

# THE EFFECT OF DIFFERENTIATION ON PRISON POPULATION: A SIMULATION STUDY OF THE SWEDISH PRISON SYSTEM

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## KEYWORDS

Prison, Discrete Event Simulation, Queuing systems.

## ABSTRACT

This paper describes the case of a simulation study of the Swedish Prison and Probation system regarded as a queuing system. The situation in Swedish prisons today is not acceptable with a utilisation over 100 per cent. The short-term solution of the problem has been to overcrowd the prisons. The purpose of this work is to describe the relations between waiting time in remand prison, the official number of cells in prisons and the degree of differentiation regarding to the expected torrent of criminals. Differentiation is the attempt to keep different categories of clients apart during their prison time. The degree of differentiation is defined as the number of defined categories used for client placement. The conclusions from this study is that there are not enough number of prison cell available. The situation for male inmates/clients is more critical than for female clients. The results from the study suggest that there needs to be approximately 11,000 prison cells in total to meet the unofficial recommendation of a maximum of seven days in remand prison.

## INTRODUCTION

The situation in Swedish prisons is strained. This has resulted in long waiting times for inmates (here called clients) before they can receive a suitable placement to serve their prison time. The queues in remand prison are not acceptable and the degree of occupancy has gone over 100 per cent according to the official statistics. The short-term solution of the problem has been to overcrowd the prisons. In the beginning of the year 2004 there was officially 4,571 number of prison cells to be shared between clients of both sexes. The target is to build 1,150 new places prior to 2007 which will result in a total capacity of 5,721 places. It is not clear that this expansion will result in an elimination of waiting time in remand prison, or even a reduction to the regulated maximum of seven days after that sentence have been made official.

The degree of differentiation is one of the regulations that makes this planning problem suitable for a more in-depth analysis. Differentiation is the attempt to keep different categories of clients apart during their prison time. The degree of differentiation is defined as the

number of defined categories used for client placement. The degree of differentiation have a direct influence on the waiting time in remand prison. With a high degree of differentiation (many different client categories) the chance of receiving a suitable placement decreases as the number of options for placements are few.

Tarling (1986) reviews the use of statistical analysis in criminology and describes a simulation model depicting the interrelation between the police, court, prison, and probation systems. With the proposed model it is possible to e.g. evaluate different strategies for trial priorities in order to reduce waiting time before the trial. Most statistical applications reported in Tarling (1986) covers the prediction of prison population. Barnett (1987) follows in the same field research with a projection model for future prison population based on historical data. Lattimore and Baker (1997) studies the effect of limited prison capacity on the average time a client serves. They use a input/output process model with feedback.

Other, similar applications of simulation has been reported in the healthcare sector. In Ridge et al. (1998) a simulation model (coded in Pascal) is used to capture the capacity need in an intensive care unit. The capacity planning in this environment is similar to that of the remand prison queuing system. The waiting is to be kept to a minimum by planning the capacity in the later parts of the flow.

The purpose of this work is to describe the relations between waiting time in remand prison, the official number of prison cells and the degree of differentiation regarding to the expected torrent of criminals. This analysis is done with use of discrete event simulation where the process of waiting to be placed, the placement and the serving time is considered as a queuing system. Each client will be provided with his/her own treatment program during the prison time. This treatment program is called a treatment chain since the client is routed through different instances of treatment in a specific order.

The methodology, using discrete event simulation, is a novel application for the National Prison and Probation Administration of Sweden. On hindsight, the most useful results came from the fact that a conceptual model was created that eventually all concerned personnel could agree upon. This conceptual model depicted a

system that none of the personnel had the complete understanding about. The methodology and results are of interest for other practitioners in the same field, but also for fellow researchers that are interested in the queuing system of a prison. There are also some modelling aspects of these kinds of systems that would be of interest for both practitioners and researchers.

## DIFFERENTIATION

All government activities are regulated by law or more loosely, by recommendations. This work is no exception. Statutory instruments must be followed and if it is possible, the visions and goals of the Swedish Prison and Probation Service. One of their goals is the degree of differentiation which influences the prison system behaviour and sets the boundaries for possible solutions.

There are three main grounds for differentiation; (i) sex; male and female clients are separated, (ii) security; open prisons, closed prisons, or closed prisons with extra high security, and (iii) age; younger, first time clients, are separated from older clients with a high return rate to crime and prison. Besides these three differentiation grounds, clients are also separated based on the nature of their crimes or on their need for treatment for drug or alcohol abuse.

Clients that have committed sex-related crimes are separated from other clients because the sex-offenders rank lowest among criminals. There is a risk for reprimands from those who rank higher in the unofficial ranking system. Another group that is separated is the clients with drug abuse. These clients are often in different treatment programs and need special care and competent supervision.

Today, there exists twenty-six different categories for differentiation, see table 1 for a limited selection of categories. As defined earlier, the degree of differentiation is equal to the number of available categories. The question is what categories should be utilised and how many places (cells) should each category have?

Table 1: Categories of Differentiation

Male	Female
Normal (open)	Normal
Normal (closed)	Treatment for drug abuse
Drug free	...
Youth	
Youth with motivation	
High security	
Treatment for drug abuse	
Treatment for alcoholics	
Sexual offenders	
...	

Laws and recommendations given by the Swedish government clearly states that a client must be placed in a suitable category or remain in remand prison. Temporarily, the normal category is utilised as placement while the client waits for a suitable categorised place to become available. There is also a desire not to move clients between different categories or placements and in some cases between different prisons. Each time a client is moved, he or her must adapt to a new environment and new prison personnel.

## SIMULATION MODEL

The used simulation methodology follows the steps described in Persson (2003) and does not differ from the methodologies described in *e.g.* Law and Kelton (1991), and Banks (1998). The first step (i) is the project planning or problem formulation where the outline of the study is determined. The next step (ii) is the conceptual modeling. The conceptual model describes the system under investigation. The conceptual model is validated as the next step (iii). The computer-based model is created as step (iv). This model must be verified (v) and validated (vi). Model verification aims at estimating if the simulation model is a valid representation of the conceptual model while model validation aims at estimating if the model is a valid representation of the system. The experimentation step (vii) consists of experimental runs with the simulation model. The results of these runs are then analysed (viii) and the result of that analysis is the base for the recommended decision or implementation (ix).

### Conceptual Model

The conceptual model is described in different levels. The highest level describes the model as a whole and contain few details. The sub levels are more detailed and shows the exact flow of each of the treatment chains. A treatment chain consists of the different instances that the client is routed through during the prison time in the system (the prison organisation). Note that the treatment chains are the ideal sequence of client activities during the prison time.

An example of a treatment chain is the treatment for a client that has problems with drug abuse; he/she gets an initial placement at a motivation wing. After the motivation (if the client is motivated), the next step is the treatment wing. After a successful treatment or when the prison stay has ended and the client is ready to leave, he/she has the possibility to continue the care outside the prison on a contract basis. Figure 1 shows the treatment chain for drug addicted males. Note that if no cell is available for in the treatment wing or in the motivational wing, the clients stays in remand prison until prison capacity is released.

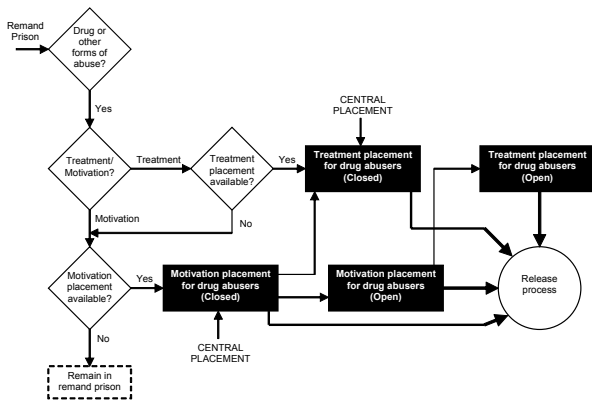


Figure 1: Treatment chain for male drug abusers

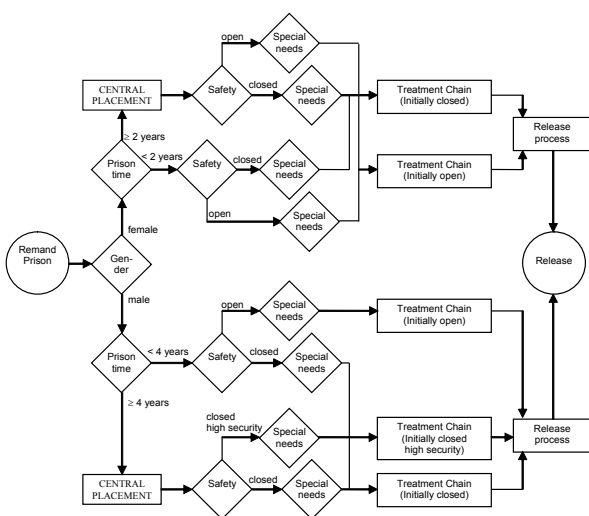


Figure 2: Conceptual Model – Highest Level

The high level conceptual model is depicted in figure 2. The model includes all initial placements to prison and placements in-between prisons. Individual prisons are not modelled, just the cells with different treatment programs. The remand prison has infinite capacity since the objective is to study the queues or waiting time for all differentiation categories.

The conceptual model is represented as a computer-based model in the simulation software Arena (version 7.0). A graphical user interface is provided in MS Excel. The user is able to adjust parameters that affects the output without any interaction with Arena. Parameters to use in experimentation is; torrent of criminals per year, number of places in different categories and the percentage share in different categories, both from remand prison and for persons liable to be detained but not yet deprived of liberty.

### Computer Model

The computer based model (the discrete event simulation model) is constructed in ARENA (version 7.00).

This section contains information about some special features included in the simulation model.

Clients with drug abuse have the opportunity to get the last part of the sentence in care outside the prison. As these clients get care outside the prison, capacity is made available at an earlier stage than anticipated. To implement this into the model all clients that were suitable for care outside the prison were given a reduction of their sentence. If the client had a sentence shorter than 30 days this treatment is not an option.

To measure the time that a client had been waiting for the requested treatment, time-attributes had to be added before entering and leaving the queue (remand prison). The difference between the two attributes is then measured as the time in queue. The number of days in queue are stored in a counter for statistics, which later is exported to MS Excel.

During the modeling effort, one of the larger problems was the warm up period. As the model runs for ten years the simulation should have a relative long warm up period. This did not work due to that the model showed an instable behavior due to the lack of capacity. Therefore, a shorter warm up period were chosen than was intended.

### Model assumptions

The following assumptions are made when constructing the computer based model.

- Different prisons are not separated in the model, all prison cells are kept together as one whole unit.
- The number of cells in remand prison is unlimited. This will not affect the final result.
- The client will stay in remand prison as long as there are no places available. With this assumption it is possible that the client serve the whole sentence in remand prison.
- When changing the degree of differentiation, clients previously belonging to categories that are removed are placed in the normal wings (open or closed).

### Model Validation

Basically, a simulation model can be divided into two distinct parts; i) the model logic, and ii) the statistical data for time between events and the stochastic occurrences of events. In this case, the model logic is easy to validate. Although there are several different opinions about how the prison system works, consensus about the model was reached by the system experts. The statistical data are more difficult to validate. Much data were collected from the official statistics of the National Prison and Probation Administration and must therefore be associated with a high degree of credibility. Other data that were needed for the simulation model proved difficult to obtain and were in the end estimated by the

proper personnel. These data might have less credibility but are still the best estimation possible.

When dealing with people's opinions about whether or not a model is valid, there is always a risk of including personal beliefs in the model validation process. The validity of a model that has been validated with subjective methods like a model walkthrough can be criticised due to the subjectivity in the technique itself. Nevertheless, subjective validation methods are, due to the simplicity in application, much used in practise. In this case, the model was validated using a walkthrough where experts found the model valid.

### **Graphical User Interface**

One of the objectives stipulated by the National Prison and Probation Administration is an easy-to-use interface for the simulation model. The model will be used as a planning tool at the National Prison and Probation Administration by personnel who is unfamiliar with simulation methodology. A graphical user interface is therefore used to define each scenario and start the simulation. The user interface (built in MS Excel) is connected to ARENA and the user needs only a basic familiarity with MS Excel. After a simulation run, experiment data are collected in the same interface and communicated by graphs and numbers.

To be able to get a high acceptance of the user interface, a hand drawn model of the MS Excel sheet was initially presented to the intended users. This model was changed many times before it was finalised and coded in MS Excel. In all, five intended users were used to test the interface before all involved were satisfied. The connection to ARENA was created with Visual Basic.

## **EXPERIMENTS AND RESULTS**

The experiments provide data to answer the following three questions:

- Q 1 What are the utilisation of available places of different categories as a function of the chosen degree of differentiation?
- Q 2 What are the minimum number of places in each category and the composition of categories to be able to reach the objective of maximum seven days in remand prison?
- Q 3 Given the forecasts of number of new clients, what is the number of places needed in ten years time?

The first experiment is based on the idea that a large number of different categories will show a low overall cell utilisation since some categories can be empty and not used by other categories. The second experiment follows the same reasoning since a small number of categories with a large number of cells will keep the

waiting time to a minimum. In the last experiment, the proposed expansion of an additional 1,150 prison cells, is tested and evaluated. If the number of clients continue to increase, this expansion will be insufficient in a couple of years.

The experiments are controlled by the MS Excel user interface. Each experiment starts with a warm-up period of one year and continue with a run length of ten years.

### **Experiment 1**

To find the relationship between the degree of differentiation and utilisation, five scenarios are created with an increasing degree of differentiation. The first scenario contains the lowest degree (as stated by law) and the fifth scenario contains the maximum degree of differentiation that is possible to obtain.

The results of experiment 1 shows that with today's number of clients, the utilisation soon reaches 100 % in each category. Even with the expansion with 1,150 new prison cells, the utilisation still reaches maximum. The situation is better with female clients than for male clients. Without a heavy expansion in prison capacity for male clients, it is impossible to find a relationship between utilization and degree of differentiation.

### **Experiment 2**

The objective concerning a maximum of seven days of waiting time in remand prison is evaluated by the best scenario in experiment 1. The percentage of clients that are placed in the correct category within seven days after that the sentence has been finalised is varying between 0 % (non of the clients) and 100 % (all clients). On average, 19.8 % of the clients in remand prison are given a correct placement within the stipulated seven days.

### **Experiment 3**

The third experiment examines the influence of a forecasted increase in clients during the next ten years. Also in this case it is clear that more capacity is needed to be able to estimate the effect of an increasing number of clients. The poor results in experiments 1, 2, and 3 resulted in a fourth experiment to capture the need of extra capacity.

### **Experiment 4**

The result of this experiment shows that the total prison system needs to be expanded with 6,700 new cells for male clients with the lowest degree of differentiation. This massive expansion is totally out of the scope of the planned expansion of 1,150 prison cells.

## **Results**

The main result from this study is that the system in its present form very quickly becomes full and the waiting

time in remand prison steadily increases. For female clients, the situation is within the desired specifications. A scenario with shorter waiting time in remand prison then seven days can be found for a high degree of differentiation. In the case of the male clients, an additional 6,700 prison cells are needed. This number is outside the scope for this project since the expansion is planned for a modest 1,150 prison cells.

## CONCLUSION

It is clear that the situation in Swedish prisons is critical. The planned expansion of 1,150 prison cells is far from enough. The situation for male clients is more critical than for female clients, who exhibit a far better situation. The female client population is also very small compared to the number of male clients (approximately 5 % of the prison cells are dedicated to female clients).

According to the results from the simulations the prison system should be expanded to include 11,000 prison cells in a few years time. It will otherwise be impossible to meet the recommendation of a maximum of seven days waiting time in remand prison.

These results are valid for a constant torrent of clients of 10,200 every year and a minimum degree of differentiation. There may be some uncertainty connected to the statistics due to the fact that some input data are estimates done by prison personnel. Nevertheless, this is the still the best estimate available.

The risk of heavily overcrowded prisons will force the National Prison and Probation Administration to increase the rate of expansion from the planned 1,150 new prison cells to the suggested 11,000 cells. Other activities that could decrease the need for traditional prison cells are the use of electronic supervision such as foot cuffs.

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