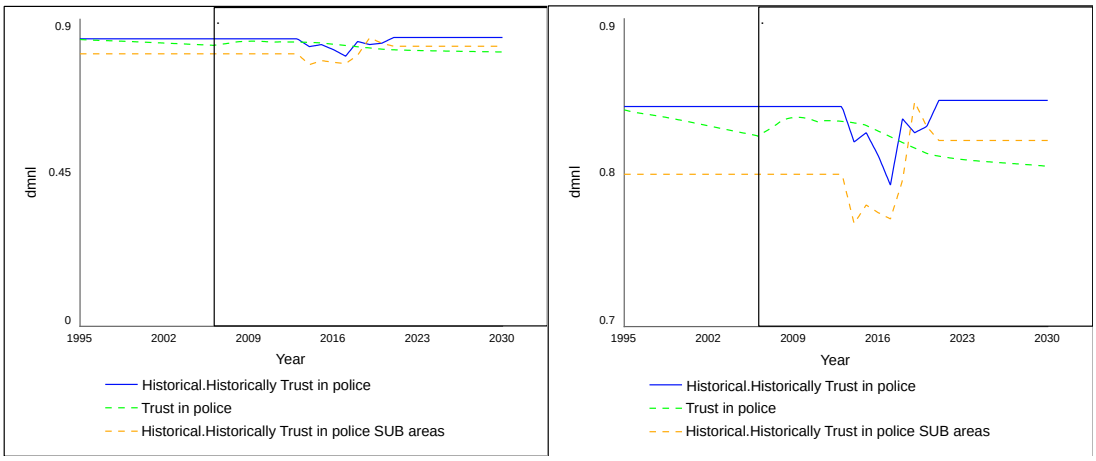


Figure 4.5 Trust in police: Simulated vs historical

The graph on the left has the Y axis values of 0 to 0.9, and the right Y axis values of 0.7 to 0.9 so we can see more clearly the values and difference in behavior. In relation to the trust in police the biggest difference in the historical and simulated graph is in 2017 where the historical behavior is 79.2 percent and the simulated is 82.3 percent. The only data available for the trust is also just from 2013 till 2021.

There are many factors to what affects the peoples trust in police, in my model there are two main drivers of the trust in police. It is the visibility, that has a heavy weight on the determination of trust in police. When the visibility decreases, so will trust in police (Hawdon et al., 2003; Maxson et al., 2003; Sindall & Sturgis, 2013; Yesberg et al., 2021). The police

intervening also effects the trust in police, when the relative police intervening decreases, so will trust (Hawdon et al., 2003). There will also be an increase in the dark figures based on the systems behavior, this will increase the SUB areas of Denmark, where the trust on average is lower than the trust of the total population in Denmark. Which can explain the decrease in trust and deviating simulated behavior from the historical one.

4.1.3 Testing the Reported

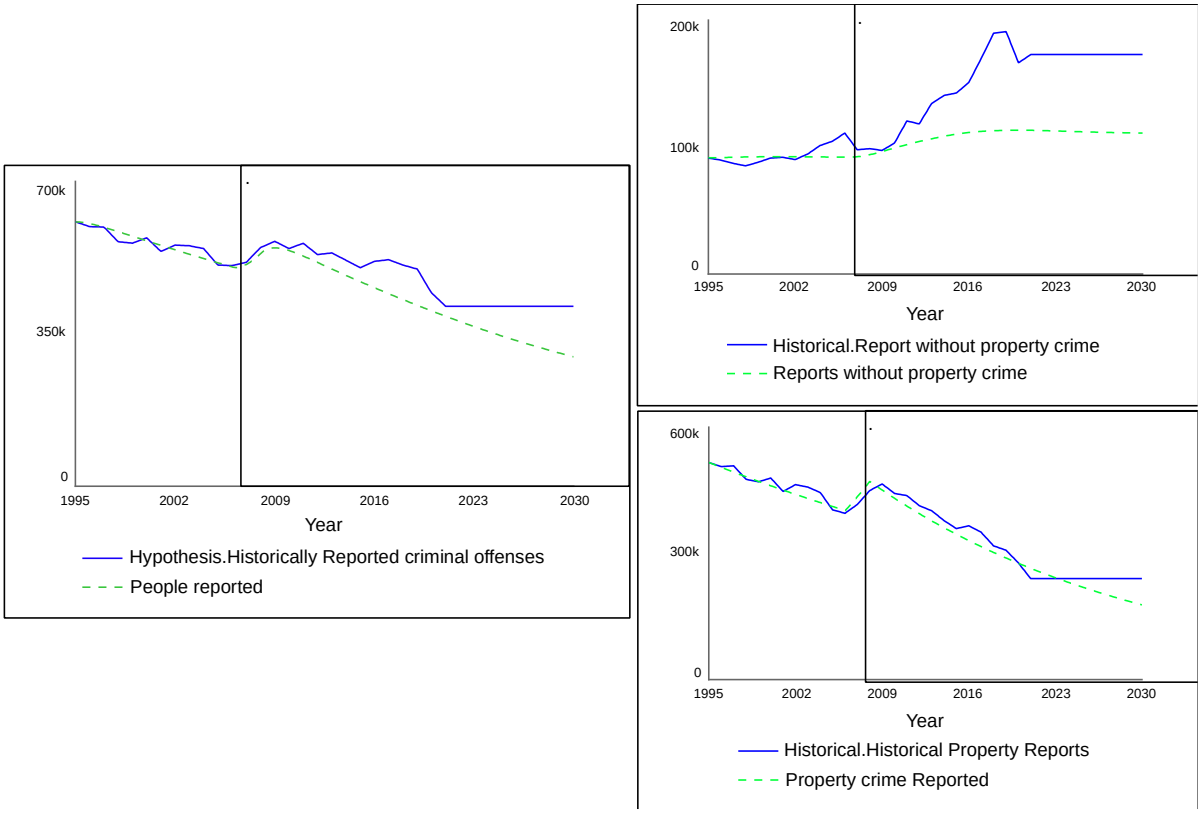


Figure 4.6 Reported Crime: Simulated vs historical.

The simulated reported crime is matching the behavior of the historical, but the main reason for this is that the property crime, which is around 80 percent of the total reported crime (Statistics Denmark, 2023f), is exogenized. To simulate the behavior of property crime, social factors would need to be added. Reporting crime is generally more effected by social conditions, although the visibility of police is also a factor effecting the reporting. Therefore, the Reporting without property crime is driven by the Effect of trust in police on reports, where if the trust increases the reporting also increases, Effect of charges per report on reports, where if the charges per report increases the reporting also increases, and Criminals undiscovered, as the people reporting is relative to how much crime there is. For all the simulated reported property

crime to match the historical behavior, the effect of trust on reported would need to have a much bigger effect, and would be extremely sensitive, which in my findings through literature is not accurate.

4.1.4 Testing the charged

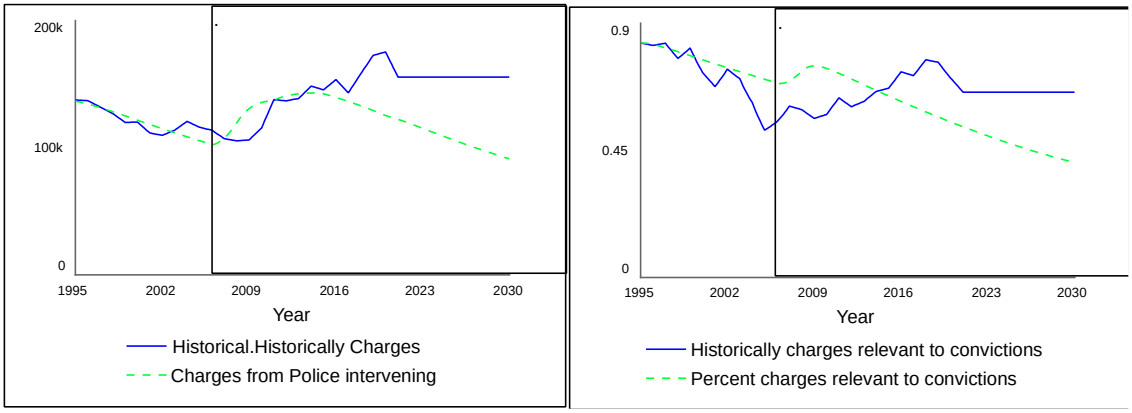


Figure 4.7 Charges made from reporting and percent charges relevant to convictions: Simulated vs historical.

The simulated behavior of the charges is deviating after around 2016 because of the impact of People reported relevant to 1995, that is determining the behavior of the percent charges relevant to convicted. Although we have a general increase in the Charges from police intervening, as the Police intervening flow increases, the behavior of charges from police intervening can replicate the behavior until 2016, but again deviates after as the percent of charges is relatively low.

4.1.5 Testing the police force

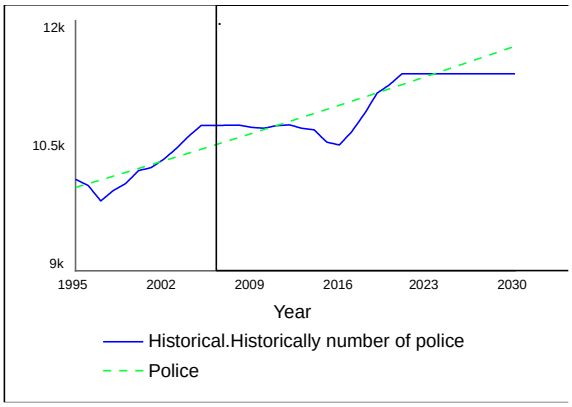


Figure 4.8 Police Force: Simulated vs historical

The simulated police force is matching the average historical behavior, as the police force stock has an exogenized inflow and outflow.

4.2 Policy implementation of the reform

4.2.1 Experimental set up

The SWITH set as 1 represents the implementation of the new police reform. When the SWITCH is set to 0, we can see how the model hypothetical would behave without the implementations of the new reform. The reform is represented in the model, where it reduces police stations by 63 police stations, increases competence by making competence of 0.9 available and where the property crime reporting is constantly decreasing, but at a slower rate.

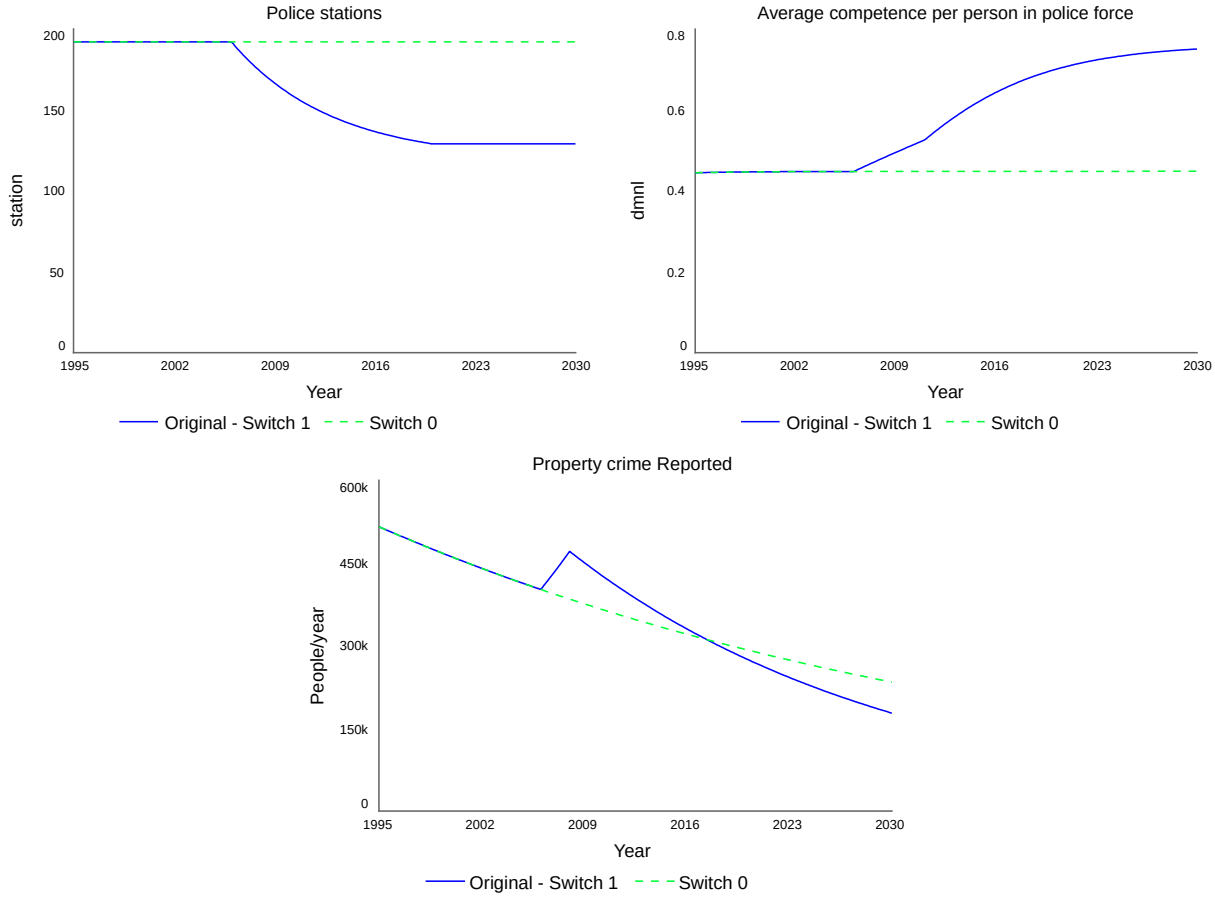


Figure 4.9 Policy implementations: SWITCH

4.2.2 Result overview

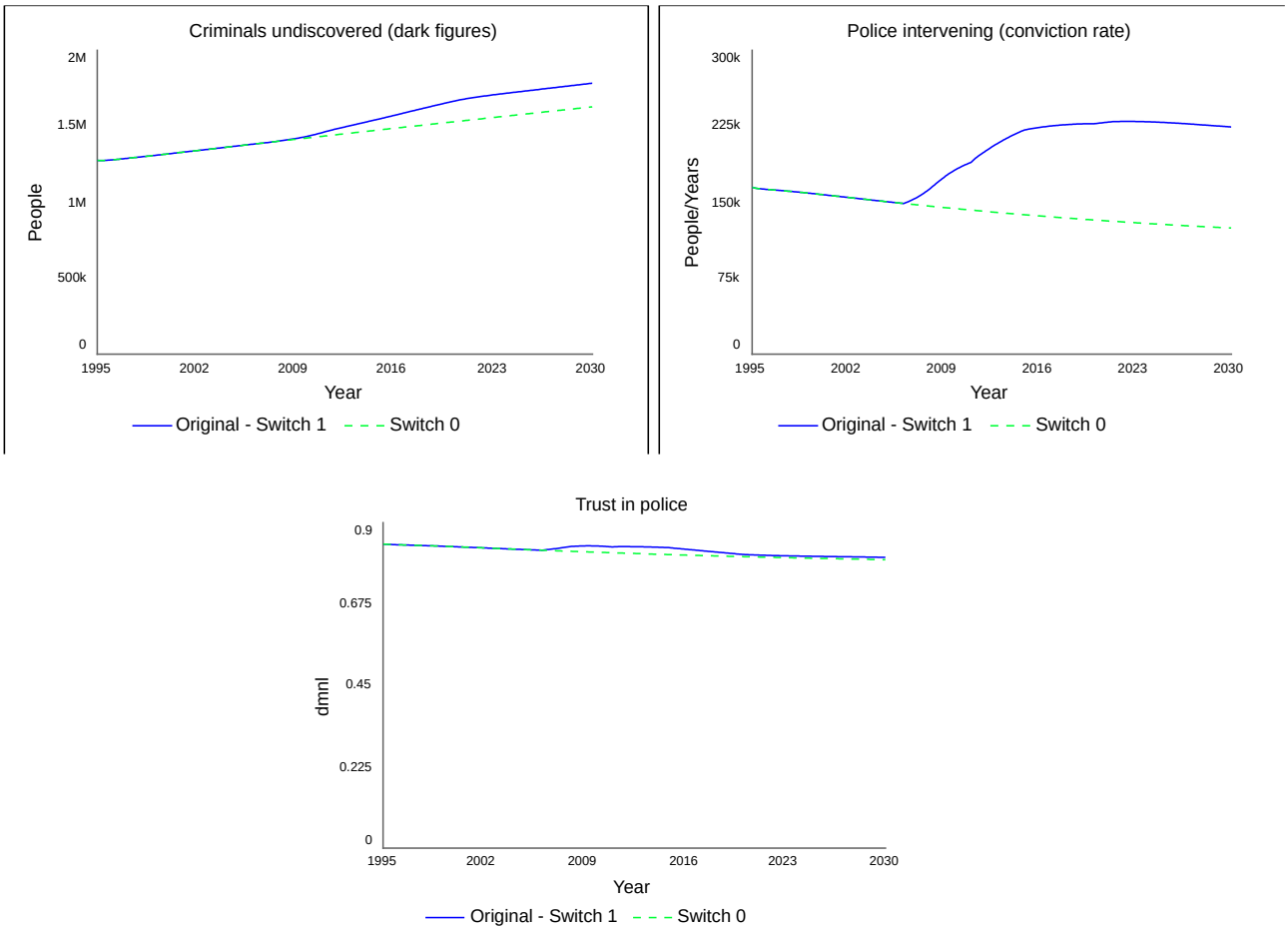


Figure 4.10 Result of Key indicators with SWITCH

The Figure 4.10 represents the simulated result of key indicators, in the SWITCH scenario. With the switch set to 1, we see the behavior as it is now, with the policy implementations of the reform. When the switch is 0, we can see the hypothetical results if the policies that came with the reform was not implemented. We can see that there is a decrease in the number of dark figures, it's not a big difference, but the dark figures are lower when the switch is 0. The number of convictions is drastically lower with the switch set to 0. The trust in police is almost the same.

4.2.3 Behavioral explanation

The reason for dark figures is lower when switch is 0, is because there is no reduction in the police station, making the visibility to stay steady, instead of decreasing as it does when switch is set to 1. Criminals convicted is a lot lower when the switch is set to 0. This is because

the competence can only reach a level of 0.5, as the implementation of focus on competence is when the switch is set to 1, that increases the police´s competence to intervene and their capacity to detect crime.

4.3Police force

4.3.1 Experimental setup

Another part of visibility is also the police force. To see how a change in the percent change in the police force will affect the main variables, we test them.

Percent change in Police	**Percent change from the original fraction**
0.0473	+50%
0.0394	+25%
0.0315 - Baseline	0% - Baseline
0.0236	-25%
0.0158	-50%

Table 4.1 Policy implementations Police

4.3.2 Result overview

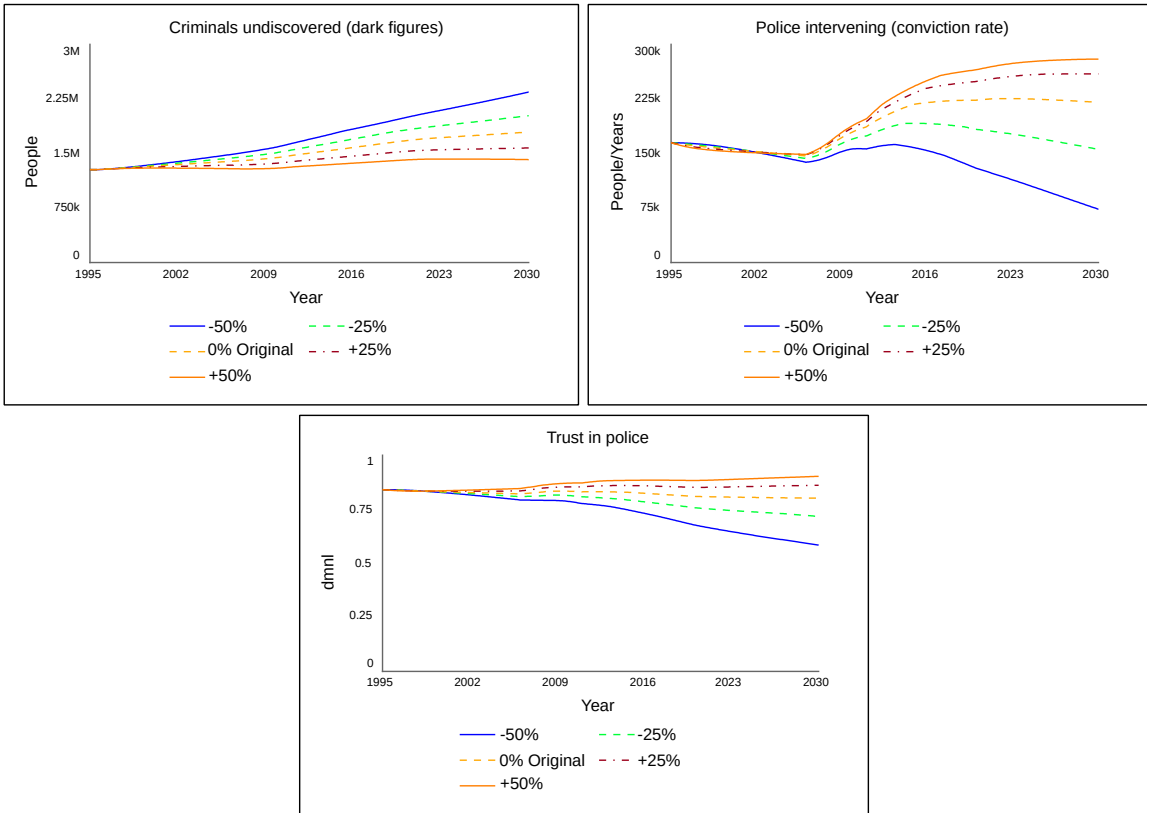


Figure 4.11 Result of key indicators for Increasing the police force

We can see a more sensitive behavior to the change in police force. The police force effect the same variables as the police station does (capacity and visibility). Where the biggest change is from the 0 percent (original) to the (+)25 percent or the (-)25 percent.

4.3.3 Behavioral explanation

The weight of people per police on capacity is making the capacity more sensitive to a change in the police force than a change in the police stations. The effect of people per police on visibility is also higher than the area per police station. Both capacity and visibility are more reliable on the police force, than the police stations as the actual police officers are the people who make people perceive their visibility and is the work force for the police capacity.

More police and more police stations are as expected, they provide good results. But there is a budget, and a cost in increasing the police force and having more police stations. I have not included the economical side to this problem in my thesis, although it is a very important factor, when making policies. It does cost to have police stations, and especially a police force. We see the largest change from the baseline (0% original) to the (+)25 percent or the (-) 25 percent.

4.4 Police stations

4.4.1 Experimental setup

From comparing the result of the reform implementation versus not implementing the policies, we understand the significance of police visibility and how closing police station may have impacts that policymakers have not accounted for. For this reason, we first experiment with scenarios targeting the number of police stations to observe the impact on main indicators.

To set up an alternative policy, to improve the situation I have changed the number of police stations that are being removed from 63, which is the original number of removed police stations. To 0 police stations being removed. The removing of police stations, is an attempt to centralize the police to increase competence, and to gain financially with the reduction in police stations (Holmberg, 2014). By removing less, it will cost more, but might help improve the crime rates.

Number of shut down police stations	Percent reduction in stations
63 - Baseline	100% - Baseline
47.3	75%
31.5	50%
15.8	25%
0	0%

Table 4.2 Policy implementations Police stations

4.4.2 Result overview

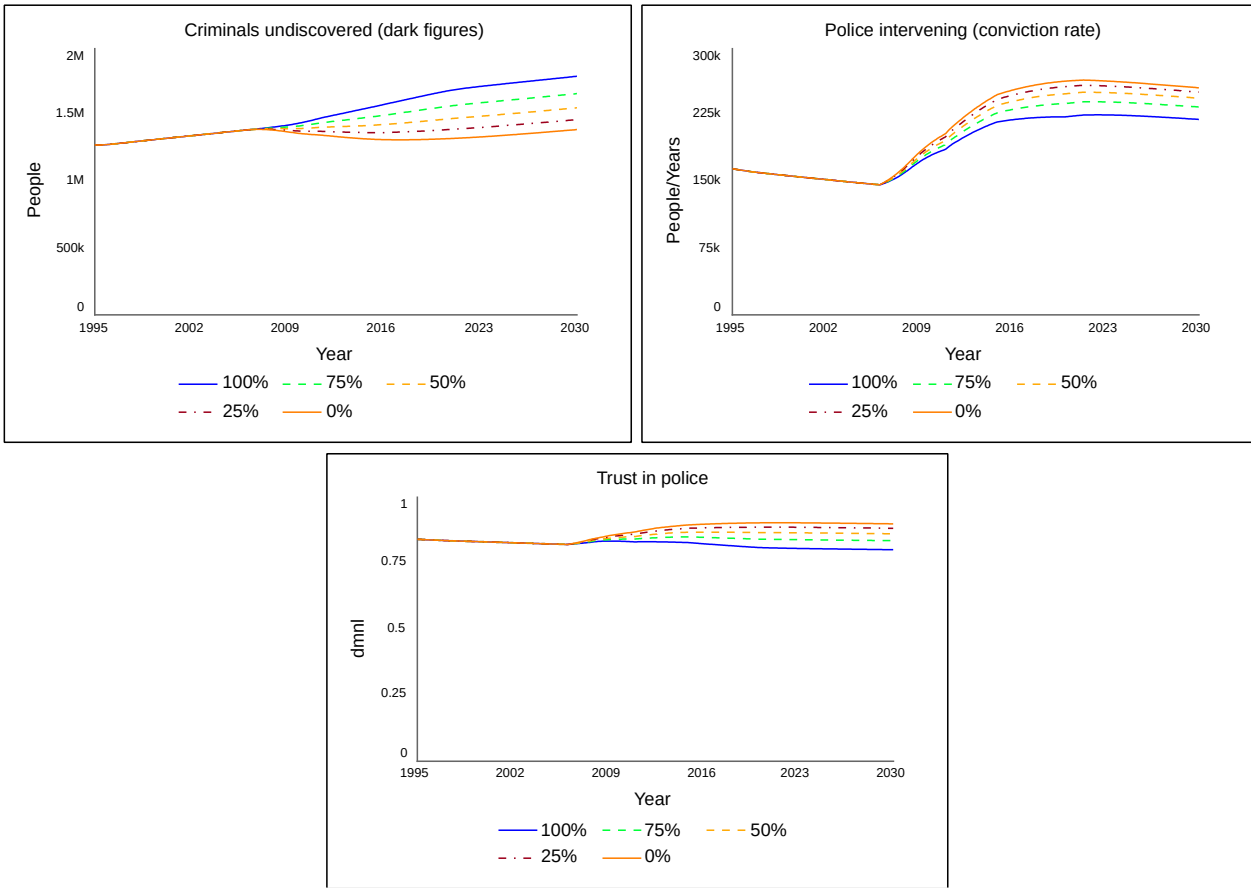


Figure 4.12 Result of key indicators for Improving Community Policing

We can see that the biggest difference is from a reduction of 100% to 75%, the difference from 75% to 50% is smaller. So just by reducing police stations by 47.3 stations, instead of 63, the dark figures will be lower, the convictions and trust in police will be higher. Maintaining police stations certainly benefits the system behavior. But to examine this we need more accurate quantification of parameters and effects, but we still see in this thesis that there are opportunities to fund a balance between optimal result and lower costs.

4.4.3 Behavioral Explanation

The reason we see this behavior is when the police stations are reduced by less, the visibility and police capacity increases. The increase in visibility increases the trust and decreases the breaking the law due to visibility. An increase in trust, increases the report rate, which gives a higher rate of reported crime increasing the criminals known to the police. The increase in capacity increases the crime detected by police rate, increasing the criminals known to the police. The capacity also effects the police capability to intervene in crime, so an increase in capacity, also increases the convictions.

4.5 Competence

4.5.1 Experimental setup

The reform also wants to focus on the competence, and we have seen its significance in decreasing the dark figures by increasing convictions. The Implementation of higher competence is when the reform implements the policy of focusing on the competence, where police officers have the opportunity to reach 0.9 in competence. The no change in competence, is where the competence stays at the same level as in 1995 (0.445). This is to see how the system would behave after the reform if the competence were not increasing.

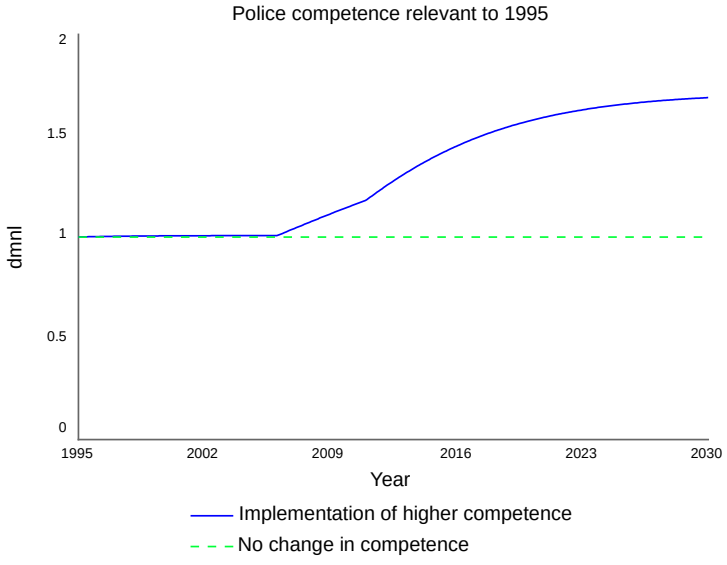


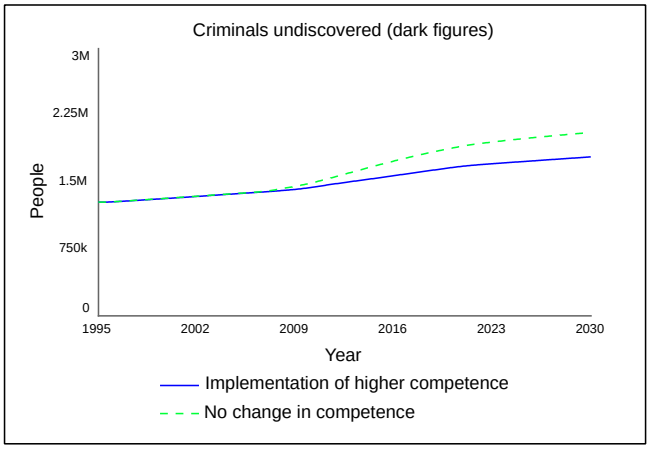
Figure 4.13 Competence level for testing

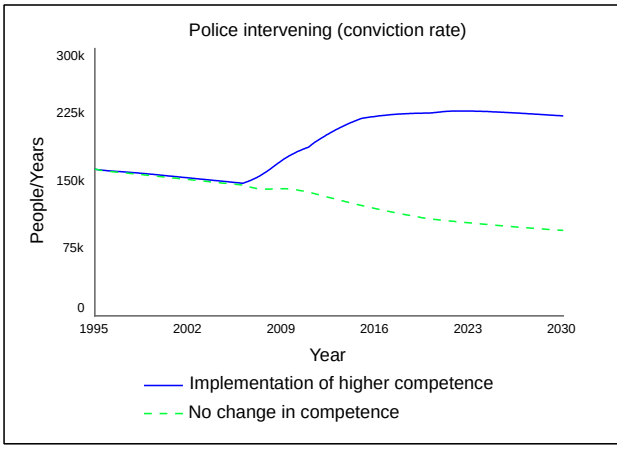
Another change to look at in the competence is the number of years it takes until they reach full competence.

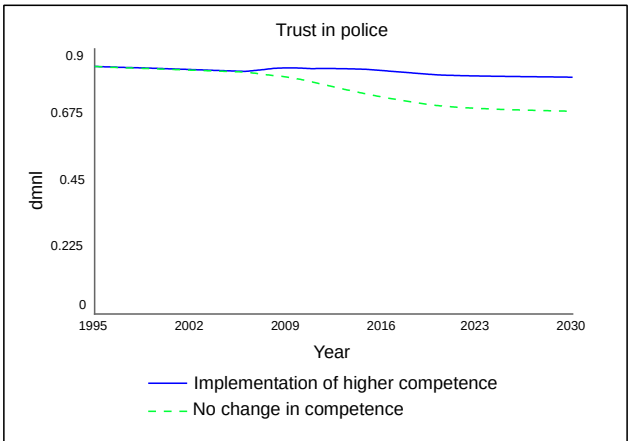
Years till full competence	Percent change from the original fraction
5	-50%
7.5	-25%
10 - Baseline	0% - Baseline
12.5	+5%
15	+50%

Table 4.3 Policy implementations of the Years till full competence

The “Implementation of higher competence” is the behavior of the competence when the reform is at play, and how I have made assumptions in how the competence develops in the police reform. To see how the system behaves if the competence stayed the same as in 1995, with the fractions of 0.445, I have made a SWITCH that can make the fraction a constant of 0.445. Therefore, the Police competence relevant to 1995 stays at 1 when the competence is at a constant of 0.445.







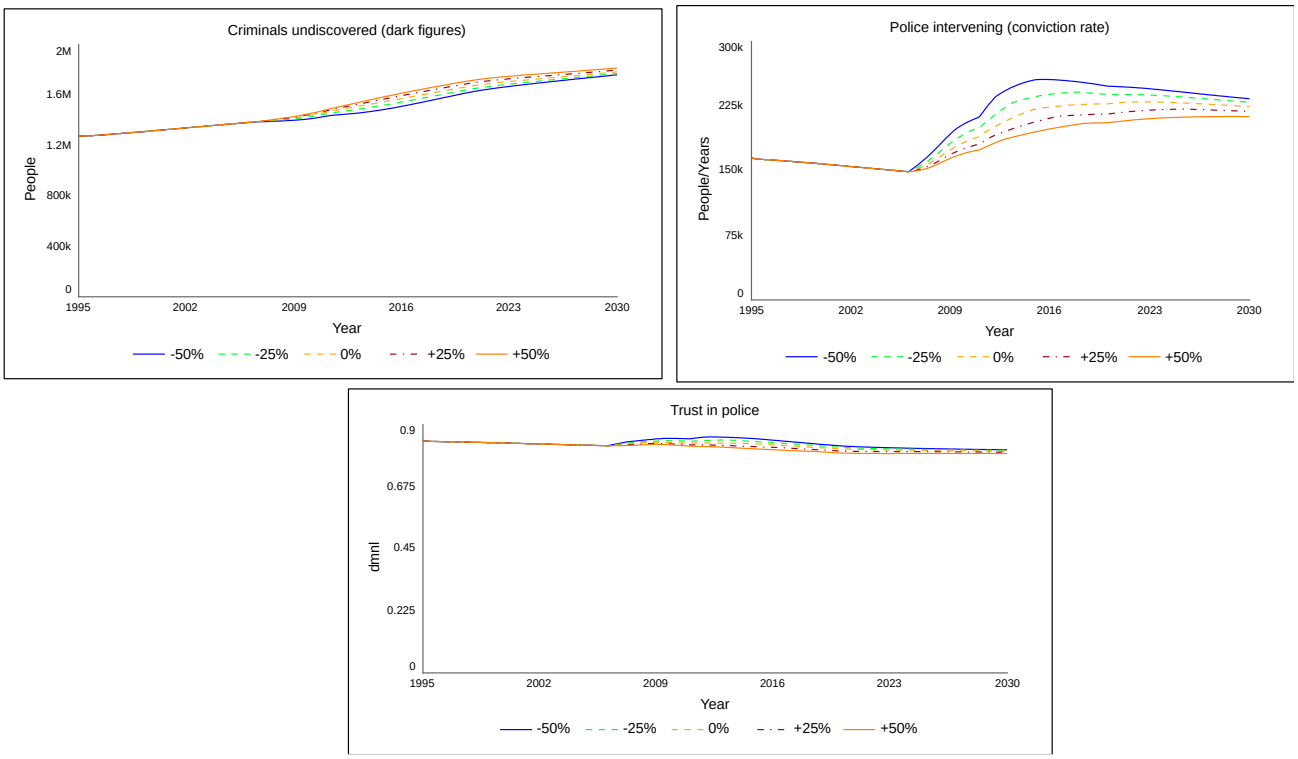


Figure 4.14 Effect of change in competence

4.5.2 Result overview

When the Competence relevant to 1995 is stable at 1, we can see that the dark figures increase, the police intervening (conviction) is drastically lower, and the trust is decreasing as the competence is not increasing.

When we change the years till full competence, we can see the biggest change in the convictions. As they gain competence at a faster or slower rate than before.

4.5.3 Behavioral explanation

The reason for this behavior in competence, is that the polices competence or knowledge to intervene in crime will decrease if the competence decreases or increase if it increases, leading to a constant decrease in police intervening as we see before the year of 2006. This will lead to an increase in the criminals undiscovered, as the availability of doing crime increases, and the perceived risk of being caught in doing crime is lower. The trust will also decrease, as the public's perception of the police work is decreasing.

4.6 Competence and police stations

4.6.1 Experimental setup

Run	SWITCH Competence without growth	Number of shut down police stations
Baseline	0	- 63 (0%)
Policy 1	1	0 (-100%)
Policy 2	0	0 (-100%)
Policy 3	1	-63 (0%)

Table 4.4 Policy test: Competence and police stations

4.6.2 Result overview

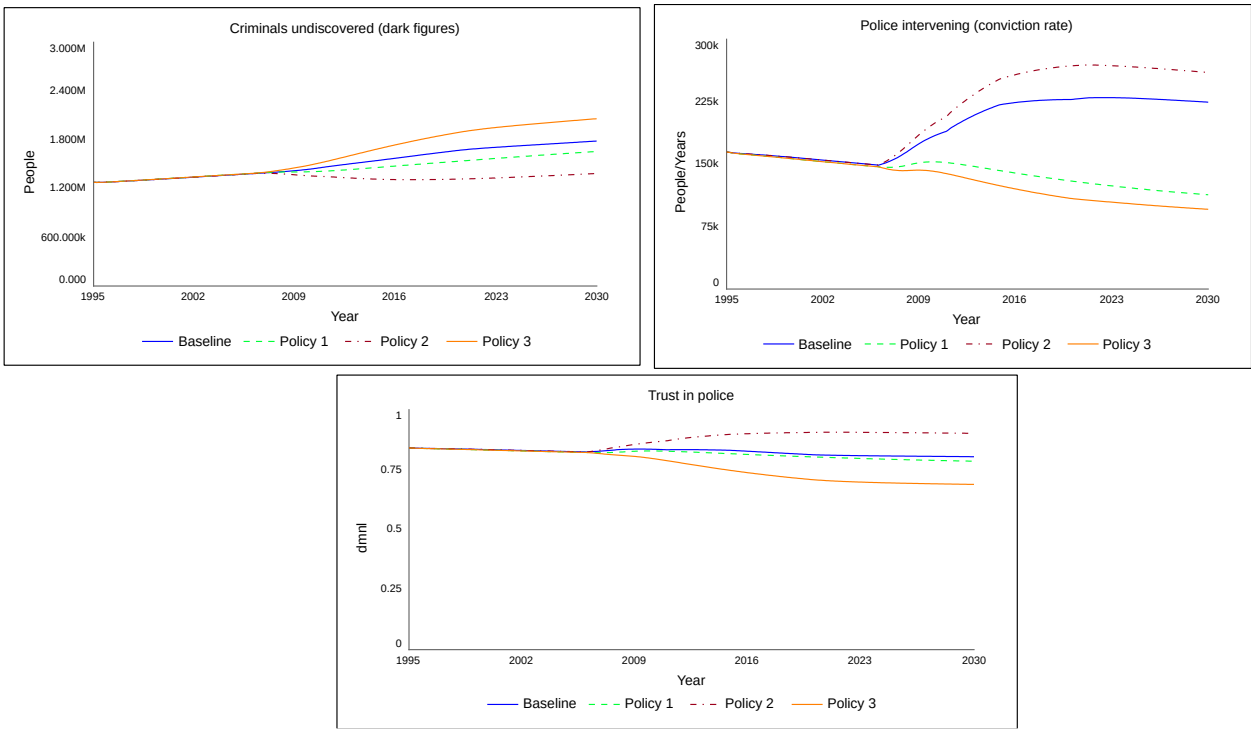


Figure 4.15 Policy test result: Competence and police stations

When we set the SWITCH competence without growth to 1, we make the competence level constant. Meaning there is no increase or decrease in the competence level, and it stays constant at a fraction of 0.455, as in 1995. Policy 1 that has the switch set to 1 and remove 63 police stations has a lower number of dark figures than the base line, but it has a much lower rate of police intervening. And the trust stays almost the same as the baseline. Policy 2 that has the switch set to 0, and don't remove any police stations has a much lower rate of dark figures than

any of the policies tested. It also has the highest number of police intervening, and the highest level of trust. Policy 3 has a higher number off dark figures than any of the other policies. It also has the lowest rate of police intervening, and trust.

4.6.3 Behavioral explanation

When we don't have an increase in competence, and do not remove any police stations, the level of trust stays almost the same. The reason for this is that the competence level also effects the trust, through the police intervening. When we don't have an increase in competence, the number of police intervening (convictions) decreases slowly, although the police stations are not removed, making the capacity larger than the baseline run. But it is not enough to compensate for the loss off competence, making the trust to be almost the same as the baseline although there are no stations removed. As expected, we get the best result with policy 2 when the Switch is set to 0, and competence increases. Where there is no police, stations removed. The reason for this is that when we don't remove any police stations, we keep the visibility and capacity at the same rate. While the competence increases, making the intervening rate higher, increasing the convicted and trust, which decreases the people breaking the law. The worst result we get is with policy 3, where the switch is set to 1, and we remove 63 police stations. This is because when we remove the police stations, we decrease visibility and competence, which will decrease detection rates, trust, reporting, and increase people breaking the law. The low competence level will make the intervention rate to slowly decrease, and not reach the same level as the baseline.

The interesting take away from this test is that when the competence increases, there are possibilities to slowly remove some police stations and keep the dark figures, police intervening and trust intact, if they carefully balance the competence and the removal of police stations.

4.7 Changing the crime trend

4.7.1 Experimental setup

I am performing a sensitivity analysis in Stella architect (3.2), to see what combination of the different policies the best match for an eventually new policy implementation are. For the percent change in police, the max value is +25 percent, as increasing it with 50 percent would be a drastic change. And after my analysis, think that a maximum value of 25 percent is a more realistic goal for a maximum value.

Value	Percent change in police	Number of shut down police stations	Years till full competence
Min	0.0315 (0%)	- 63 (0%)	5 (-50%)
Max	0.0393 (+25%)	-31.5 (-50%)	10 (0%)

Table 4.5 Policy implementations Police, Police stations and competence

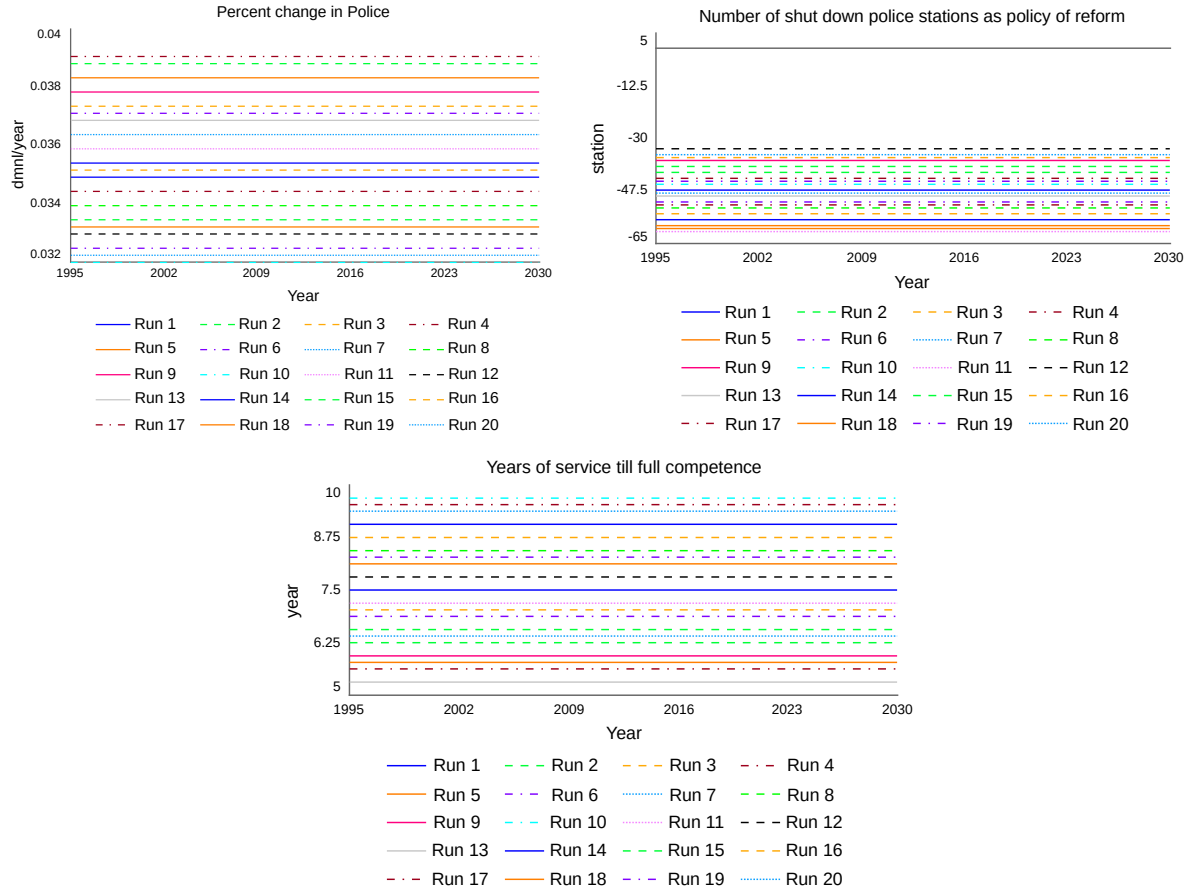


Figure 4.16 Values of the sensitivity tests in the policy options

4.7.2 Result overview

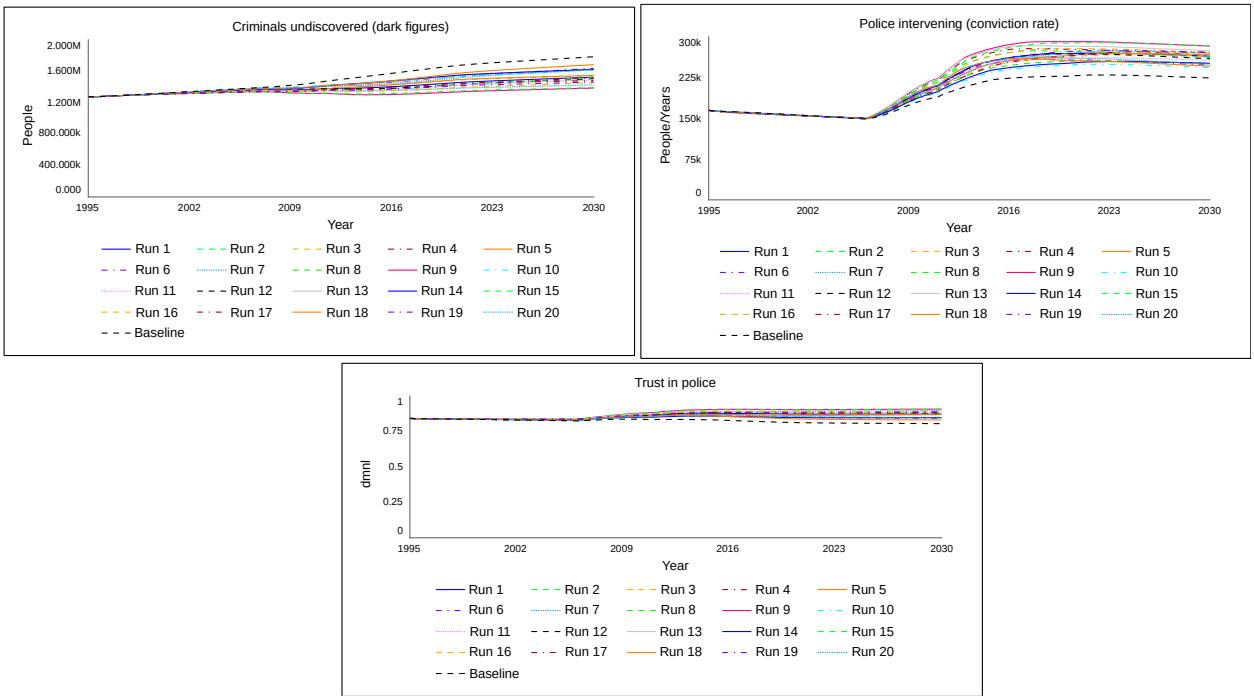


Figure 4.17 Result of sensitivity on police, police station and competence

The behaviors we see are very similar to one another. But when testing the values, I have only used values that can make the "situation better". Where the police force can only stay at the same rate or increase by maximum 50 percent. The police station can either say at the same value of -63, or it can reach a maximum of -31.5, which is an increase of 50 percent. The year till full competence has a base value of 10 and can only be reduced by 50 percent. So, the change happening in the system, can only show positive behavior.

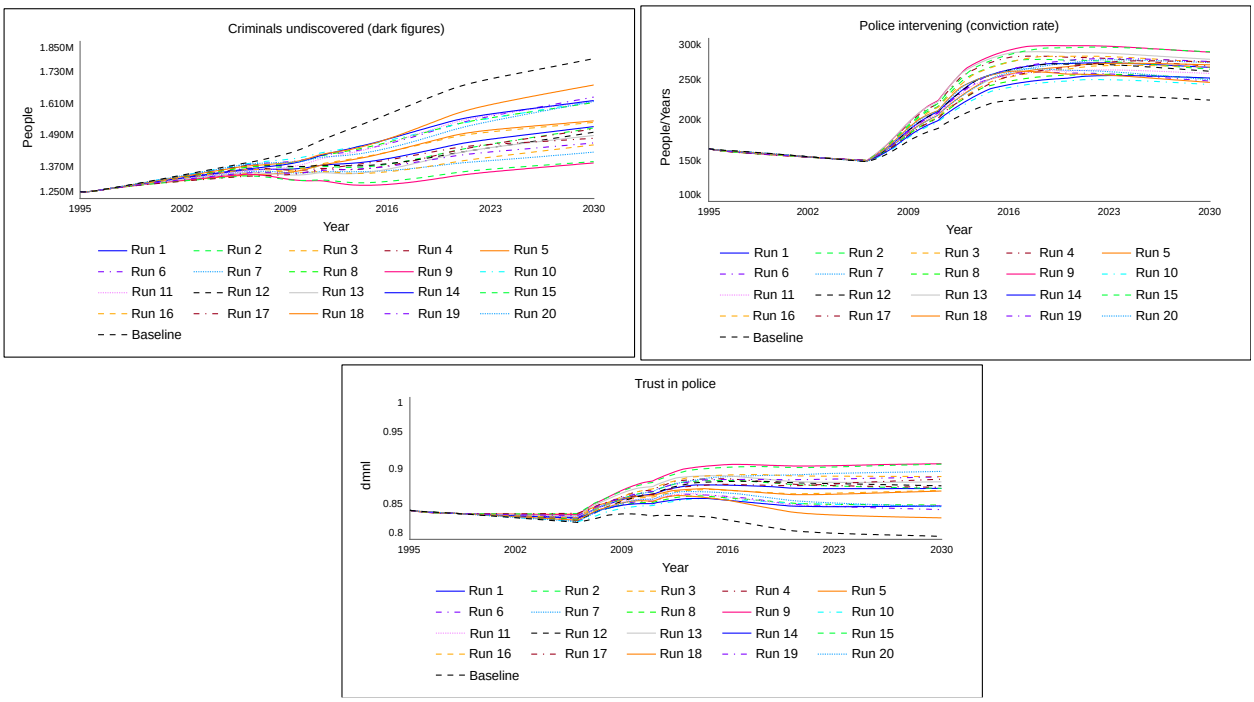


Figure 4.18 Result of sensitivity on policies: Closeup

Taking a closer look at the result, we can see that run 9 (the pink line), defiantly gives the best result. But we have several runs that give off good results. There is run 9 and 15 that has the best outcomes. And run 7, 13, 16, 17 and 19 which also show great results.

Runs	**Percent change in police (0.0315)**	**Number of shut down police stations (-63)**	**Years till full competence (10)**	**Outcome: *Dark figures (1.784M)***
Run 9	0.0378 (+20%)	- 37.4 (-41%)	5.94 (-41%)	1.386M (-28.7%)
Run 15	0.0388 (+23%)	-41.3 (-45%)	6.56 (-34%)	1.391M (-28.25%)
Run 7	0.0364 (+15%)	-35.4 (-44%)	9.38 (-6.7%)	1.427M (-25%)
Run 13	0.0369 (+17%)	-49.2 (-32%)	5.31 (-47%)	1.491M (-19.7%)
Run 16	0.0352 (+11.7%)	-36.4 (-42%)	7.03 (-30%)	1.455M (-22.6%)
Run 17	0.0391 (+24%)	-52.2 (-18%)	9.53 (-5%)	1.480M (-20.5%)
Run 19	0.0371 (+17.7%)	-44.3 (-30%)	8.28 (-21%)	1.462M (-22%)

Table 4.6 Best policy options based on sensitivity analysis

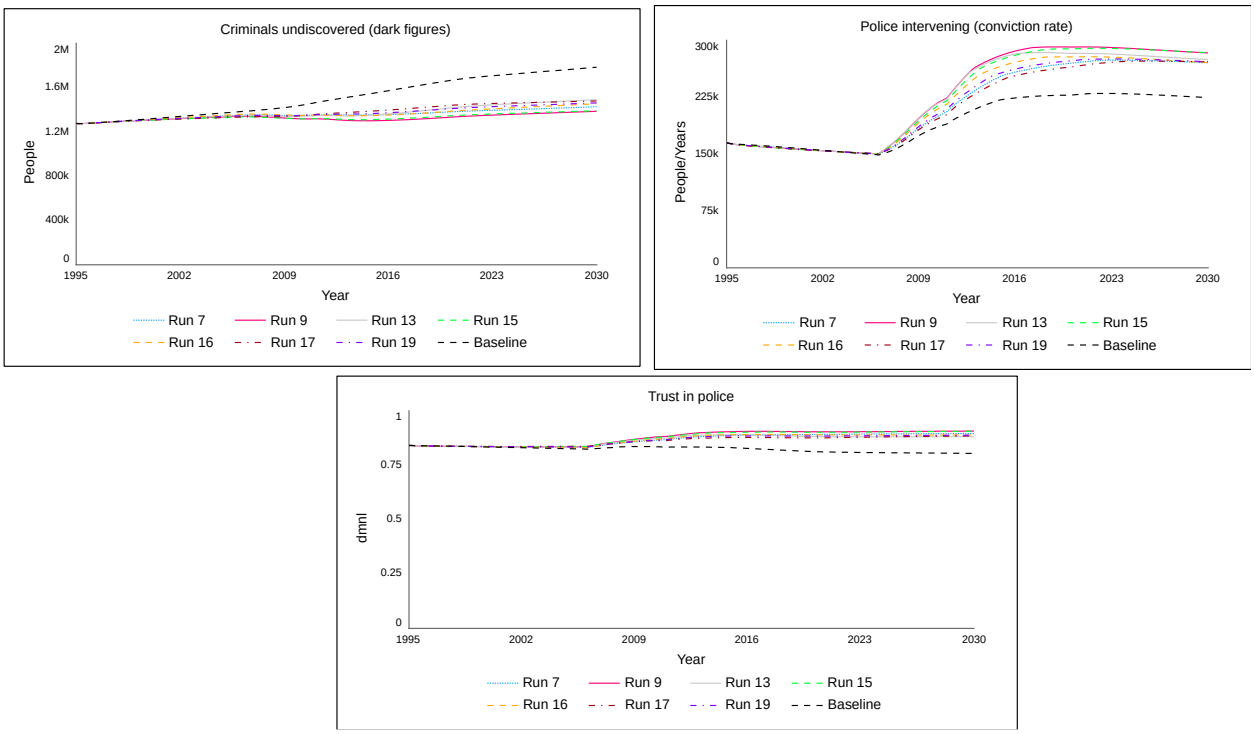


Figure 4.19 Result of the best policy options

There is still some difference in the outcomes, but all of them has a much better outcome than the original baseline. The graph above has the Y axis values starting at 0, but to take a closer look at the different runs I will use the lowest Y value for the Criminals undiscovered being 1.25 million. Police intervening will have the lowest Y value of 100 thousand, and the trust will have 0.8. This allows us to zoom in, and see the behaviors more clearly:

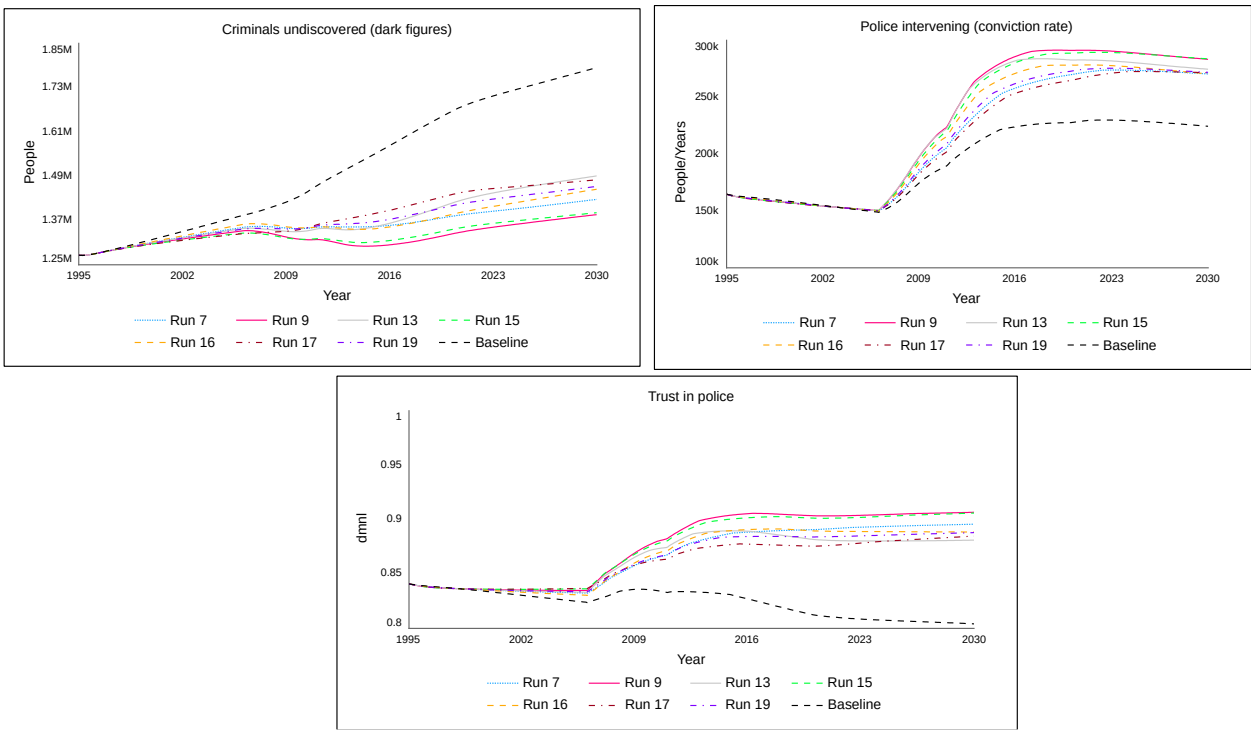


Figure 4.20 Closeup of the best policy options

Run number 9 is overall the best policy option, but it has a high change in all the policy options, where costs play a role in how much actually can be changed. By doing this sensitivity test, it is possible to adjust the focus of the changes based on economical grounding. Where if police force is cheaper to change, than police stations it's possible to find an optimal solution where there is more change in the stations than the police force.

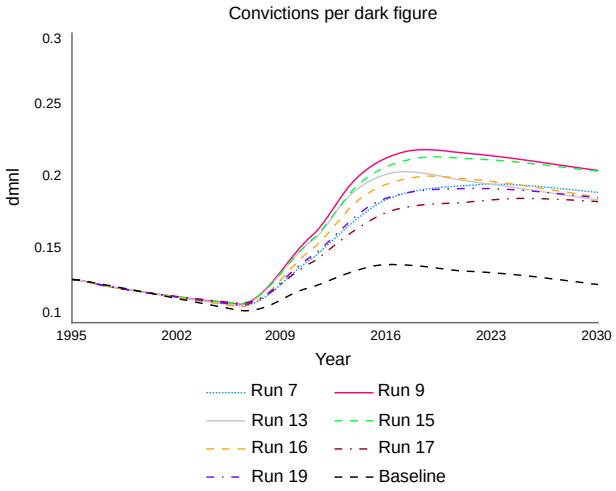


Figure 4.21 Best policy options: Convictions per dark figure

Another indicator to show how good the results are with the combinations of these policies, is the convictions per dark figure. When looking at main indicators I use for the graphs

(criminals undiscovered (dark figure), convictions and trust in police), we can get a good indication of the impact of the policies. But as I showed in chapter 1 where the convictions are historically increasing, and the number of reports is decreasing, it can look like the crime is decreasing, and the police are capturing a higher percent of the criminals. But if we take the convictions over the number of dark figures, we saw that it was stable at around 11 percent. I wanted to show this graph again, to show how many percent of the dark figures are convicted. As this can show more clearly, exactly how much the police are able to convict when we adjust the policies. In all the runs above, we can see that it has a much higher percentage than the base line. Run 9 shows the best result, almost reaching 25 percent.

4.7.3 Behavioral explanation

The reason we see this behavior is that we have decreased the number of years till full competence, which increases the competence faster. Making the police able to intervene in crime more, increasing the convictions, which decreases the fraction breaking the law. The increase in convictions will also make the trust to increase.

We have also decreased the number of police stations that are removed, and increased the change in police, that increasing the visibility. When the visibility increases, the trust also increases, making the number of reports to increase. This increases the people reported, making criminals known to the police to increase. That increases convictions, making the fraction of people breaking the law to decrease. The visibility also decreases the fraction breaking the law directly, which decreases the dark figures. The decrease in removed police stations and the change in police force, also increases the police capacity that effects and increases the detection rate, increasing the number of known criminals, increasing the convictions that decreases people breaking the law. It also increases the fraction of criminals the police convict.

What I have learned from this test is that any decrease in the reduction of police stations or years till full competence, or an increase in the police force make the systems behavior to change in a positive direction. The change in police force defiantly has the most sensitive effect on the system, as the police force weigh heavier on the capacity, than what the stations does. But the change in police force and the number of police stations both influence the system greatly. The competence is mostly affecting the conviction rates, which is an important factor to decrease the people breaking the law, and to increase the trust in police.

5. Discussion

In 2006, Denmark implemented a police reform focusing on efficiency, fast response times, local police, and a unified organization across districts (Holmberg, 2019). The reform was necessary due to increased organized crime, rising crime across borders, technology advancements, and public demand for better service (Holmberg, 2014). However, trust and safety decreased in the first years, and local policing never recovered (Holmberg, 2014, 2019). This thesis focuses on the impact of the reform on dark figures.

The goal of this thesis was (1) to assess the long-term effects of the new policies that came with the police reform in Denmark. It was also (2) to understand the impact of the police reform on dark figures, visibility, reporting, convictions, and trust. The research questions of the paper are (1) what is the long-term impacts of the police reform on the dark figures? And (2) what is the long-term impacts of the reform on police visibility, trust, and competence. And as a follow up to the latter question (2.1) Can competence compensate for the loss of community policing (visibility) in terms of crime prevention and detection?

5.1 Impact of the reform

5.1.1 Long-term impact of the reform on dark figures

The policies of the new police reform in Denmark have shown in both the historical and simulated result to increase the number of convictions, and a decreasing number of reports. This could indicate that the crime rates have decreased, and with the increase in competence the police are able to catch more criminals. To further investigate this, I have been focusing on the dark figures in Denmark. Dark figures are the unknown crime that is not reported or detected by the police and is a more accurate understanding of the crime levels in a country than reports, detection, and convictions. The dark figures have been calculated based on research finding, where the crime reported of detected is only 40 percent of the dark figures (Baumer, 2002; Buil-Gil et al., 2021; Goudriaan et al., 2006; Skogan, 1977). With the new police reform, we can see in the simulation that the dark figures will increase. Although the convictions are increasing, the convictions per dark figure lies stable around 12%, indicating that the crime is rising in line with the increase we can see in convictions. I will revise the second research question to investigate this dynamic of the reform, and the effects it has on the dark figures.

5.1.2 Impact of the reform on police visibility, trust, and competence

Competence

The new police reform has impacted the visibility, reporting rates, convictions, and trust. When the new reform was implemented, they wanted to focus on an increase in competence. Competence has been shown to affect the Police detection rate. An increase in competence will increase the detection rate, which increases the number of criminals known to the police. Competence also affects the police intervening (conviction rate). An increase in competence increases the intervening, which can explain the increase in convictions after the reform. The intervening rate influences trust, so an increase in police intervening will lead to an increase in trust, which will increase the report rate, which also increases the number of criminals known to the police. An increase in the intervening rate also decreases the fraction of people breaking the law, decreasing the dark figures. So, competence affects the people breaking the law, trust, and reporting indirectly. Where an increase in competence will increase the convictions, detection, trust, and reports, and it will reduce the dark figures.

Community policing

The new reform wanted to keep community policing when it was first implemented. What happened is that they centralized the police by removing 63 out of 196 police stations (Justitsministeriet, 2017). The decrease in police stations, first of all, reduces the police capacity. The decrease in police capacity decreases the police detection rates, and decreases the police intervening rate as they are not as localized and available in communities (Blesse & Diegmann, 2022). The decrease in police detection rates, will decrease the criminals known to the police and conviction rates. The decrease in the police intervening rates decreases the convictions, and decreases the trust, which decreases the reports and decreases the fraction of people known to the police.

The removal of police stations also causes a decrease in visibility, this increases the fraction of people breaking the law as the fear of being caught doing crime decreases, as the risk is perceived as lower when the visibility decreases (Baumer, 2002; Goudriaan et al., 2006; Jackson et al., 2012; Levitt, 1998b). High police visibility gives people a sense of safety, it makes the police more familiar and approachable (Bradford et al., 2009). When the visibility decreases, the community has less contact with the police decreasing the positive opinion of police performance (Maxson et al., 2003). The decrease in police patrols also decreases peoples

trust in the police (Hawdon et al., 2003). The decrease in trust, will decrease the report rates and decrease the fraction of criminals known to the police. So, a reduction in police stations will decrease the convictions, detection, trust, and reports. And increase the dark figures.

Competence and community policing

The long-term effect is that the competence will grow, giving them important tools that will increase their ability to both detect crime, and to intervene (convict) criminals (Blesse & Diegmann, 2022). Competence is an important instrument for the police, to be versatile. But my findings show the importance of visibility in such a system. The decision-makers need to pay close attention to this aspect when creating such a reform. Is the increase in competence enough to compensate for the lack of visibility?

5.2 Model based policy insight

In Chapter 4, I looked at what the dynamics between the reduction of police stations and competence look like (see 4.6 Competence and police stations). Where the best effect was to keep the competence growing and not remove any of the police stations, as expected. But when we don't have an increasing competence, and do not remove any police stations the dark figures are a bit under the baseline, and the trust stays almost the same as the baseline. This might indicate there is a possibility to gradually remove police stations, while competence is growing. The reduction of police stations has a stronger effect on the system, than what competence has. So, competence must grow quite a lot each time for a possible reduction of police stations, but it might be an alternative policy, if the removal of police stations is necessary.

In an attempt to find a policy to balance the system and change the behavior of the crime rates in the future, I tested the Percent change in police, Number of shut down police stations and years till full competence (4.7 Changing the crime trend) to find possible policies. The fewer shut down police stations and the years till full competence and the more we can increase the police force the better. But as any system, it has limitations. The tests show several runs, with different increases and decreases in the three policies we tested, where it's possible to find a suitable solution based on what percent the different policies are suitable to change by.

One of my arguments as to why trust will decrease, was that the dark figures will increase. Because, when the dark figures increase, it will also be a risk that the number of SUB areas will increase or that the crime rates in the already existing SUB areas will increase. The trust is relatively lower in these SUB areas. Alternative policies for these specific situations

could be to focus on increasing or keeping police stations, patrols, or police with higher competence in these areas, to reduce the crime rates. It is possible to make policies place-based as in this example, to change the crime trend.

After researching the effects and policies of the police reform, I find that while competence is important, visibility of the police plays a very important complementary role that cannot be neglected or simply replaced by competence. With the change in visibility and competence we see in the simulated result, the dark figures will increase. Without the visibility recovering, the increase in competence will only make a small difference in the dark figures, and cannot compensate for the loss of visibility.

5.3Limitations and further work

5.3.1 Modelled structure

In my model we have the competence which is a fully exogenous system. The competence is based on assumptions on how competence work, and how long it takes to get X amounts of competence. For the system to be more complete, it would need proper research on how much competence the reforms' goal is to reach. How long does it take for the police force to improve their competence. And if there are any relationships, I have not been able to capture with the system I have created.

We have another exogenous system, the property reports. The total reports have both the property crime reported and the reported crime without property. The reported crime without property is simulated by the model, where it's effected by the charges and the trust in police. But the reported crime without the property is only 15 percent of the total crime. Where the reported property crime is 85 percent of the total crime. Making total crime more exogenous than endogenous, as most of its behavior comes from the exogenous system of property reports that is modelled by finding the average change in property crime reporting based on the historical data. For the reports to be endogenous in the system, there would need to be social factors included to influence the reports. As reporting is more influenced by personal perceptions and believes. Trust in police is one of these perceptions that can influence the report rate but does not affect the report rate enough to determine the report rate alone. For a more accurate capturing of the reports, there would need to be a system of social factors effecting the system.

5.3.2 Policy implementation and costs

I have used several graphical functions to represent the effect of Y on X. For example, the effect of visibility on trust. These graphical functions are based on literature review, where the strength of the effect is not always certain, and therefore needs more research to define the effects more accurately on the variables. The effectiveness of the implementation of policies has also not been implemented. I have added an intensity effect to the policies that the reform switch effects, to gradually implement the new policies. But this has not been done to the testing of policy options. Therefore, the effectiveness of policy implementations has not been accounted for.

The suggested implementations of an increased police force and increasing the number of police stations also have a cost. The policy decisions are based off economic grounding that is not considered in this thesis, or model. And would need a further investigation as to the cost of implementing these policies.

5.3.3 Socio- and economic factors

As mentioned, there are several other reasons for a growth in criminal activity and dark figures. The culture, childhood, social mobility, poverty, educational resources, unemployment rates, and much more. That all are a factor to the crime levels, and other factors like trust in police or reporting rates. The socio and economic factor have not been accounted for in this thesis or model, and for a more in depth and extensive investigation of the crime activity in a country, these factors are needed.

References

Bala, B. K., Arshad, F. M., & Noh, K. M. (2017). *System Dynamics*. Springer Singapore. https://doi.org/10.1007/978-981-10-2045-2

Barlas, Y. (1996). Formal aspects of model validity and validation in system dynamics. *System Dynamics Review*, *12*(3), 183–210. https://doi.org/10.1002/(SICI)1099-1727(199623)12:3<183::AID-SDR103>3.0.CO;2-4

Baumer, E. P. (2002). Neighborhood disadvantage and police notification by victims of violence*. *Criminology*, *40*(3), 579–616. https://doi.org/10.1111/j.1745-9125.2002.tb00967.x

Bennell, C., Jenkins, B., Blaskovits, B., Semple, T., Khanizadeh, A.-J., Brown, A. S., & Jones, N. J. (2022). Knowledge, Skills, and Abilities for Managing Potentially Volatile Police–Public Interactions: A Narrative Review. *Frontiers in Psychology*, *13*, 818009. https://doi.org/10.3389/fpsyg.2022.818009

Blesse, S., & Diegmann, A. (2022). The place-based effects of police stations on crime: Evidence from station closures. *Journal of Public Economics*, *207*, 104605. https://doi.org/10.1016/j.jpubeco.2022.104605

Boateng, F. D. (2018). Crime Reporting Behavior: Do Attitudes Toward the Police Matter? *Journal of Interpersonal Violence*, *33*(18), 2891–2916. https://doi.org/10.1177/0886260516632356

Bradford, B., Jackson, J., & Stanko, E. A. (2009). Contact and confidence: Revisiting the impact of public encounters with the police. *Policing and Society*, *19*(1), 20–46. https://doi.org/10.1080/10439460802457594

Buil-Gil, D., Medina, J., & Shlomo, N. (2021). Measuring the dark figure of crime in geographic areas: Small area estimation from the Crime Survey for England and Wales. *The British Journal of Criminology*, *61*(2), 364–388. https://doi.org/10.1093/bjc/azaa067

Bun, M. J. G., Kelaher, R., Sarafidis, V., & Weatherburn, D. (2020). Crime, deterrence and punishment revisited. *Empirical Economics*, *59*(5), 2303–2333. https://doi.org/10.1007/s00181-019-01758-6

Forrester, J. W., & Senge, P. M. (1980). Tests for Building Confidence in Sysem Dynamics Models. In *A. Legasto, J. W. Forrester & J. W. Lyneis (Eds.), TIMS Studies in Management Sciences* (pp. 209–228).

Goudriaan, H., Wittebrood, K., & Nieuwbeerta, P. (2006). Neighbourhood characteristics and reporting crime: Effects of social cohesion, confidence in police effectiveness and socio-economic disadvantage. *The British Journal of Criminology*, *46*(4), 719–742.

Hawdon, J. E., Ryan, J., & Griffin, S. P. (2003). Policing Tactics and Perceptions of Police Legitimacy. *Police Quarterly*, *6*(4), 469–491. https://doi.org/10.1177/1098611103253503

Holmberg, L. (2014). Scandinavian police reforms: Can you have your cake and eat it, too? *Police Practice and Research*, *15*(6), 447–460. https://doi.org/10.1080/15614263.2013.795745

Holmberg, L. (2019). Continuity and change in Scandinavian police reforms. *International Journal of Police Science & Management*, *21*(4), 206–217. https://doi.org/10.1177/1461355719889461

Holmberg, L. (2021). Evaluations of Police Reforms: Utility or Futility? *Policing: A Journal of Policy and Practice*, *15*(1), 314–326. https://doi.org/10.1093/police/pay023

Holmberg, L., Larsson, P., Graner, R., & Bjørkelo, B. (Eds.). (2017). *NORDISK POLITIFORSKNING*. *4*(2). https://doi.org/10.18261/issn.1894-8693

Homer, J. B. (2012). Partial-model testing as a validation tool for system dynamics (1983): Partial-Model Testing as a Validation Tool. *System Dynamics Review*, *28*(3), 281–294. https://doi.org/10.1002/sdr.1478

ICPRA. (2018). *PD ICPRA 2006 Major Issues*. ICPRA. https://icpra.org/wp-content/uploads/2018/08/21PD_ICPRA_2006_Major_Issues.pdf

Jackson, J., Bradford, B., Hough, M., Myhill, A., Quinton, P., & Tyler, T. R. (2012). Why do People Comply with the Law?: Legitimacy and the Influence of Legal Institutions. *British Journal of Criminology*, *52*(6), 1051–1071. https://doi.org/10.1093/bjc/azs032

Justitsministeriet. (2017). *REU, Alm.del—2017-18—Endeligt svar på spørgsmål 7: Spm. Om antallet af fysiske politistationer i 2006 og i 2016/17, til justitsministeren*. https://www.ft.dk/samling/20171/almdel/reu/spm/7/svar/1444105/1819962/index.htm

Justitsministeriets. (2022). *Tryghedsundersøgelse 2021*. https://www.justitsministeriet.dk/wp-content/uploads/2022/08/Tryghedsundersoegelse-2021-web.pdf

Klick, J., & Tabarrok, A. (2005). Using Terror Alert Levels to Estimate the Effect of Police on Crime. *The Journal of Law & Economics*, *48*(1), 267–279. https://doi.org/10.1086/426877

Levitt, S. D. (1998a). The Relationship Between Crime Reporting and Police: Implications for the Use of Uniform Crime Reports. *Journal of Quantitative Criminology*, *14*(1), 61–81.

Levitt, S. D. (1998b). Why do increased arrest rates appear to reduce crime: Deterrence, incapacitation, or measurement error? *Economic Inquiry*, *36*(3), 353–372. https://doi.org/10.1111/j.1465-7295.1998.tb01720.x

Loureiro, P. R. A., Mendonça, M. J. C. D., Moreira, T. B. S., & Sachsida, A. (2009). Crime, economic conditions, social interactions and family heritage. *International Review of Law and Economics*, *29*(3), 202–209. https://doi.org/10.1016/j.irle.2009.01.002

Maxson, C., Hennigan, K., & Sloane, D. C. (2003). *Factors That Influence Public Opinion of the Police*. 17.

Politidirektoratet. (2023). *Politiets innbyggerundersøkelse 2022* (pp. 3–75). https://www.politiet.no/globalassets/04-aktuelt-tall-og-fakta/innbyggerundersokelsen/politiets-innbyggerundersokelse-2022.pdf

Rahmandad, H., & Sterman, J. D. (2012). Reporting guidelines for simulation-based research in social sciences: Reporting Guidelines for Simulation-Based Research. *System Dynamics Review*, *28*(4), 396–411. https://doi.org/10.1002/sdr.1481

Rigspolitiet. (2022). *Politiets ansatte | | Politi*. Politi. https://politi.dk/aktuelt/statistik/politiets-ansatte

Robson, C., & McCartan, K. (2016). *Real world research: A resource for users of social research methods in applied settings* (Fourth Edition). Wiley.

Rouse, J. J. (1985). The Relationship between Police Presence and Crime Deterrence. *The Police Journal: Theory, Practice and Principles*, *58*(2), 118–131. https://doi.org/10.1177/0032258X8505800204

Simons, R. L., & Burt, C. H. (2011). Learning to be bad: Adverse social conditions, social schemas, and crime*. *Criminology*, *49*(2), 553–598. https://doi.org/10.1111/j.1745-9125.2011.00231.x

Sindall, K., & Sturgis, P. (2013). Austerity policing: Is visibility more important than absolute numbers in determining public confidence in the police? *European Journal of Criminology*, *10*(2), 137–153. https://doi.org/10.1177/1477370812461237

Skogan, W. G. (1977). Dimensions of the Dark Figure of Unreported Crime. *Crime & Delinquency*, *23*(1), 41–50. https://doi.org/10.1177/001112877702300104

Statistics Denmark. (2023a). *Area* [Statistical bank]. ARE207: Area 1. January by Region. https://www.statbank.dk/statbank5a/selectvarval/define.asp?PLanguage=1&subword=tabsel&MainTable=ARE207&PXSId=146445&tablestyle=&ST=SD&buttons=0

Statistics Denmark. (2023b). *Average length of suspended sentences* [Statistical bank]. STRAF48: Average Length (Months) of Suspended Sentences by Sex, Age, Type of Offence and Type of Decision. https://www.statbank.dk/statbank5a/SelectVarVal/Define.asp?MainTable=STRAF48&PLanguage=1&PXSId=0&wsid=cftree

Statistics Denmark. (2023c). *Average length of unsuspended sentences* [Statistical bank]. STRAF49: Average Length of Unsuspended Sentences (Month) by Sex, Age, Type of Offence and Type of Decision. https://www.statbank.dk/statbank5a/SelectVarVal/Define.asp?MainTable=STRAF49&PLanguage=1&PXSId=0&wsid=cftree

Statistics Denmark. (2023d). *Convictions StatBank Denmark* [Statistical bank]. STRAF42: Decisions, Total by Affiliation to Denmark, Type of Offence, Type of Decision, Age and Sex. https://www.statbank.dk/statbank5a/default.asp?w=1440

Statistics Denmark. (2023e). *Population StatBank Denmark* [Statistical bank]. BEFOLK1: Population 1. January by Sex, Age and Marital Status.

https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=BEFOLK1&PLanguage=0

Statistics Denmark. (2023f). *Reported criminal offences StatBank Denmark* [Statistical bank]. STRAF20: Reported Criminal Offences and Charges by Type of Offence and Reported Criminal Offences and Charges. https://www.statbank.dk/statbank5a/default.asp?w=1440

Sterman, J. (2000). *Business dynamics: Systems thinking and modeling for a complex world*. Irwin/McGraw-Hill.

Tolsma, J., Blaauw, J., & te Grotenhuis, M. (2012). When do people report crime to the police? Results from a factorial survey design in the Netherlands, 2010. *Journal of Experimental Criminology*, *8*(2), 117–134. https://doi.org/10.1007/s11292-011-9138-4

Wilson, J. Q., & Boland, B. (1978). The Effect of the Police on Crime. *Law & Society Review*, *12*(3), 367. https://doi.org/10.2307/3053285

Yesberg, J., Brunton-Smith, I., & Bradford, B. (2021). Police visibility, trust in police fairness, and collective efficacy: A multilevel Structural Equation Model. *European Journal of Criminology*, 147737082110353. https://doi.org/10.1177/14773708211035306

Appendices

I. Sensitivity Analysis

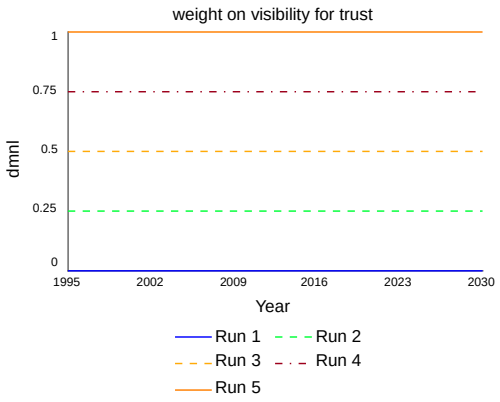
To do a sensitivity analysis, I have used the Model Analysis Took in Stella Architect 3.2. The scenarios have been tested with the SWITCH set to 1. It has been set to 5 runs (except for the Graphical functions, tested manually). The range of the parameters is noted bellow by the name of the parameter that is being tested. The results of this sensitivity test are categorized by the type of parameter: (1) Weights, (2) delays, (3) reference value (where the parameter has a known or calculated value) and (4) assumed value (uncertain value for parameter and need further research). And the (5) graphical functions.

We use the following indicators to see the result of the sensitivity analysis: Criminals undiscovered (dark figures), Police intervening (conviction rate) and Trust in police.

Weights and delays

There are three different weights in the model, where two of them show sensitivity. We also have three delays, but none of them showed any sensitivity.

Weight on visibility for trust (0 – 1 (0.7 original))



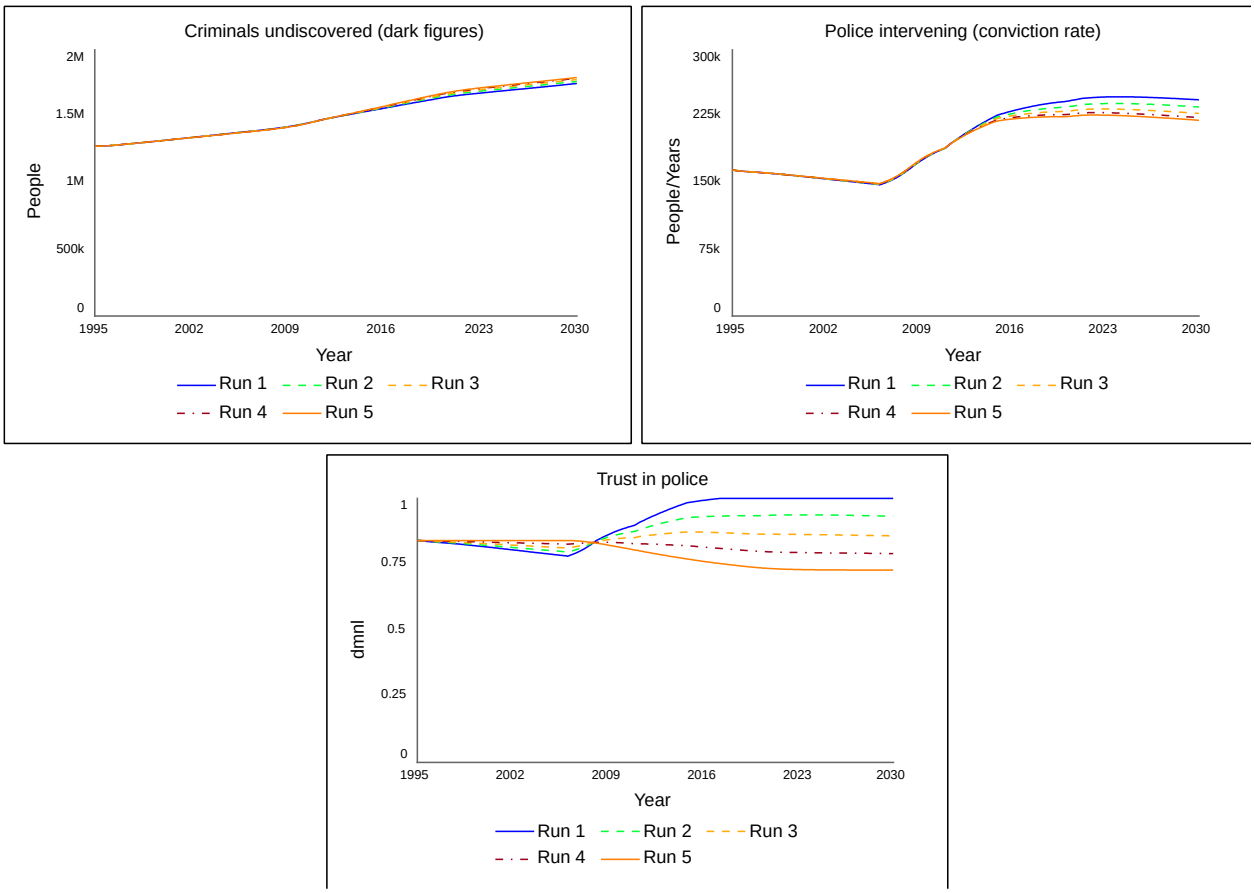
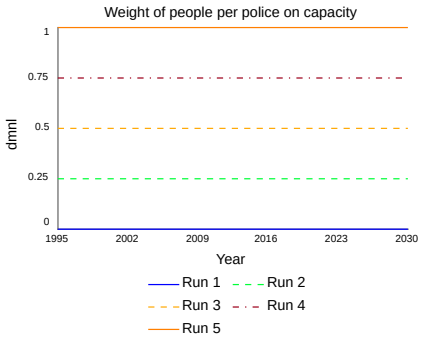


Figure I 0.1 Sensitivity runs for Weight on visibility for trust

The sensitivity we see is mostly in the Trust in police, the reason for this is when the weight is 1, the trust is only dependent on visibility, creating a decrease as the visibility decreases. But when the weight is 0, the trust is only affected by the intervening rate, which is increasing.

Weight of people per police on capacity (0 – 1 (0.65 original))



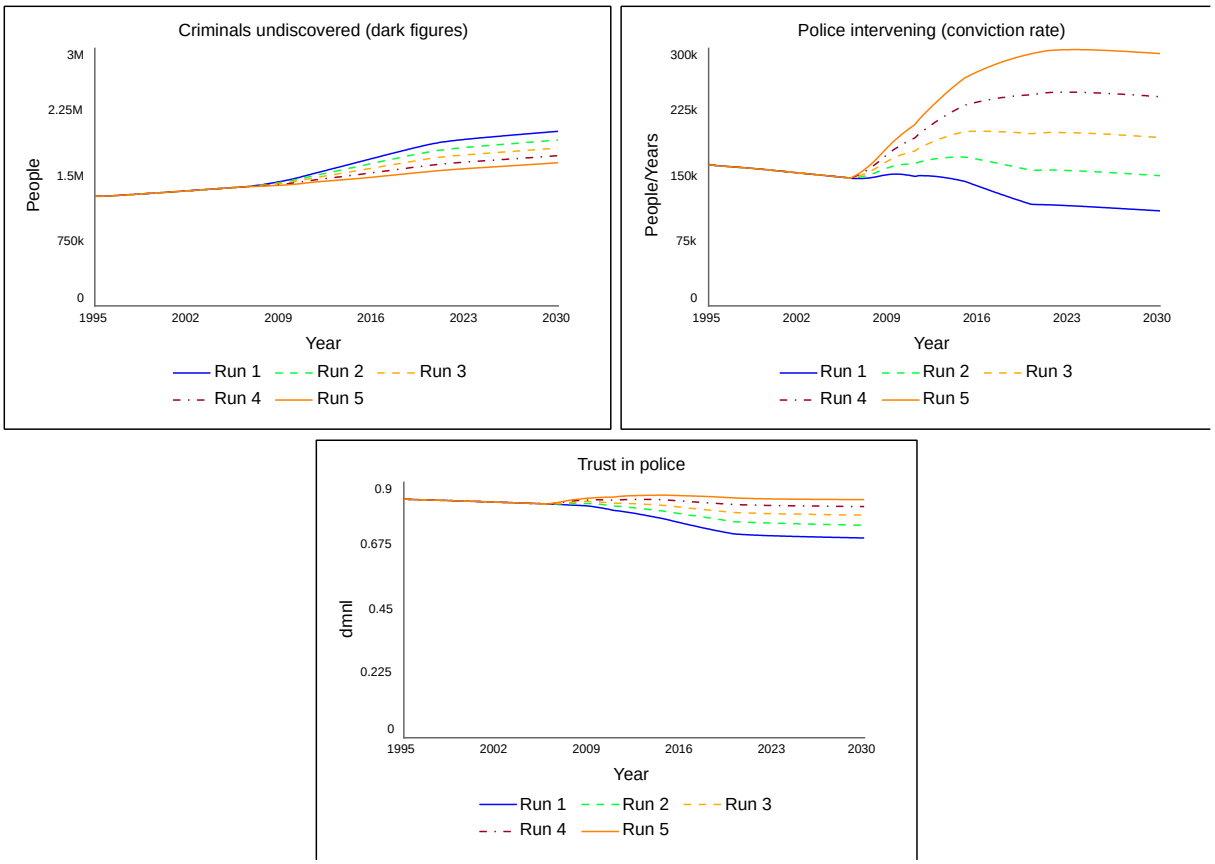


Figure I 0.2 Sensitivity Runs for Weight of people per police on capacity

We can see a lot of sensitivity in the conviction rate, the reason for this is that the people per police is decreasing, as the police is increasing. But the counterweight is the area per police station that is decreasing faster than the people per police. So, when the weight of people per police is 1, we can see that the conviction rate is very high, as the capacity is increasing. And when the weight of people per police is 0, the capacity is only dependent on the area per police station, that is increasing, making the capacity to decrease drastically.

Reference values

We have 7 reference parameter values, where 5 of them were sensitive.

Percent change in Police (0 – 0.1(0.0315 original))

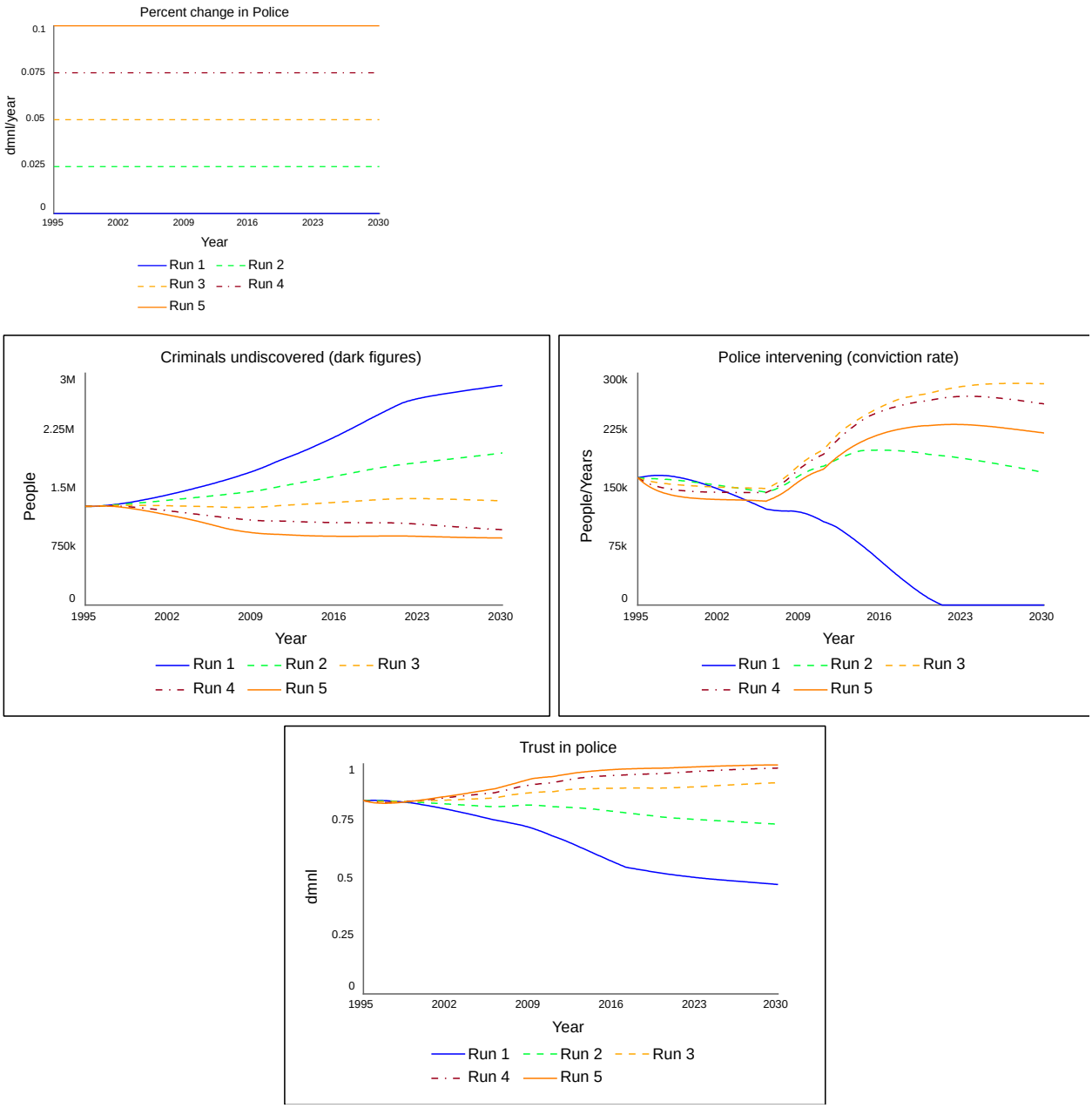


Figure I 0.3 Sensitivity runs for Percent change in Police

As expected, without an increase in the police force, the criminals undiscovered is increasing drastically, the police intervening reaches 0 and the trust decreases. But with a very high fraction of an increase in the police force the criminals undiscovered decreases, and the conviction rate increases, but not as much as with the lower fraction of change in the police force. The reason for this Is that crime is much lower. And trust will also be at the highest.

Average years till retirement (10 – 55 years(37 original))

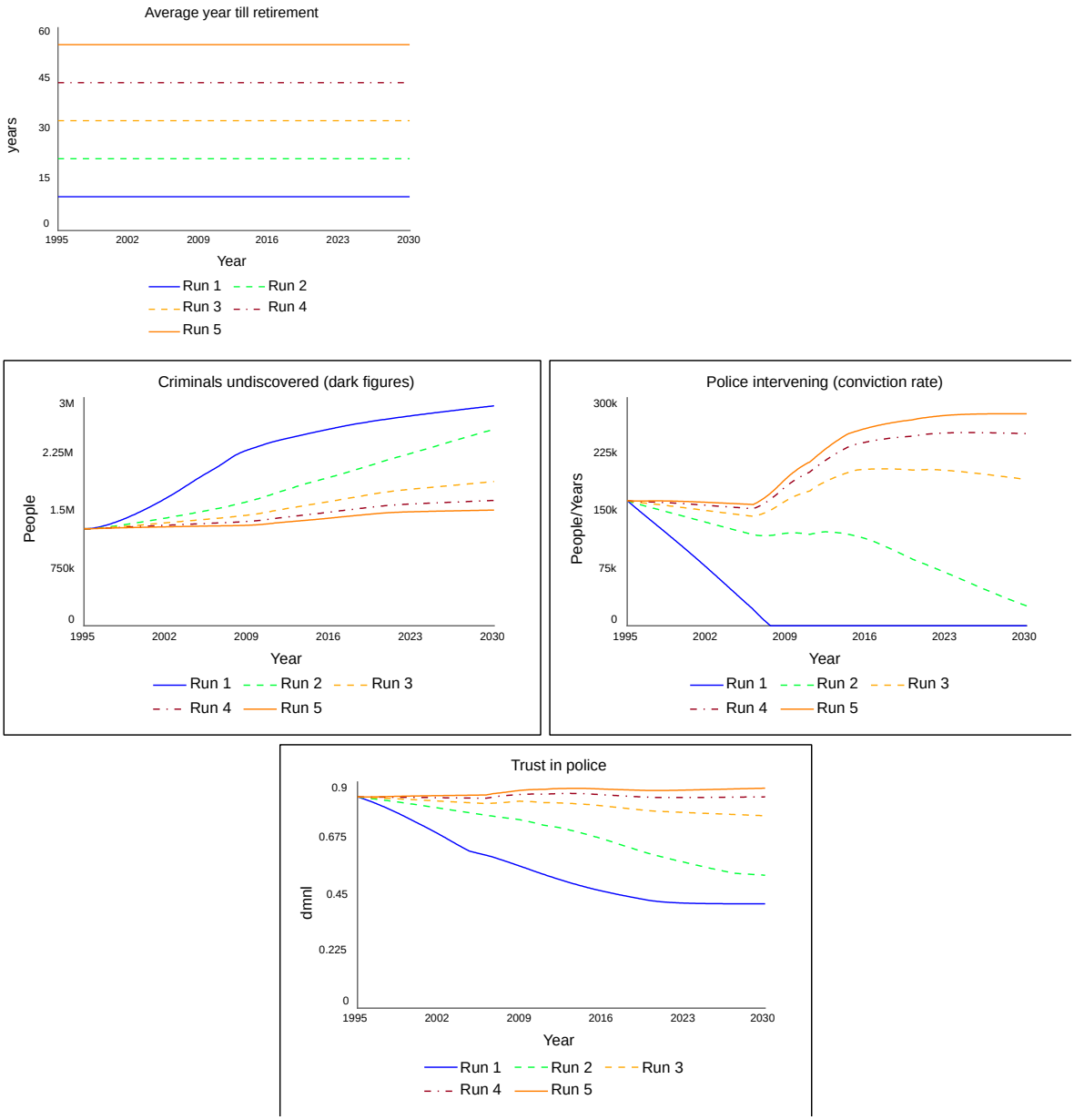


Figure I 0.4 Sensitivity runs for Average years till retirement

When the retirement happens after 10 years (run 1), the criminals undiscovered is high, the police intervening rate is low and the trust is low. The reason for this is that they retire faster than they can hire enough people to fill the gap of retired police. When the retirement year is 55, the criminals undiscovered is low, the conviction is high, so is the trust. The reason for this is that there is a high number of police, as they stay in the stock for a long time, making the number of police high.

Number of shut down police stations (-100 – 100 (-63 original))

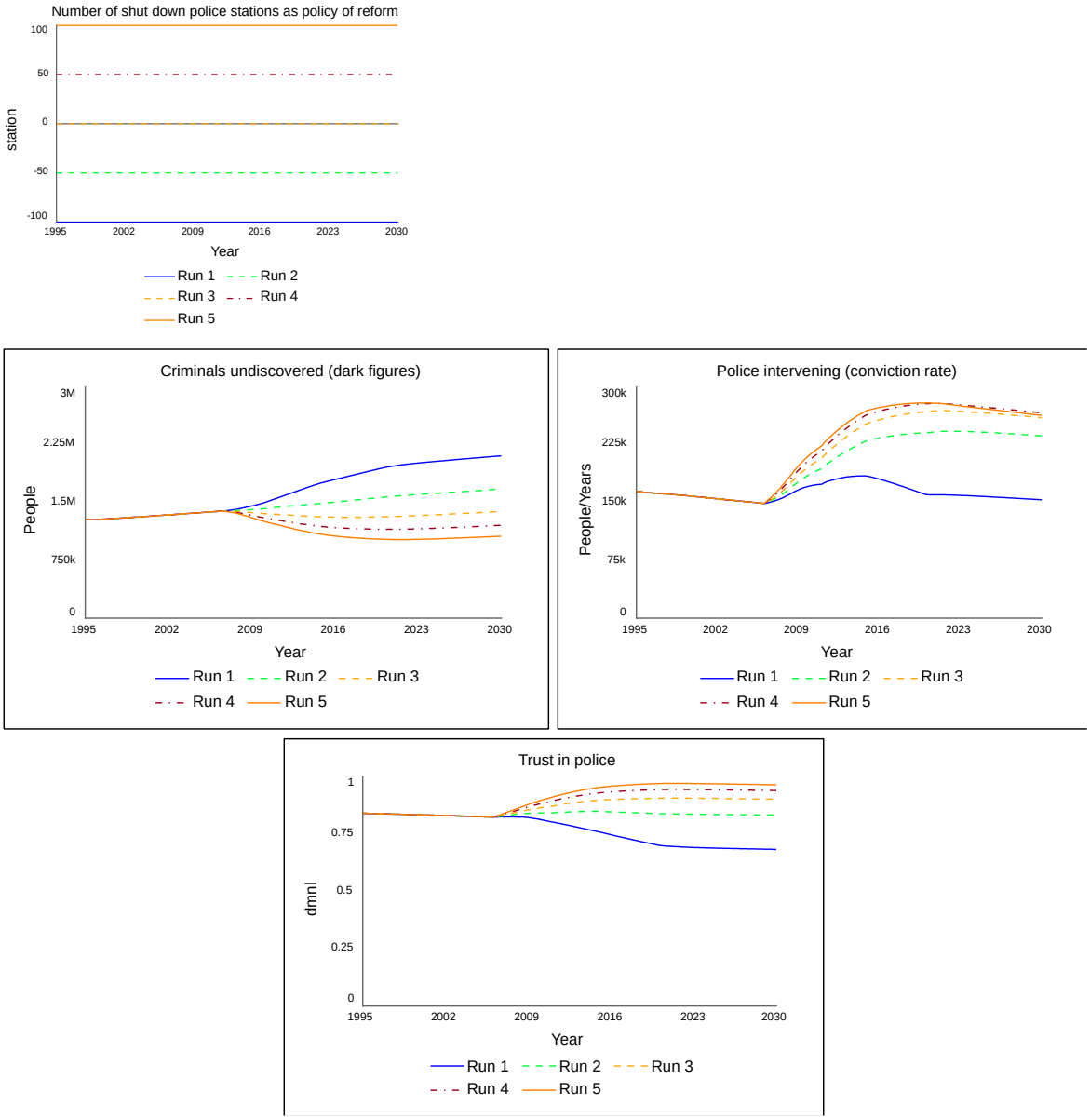


Figure I 0.5 Sensitivity runs for Number of shut down police stations

When they remove (-)100 police stations (run 1) the criminals undiscovered is high, as the visibility drastically decreases. The police intervening is low, as the police capacity is decreasing making the police discovering crime low, and their capability of intervening decreases through the capacity. The trust will therefore also decrease. When they add 100 stations (run 5), the criminals undiscovered decreases, because visibility increases. The conviction rate is also high, as the capacity increases, increasing the detection rate of crime and the polices capability of intervening. Making trust increase.

Percent police intervening 1995 (0.001 – 1 (0.27 original))

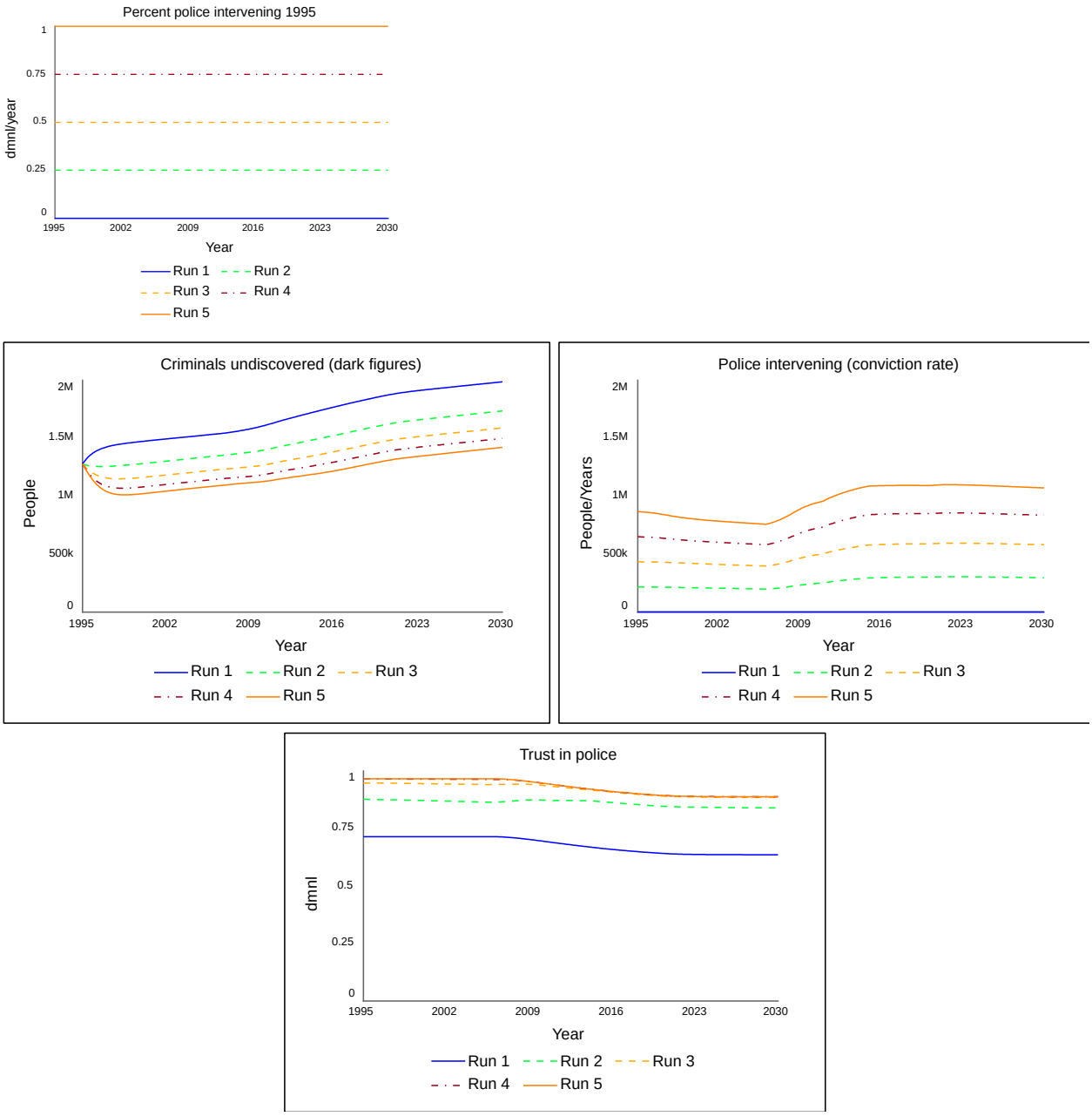
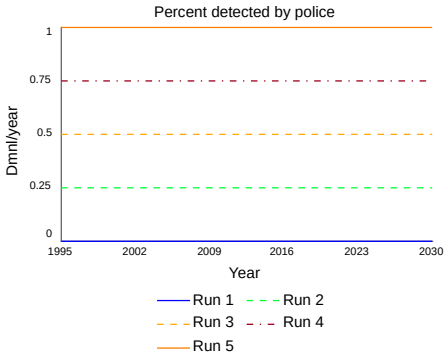
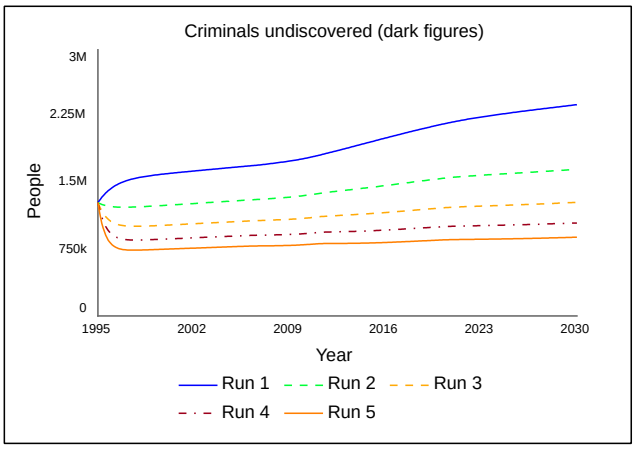


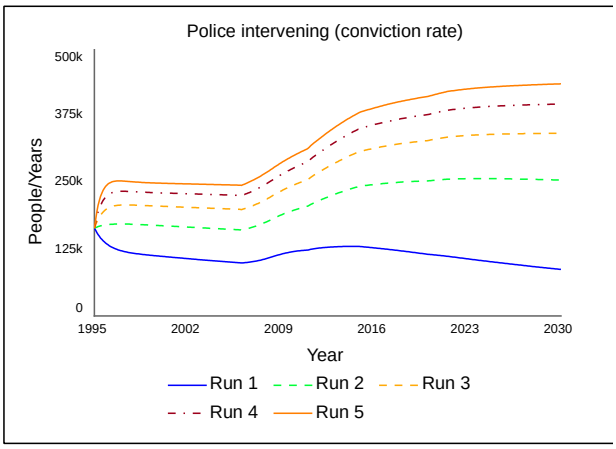
Figure I 0.6 Sensitivity runs for Percent police intervening

When percent police intervening is 0.001 (run 1) the criminals undiscovered increases as the perception of police catching crime decreases, making the availability of doing crime to increase. The police intervening rate will be 0, as they don't intervene in the crime. The trust in the police will be low, as they don't convict anyone. When the police intervening, rate is 1 (run 5) the crime undiscovered will decrease, as they intervene in all crime, the police intervening rate will be high, as they intervene in all crime. This will increase the trust in police.

Percent detected by police (0 – 1 (0.188 original))







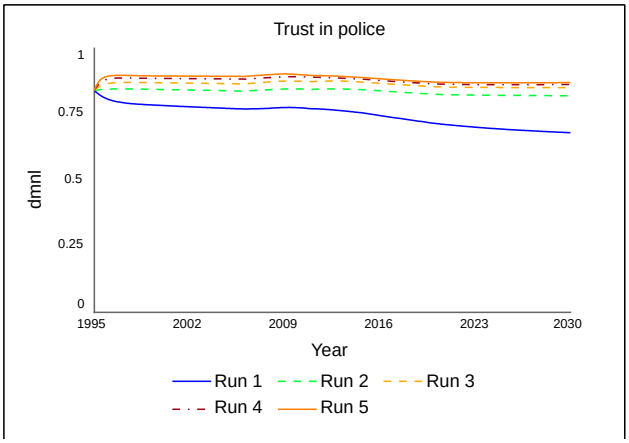


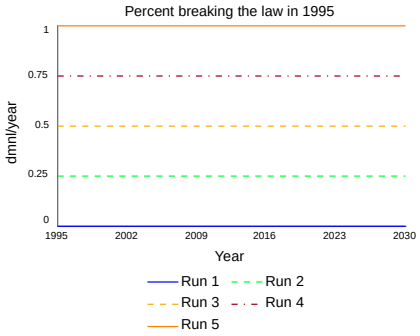
Figure I 0.7 Sensitivity runs for Percent detected by police

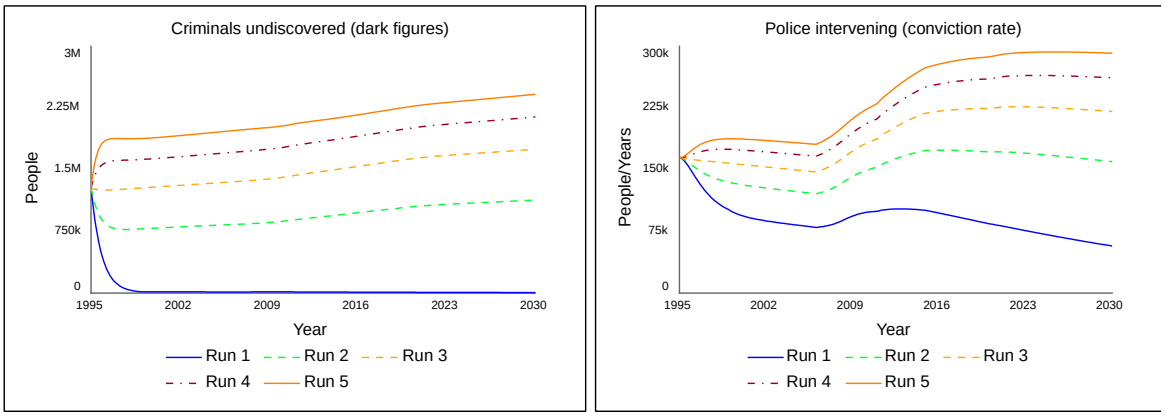
When the percent detected by police is 0 (run 1), the criminals undiscovered is high as the detection rate is low, making the stock to increase. The police intervening is low, as the crime is not detected by the police, making them dependent on only the reported crime. Therefore, the trust decrease, as they are not able to intervene. When the detection rate is 1 (run 5) the criminals undiscovered is low, as they detect most crime, and the police intervening is high, as they capture most crimes. And the trust increases, due to the intervening rate.

Assumed values

We have 4 assumed values, where three of them are sensitive.

Percent breaking the law in 1995 (0.001 – 1(0.52 original))





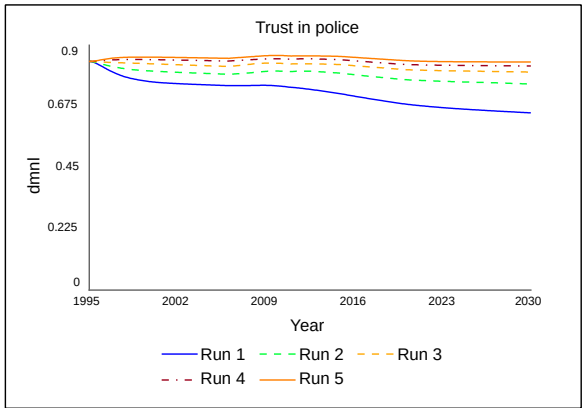


Figure I 0.8 Sensitivity runs for Percent breaking the law in 1995

When the Percent breaking the law is 0.001 (run 1), the criminals undiscovered is low, as there are no people breaking the law. The police intervening rate is decreasing, as there are no crimes to discover when the criminals discovered hits 0. The trust decreases, because the police intervening is relatively low compared to 1995.

Years of training (0.5 - 20 (3 original)

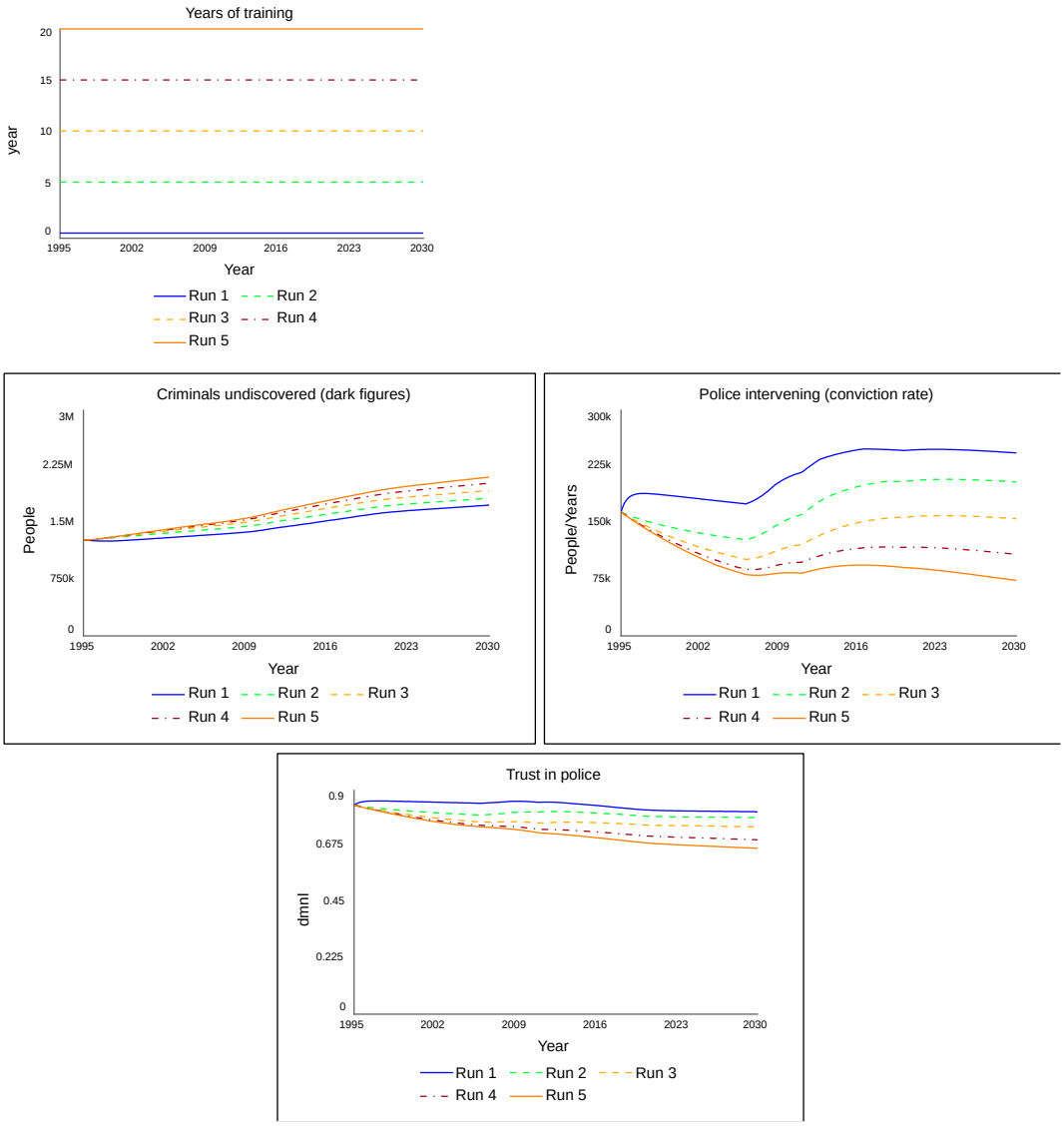


Figure I 0.9 Sensitivity runs for Years of training

When years of training is 0.5 (run 1) the criminals undiscovered is lower, due to the high conviction rate. That is high because the competence is increasing drastically, due to the short training time. Making the trust in police to increase. When the year of training is 20 (run 5) we can see that the criminals undiscovered is increasing, as the conviction is lower. The reason its lower, is that the competence is not increasing effectively due to the amount of years training. Making a decrease in trust.

Years of service till full competence (0.5 – 20 (10 original))

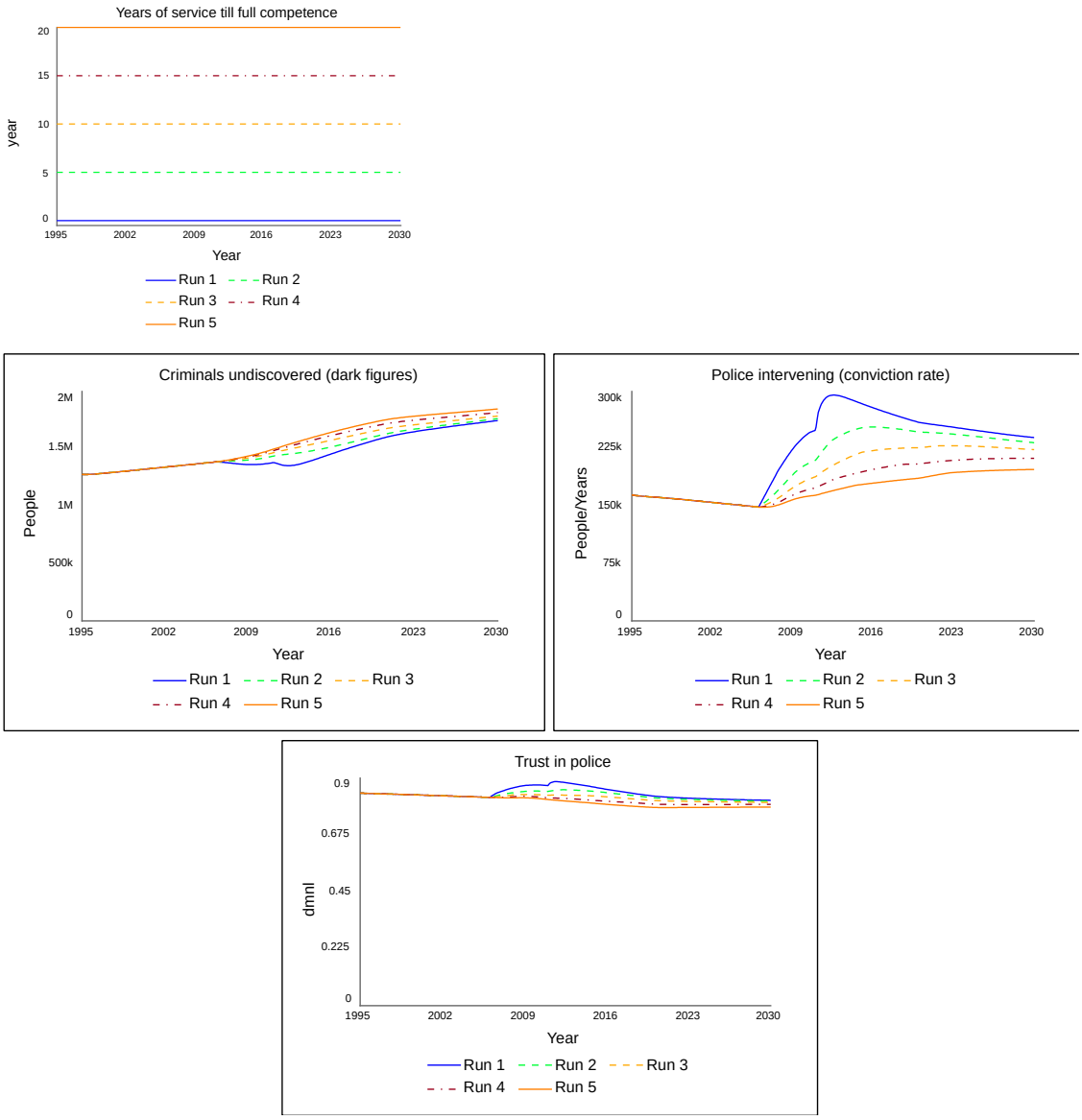


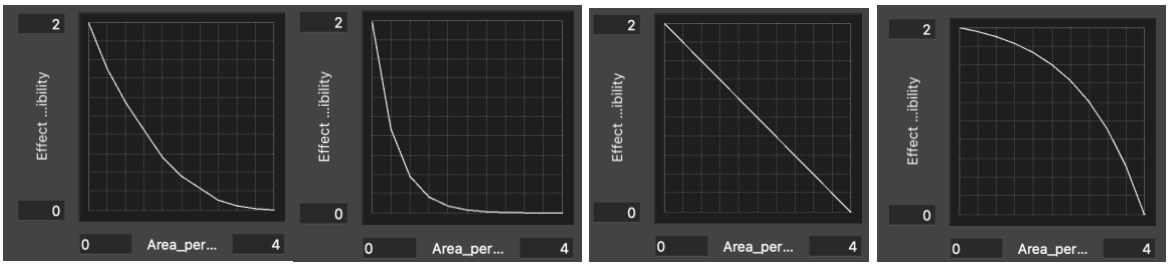
Figure I 0.10 Sensitivity runs for Years of service till full competence

When the years of service till full competence is 0.5 (run 1), the criminals undiscovered is a bit smaller, the reason for this is the increase in police intervening rate, due to that the competence reaches 0.9 in a very short time, due to the short training. This makes the trust increase. When the years of service till full competence is 20 (run 5), the criminals undiscovered is higher because of the low police intervening rate. The conviction rate is low, due to the competence increasing very slowly, since the time of training is now 20 years. Making the trust to decrease.

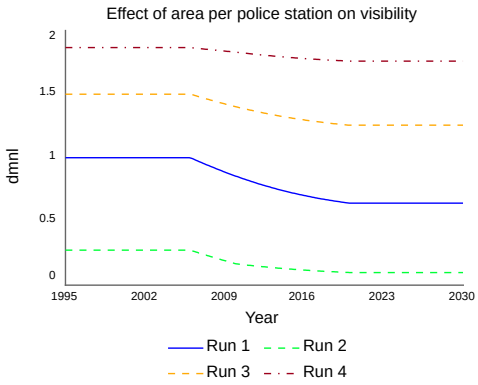
Graphical functions

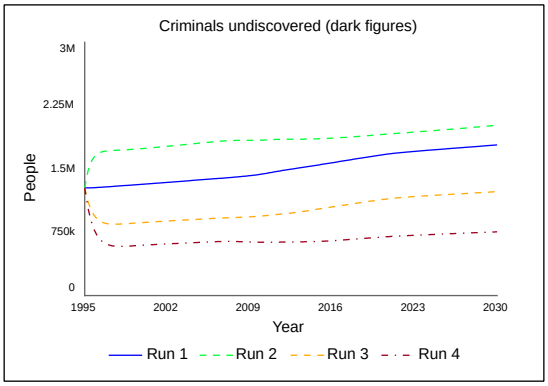
We have 10 graphical functions, where three of them were moderately sensitive:

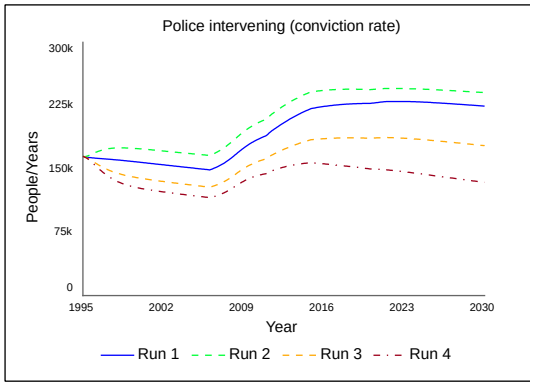
Effect of area per police station on visibility



Original Run 1 *Run 2* *Run 3* *Run 4*







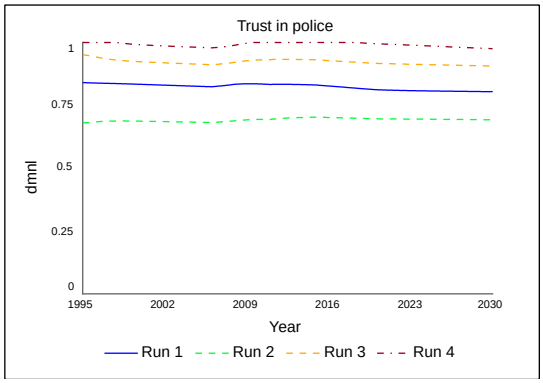
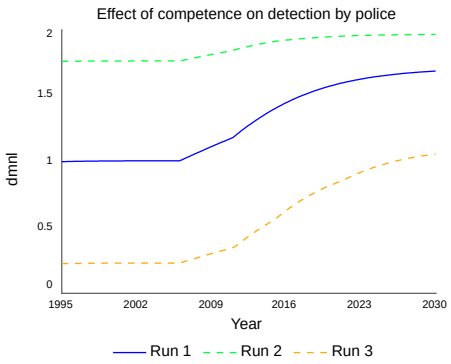


Figure I 0.11 Sensitivity runs for Effect of area per police station on visibility

When the effect of area per police on visibility is low as in run 2, the criminals undiscovered is higher due to the decrease in visibility. The police intervening is also increasing, due to the increase in criminals undiscovered. Therefor the trust will be lower, due to the lack of visibility. When the effect is high as in run 4 the criminals undiscovered will be lower, creating the decrease in police intervening. But due to the increase in visibility, the trust will be higher.

Effect of competence on detection by police

Original Run 1 *Run 2* *Run 3*



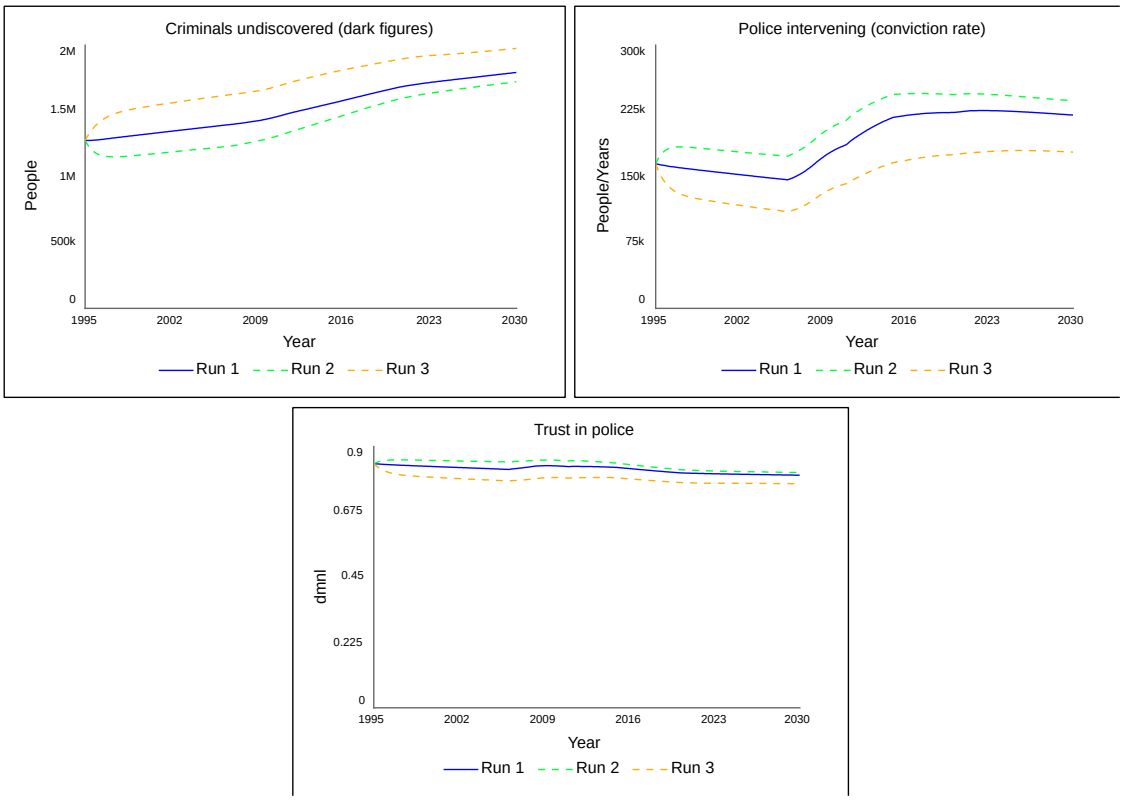
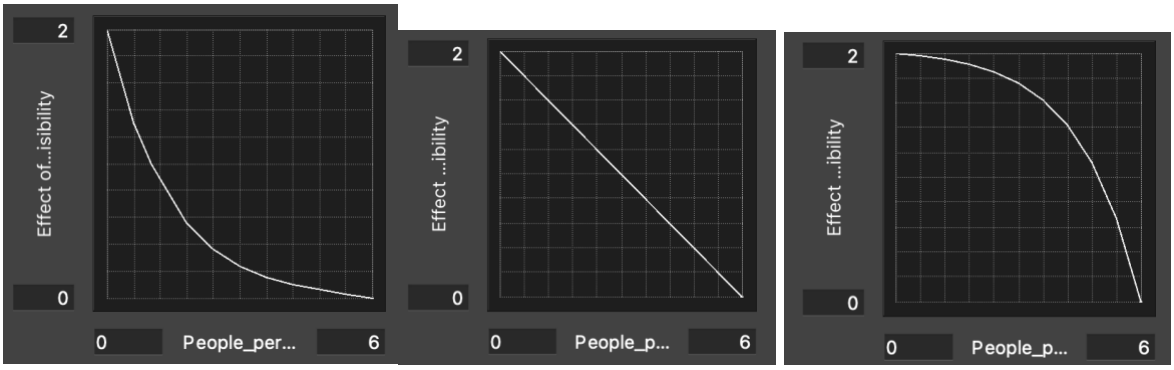


Figure I 0.12 Sensitivity runs for Effect of competence on detection by police

When the effect of competence on detection by police is low like run 3, the criminals undiscovered will be higher as there are less crime discovered. The police intervening rate will be lower, as crime is not discovered, and trust will be at a lower rate. When the effect is high as in run 2 the criminals undiscovered will be low, and the police intervening will be high, due to the increase in detection by police, making the trust to increase.

Effect of people per police on visibility



Original Run 1 *Run 2* *Run 3*

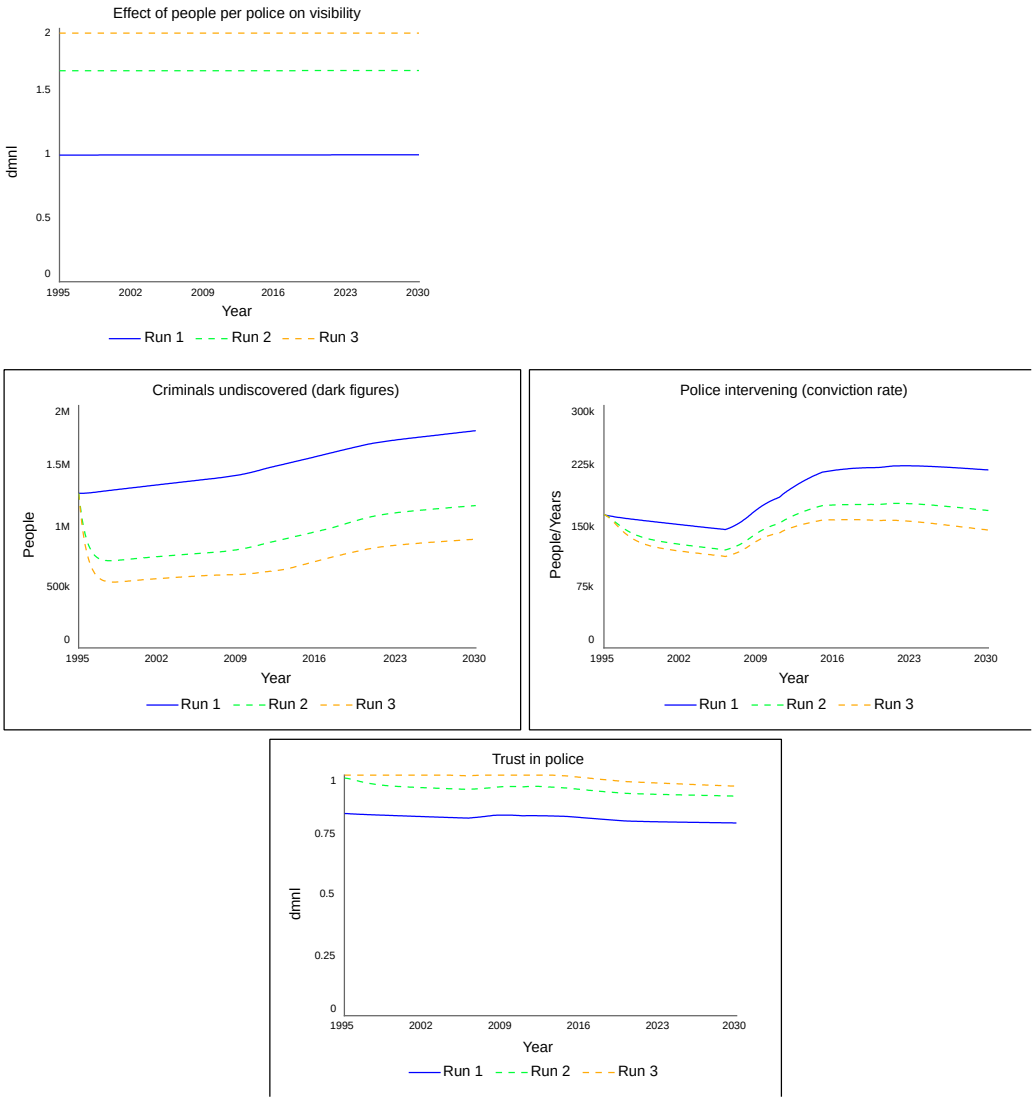


Figure I 0.13 Sensitivity runs for Effect of people per police on visibility

When the effect of people per police on visibility is high as both in run 2 and run 3, we see that the criminals undiscovered is much lower, the intervening is also lower as there are not many people breaking the law sue to the increase in visibility. The trust will also be much higher.

II. Model Documentation

Variables: 168

Modules: 1

Sectors: 18

Stocks: 11

Flows: 21

Converters: 136

Constants: 40

Equations: 117

Graphical functions: 39

Expanded macro variables: 20

Breaking the law sector

Breaking the law Sector
Breaking_the_law_due_to_police_intervening = Effect_of_police_intervening_on_breaking_the_law*Percent_breaking_the_law_in_1995 UNITS: dmnl/year DOCUMENT: This variable represents the Breaking the law due to police intervening. We use the equation Effect_of_police_intervening_on_breaking_the_law *Percent_breaking_the_law_in_1995, to find the change in percent due to police intervening.
Breaking_the_law_due_to_visibility = Percent_breaking_the_law_in_1995*Effect_of_police_visibility_on_breaking_the_law UNITS: dmnl/year DOCUMENT: This variable represents the Breaking the law due to visibility. We use the equation "Percent_breaking_the_law_in_1995 * Effect_of_police_visibility_on_breaking_the_law" to find the change in percent breaking the law due to visibility.
Effect_of_police_intervening_on_breaking_the_law = GRAPH(Police_intervening_relevant_to_1995) Points: (0.000, 1.750), (0.400, 1.377), (0.800, 1.097), (1.000, 1.000), (1.600, 0.7285), (2.000, 0.6096), (2.400, 0.5202), (2.800, 0.434), (3.200, 0.362), (3.600, 0.306), (4.000, 0.250)

UNITS: dmnl

DOCUMENT: This variable is a graphical function, and represents the Effect of police intervening on breaking the law (Rouse, 1985; Wilson & Boland, 1978). The police have to intervene 4 times as much as in 1995, to reach the lowest level, on 0.25. The reason as to why it does not reach 0, is because some people will break the law, no matter how much the police intervene.

Effect_of_police_visibility_on_breaking_the_law =
GRAPH(Police_visibility_relevant_to_1995)
Points: (0.000, 1.987), (0.200, 1.964), (0.400, 1.905), (0.600, 1.762), (0.800, 1.462), (1.000, 1.000), (1.200, 0.5379), (1.400, 0.2384), (1.600, 0.09485), (1.800, 0.03597), (2.000, 0.01339)

UNITS: dmnl

DOCUMENT: This variable is a graphical function and represents the Effect of police visibility on breaking the law. Where breaking the law will increase when the visibility of police is decreasing (Bun et al., 2020; Klick & Tabarrok, 2005; Levitt, 1998b; Rouse, 1985).

Percent_breaking_the_law =
Breaking_the_law_due_to_visibility*Weight_of_visibility_on_breaking_the_law+(1-Weight_of_visibility_on_breaking_the_law)*Breaking_the_law_due_to_police_intervening

UNITS: dmnl/year

DOCUMENT: This variable represents the Percent breaking the law. We use the equation Breaking_the_law_due_to_visibility*Weight_of_visibility_on_breaking_the_law+(1-Weight_of_visibility_on_breaking_the_law) *Breaking_the_law_due_to_police_intervening. This gives us the percent change due to both the visibility and police intervening, where we have a weight of 0.85 on the visibility, and the remaining 0.25 on the police intervening.

Percent_breaking_the_law_in_1995 = 0.52

UNITS: dmnl/year

DOCUMENT: This parameter is representing the Percent breaking the law in 1995.The parameter has been calibrated din the model relevant to the number of dark figures at time 1995 and the population at time 1995 (Statistics Denmark, 2023e), which gives us the fraction of 0.52.

Weight_of_visibility_on_breaking_the_law = 0.85

UNITS: dmnl

DOCUMENT: This parameter represents the Weight of visibility on breaking the law. As the visibility has a bigger effect on the percent change in breaking the law, compared to police intervening. As the police intervening is not necessary known to the public. This is assumed to be 0.85.

Table II 0.1 Documentation: Breaking the law sector

Charges sector

Charges sector
Average_charges_from_police_intervening = 0.83 UNITS: dmnl DOCUMENT: This parameter represents the Average charges from police intervening. This has been calculated by dividing the number of Charges (Statistics Denmark, 2023d) in 1995 on the number of total convictions (Statistics Denmark, 2023d) in 1995. Which gives us the values of 0.83.6/29/2023 9:13:00 AM
Charges_from_Police_intervening = "Police_intervening_(convictions)"*Percent_charges_relevant_to_convictions UNITS: People/year DOCUMENT: This variable represents the Charges from police intervening. We use the equation "Police_intervening_(convictions)"*Percent_charges_relevant_to_convictions" to calculate the number of charges based on the number of police intervening.
Charges_from_police_intervening_in_1995 = 136000 UNITS: people/year DOCUMENT: This parameter represents the Charges from police intervening in 1995. The value is 136900, as there were 136900 charges in 1995 (Statistics Denmark, 2023d).
Charges_from_police_intervening_relevant_to_1995 = SMTH1(Charges_from_Police_intervening/Charges_from_police_intervening_in_1995, Perception_delay_for_the_charged_per_report) {DELAY CONVERTER} UNITS: dmnl DOCUMENT: This variable represents the Charges from reports relevant to 1995. We use the equation SMTH1(Charges_from_Police_intervening/Charges_from_police_intervening_in_1995,

Perception_delay_for_the_charged_per_report) to measure the change in charges from reports compared to the number of charges from reports in 1995.We use a delay function, as it takes time for people to perceive the reported being charged.
Percent_charges_relevant_to_convictions = People_reported_relevant_to_1995*Average_charges_from_police_intervening UNITS: dmnl DOCUMENT: This variable represents the Percent charges relevant to convictions. Where we use the equation People_reported_relevant_to_1995 * Average_charges_from_police_intervening to determine the change in charges, due to change in reports.
Perception_delay_for_the_charged_per_report = 2 UNITS: years DOCUMENT: This parameter represents the Perception delay for the charged per report. And is set as 2 years. It takes time for a report to be handled, and it takes time to know about the handling of the charge made of the reports.

Table II 0.2 Documentation: Charges sector

Criminal activity sector

Criminal activity sector
Change_in_population = Change_in_population_per_year UNITS: People/year DOCUMENT: This flow represents the Change in population. Where we use the input Change_in_population_per_year to have the yearly increase of the population in the stock and flow system.
Crime_detected_by_police = MIN("Criminals_undiscovered_(dark_figures)"*Detected_by_police, "Criminals_undiscovered_(dark_figures)"/DT) UNITS: people/year DOCUMENT: This flow represent the Crime detected by police, where we use the equation MIN("Criminals_undiscovered_(dark_figures)"*Detected_by_police, "Criminals_undiscovered_(dark_figures)"/DT We use the MIN function to limit the flow from

taking more from the stock it outflows, than what the stock obtains. The flow depletes the stock of “Criminals undiscovered (dark figures)” and increased the stock of “criminals known to the police”.
Criminals_convicted(t) = Criminals_convicted(t - dt) + ("Police_intervening_(convictions)" - Not_guilty_convictions - Guilty_convictions - Criminals_sentenced_to_prison) * dt INIT Criminals_convicted = 165564 UNITS: People DOCUMENT: This stock represents the number of caught criminals. The initial value for this stock is 165564 in 1995 (Statistics Denmark, 2023d). The stock increases by the flow of "police intervening" and depletes by the flows "guilty”, “not guilty” and "criminals sentenced to prison".
Criminals_known_to_the_police(t) = Criminals_known_to_the_police(t - dt) + (Criminals_reported + Crime_detected_by_police - "Police_intervening_(convictions)" - Criminals_never_caught) * dt INIT Criminals_known_to_the_police = 866000 UNITS: People DOCUMENT: This stock represents the Known criminals where the set value is 866000, this is determined by a calculation of the reported, charged (Statistics Denmark, 2023d) and the relevant number that are detected by police The stock depletes by the flow of "police intervening" and "never caught". It increases by the flow of "crime reported"
Criminals_never_caught = MIN(Criminals_known_to_the_police*(1-Percent_police_intervening), Criminals_known_to_the_police/DT) UNITS: People/year DOCUMENT: This flow represents the Never caught. Where we use the equation MIN(Criminals_known_to_the_police*(1-Percent_police_intervening), Criminals_known_to_the_police/DT) to calculate how many of the known criminals are “never caught”. We use the MIN function to limit the flow from taking more from the stock it outflows, than what the stock obtains. This flow depletes the "Known criminals", and increases the "people - not committing crime".

Criminals_Never_reported_or_discovered = MIN("Criminals_undiscovered_(dark_figures)"*(1-Percent_crime_reported_to_police), "Criminals_undiscovered_(dark_figures)"/DT) UNITS: People/year DOCUMENT: This flow represents the Never reported. We use the equation MIN("Criminals_undiscovered_(dark_figures)"*(1-Percent_crime_reported_to_police), "Criminals_undiscovered_(dark_figures)"/DT) to calculate the number of people who do not report crime. We use the MIN function to limit the flow from taking more from the stock it outflows, than what the stock obtains. This flow depletes the "unknown criminals" stock, and increases the "People - not committing crime"
Criminals_released_from_prison = MIN(Imprisonment/Prison_time_average, Imprisonment/DT) UNITS: People/year DOCUMENT: We use the equation MIN(Imprisonment/Prison_time_average, Imprisonment/DT) to determine the amount of people who are imprisoned depletes based on a delay time. We use the MIN function to limit the flow from taking more from the stock it outflows, than what the stock obtains. This flow depletes the “Imprisoned” stock and increases the “people not committing crime” stock.
Criminals_reported = MIN("Criminals_undiscovered_(dark_figures)"*Percent_crime_reported_to_police, "Criminals_undiscovered_(dark_figures)"/DT) UNITS: People/Years DOCUMENT: This flow represents the Crime reported. We calculate this using the equation MIN("Criminals_undiscovered_(dark_figures)"*Percent_crime_reported_to_police, "Criminals_undiscovered_(dark_figures)"/DT). We use the MIN function to limit the flow from taking more from the stock it outflows, than what the stock obtains. This flow depletes the "Unknown criminals" stock, and increases the "Known criminals" stock.
Criminals_sentenced_to_prison = MIN(Criminals_convicted*percent_imprissoned, Criminals_convicted/DT) UNITS: People/Year

DOCUMENT: We use the equation MIN(Criminals_convicted*percent_imprissoned, Criminals_convicted/DT) to calculate the number of criminals that are sentenced to prison. We use the MIN function to limit the flow from taking more from the stock it outflows, than what the stock obtains. The flow depletes the “criminals convicted” stock and increases the “imprisoned” stock.

"Criminals_undiscovered_(dark_figures)"(t) = "Criminals_undiscovered_(dark_figures)"(t - dt) + (People_Breaking_the_law - Criminals_Never_reported_or_discovered - Criminals_reported - Crime_detected_by_police) * dt

INIT "Criminals_undiscovered_(dark_figures)" = 1276000

UNITS: People

DOCUMENT: This stock represents the Unknown criminals. This is a somewhat calibrated number, as the percent of crime unknown to the police is around 60% (Buil-Gil et al., 2021). So the reported number of criminals is just around 40%.

Around 68% of the convictions, are convicted because of the report based on historical data. Or as i have represented them here, 68% is charges from reports. That means 32% is made from the police.
In 1995 40% of the criminals undiscovered were reported to the police (Buil-Gil et al., 2021) base don litteraturen. 40/68=0.588 Which gives us the fraction of charges or convicted per undiscovered. To make up to 100% we take 0.588*32=18.8, that gives us the fraction that are discovered by police.

People reported are 607 000. If we divide this by 40, this gives us 15 175. If we then times this by 100, it gives us 1 517 500

Detected_by_police = Detection_by_police_due_to_competence*Police_capacity_relevant_to_1995

UNITS: Dmnl/year

DOCUMENT: This variable is representing the Detected by police. We use the equation Detection_by_police_due_to_competence*Police_capacity_relevant_to_1995 to measure the percent detected by police, based on their capacity (Blesse & Diegmann, 2022).

Detection_by_police_due_to_competence = Effect_of_competence_on_detection_by_police*Percent_detected_by_police UNITS: Dmnl/year DOCUMENT: We use the equation Effect_of_competence_on_detection_by_police *Percent_detected_by_police to determine the change in detection by police based on the competence.
Effect_of_competence_on_detection_by_police = GRAPH(Police_competence_relevant_to_1995) Points: (0.000, 0.000), (0.200, 0.200), (0.400, 0.400), (0.600, 0.600), (0.800, 0.800), (1.000, 1.000), (1.200, 1.200), (1.400, 1.400), (1.600, 1.600), (1.800, 1.800), (2.000, 2.000) UNITS: dmnl DOCUMENT: When the police improve their competence, they are able to work more efficiently, where factors like knowledge of police and laws, understanding of mental health issues and other diverse communities, decision making and problem solving can increase the police detection of crime (Bennell et al., 2022).
Guilty_convictions = MIN(Criminals_convicted*Percent_Guilty_1995, Criminals_convicted/DT) UNITS: People/year DOCUMENT: This flow represents the Guilty. We use the equation MIN(Criminals_convicted*Percent_Guilty_1995, Criminals_convicted/DT) to calculate the number of criminals convicted that enter the flow. We use the MIN function to limit the flow from taking more from the stock it outflows, than what the stock obtains. The flow depletes the "caught criminals" stock an increases the stock of "people- not committing crime"
Imprisonment(t) = Imprisonment(t - dt) + (Criminals_sentenced_to_prison - Criminals_released_from_prison) * dt INIT Imprisonment = 13500 UNITS: People DOCUMENT: This stock represents the Imprisonment. Where the initial value is 13500 based on data from Denmark (Statistics Denmark, 2023d). The stock increases by the flow of “Criminals sentenced to prison. And depletes by the flow of “criminals released from prison”.

Not_guilty_convictions = MIN(Criminals_convicted*(Percent_not_guilty), Criminals_convicted/DT) UNITS: People/year DOCUMENT: This flow represents the Not guilty. We use the equation MIN(Criminals_convicted*(Percent_not_guilty), Criminals_convicted/DT) to calculate the number of not guilty centences. We use the MIN function to limit the flow from taking more from the stock it outflows, than what the stock obtains. This flow depletes the "criminals convicted" and increases the "people - not committing crime" stock.
"People_-_not_committing_crime"(t) = "People_-_not_committing_crime"(t - dt) + (Change_in_population + Criminals_never_caught + Criminals_Never_reported_or_discovered + Criminals_released_from_prison + Guilty_convictions + Not_guilty_convictions - People_Breaking_the_law) * dt INIT "People_-_not_committing_crime" = Population-("Criminals_undiscovered_(dark_figures)"+Criminals_known_to_the_police+ Criminals_convicted) UNITS: People DOCUMENT: This stock represents the People - Not committing crime. The initial value for this stock is Population-(Unknown_criminals+Known_criminals+ Caught_criminals). This is to calculate the population not doing crime. The stock depletes by the flow of "People breaking the law". The stock increases by the flows of “change in population”, "Never reported", "never caught","not guilty", "guilty" and “criminals released from prison”
People_Breaking_the_law = MIN("People_-_not_committing_crime"*Percent_breaking_the_law, "People_-_not_committing_crime"/DT) UNITS: People/Year DOCUMENT: This flow is calculated by the equation of MIN("People_-_not_committing_crime"*Percent_breaking_the_law, "People_-_not_committing_crime"/DT) to calculate the number of people breaking the law. We use the MIN function to limit the flow from taking more from the stock it outflows, than what the stock obtains. It depletes the stock of "people - Not committing crime" and increases the stock of "unknown criminals"
Percent_crime_reported_to_police = People_reported/"Criminals_undiscovered_(dark_figures)"

UNITS: dmnl/year DOCUMENT: This parameter represents the Percent crime reported to Police. We use the equation People_reported/"Criminals_undiscovered_(dark_figures)" to calculate the percent of reported crime.
Percent_detected_by_police = 0.188 UNITS: Dmnl/year DOCUMENT: This parameter represents the detected by police. Around 68% of the convictions, are convicted because of the report based on historical data. Or as i have represented them here, 68% is charges from reports. That means 32% is made from the police. In 1995 40% of the criminals undiscovered were reported to the police. 40/68=0.588 Which gives us the fraction of charges or convicted per undiscovered. To make up to 100% we take 0.588*32=18.8, that gives us the fractions that are discovered by police.
Percent_Guilty_1995 = 0.788 UNITS: Dmnl/year DOCUMENT: This variable represents the Percent guilty in 1995. When I calculate the number of guilty per the total decisions the ratio is 0.922 (Statistics Denmark, 2023d), but 0.134 of the guilty fraction is part of the percent imprisoned. So 0.922-0.134=0.788.
Percent_imprisoned = 0.134 UNITS: dmnl/year DOCUMENT: This parameter represents the percent imprisoned. The fraction is set at 0.134 (Statistics Denmark, 2023d).
Percent_not_guilty = 1-(Percent_Guilty_1995+percent_imprissoned) UNITS: dmnl/year DOCUMENT: We use the equation of 1-(Percent_Guilty_1995+Percent_imprisoned) to calculate the number of Not guilty fraction.
"Police_intervening_(convictions)" = MIN(Criminals_known_to_the_police*Percent_police_intervening, Criminals_known_to_the_police/DT) UNITS: People/Years DOCUMENT: This flow represents the Police intervening. We use the equation MIN(Criminals_known_to_the_police*Percent_police_intervening,

Criminals_known_to_the_police/DT) to calculate the number of people being caught by the police intervening. We use the MIN function to limit the flow from taking more from the stock it outflows, than what the stock obtains. This stock increases the "Caught criminals" and depletes the "Known criminals' stock"
Prison_time_average = 0.6 UNITS: years DOCUMENT: The prison time average is set as 0.6, based on data of average time spent in prison in Denamrk (Statistics Denmark, 2023b, 2023c)
Total_guilty = Criminals_sentenced_to_prison+Guilty_convictions UNITS: People/Years DOCUMENT: We use the equation Criminals_sentenced_to_prison+Guilty_convictions to calculate the total number of guilty sentences.

Table II 0.3 Documentation: Criminal activity sector

Police competence sector

Police competence sector
"Percent_of_police_with_competence_of_0.5_percent" = "Police_with_competence_of_0.5_percent"/Police UNITS: dmnl DOCUMENT: This variable represents the Percent of police with 0.5 competence. We use the equation "Competence_of_0.5"/Police. This is to calculate how high the percent is of people with 0.5 in competence compared to the whole police force.
"Percent_of_police_with_competence_of_0.9_percent" = "Police_with_competence_of_0.9_percent"/Police UNITS: dmnl DOCUMENT: This variable represents the Percent of police with 0.9 competence. We use the equation "Competence_of_0.9"/Police to calculate how high the percent is of people with 0.9 in competence compared to the whole police force.
"Percent_retired_in_competence_of_0.5" = IF TIME<2006 OR SWITCH_Police_reform_2006 = 0 THEN 1 ELSE 0.3 UNITS: dmnl

DOCUMENT: We use the equation IF TIME<2006 OR SWITCH_Police_reform_2006 = 0 THEN 1 ELSE 0.3. This is because the focus of competence came after the reform. So if the time is before 2006 or the Switch is 0 (meaning the reform did not happen), the fraction would be 1. If the time is more than 2006 or the switch is set to 1, only a fraction of 0.3 is retired in the competence of 0.5 stock.

"Police_with_competence_bellow_0.5_percent"(t) = "Police_with_competence_bellow_0.5_percent"(t - dt) + (Rookies - Training) * dt

INIT "Police_with_competence_bellow_0.5_percent" = 990

UNITS: police

DOCUMENT: This stock represents the number of police with competence bellow 0.5. It increases by the inflow of Rookies and depletes by the outflow of Training. It has the initial value of 990, which is calibrated.

"Police_with_competence_of_0.5_percent"(t) = "Police_with_competence_of_0.5_percent"(t - dt) + (Training - Reform_policy_of_competence - "Retirement_of_police_with_competence_of_0.5") * dt

INIT "Police_with_competence_of_0.5_percent" = 8900

UNITS: police

DOCUMENT: This stock represents the Competence of 0.5. Where the initial value is the Police stock, as I have assumed that all police at time 1995 has the competence of 0.5. The stock increases by the Training flow, and depletes by the Retirement of police with competence of 0.5 and the reform policy of competence.

"Police_with_competence_of_0.9_percent"(t) = "Police_with_competence_of_0.9_percent"(t - dt) + (Reform_policy_of_competence - "Retirement_of_police_with_competence_of_0.9") * dt

INIT "Police_with_competence_of_0.9_percent" = 0

UNITS: police

DOCUMENT: This stock is representing the Competence of 0.9. The set value for this stock is 0. The new policy was focusing on increasing the competence of the police force. There are no actual measures of their competence. But I have assumed that none has 0.9 in competences, and that this is first reachable after the policy of the reform. The reason for this is because before the policy, people would be trained in their "field", while now they focus on a variety of

situations, and techniques that needs to be covered by the police for them to be more efficient and have work in a certain quality (Holmberg, 2014).
"Retirement_of_police_with_competence_of_0.5" = (Retired_police*"Percent_retired_in_competence_of_0.5") UNITS: police/Year DOCUMENT: This flow represents the Retirement of police with competence of 0.5. We use the equation (Retired_police*"Percent_retired_in_competence_of_0.5") to calculate the number of police officers that retire with competence of 0.5
"Retirement_of_police_with_competence_of_0.9" = (Retired_police*(1-"Percent_retired_in_competence_of_0.5")) UNITS: police/Year DOCUMENT: This flow represent the Retirement of police with competence of 0.9. We use the equation "Competence_of_0.9"/"Years_till_retirement_after_reaching_0.9" to calculate the number of police officers that retire with competence of 0.9
Average_competence_per_person_in_police_force = ("Percent_of_police_with_competence_of_0.5_percent"*0.5)+("Percent_of_police_with_competence_of_0.9_percent"*0.9) UNITS: dmnl DOCUMENT: This variable represents the Average competence per person in police force. We use the equation ("Percent_of_police_with_0.5_competence"*0.5)+("Percent_police_with_0.9_competence"*0.9). This is to calculate the average competence per person, to measure the growth in competence dependent on the number of police with the different competence levels.
Police_competence_in_1995 = 0.445 UNITS: dmnl DOCUMENT: This Parameter represents the Police competence in 1995. I have set the value to 0.445. This is calibrated to fit the “average competence per person in police force” in 1995.

Police_competence_relevant_to_1995 = IF SWITCH_Competence_without_growth=0 THEN Average_competence_per_person_in_police_force/Police_competence_in_1995 ELSE Police_competence_in_1995/Police_competence_in_1995

UNITS: dmnl

DOCUMENT: This variable represents the Police competence relevant to 1995. We use the equation Average_competence_per_person_in_police_force/Police_competence_in_1995 to measure the change in competence relevant to 1995. And the SWITCH function to be able to see how the system works if the competence did not change.

Police_reform_INTENSITY_on_competence = GRAPH(TIME)
Points: (2006.00, 1.0000), (2006.68571429, 0.9541), (2007.37142857, 0.9124), (2008.05714286, 0.8745), (2008.74285714, 0.8402), (2009.42857143, 0.8089), (2010.11428571, 0.7806), (2010.80, 0.7548), (2011.48571429, 0.7314), (2012.17142857, 0.7102), (2012.85714286, 0.6909), (2013.54285714, 0.6734), (2014.22857143, 0.6574), (2014.91428571, 0.6430), (2015.60, 0.6299), (2016.28571429, 0.6179), (2016.97142857, 0.6071), (2017.65714286, 0.5973), (2018.34285714, 0.5883), (2019.02857143, 0.5802), (2019.71428571, 0.5729), (2020.40, 0.5662), (2021.08571429, 0.5601), (2021.77142857, 0.5546), (2022.45714286, 0.5496), (2023.14285714, 0.5450), (2023.82857143, 0.5409), (2024.51428571, 0.5371), (2025.20, 0.5337), (2025.88571429, 0.5306), (2026.57142857, 0.5278), (2027.25714286, 0.5253), (2027.94285714, 0.5229), (2028.62857143, 0.5208), (2029.31428571, 0.5189), (2030.00, 0.5172)

UNITS: dmnl

DOCUMENT: This parameter represents a Policy reform intensity on competence. This is to calculate the intensity of the reform. The more integrated the policy of the reform is, the faster they can develop competence, as they learn more efficient ways to reach the competence level of 0.9.

Reform_policy_of_competence = IF SWITCH_Police_reform_2006 =1 AND TIME > 2006 THEN "Police_with_competence_of_0.5_percent"/Years_to_develop_competence ELSE 0

UNITS: police/Year

DOCUMENT: This flow represents the Reform policy of competence. We use the equation IF SWITCH_Police_reform_2006 =1 AND TIME > 2006 THEN "Police_with_competence_of_0.5_percent"/Years_to_develop_competence ELSE 0. The

switch represents the implementation of policy. So, if Switch is 1, then the policy is implemented. If the switch is 0 the policy was never implemented. We use IF THEN ELSE function to have the policy implemented as set time (2006), as this is the year the policy started in Denmark. This flow depletes the Police with competence of 0.5 and increases the Police with competence of 0.9 percent.
Rookies = Average_change_in_police_per_year UNITS: police/Year DOCUMENT: This flow represents the Rookies in the police force. We use the input Average_change_in_police_per_year to capture the change in new police every year. This flow increases the Police with competence below 0.5.
Training = "Police_with_competence_bellow_0.5_percent"/Years_of_training UNITS: police/Year DOCUMENT: This flow represents the Training. Where we use the equation "Competence_bellow_0.5"/Years_of_training to calculate the number of people in the Competence bellow 0.5 stock, that enters the "competence of 0.5" stock with the delay of Years of training.
Years_for_the_reform_policy_to_be_integrated = 5 UNITS: year DOCUMENT: This parameter represents the Years for the reform policy to be integrated. The value for this parameter is set as 5 years. This is a pure assumption, but it takes time to integrate such a system, and 5 years seems reasonable for them to fully implement this new policy.
Years_of_service_till_full_competence = 10 UNITS: year DOCUMENT: This parameter represents the Years of service till full competence. The value for this parameter is 10 years. As I assume it takes a long time to reach this high of a competence, and a lot of work experience.
Years_of_training = 3 UNITS: year DOCUMENT: This variable represents the Years of training. It is set to 3 years, as it takes about 3 years before they reach a common understanding of the field and work experience.

Years_to_develop_competence = IF TIME >2006 AND TIME < 2011 THEN Years_for_the_reform_policy_to_be_integrated+(Years_of_service_till_full_competence*Police_reform_INTENSITY_on_competence) ELSE Years_of_service_till_full_competence*Police_reform_INTENSITY_on_competence UNITS: Years DOCUMENT: This variable represents the Years to develop competence. Where we use the equation IF TIME >2006 AND TIME < 2011 THEN Years_for_the_reform_policy_to_be_integrated+(Years_of_service_till_full_competence*Police_reform_INTENSITY_on_competence) ELSE Years_of_service_till_full_competence*Police_reform_INTENSITY_on_competence. This is to add the integration time, as well as the "training" time, that are both effected by the policy intensity that decreases the time to develop competence, the longer the system is integrated.
SWITCH_Competence_without_growth=0 UNITS: Dmnl DOCUMENT: This SWITCH is a switch to see how the system works if the competence stayed at the same level over the simulated time as it was in 1995, without any growth.

Table II 0.4 Documentation: Police competence sector

Police intervening sector

Police intervening sector
Effect_of_competence_on_police_intervening = GRAPH(Police_competence_relevant_to_1995) Points: (0.000, 0.000), (0.200, 0.1063), (0.400, 0.2068), (0.600, 0.3831), (0.800, 0.6548), (1.000, 1.000), (1.200, 1.345), (1.400, 1.617), (1.600, 1.793), (1.800, 1.894), (2.000, 2.000) UNITS: dmnl DOCUMENT: This variable is a graphical function that represents the Effect of competence on police intervening. When the police improves their competence, they are able to work more efficiently, where factors like knowledge of police and laws, perceptual skills, decision making and problem solving can increase the police intervening, or their skills of convicting criminals in an efficient way (Bennell et al., 2022)

Percent_police_intervening = Police_intervening_due_to_competence*Police_capacity_relevant_to_1995 UNITS: Dmnl/year DOCUMENT: This variable represents the Percent police intervening. We use the equation Police_intervening_due_to_competence*Police_capacity_relevant_to_1995. Police capacity will determine the capacity the police has to intervene (Blesse & Diegmann, 2022), but its also effected by the competence. As a police force with high capacity but no competence, will not intervene and convict as much as a police force with a high capacity and a high level of competence.
Percent_police_intervening_1995 = 0.19 UNITS: dmnl/year DOCUMENT: This parameter represents the Percent police intervening in 1995. This is calculated by looking at the historical data, and how many of the reported incidents ends up being convicted in 1995. which gives us the fraction of 0.27, but this is just from the reports. So when we calculate the number of detection from police and the reported we get the fraction of 0.19 in 1995.
Police_intervening_due_to_competence = Effect_of_competence_on_police_intervening*Percent_police_intervening_1995 UNITS: dmnl/year DOCUMENT: This variable represents the Police intervening due to competence. We use the equation Effect_of_competence_on_police_intervening*Percent_police_intervening_1995 to calculate how much of the police intervening is changed due to the change in competence.
Police_intervening_In_1995 = 164000 UNITS: people/years DOCUMENT: This is based on what the Police intervening (convictions) flow is at time 1995.
Police_intervening_relevant_to_1995 = "Police_intervening_(convictions)"/Police_intervening_In_1995 UNITS: dmnl

DOCUMENT: We use the equation "Police_intervening_(convictions)"/Police_intervening_In_1995 to calculate the relative number of police intervening.

Table II 0.5 Documentation: Police Intervening Sector

Population and police sector

Population and police sector
Area_of_Denmark = 42951 UNITS: km2 DOCUMENT: This parameter represents the area of Denmark, which is measured in km2 (Statistics Denmark, 2023a).
Area_per_police_station = Area_of_Denmark/Police_stations UNITS: km2/station DOCUMENT: This variable represents the area per police station. The equation for the variable is Area_of_Denmark/Police_stations. This is to measure the density of police stations.
Area_per_police_station_in_1995 = 224 UNITS: km2/station DOCUMENT: This parameter is representing the area per police station in 1995. The variable "area per police station" is 224 in 1995.
Area_per_police_station_relevent_to_1995 = Area_per_police_station/Area_per_police_station_in_1995 UNITS: dmnl DOCUMENT: This variable represents the Area per police station relevant to 1995. Where the equation is Area_per_police_station/Area_per_police_station_in_1995. This gives us the relative change over the years compared to 1995.
Average_change_in_police_per_year = Police*Percent_change_in_Police UNITS: police/Year DOCUMENT: This flow is the inflow to the Police stock and represents the Average change in police per year. It is calculated by the equation Police*Percent_change_in_Police.
Average_change_in_population_per_year_in_Percent = 0.0044 UNITS: dmnl/year

DOCUMENT: This parameter represents the percent change in the population per year. This is a calculated percent, where i found the percent change from year to year. Then found the average change since 1995, which is 0.0044 (Statistics Denmark, 2023e).
Average_year_till_retirement = 37 UNITS: years DOCUMENT: This parameter represents the average year till retirement. The retirement age in Denmark for police is 60 years old. I have assumed that many start around the age of 25. Some are older when starting in the police force, and some are older than 62 (ICPRA, 2018) when retiring. To simplify this, I have taken 62-25, getting 37 years of services, before they retire.
Change_in_population_per_year = Population*Average_change_in_population_per_year_in_Percent UNITS: People/Year DOCUMENT: This flow represent the number of people that the population increases by every year. This is calculated by the equation Population*Averagechange_in_population_per_year_in_Percent.
Number_of_shut_down_police_stations_as_policy_of_reform = -63 UNITS: station DOCUMENT: This parameters represent the number of police stations that has been removed, as a policy of the police reform that was implemented in 2006 (Justitsministeriet, 2017).
People_per_police = Population/Police UNITS: people/police DOCUMENT: This variable represents the people per police. This is to measure the density of the population per police. The equation for this variable is Population/Police.
People_per_police_in_1995 = 522 UNITS: people/police DOCUMENT: This parameter represents the people per police in 1995. This is calculated by the population in 1995 divided by the number of police in 1995. Which is 521 (Rigspolitiet, 2022; Statistics Denmark, 2023e).
People_per_police_relevant_to_1995 = People_per_police/People_per_police_in_1995

UNITS: dmnl

DOCUMENT: This variable represents the people per relevant to police in 1995. This is to measure the difference in population density per police officer from 1995.

Percent_change_in_Police = 0.0315

UNITS: dmnl/year

DOCUMENT: This parameter represents the percent change in Police. This fraction has been calibrated to match the historical number of police, and has a fraction of 0.0315.

Police(t) = Police(t - dt) + (Average_change_in_police_per_year - Retired_police) * dt

INIT Police = 10000

UNITS: police

DOCUMENT: This stock represents the number of police in Denmark and has the initial value of 10000 based on the historical data (Rigspolitiet, 2022). The stock increases by the Averege change in police per year inflow. And depletes by the Retired police outflow.

Police_capacity_relevant_to_1995 = GRAPH(People_per_police_relevant_to_1995*Weight_of_people_per_police_on_capacity+Area_per_police_station_relevent_to_1995*(1-Weight_of_people_per_police_on_capacity))

Points: (0.000, 2.000), (0.200, 1.800), (0.400, 1.600), (0.600, 1.400), (0.800, 1.200), (1.000, 1.000), (1.200, 0.800), (1.400, 0.600), (1.600, 0.400), (1.800, 0.200), (2.000, 0.000)

UNITS: dmnl

DOCUMENT: This variable represents the Police capacity relevant to 1995. We use the equation People_per_police_relevant_to_1995*Weight_of_people_per_police_on_capacity+Area_per_police_station_relevent_to_1995*(1-Weight_of_people_per_police_on_capacity) to measure the capacity. Where we use the weight to determine the strength of people per police compared to area per police on capacity

Police_reform_INTENSITY_on_police_stations = GRAPH(TIME)

Points: (2006.00, 0.000), (2006.40, 0.064233987959), (2006.80, 0.124900364792), (2007.20, 0.182197278701), (2007.60, 0.236311872564), (2008.00, 0.287420895182), (2008.40, 0.335691278577), (2008.80, 0.381280683221), (2009.20, 0.424338012986), (2009.60, 0.465003901498), (2010.00, 0.503411171467), (2010.40, 0.539685268516), (2010.80, 0.573944670911), (2011.20, 0.60630127653), (2011.60, 0.63686076835), (2012.00,

0.66572295962), (2012.40, 0.69298211988), (2012.80, 0.718727282853), (2013.20, 0.743042537257), (2013.60, 0.766007301448), (2014.00, 0.787696582816), (2014.40, 0.808181222779), (2014.80, 0.82752812816), (2015.20, 0.84580048972), (2015.60, 0.86305798855), (2016.00, 0.879356991002), (2016.40, 0.894750732791), (2016.80, 0.909289492876), (2017.20, 0.923020757679), (2017.60, 0.935989376185), (2018.00, 0.948237706427), (2018.40, 0.959805753837), (2018.80, 0.970731301911), (2019.20, 0.981050035615), (2019.60, 0.990795657945), (2020.00, 1.000)

UNITS: dmnl

DOCUMENT: This parameter represents a Policy reform intensity on police station. This is to calculate the intensity of the reform. The more integrated the policy of the reform is, the more police stations are removed, they don't remove them instantaneously.

Police_stations = Police_stations_in_1995+IF SWITCH_Police_reform_2006>0 THEN STEP((Number_of_shut_down_police_stations_as_policy_of_reform*Police_reform_INTENSITY_on_police_stations), 2006) ELSE 0

UNITS: station

DOCUMENT: This variable represents the number of Police stations in Denmark. Where we use the equation Police_stations_in_1995+IF SWITCH_Police_reform_2006>0 THEN STEP((Number_of_shut_down_police_stations_as_policy_of_reform*Police_reform_INTENSITY_on_police_stations), 2006) ELSE 0.

If the switch is 1, then the policy is implemented and x amount of police stations are shut down. If the switch is 0, the policy is not implemented. And the number of police stations remain the same as in 1995. Its also affected by the intensity, to slowly integrate the new policy in the model.

Police_stations_in_1995 = 192

UNITS: station

DOCUMENT: This parameter represents the number of police stations (Justitsministeriet, 2017) in Denmark in 1995.

Population(t) = Population(t - dt) + (Change_in_population_per_year) * dt

INIT Population = 5215718

UNITS: People

DOCUMENT: This stock represents the population in Denmark and is base don historical data (Statistics Denmark, 2023e).The stock only has an inflow, as the population in Denmark has been constantly increasing.
Retired_police = Police/Average_year_till_retirement UNITS: police/Year DOCUMENT: This flow represent the number of police retired. And is the outflow of the Police stock. The calculation for this is Police/Average_year_till_retirement.
SWITCH_Police_reform_2006 = 1 UNITS: dmnl DOCUMENT: This parameter represents a Switch. The switch represents the police reform that was implemented in 2006. The reform had several policies to implement in the police institution. A reduction in police station, to unify the police and focus on increasing the competence (Holmberg, 2019).
Weight_of_people_per_police_on_capacity = 0.65 UNITS: dmnl DOCUMENT: This parameter represents the Weight of people per police on capacity. As the people per police has a bigger effect on the capacity, compared to area per police station. This is assumed to be 0.65

Table II 0.6 Documentation: Population and Police sector

Report sector

Report sector
Change_in_property_crime_per_year = Property_crime_Reported*Percent_decrease_in_property_crime_per_year UNITS: People/Years^2 DOCUMENT: This flow represents the change in property crime per year. We use the equation Property_crime*Percent_decrease_in_property_crime_per_year to calculate the yearly output of the stock.
Change_in_reports_due_to_trust_in_police = Effect_of_trust_in_police_on_reports*Reports_except_property_in_1995 UNITS: people/year

DOCUMENT: This variable represents the Change in reports due to trust in police. We use the equation Effect_of_trust_in_police_on_reports*Reports_except_property_in_1995 to calculate the change in reports due to trust.

Changes_in_reports_due_to_charges_per_report = Effect_of_charges_per_report_on_reports*Reports_except_property_in_1995

UNITS: people/year

DOCUMENT: This variable represents the Change in reports due to charges per report. We use the equation Effect_of_charges_per_report_on_reports*Reports_except_property_in_1995 to calculate the difference in number of reports due to charges.

Criminals_undiscovered_in_1995 = 1276000

UNITS: People

DOCUMENT: This parameter is based on the number of undiscovered criminals in 1995, and set as 1276000.

Criminals_undiscovered_relevant_to_1995 = "Criminals_undiscovered_(dark_figures)"/Criminals_undiscovered_in_1995

UNITS: dmnl

DOCUMENT: We use the equation "Criminals_undiscovered_(dark_figures)"/Criminals_undiscovered_in_1995 to determine the relative number of criminals undiscovered compared to 1995.

Delay_of_reports_being_reported = 1

UNITS: year

DOCUMENT: This parameter represents the Delay of reporting being reported. Which is set to 1 year. As it takes time for the reports to be reported.

Effect_of_charges_per_report_on_reports = GRAPH(Charges_from_police_intervening_to_1995)

Points: (0.000, 0.500), (0.200, 0.600), (0.400, 0.700), (0.600, 0.800), (0.800, 0.900), (1.000, 1.000), (1.200, 1.100), (1.400, 1.200), (1.600, 1.300), (1.800, 1.400), (2.000, 1.500)

UNITS: dmnl

DOCUMENT: This variable is a graphical function, and represents the Effect of charges per report on reports. If there was never any reports that were changed, then there would be no point in reporting. But when you report, you will not always be informed of the process of the

charge (Boateng, 2018; Goudriaan et al., 2006). And the lowest effect is set as 0.25 as there will always be some reports, even if charges of reports is 0.

Effect_of_trust_in_police_on_reports = GRAPH(Trust_in_police_relevant_to_1995)
Points: (0.200, 0.000), (0.250, 0.01355), (0.300, 0.02954), (0.350, 0.04842), (0.400, 0.07071), (0.450, 0.113), (0.500, 0.169), (0.550, 0.225), (0.600, 0.282), (0.650, 0.345), (0.700, 0.423), (0.750, 0.500), (0.800, 0.570), (0.850, 0.641), (0.900, 0.746), (0.950, 0.852), (1.000, 1.000), (1.050, 1.186), (1.100, 1.414), (1.150, 1.683), (1.200, 2.000)

UNITS: dmnl

DOCUMENT: This variable is a graphical function, and represent the effect of trust in police on reports. People who were satisfied with police work showed to be 1.37 times more likely to report crime to the police (Boateng, 2018). People who live in deprived neighbourhoods, very low trust to police, and mentioned this as the most important factor as to why they did not report crime (Buil-Gil et al., 2021). Although the variable i have used is not satisfaction, but trust, there would not be trust if they were not satisfied with the work that the police does. But as trust and satisfaction is not the same, there will be less effect of trust on reported than satisfaction would, as trust is rather implanted in the perception we have of police work. We can be somewhat dissatisfied with the work police does, and still have relatively high trust.
The reason that 1.5 in "trust in police relevant to 1995" is set to have an effect of 2 on reports, is because in 1995 the trust was already very high. So, the most it can increase is 1.18. Then trust is at 1.

Initial_value_of_reports = 607000

UNITS: People/year

DOCUMENT: This parameter represents the Initial value of reports. The value for this parameter is 607 000, as this was the number of reports in 1995 (Statistics Denmark, 2023f).

People_reported = SMTH1(Reports_without_property_crime+Property_crime_Reported, Delay_of_reports_being_reported, Initial_value_of_reports) {DELAY CONVERTER}

UNITS: People/year

DOCUMENT: This delay converter represents the number of reports. We use the equation SMTH1(Change_in_reports_due_to_trust_in_police*Weight_of_Trust_on_reporting+Changes

_in_reports_due_to_charges_per_report*(1-Weight_of_Trust_on_reporting) +Property_crime, Delay_of_reporting_being_reported, Initial_value_of_reports). By adding Change_in_reports_due_to_trust_in_police*Weight_of_Trust_on_reporting+Changes_in_reports_due_to_charges_per_report*(1-Weight_of_Trust_on_reporting) we get the number of reports excluding property crime, and using the weight to determine that the trust has a stronger effect than changes per report. We also add the property crime, as this is an exogenous variable, that cannot be explained by the system I am creating. We have a delay, as it takes 1 year for the reports to be reported.
People_reported_in_1995 = 607000 UNITS: People/year People_reported_relevant_to_1995 = People_reported/People_reported_in_1995 UNITS: dmnl DOCUMENT: The set value for this is 607 000, and is based on historical data (Statistics Denmark, 2023f).
Percent_decrease_in_property_crime_per_year = IF SWITCH_Police_reform_2006=1 AND TIME >2006 THEN Percent_decrease_in_property_crime_reported_WITH_Police_reform ELSE Percent_decrease_in_property_crime_reported_WITHOUT_Police_reform UNITS: dmnl/year DOCUMENT: We use the equation IF SWITCH_Police_reform_2006=1 AND TIME >2006 THEN Percent_decrease_in_property_crime_reported_WITH_Police_reform ELSE Percent_decrease_in_property_crime_reported_WITHOUT_Police_reform. This is based on the calculation of the average change in the property crime reported (Statistics Denmark, 2023f). Where the decrease in property crime is higher with the reform, than without it.
Percent_decrease_in_property_crime_reported_WITH_Police_reform = 0.0443 UNITS: dmnl/year DOCUMENT: The value for this parameter is 0.0443, and is calculated based on historical data (Statistics Denmark, 2023f).
Percent_decrease_in_property_crime_reported_WITHOUT_Police_reform = 0.0226 UNITS: dmnl/year

DOCUMENT: The value for this parameter is 0.0226, and is calculated based on historical data (Statistics Denmark, 2023f).

Percent_increase_in_2006_till_2008 = 0.125

UNITS: dmnl/year

DOCUMENT: The value for this parameter is 0.125, and is calculated based on historical data (Statistics Denmark, 2023f).

Property_crime_increase = IF SWITCH_Police_reform_2006= 1 AND TIME > 2006 AND TIME <2008 THEN Percent_increase_in_2006_till_2008*Property_crime_Reported ELSE 0

UNITS: People/Years^2

DOCUMENT: This is the inflow to the Property crime Reported. We use the if then else function, because the only increase we can see, is when the reform happened. So if the switch is 0, then there is no increase in property crime reporting.

Property_crime_Reported(t) = Property_crime_Reported(t - dt) + (Property_crime_increase - Change_in_property_crime_per_year) * dt

INIT Property_crime_Reported = 516000

UNITS: People/year

DOCUMENT: This stock represents the Property crime historical development. This is the proportion property crimes and is set as 516 000 (Statistics Denmark, 2023f). The reporting of property crime makes up for as much as 85 percent of the total reported incidents throughout a year. The stock depletes constantly by the outflow Change in property crime per year.

The reason for the reports to go down as much as they do, is mainly the reports of property crimes, that has gone down. Most other categories is increasing. I did not find an explanation as to why this is happening in Denmark. But i found an article that stated that crime reporting, especially minor offenses (suck as property crime often is), is driven by a will to keep the area safe rather than restoration of harm (Buil-Gil et al., 2021). And the main reason for not reporting, was a lack of confidence in the police work (Buil-Gil et al., 2021).

Reports_except_property_in_1995 = 91300

UNITS: people/year

DOCUMENT: This parameter represent the Reports except property in 1995. Which was 91000 (Statistics Denmark, 2023f).

Reports_without_property_crime = (Change_in_reports_due_to_trust_in_police*Weight_of_Trust_on_reporting+Changes_in_reports_due_to_charges_per_report*(1-Weight_of_Trust_on_reporting))*Criminals_undiscovered_relevant_to_1995 UNITS: people/year DOCUMENT: We use the equation (Change_in_reports_due_to_trust_in_police*Weight_of_Trust_on_reporting+Changes_in_reports_due_to_charges_per_report*(1-Weight_of_Trust_on_reporting))*Criminals_undiscovered_relevant_to_1995 to calculate the change in reports without property crime. The weight is there to determine the strength of the different effects.
Weight_of_Trust_on_reporting = 0.55 UNITS: dmnl DOCUMENT: This parameter represents the Weight of Trust on reporting. The value is set as 0.75, as trust will have more effect on reporting than what Charges per report has.

Table II 0.7 Documentation: Report sector

Trust sector

Trust sector
Effect_of_police_intervening_on_Trust = GRAPH(Police_intervening_relevant_to_1995) Points: (0.250, 0.500), (0.625, 0.734), (1.000, 1.000), (1.375, 1.170), (1.750, 1.298), (2.125, 1.362), (2.500, 1.410), (2.875, 1.457), (3.250, 1.477), (3.625, 1.491), (4.000, 1.500) UNITS: dmnl DOCUMENT: This variable is a graphical function and represents the effect of police intervening on trust. The knowledge about community policing is related to trust in police, but it does not have a strong effect on the trust (Hawdon et al., 2003). If there was never records of arrests, or no perceived arrests in the population, the trust would decrease, as the perceived effect of police intervening is low. But although the arrests are not always recorded or talked about it the media, the level of trust would not decrease to 0 if there was a 0 rate for police intervening. Therefor the lowest input is 0.25.

Effect_of_visibility_on_trust = GRAPH(Police_visibility_relevant_to_1995)
Points: (0.000, 0.250), (0.200, 0.400), (0.400, 0.550), (0.600, 0.700), (0.800, 0.850), (1.000, 1.000), (1.200, 1.150), (1.400, 1.300), (1.600, 1.450), (1.800, 1.600), (2.000, 1.750)

UNITS: dmnl

DOCUMENT: This variable is a graphical function and represents the effect of visibility on trust. Informal contact with the police increases the positive opinion of police performance (Maxson et al., 2003). Also patrols in neighborhoods is significantly related to the trust in the police (Hawdon et al., 2003).

The effect is based on these qualitative findings, where if the Police visibility relevant to 1995 is >1 it will have an increasing effect on the trust, and if its <1 it will have a decreasing effect on the trust in police.

I have assumed that if the visibility is 0, there will also be 0 as an effect.

Perceived_trust_in_police = SMTH1(Trust_in_police, Perception_delay_trust_in_police)
{DELAY CONVERTER}

UNITS: dmnl

DOCUMENT: We use the function SMTH1(Trust_in_police, Perception_delay_trust_in_police) to etermine the delay process of the trust in police.

Perception_delay_trust_in_police = 2

UNITS: year

DOCUMENT: This parameter has the value of 2 years and is a perception delay for trust in police. As it takes time to perceive trust.

Trust_due_to_police_intervening = Effect_of_police_intervening_on_Trust*Trust_in_1995

UNITS: dmnl

DOCUMENT: This variable represents the Trust due to police intervening. We use the equation Effect_of_police_intervening_on_Trust*Trust_in_1995 to find the change in trust due to police intervening.

Trust_in_1995 = 0.84

UNITS: dmnl

DOCUMENT: This parameter represents the Trust in police in 1995. The percent of trust is set on 0.843, this is numbers from 2013, as there is no recorded survey on trust before 2013 (Justitsministeriets, 2022).

Trust_in_police = MIN((weight_on_visibility_for_trust*Trust_in_police_due_to_visibility) + (1-weight_on_visibility_for_trust) *Trust_due_to_police_intervening, 1) UNITS: dmnl DOCUMENT: This variable represents the trust in police. We use the equation MIN(1,(weight_on_visibility_for_trust*Trust_in_police_due_to_visibility)+(1-weight_on_visibility_for_trust)*Trust_due_to_police_intervening). We use a min function of 1, as trust can never be over 100%. We use the weight which is set as 0.7 on the visibility effect. As the visibility has a stronger effect on the trust than police intervening.
Trust_in_police_due_to_visibility = Effect_of_visibility_on_trust*Trust_in_1995 UNITS: dmnl DOCUMENT: This variable represents the Trust due to visibility. We use the equation Effect_of_visibility_on_trust*Trust_in_1995 to find the change in trust due to visibility.
Trust_in_police_relevant_to_1995 = Perceived_trust_in_police/Trust_in_1995 UNITS: dmnl DOCUMENT: This variable represents the Trust in police relevant to 1995. We use the equation Trust_in_police/Trust_in_1995 to measure the difference in trust from 1995.
Weight_on_visibility_for_trust = 0.7 UNITS: dmnl DOCUMENT: This parameter represents the Weight on visibility for trust. And is set as 0.7. This is because visibility has a stronger effect on trust, than what the police intervening has.

Table II 0.8 Documentation: Trust sector

Visibility sector

Visibility sector
Effect_of_area_per_police_station_on_visibility = GRAPH(Area_per_police_station_relevent_to_1995) Points: (0.000, 2.000), (0.400, 1.510), (0.800, 1.150), (1.000, 1.000), (1.600, 0.561), (2.000, 0.364), (2.400, 0.235), (2.800, 0.106), (3.200, 0.045), (3.600, 0.015), (4.000, 2.22044604925e-16) UNITS: dmnl

DOCUMENT: This variable is a graphical function, and the effect of area per police station on visibility. When police stations are closing for good there is a decrease in perceived detection risks, which makes crime more "available" or "persuadable" (Blesse & Diegmann, 2022).

When Area per police station relevant to 1995 is <1 there will be an increase in the visibility. The effect is not very sensitive. As the relative number must be 4, so 4 times as much area per police station to reach close to 0 in visibility. With Area_per_police_station_relevent_to_1995 as input

---

Effect_of_people_per_police_on_visibility = GRAPH(People_per_police_relevant_to_1995)
Points: (0.000, 2.000), (0.600, 1.307), (1.000, 1.000), (1.800, 0.5585), (2.400, 0.3651), (3.000, 0.2386), (3.600, 0.156), (4.200, 0.1019), (4.800, 0.06664), (5.400, 0.030), (6.000, 0.000)

UNITS: dmnl

DOCUMENT: This variable is a graphical function and represent the effect of people per police on visibility. An increase in the police force, will eventually lead to a higher number of reported victimizations to the police (Levitt, 1998). The effect is set to 0 when the people per police is 6 times as high as in 1995, as there will be too few police for them to be visible in the community. And if the police is never in sight the perceived risk for doing crime will decrease. With People_per_police_relevant_to_1995 as input

---

Perceived_visibility = SMTH1(Police_visibility, Perception_delay_for_visibility) {DELAY CONVERTER}

UNITS: dmnl

DOCUMENT: This variable represents the Perceived visibility. Where we use the equation SMTH1(Police_visibility, Perception_delay_for_visibility) to determine the delay of the perceived visibility.

Perception_delay_for_visibility = 2

UNITS: years

DOCUMENT: This parameter represents the Perception delay for visibility. Its set for 2 years, as it takes time for people to perceive the loss of a police station, or less police in the area.

Police_visibility = Police_visibility_due_to_area_per_police_station*weight_of_area_per_police_station_on_police_visibility+Police_visibility_due_to_people_per_police*(1-weight_of_area_per_police_station_on_police_visibility) UNITS: dmnl DOCUMENT: This variable is representing police visibility. We use the equation Police_visibility_due_to_area_per_police_station*weight_of_area_per_police_station_on_police_visibility+Police_visibility_due_to_people_per_police*(1-weight_of_area_per_police_station_on_police_visibility). This is to measure the weight that area per police has compared to area per police station on visibility
Police_visibility_due_to_area_per_police_station = Effect_of_area_per_police_station_on_visibility*Police_visibility_in_1995 UNITS: dmnl DOCUMENT: This variable represents the Police visibility due to area per police Where the equation is Effect_of_area_per_police_station_on_visibility*Police_visibility_in_1995 to determine the change in visibility due to area per police station.
Police_visibility_due_to_people_per_police = Effect_of_people_per_police_on_visibility*Police_visibility_in_1995 UNITS: dmnl DOCUMENT: This variable represents the Police visibility due to people per police. Where the equation is Effect_of_people_per_police_on_visibility*Police_visibility_in_1995, to calculate the change in visibility due to people per police.
Police_visibility_in_1995 = 0.495 UNITS: dmnl DOCUMENT: This parameter represents the Police visibility in 1995. In Norway 44% of people have been in contact with the police the latest week (Politidirektoratet, 2023) and 43% have stated that they are satisfied with the police visibility. I have assumed a small fraction more has in Denmark at the time as Denmark is smaller. And I do not have the data for contacts that the Danish has had.

Police_visibility_relevant_to_1995 = Perceived_visibility/Police_visibility_in_1995 UNITS: dmnl DOCUMENT: This variable represents the Police visibility relevant to 1995. We use the equation Police_visibility/Police_visibility_in_1995 to measure the change in visibility since 1995.
weight_of_area_per_police_station_on_police_visibility = 0.5 UNITS: dmnl DOCUMENT: This parameter represents the weight of area per police station on police visibility. Where the set value is 0.5

Table II 0.9 Documentation: Visibility sector

Historical. Historical data sector

Historical. Historical data sector
Historical.Charges_from_reports_per_conviction = Historically_Charges/Historical_Convictions UNITS: 1/convictions DOCUMENT: We use the equation Historically_Charges/Historical_Convictions to calculate the historical number of charges from reports per convicted.
Historical.Guilty_ratio_Other = GRAPH(TIME) Points: (1995.00, 0.758412425), (1996.00, 0.757681343), (1997.00, 0.735785953), (1998.00, 0.728284389), (1999.00, 0.727065712), (2000.00, 0.758151314), (2001.00, 0.726898175), (2002.00, 0.735325225), (2003.00, 0.716820795), (2004.00, 0.747884574), (2005.00, 0.757097792), (2006.00, 0.733407572), (2007.00, 0.733539674), (2008.00, 0.688363911), (2009.00, 0.73318872), (2010.00, 0.744640605), (2011.00, 0.738344051), (2012.00, 0.730864198), (2013.00, 0.724960876), (2014.00, 0.730565371), (2015.00, 0.709503482), (2016.00, 0.723264312), (2017.00, 0.725970305), (2018.00, 0.717448603), (2019.00, 0.700665188), (2020.00, 0.691913804), (2021.00, 0.679364433) UNITS: dmnl DOCUMENT: This is the historical data for the Guilty Ratio Other (Statistics Denmark, 2023d).
Historical.Guilty_ratio_Property = GRAPH(TIME)

Points: (1995.00, 0.840519297), (1996.00, 0.823059983), (1997.00, 0.825921396), (1998.00, 0.815310517), (1999.00, 0.809290954), (2000.00, 0.798589483), (2001.00, 0.790676732), (2002.00, 0.782697117), (2003.00, 0.757498593), (2004.00, 0.751717473), (2005.00, 0.751423954), (2006.00, 0.749894087), (2007.00, 0.746584624), (2008.00, 0.765312999), (2009.00, 0.772752549), (2010.00, 0.757229378), (2011.00, 0.754514223), (2012.00, 0.760659836), (2013.00, 0.761056913), (2014.00, 0.761052471), (2015.00, 0.767393154), (2016.00, 0.76517406), (2017.00, 0.760837696), (2018.00, 0.77369463), (2019.00, 0.757147055), (2020.00, 0.733080798), (2021.00, 0.697689743)

UNITS: dmnl

DOCUMENT: This is the historical data for the Guilty Ratio Property (Statistics Denmark, 2023d).

Historical.Guilty_ratio_Sexual = GRAPH(TIME)

Points: (1995.00, 0.573363431), (1996.00, 0.549618321), (1997.00, 0.587485516), (1998.00, 0.58045292), (1999.00, 0.570726916), (2000.00, 0.538085938), (2001.00, 0.559772296), (2002.00, 0.548214286), (2003.00, 0.566176471), (2004.00, 0.517371601), (2005.00, 0.55707107), (2006.00, 0.519844358), (2007.00, 0.504332756), (2008.00, 0.508239376), (2009.00, 0.535245902), (2010.00, 0.543873518), (2011.00, 0.496779388), (2012.00, 0.543929712), (2013.00, 0.508038585), (2014.00, 0.482517483), (2015.00, 0.508268059), (2016.00, 0.473970474), (2017.00, 0.435419441), (2018.00, 0.387060159), (2019.00, 0.458333333), (2020.00, 0.450798991), (2021.00, 0.431903374)

UNITS: dmnl

DOCUMENT: This is the historical data for the Guilty Ratio Sexual (Statistics Denmark, 2023d).

Historical.Guilty_ratio_Special = GRAPH(TIME)

Points: (1995.00, 0.57336343), (1996.00, 0.54961832), (1997.00, 0.58748552), (1998.00, 0.58045292), (1999.00, 0.57072692), (2000.00, 0.53808594), (2001.00, 0.5597723), (2002.00, 0.54821429), (2003.00, 0.56617647), (2004.00, 0.5173716), (2005.00, 0.55707107), (2006.00, 0.51984436), (2007.00, 0.50433276), (2008.00, 0.50823938), (2009.00, 0.5352459), (2010.00, 0.54387352), (2011.00, 0.49677939), (2012.00, 0.54392971), (2013.00, 0.50803859), (2014.00, 0.48251748), (2015.00, 0.50826806), (2016.00, 0.47397047), (2017.00,

0.43541944), (2018.00, 0.38706016), (2019.00, 0.45833333), (2020.00, 0.45079899), (2021.00, 0.43190337)

UNITS: dmnl

DOCUMENT: This is the historical data for the Guilty Ratio special (Statistics Denmark, 2023d).

Historical.Guilty_ratio_Traffic = GRAPH(TIME)

Points: (1995.00, 0.993674367), (1996.00, 0.994612311), (1997.00, 0.994723142), (1998.00, 0.994806863), (1999.00, 0.994003367), (2000.00, 0.995499653), (2001.00, 0.994851738), (2002.00, 0.993841369), (2003.00, 0.993786233), (2004.00, 0.994851827), (2005.00, 0.995091302), (2006.00, 0.993126347), (2007.00, 0.992885101), (2008.00, 0.992939263), (2009.00, 0.990934648), (2010.00, 0.989870001), (2011.00, 0.990968732), (2012.00, 0.990858703), (2013.00, 0.991757721), (2014.00, 0.990625764), (2015.00, 0.990580639), (2016.00, 0.990618472), (2017.00, 0.980764113), (2018.00, 0.990837147), (2019.00, 0.98873935), (2020.00, 0.989501808), (2021.00, 0.989140245)

UNITS: dmnl

DOCUMENT: This is the historical data for the Guilty Ratio Traffic (Statistics Denmark, 2023d).

Historical.Guilty_ratio_violent_crimes = GRAPH(TIME)

Points: (1995.00, 0.697820465), (1996.00, 0.693738538), (1997.00, 0.677371173), (1998.00, 0.67544176), (1999.00, 0.661026509), (2000.00, 0.668506528), (2001.00, 0.666796495), (2002.00, 0.663167939), (2003.00, 0.661149146), (2004.00, 0.658691005), (2005.00, 0.664928498), (2006.00, 0.663863527), (2007.00, 0.656405252), (2008.00, 0.646632938), (2009.00, 0.672135533), (2010.00, 0.677805852), (2011.00, 0.667859949), (2012.00, 0.670573272), (2013.00, 0.631940357), (2014.00, 0.615961435), (2015.00, 0.642440605), (2016.00, 0.632764141), (2017.00, 0.598653689), (2018.00, 0.595382853), (2019.00, 0.558816194), (2020.00, 0.560310691), (2021.00, 0.569992061)

UNITS: dmnl

DOCUMENT: This is the historical data for the Guilty Ratio Violent crimes (Statistics Denmark, 2023d).

Historical.Historical_Convictions = GRAPH(TIME)

Points: (1995.00, 165564.0), (1996.00, 166816.0), (1997.00, 159145.0), (1998.00, 163574.0), (1999.00, 147618.0), (2000.00, 165567.0), (2001.00, 164934.0), (2002.00, 148843.0), (2003.00, 161714.0), (2004.00, 194926.0), (2005.00, 222799.0), (2006.00, 206089.0), (2007.00, 176566.0), (2008.00, 177409.0), (2009.00, 188353.0), (2010.00, 200328.0), (2011.00, 216808.0), (2012.00, 226320.0), (2013.00, 222617.0), (2014.00, 225359.0), (2015.00, 217064.0), (2016.00, 210884.0), (2017.00, 200381.0), (2018.00, 205228.0), (2019.00, 226471.0), (2020.00, 248448.0), (2021.00, 237237.0)

UNITS: convictions

DOCUMENT: This is the historical data for the convictions (Statistics Denmark, 2023d).

Historical.historical_Imprisonment = GRAPH(TIME)

Points: (1995.00, 22249.0), (1996.00, 21942.0), (1997.00, 22260.0), (1998.00, 22253.0), (1999.00, 22081.0), (2000.00, 20546.0), (2001.00, 22488.0), (2002.00, 22604.0), (2003.00, 23555.0), (2004.00, 23634.0), (2005.00, 24226.0), (2006.00, 22050.0), (2007.00, 17870.0), (2008.00, 18557.0), (2009.00, 20916.0), (2010.00, 23793.0), (2011.00, 23169.0), (2012.00, 22919.0), (2013.00, 21068.0), (2014.00, 18292.0), (2015.00, 17601.0), (2016.00, 17980.0), (2017.00, 17269.0), (2018.00, 15550.0), (2019.00, 15826.0), (2020.00, 16073.0), (2021.00, 15206.0)

UNITS: dmnl

DOCUMENT: This is the historical data for the imprisonment (Statistics Denmark, 2023d).

Historical.Historical_Other_charges = GRAPH(TIME)

Points: (1995.00, 5705.0), (1996.00, 5251.0), (1997.00, 5038.0), (1998.00, 5325.0), (1999.00, 5299.0), (2000.00, 5749.0), (2001.00, 5970.0), (2002.00, 6516.0), (2003.00, 6518.0), (2004.00, 6920.0), (2005.00, 6536.0), (2006.00, 6184.0), (2007.00, 5591.0), (2008.00, 5310.0), (2009.00, 5478.0), (2010.00, 6556.0), (2011.00, 7654.0), (2012.00, 6531.0), (2013.00, 6692.0), (2014.00, 6434.0), (2015.00, 6241.0), (2016.00, 6557.0), (2017.00, 6334.0), (2018.00, 7067.0), (2019.00, 7406.0), (2020.00, 7860.0), (2021.00, 7770.0)

UNITS: charges

DOCUMENT: This is the historical data for the Other charges (Statistics Denmark, 2023d)

Historical.Historical_Other_Reports = GRAPH(TIME)

Points: (1995.00, 6873.0), (1996.00, 6475.0), (1997.00, 6532.0), (1998.00, 6788.0), (1999.00, 6675.0), (2000.00, 7084.0), (2001.00, 7394.0), (2002.00, 8288.0), (2003.00, 7951.0),

(2004.00, 8569.0), (2005.00, 7721.0), (2006.00, 7356.0), (2007.00, 6772.0), (2008.00, 6561.0), (2009.00, 6511.0), (2010.00, 7637.0), (2011.00, 8811.0), (2012.00, 7562.0), (2013.00, 8535.0), (2014.00, 8163.0), (2015.00, 8459.0), (2016.00, 8889.0), (2017.00, 9165.0), (2018.00, 10300.0), (2019.00, 11601.0), (2020.00, 13069.0), (2021.00, 13690.0)

UNITS: reports

DOCUMENT: This is the historical data for the Other reports (Statistics Denmark, 2023f).

Historical.Historical_Property_charges = GRAPH(TIME)

Points: (1995.00, 91294.0), (1996.00, 90857.0), (1997.00, 87468.0), (1998.00, 83543.0), (1999.00, 78120.0), (2000.00, 76189.0), (2001.00, 67715.0), (2002.00, 65098.0), (2003.00, 65358.0), (2004.00, 65202.0), (2005.00, 56781.0), (2006.00, 51913.0), (2007.00, 50374.0), (2008.00, 49374.0), (2009.00, 51359.0), (2010.00, 55822.0), (2011.00, 61043.0), (2012.00, 57724.0), (2013.00, 58034.0), (2014.00, 62218.0), (2015.00, 62354.0), (2016.00, 68532.0), (2017.00, 62393.0), (2018.00, 58528.0), (2019.00, 60520.0), (2020.00, 69919.0), (2021.00, 51866.0)

UNITS: charges

DOCUMENT: This is the historical data for the Property charges (Statistics Denmark, 2023d)

Historical.Historical_Property_Reports = GRAPH(TIME)

Points: (1995.00, 515954.0), (1996.00, 506461.0), (1997.00, 508283.0), (1998.00, 476269.0), (1999.00, 470280.0), (2000.00, 479190.0), (2001.00, 447377.0), (2002.00, 463479.0), (2003.00, 457759.0), (2004.00, 444696.0), (2005.00, 403407.0), (2006.00, 395528.0), (2007.00, 416478.0), (2008.00, 449429.0), (2009.00, 465082.0), (2010.00, 442678.0), (2011.00, 437514.0), (2012.00, 413718.0), (2013.00, 401516.0), (2014.00, 378274.0), (2015.00, 359259.0), (2016.00, 365639.0), (2017.00, 350377.0), (2018.00, 318130.0), (2019.00, 307826.0), (2020.00, 278011.0), (2021.00, 240259.0)

UNITS: reports

DOCUMENT: This is the historical data for the Property reports (Statistics Denmark, 2023f).

Historical.Historical_sexual_offense_charges = GRAPH(TIME)

Points: (1995.00, 1530.0), (1996.00, 1442.0), (1997.00, 1590.0), (1998.00, 1485.0), (1999.00, 1725.0), (2000.00, 1620.0), (2001.00, 1604.0), (2002.00, 1776.0), (2003.00, 1739.0),

(2004.00, 2123.0), (2005.00, 1912.0), (2006.00, 1790.0), (2007.00, 1818.0), (2008.00, 1692.0), (2009.00, 1568.0), (2010.00, 1938.0), (2011.00, 1831.0), (2012.00, 1933.0), (2013.00, 1824.0), (2014.00, 1921.0), (2015.00, 2026.0), (2016.00, 2653.0), (2017.00, 3930.0), (2018.00, 5061.0), (2019.00, 3529.0), (2020.00, 4280.0), (2021.00, 4737.0)

UNITS: charges

DOCUMENT: This is the historical data for the sexual offence charges (Statistics Denmark, 2023d).

Historical.Historical_sexual_offense_Reports = GRAPH(TIME)

Points: (1995.00, 2779.0), (1996.00, 2536.0), (1997.00, 2706.0), (1998.00, 2688.0), (1999.00, 2981.0), (2000.00, 2800.0), (2001.00, 2738.0), (2002.00, 2919.0), (2003.00, 2758.0), (2004.00, 3095.0), (2005.00, 2799.0), (2006.00, 2652.0), (2007.00, 2602.0), (2008.00, 2477.0), (2009.00, 2231.0), (2010.00, 2642.0), (2011.00, 2606.0), (2012.00, 2616.0), (2013.00, 2532.0), (2014.00, 2640.0), (2015.00, 2965.0), (2016.00, 4425.0), (2017.00, 6869.0), (2018.00, 7256.0), (2019.00, 6554.0), (2020.00, 7294.0), (2021.00, 8485.0)

UNITS: reports

DOCUMENT: This is the historical data for the sexual offence reports (Statistics Denmark, 2023f).

Historical.Historical_Special_charges = GRAPH(TIME)

Points: (1995.00, 28737.0), (1996.00, 29559.0), (1997.00, 27515.0), (1998.00, 26117.0), (1999.00, 23776.0), (2000.00, 24694.0), (2001.00, 23780.0), (2002.00, 23010.0), (2003.00, 26026.0), (2004.00, 31989.0), (2005.00, 35709.0), (2006.00, 38522.0), (2007.00, 34049.0), (2008.00, 35185.0), (2009.00, 34296.0), (2010.00, 37433.0), (2011.00, 53454.0), (2012.00, 57366.0), (2013.00, 59515.0), (2014.00, 65053.0), (2015.00, 62461.0), (2016.00, 61911.0), (2017.00, 54743.0), (2018.00, 70628.0), (2019.00, 83353.0), (2020.00, 75271.0), (2021.00, 74221.0)

UNITS: charges

DOCUMENT: This is the historical data for the Special charges (Statistics Denmark, 2023d).

Historical.Historical_Special_Reports = GRAPH(TIME)

Points: (1995.00, 68327.0), (1996.00, 67702.0), (1997.00, 64277.0), (1998.00, 62285.0), (1999.00, 64017.0), (2000.00, 66265.0), (2001.00, 66015.0), (2002.00, 62148.0), (2003.00, 66050.0), (2004.00, 71463.0), (2005.00, 75232.0), (2006.00, 81463.0), (2007.00, 69046.0), (2008.00, 71216.0), (2009.00, 70614.0), (2010.00, 74679.0), (2011.00, 91296.0), (2012.00, 91195.0), (2013.00, 106566.0), (2014.00, 112800.0), (2015.00, 113338.0), (2016.00, 115169.0), (2017.00, 126833.0), (2018.00, 144282.0), (2019.00, 143990.0), (2020.00, 118945.0), (2021.00, 123684.0)

UNITS: reports

DOCUMENT: This is the historical data for the special reports (Statistics Denmark, 2023f).

Historical.Historical_Violent_crimes_charges = GRAPH(TIME)

Points: (1995.00, 10198.0), (1996.00, 9947.0), (1997.00, 10381.0), (1998.00, 10435.0), (1999.00, 10989.0), (2000.00, 11872.0), (2001.00, 12435.0), (2002.00, 13372.0), (2003.00, 14157.0), (2004.00, 14476.0), (2005.00, 15146.0), (2006.00, 15315.0), (2007.00, 15295.0), (2008.00, 13843.0), (2009.00, 13405.0), (2010.00, 13790.0), (2011.00, 13836.0), (2012.00, 13320.0), (2013.00, 12664.0), (2014.00, 12821.0), (2015.00, 12435.0), (2016.00, 13903.0), (2017.00, 15737.0), (2018.00, 16874.0), (2019.00, 17797.0), (2020.00, 18004.0), (2021.00, 16983.0)

UNITS: charges

DOCUMENT: This is the historical data for the Violent crime charges (Statistics Denmark, 2023d).

Historical.Historical_Violent_crimes_Reports = GRAPH(TIME)

Points: (1995.00, 13357.0), (1996.00, 13016.0), (1997.00, 13581.0), (1998.00, 13422.0), (1999.00, 14255.0), (2000.00, 15157.0), (2001.00, 15781.0), (2002.00, 16825.0), (2003.00, 17706.0), (2004.00, 18059.0), (2005.00, 18777.0), (2006.00, 19557.0), (2007.00, 19419.0), (2008.00, 18486.0), (2009.00, 17968.0), (2010.00, 18131.0), (2011.00, 17834.0), (2012.00, 16876.0), (2013.00, 16710.0), (2014.00, 17086.0), (2015.00, 17860.0), (2016.00, 22454.0), (2017.00, 27026.0), (2018.00, 27856.0), (2019.00, 28878.0), (2020.00, 27109.0), (2021.00, 27063.0)

UNITS: reports

DOCUMENT: This is the historical data for the violent crimes reports (Statistics Denmark, 2023f).

Historical.Historically_Charges = GRAPH(TIME)

Points: (1995.00, 137464.0), (1996.00, 137056.0), (1997.00, 131992.0), (1998.00, 126905.0), (1999.00, 119908.0), (2000.00, 120124.0), (2001.00, 111504.0), (2002.00, 109772.0), (2003.00, 113798.0), (2004.00, 120710.0), (2005.00, 116084.0), (2006.00, 113724.0), (2007.00, 107127.0), (2008.00, 105404.0), (2009.00, 106106.0), (2010.00, 115539.0), (2011.00, 137818.0), (2012.00, 136874.0), (2013.00, 138729.0), (2014.00, 148447.0), (2015.00, 145517.0), (2016.00, 153556.0), (2017.00, 143137.0), (2018.00, 158158.0), (2019.00, 172605.0), (2020.00, 175334.0), (2021.00, 155577.0)

UNITS: dmnl

DOCUMENT: This is the historical data for the charges (Statistics Denmark, 2023d).

Historical.Historically_charges_relevant_to_convictions = Historically_Charges/Historical_Convictions

UNITS: 1/convictions

DOCUMENT: This variable represents the Historically charges relevant to convictions. Where we use Historical. Historically_Charges/Historical.Historical_Convictions to calculate the chharges per convicted.

Historical.Historically_Guilty = GRAPH(TIME)

Points: (1995.00, 152841.0), (1996.00, 154006.0), (1997.00, 146598.0), (1998.00, 150559.0), (1999.00, 134502.0), (2000.00, 152377.0), (2001.00, 151015.0), (2002.00, 134584.0), (2003.00, 145665.0), (2004.00, 178177.0), (2005.00, 205898.0), (2006.00, 190152.0), (2007.00, 162863.0), (2008.00, 163414.0), (2009.00, 173555.0), (2010.00, 183758.0), (2011.00, 200091.0), (2012.00, 209839.0), (2013.00, 206351.0), (2014.00, 209446.0), (2015.00, 202325.0), (2016.00, 196503.0), (2017.00, 184924.0), (2018.00, 189915.0), (2019.00, 208545.0), (2020.00, 228899.0), (2021.00, 217555.0)

UNITS: convictions

DOCUMENT: This is the historical data for the convictions guilty (Statistics Denmark, 2023d).

Historical.Historically_Not_guilty = GRAPH(TIME)

Points: (1995.00, 12723.0), (1996.00, 12810.0), (1997.00, 12547.0), (1998.00, 13015.0), (1999.00, 13116.0), (2000.00, 13190.0), (2001.00, 13919.0), (2002.00, 14259.0), (2003.00, 16049.0), (2004.00, 16749.0), (2005.00, 16901.0), (2006.00, 15937.0), (2007.00, 13703.0), (2008.00, 13995.0), (2009.00, 14798.0), (2010.00, 16570.0), (2011.00, 16717.0), (2012.00, 16481.0), (2013.00, 16266.0), (2014.00, 15913.0), (2015.00, 14739.0), (2016.00, 14381.0), (2017.00, 15457.0), (2018.00, 15313.0), (2019.00, 17926.0), (2020.00, 19549.0), (2021.00, 19682.0)

UNITS: convictions

DOCUMENT: This is the historical data for the convictions not guilty (Statistics Denmark, 2023d).

Historical.Historically_number_of_police = GRAPH(TIME)

Points: (1995.00, 10096.0), (1996.00, 10022.0), (1997.00, 9837.0), (1998.00, 9962.0), (1999.00, 10048.0), (2000.00, 10201.0), (2001.00, 10236.0), (2002.00, 10336.0), (2003.00, 10464.0), (2004.00, 10614.0), (2005.00, 10742.0), (2006.00, 10742.0), (2007.00, 10745.0), (2008.00, 10747.0), (2009.00, 10720.0), (2010.00, 10710.0), (2011.00, 10740.0), (2012.00, 10750.0), (2013.00, 10710.0), (2014.00, 10689.0), (2015.00, 10542.0), (2016.00, 10509.0), (2017.00, 10670.0), (2018.00, 10882.0), (2019.00, 11129.0), (2020.00, 11232.0), (2021.00, 11364.0)

UNITS: dmnl

DOCUMENT: This is the historical data for the number of police in Denmark (Rigspolitiet, 2022).

Historical.Historically_Reported_criminal_offenses = GRAPH(TIME)

Points: (1995.00, 607290.0), (1996.00, 596190.0), (1997.00, 595379.0), (1998.00, 561452.0), (1999.00, 558207.0), (2000.00, 570496.0), (2001.00, 539305.0), (2002.00, 553659.0), (2003.00, 552224.0), (2004.00, 545882.0), (2005.00, 507936.0), (2006.00, 506556.0), (2007.00, 514317.0), (2008.00, 548169.0), (2009.00, 562406.0), (2010.00, 545767.0), (2011.00, 558061.0), (2012.00, 531967.0), (2013.00, 535859.0), (2014.00, 518963.0), (2015.00, 501881.0), (2016.00, 516576.0), (2017.00, 520270.0), (2018.00, 507824.0), (2019.00, 498849.0), (2020.00, 444428.0), (2021.00, 413181.0)

UNITS: reports

DOCUMENT: This is the historical data for the reports (Statistics Denmark, 2023f).
Historical.Historically_Trust_in_police = GRAPH(TIME) Points: (2013.000, 0.843), (2014.000, 0.82), (2015.000, 0.826), (2016.000, 0.811), (2017.000, 0.792), (2018.000, 0.835), (2019.000, 0.826), (2020.000, 0.83), (2021.000, 0.847) UNITS: dmnl DOCUMENT: This is the historical data for the trust in police (Justitsministeriets, 2022).
Historical.Percent_guilty_of_total_crime = Historically_Guilty/Historical_Convictions UNITS: dmnl DOCUMENT: We use the equation Historically_Guilty/Historical_Convictions to calculate the number of guilty, of the total crime.
Historical.Percent_property_of_total_reports = Historical_Property_Reports/Total_reports UNITS: dmnl DOCUMENT: We use the equation Historical_Property_Reports/Total_reports to calculate the property reports relevant to total reports.
Historical.Relative_other = Historical_Other_charges/Historical_Other_Reports UNITS: charges/reports DOCUMENT: We use the equation Historical_Other_charges/Historical_Other_Reports to calculate the relative charges dependent on the reports.
Historical.Relative_property = Historical_Property_charges/Historical_Property_Reports UNITS: charges/reports DOCUMENT: We use the equation Historical_Property_charges/Historical_Property_Reports to calculate the relative charges dependent on the reports.
Historical.Relative_sexual = Historical_sexual_offense_charges/Historical_sexual_offense_Reports UNITS: charges/reports

DOCUMENT: We use the equation Historical_sexual_offense_charges/Historical_sexual_offense_Reports to calculate the relative charges dependent on the reports.
Historical.Relative_special = Historical_Special_charges/Historical_Special_Reports UNITS: charges/reports DOCUMENT: We use the equation Historical_Special_charges/Historical_Special_Reports to calculate the relative charges dependent on the reports.
Historical.Relative_violent = Historical_Violent_crimes_charges/Historical_Violent_crimes_Reports UNITS: charges/reports DOCUMENT: We use the equation Historical_Violent_crimes_charges/Historical_Violent_crimes_Reports to calculate the relative charges dependent on the reports.
Historical.Report_without_property_crime = Historical_sexual_offense_Reports+Historical_Violent_crimes_Reports+Historical_Other_Reports+Historical_Special_Reports UNITS: reports DOCUMENT: We use the equation Historical_sexual_offense_Reports+Historical_Violent_crimes_Reports+Historical_Other_Reports+Historical_Special_Reports to calculate the total reports without the property.
Historical.Total_charges = Historical_sexual_offense_charges+Historical_Violent_crimes_charges+Historical_Other_charges+Historical_Special_charges+Historical_Property_charges UNITS: charges DOCUMENT: We use the equation Historical_sexual_offense_charges+Historical_Violent_crimes_charges+Historical_Other_charges+Historical_Special_charges+Historical_Property_charges to calculate the total number of charges.

Historical."Total_charges/report" = Total_charges/Total_reports UNITS: charges/reports DOCUMENT: We use the equation Total_charges/Total_reports to calculate the relative charges over reports.
Historical.Total_reports = Historical_sexual_offense_Reports+Historical_Violent_crimes_Reports+Historical_Other_Reports+Historical_Special_Reports+Historical_Property_Reports UNITS: reports DOCUMENT: We use the equation Historical_sexual_offense_Reports+Historical_Violent_crimes_Reports+Historical_Other_Reports+Historical_Special_Reports+Historical_Property_Reports to calculate the total number of reports
Historical.Historically_Trust_in_police_SUB_areas = GRAPH(TIME) Points: (2013.000, 0.799), (2014.000, 0.767), (2015.000, 0.779), (2016.000, 0.774), (2017.000, 0.77), (2018.000, 0.795), (2019.000, 0.846), (2020.000, 0.83), (2021.000, 0.821) UNITS: dmnl DOCUMENT: SUB areas are residential areas that are particularly exposed to crime (Justitsministeriets 2022)

Table II 0.10 Documentation: Historical. Historical sector

Variables outside sectors

Variables outside sectors
Convictions_per_criminal_known_to_the_police = Criminals_convicted/Criminals_known_to_the_police UNITS: dmnl DOCUMENT: We use the equation Criminals_convicted/Criminals_known_to_the_police to calculate the relative number of convictions over the criminals known to the police.
Convictions_per_dark_figure = Criminals_convicted/"Criminals_undiscovered_(dark_figures)" UNITS: dmnl

DOCUMENT: We use the equation Criminals_convicted/"Criminals_undiscovered_(dark_figures)" to calculate the relative number of convictions over the dark figures.

Table II 0.11 Documentation: Variables outside sectors

III Simulation Experiment Report

In the simulation experiment report I provide the minimum simulation reporting requirements by (Rahmandad & Sterman, 2012).

Modelling software: Stella Architect 3.2

Integration Method: Euler´s Integration

DT= 1/32

Time units: Years

Simulation Start Time: 1995

Simulation End Time: 2030

Baseline scenario

Breaking the law sector

Parameter value	**Units**
Percent_breaking_the_law_in_1995 = 0.52	dmnl/year
Weight_of_visibility_on_breaking_the_law = 0.85	dmnl

Table III 0.12 Parameter values and units for Breaking the law sector in BS

Charges sector

Parameter value	**Units**
Average_charges_from_police_intervening = 0.83	dmnl
Charges_from_police_intervening_in_1995 = 136000	people/year
Perception_delay_for_the_charged_per_report = 2	years

Table III 0.13 Parameter values and units for Charges sector in BS

Criminal activity sector

Parameter value	**Units**
INIT Criminals_convicted = 165564	People
INIT Criminals_known_to_the_police = 866000	People
INIT "Criminals_undiscovered_(dark_figures)" = 1276000	People
INIT Imprisonment = 13500	People
Percent_detected_by_police = 0.188	Dmnl/year
Percent_Guilty_1995 = 0.788	Dmnl/year
Percent_imprisoned = 0.134	Dmnl/year

Prison_time_average = 0.6	years

Table III 0.14 Parameter values and units for Criminal activity sector in BS

Police competence sector

Parameter value	**Units**
INIT "Police_with_competence_bellow_0.5_percent" = 990	police
INIT "Police_with_competence_of_0.5_percent" = 8900	Police
INIT "Police_with_competence_of_0.9_percent" = 0	Police
Police_competence_in_1995 = 0.445	dmnl
Years_for_the_reform_policy_to_be_integrated = 5	Year
Years_of_service_till_full_competence = 10	Year
Years_of_training = 3	Year
SWITCH_Competence_without_growth=0	dmnl

Table III 0.15 Parameter values and units for Police competence in BS

Police intervening sector

Parameter value	**Units**
Percent_police_intervening_1995 = 0.19	Dmnl/year
Police_intervening_In_1995 = 164000	People/ year

Table III 0.16 Parameter values and units for Police intervening sector in BS

Population and police sector

Parameter value	**Units**
Area_of_Denmark = 42951	Km2
Area_per_police_station_in_1995 = 224	Km2/station
Average_change_in_population_per_year_in_Percent = 0.0044	Dmnl/year
Average_year_till_retirement = 37	Years
Number_of_shut_down_police_stations_as_policy_of_reform = -63	Station
People_per_police_in_1995 = 522	People/police
Percent_change_in_Police = 0.0315	Dmnl/year
INIT Police = 10000	Police
Police_reform_INTENSITY_on_police_stations = GRAPH(TIME)	Dmnl
Police_stations_in_1995 = 192	Station

INIT Population = 5215718	People
SWITCH_Police_reform_2006 = 1	Dmnl
Weight_of_people_per_police_on_capacity = 0.65	dmnl

Table III 0.17 Parameter values and units for population and police sector in BS

Report sector

Parameter value	**Units**
Criminals_undiscovered_in_1995 = 1276000	people
Delay_of_reports_being_reported = 1	year
Initial_value_of_reports = 607000	People/year
People_reported_in_1995 = 607000	People/year
Percent_decrease_in_property_crime_reported_WITH_ Police_reform = 0.0443	Dmnl/year
Percent_decrease_in_property_crime_reported_WITHOUT_ Police_reform = 0.0226	Dmnl/year
Percent_increase_in_2006_till_2008 = 0.125	Dmnl/year
INIT Property_crime_Reported = 516000	People/year
Reports_except_property_in_1995 = 91300	People/year
Weight_of_Trust_on_reporting = 0.55	dmnl

Table III 0.18 Parameter values and units for report sector in BS

Trust sector

Parameter value	**Units**
Perception_delay_trust_in_police = 2	Year
Trust_in_1995 = 0.84	Dmnl
Weight_on_visibility_for_trust = 0.7	Dmnl

Table III 0.19 Parameter values and units for trust police sector in BS

Visibility sector

Parameter value	**Units**
Perception_delay_for_visibility = 2	year
Police_visibility_in_1995 = 0.495	dmnl
weight_of_area_per_police_station_on_police_visibility = 0.5	dmnl

Table III 0.20 Parameter values and units for visibility sector in BS

Policy implementation of the reform Scenario

In this scenario, all parameter values from the Baseline scenario stay unchanged in this scenario, except from the following:

Parameter value	**Units**
SWITCH_Police_reform_2006 = 0 - 1	Dmnl

Figure III 0.14 Parameter value and units for Policy implementation of the reform Scenario

Police force Scenario

In this scenario, all parameter values from the Baseline scenario stay unchanged in this scenario, except from the following:

Parameter value	**Units**
Percent_Change_in_Police= 0.0158 – 0.0473	Dmnl/year

Figure III 0.15 Parameter value and units for Police force scenario

Police stations Scenario

In this scenario, all parameter values from the Baseline scenario stay unchanged in this scenario, except from the following:

Parameter value	**Units**
Number_of_Shut_down_police_stations = 0 – (-) 63	station

Figure III 0.16 Parameter value and units for Police stations Scenario

Competence Scenario

In this scenario, all parameter values from the Baseline scenario stay unchanged in this scenario, except from the following:

Parameter value	**Units**
SWITCH_Competence_without_growth= 0 - 1	Dmnl
Years_till_full_competence = 5 - 15	year

Figure III 0.17 Parameter value and units for Competence Scenario

Competence and police stations Scenario

In this scenario, all parameter values from the Baseline scenario stay unchanged in this scenario, except from the following:

Parameter value	Units
SWITCH_Competence_without_growth= 0 - 1	Dmnl
Number_of_Shut_down_police_stations = 0 – (-) 63	station

Figure III 0.18 Parameter value and units for competence and police stations Scenario

Changing the crime trend Scenario

In this scenario, all parameter values from the Baseline scenario stay unchanged in this scenario, except from the following:

Parameter value	Units
Years_till_full_competence = 5 - 10	year
Number_of_Shut_down_police_stations = (-)31- (-) 63	Station
Percent_Change_in_Police= 0.0315 – 0.0393	Dmnl/year

Figure III 0.19 Parameter value and units for Changing the crime trend Scenario

IV. Stock and flow diagram

The model structure has also been discussed and reviewed in chapter 3.2.2.

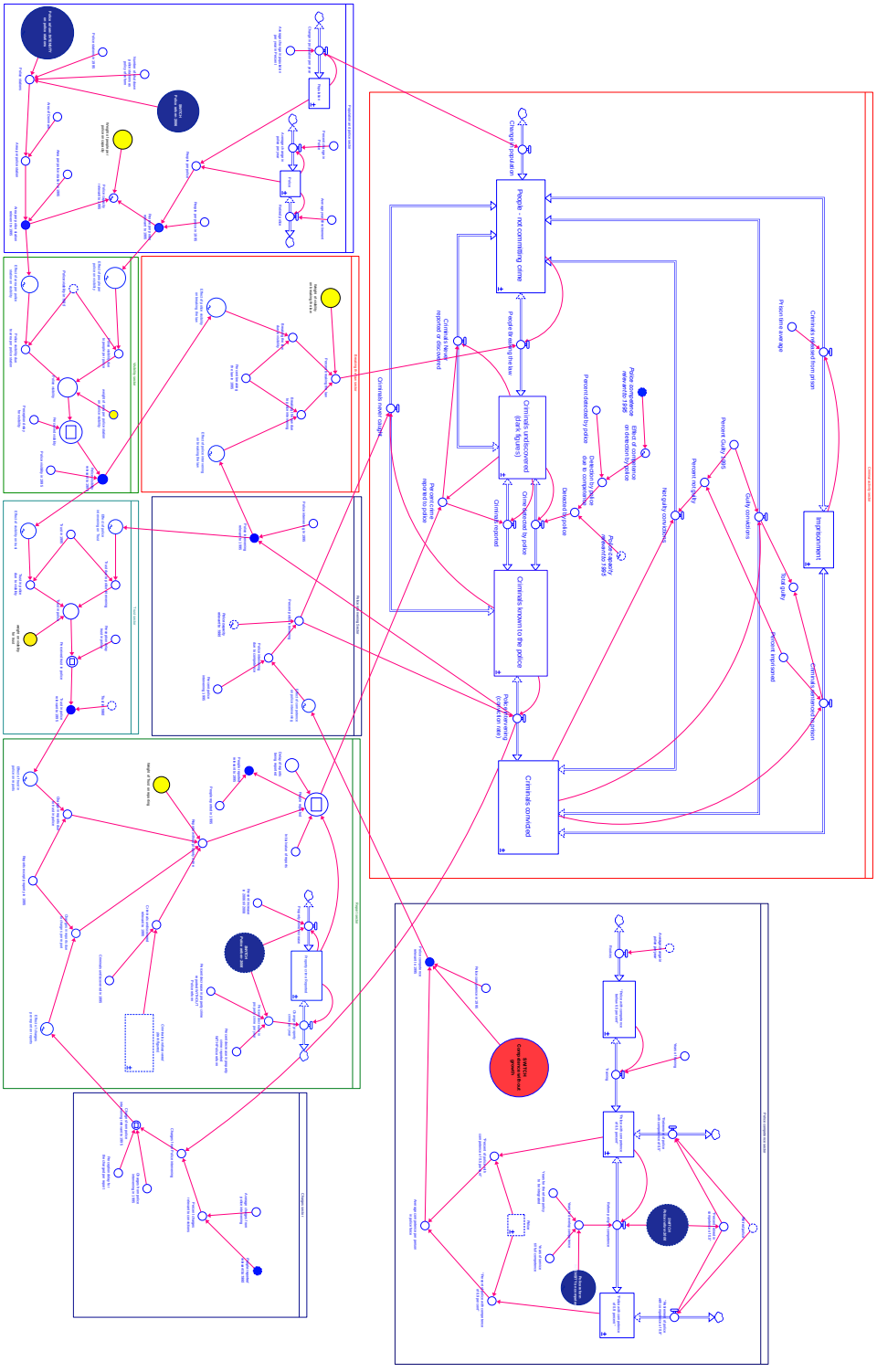


Figure IV 0.20 Full model structure