SIMULATING THE NEW SOUTH WALES CRIMINAL JUSTICE SYSTEM: A STOCK AND FLOW APPROACH

Bronwyn Lind, Marilyn Chilvers and Don Weatherburn

New South Wales Bureau of Crime Statistics and Research

2001

Published by the NSW Bureau of Crime Statistics and Research

Attorney General's Department

Level 8

St James Centre

111 Elizabeth Street

Sydney

ISBN 0 7313 2627 X

Website: www.lawlink.nsw.gov.au/bocsar

ACKNOWLEDGMENTS

The work documented in this report was undertaken in response to a request from NSW Treasury. Data were provided by the Police Service and the Department of Corrective Services. Barbara Thompson from the Department of Corrective Services was particularly helpful in extracting data specifically for the model.

Within the Attorney General's Department both Anita Mak (Local Courts) and Jason McDonald (District Court) assisted by providing court registration and stock data.

Desktop publishing of the report was carried out by Florence Sin and Jonathan Nichol.

CONTENTS

EXECUTIVE SUMMARY

In New South Wales there has not to date been any means of assessing the impact of legislative, policy or resource changes on the criminal justice system. While it is always theoretically possible to conduct policy experiments and evaluate the results, in many instances policy experiments are for practical purposes impossible. One way to get around this problem is to develop a simulation model of the criminal justice system. Such models, as the term 'simulation' suggests, mimic the operation of the system. By changing various aspects of their functioning it is possible to artificially 'experiment' with policy changes and examine their probable effects on such things as the number of cases awaiting trial or the number of people serving a prison sentence.

The purpose of this report is to describe and document the development of a model of the NSW criminal justice system. To reduce development costs and time, and to facilitate diagnostic checking of the model, it has only a simple structure and few parameters. Persons can only enter the system as a result of police action (either arrest, or the issue of a Court Attendance Notice or summons). Persons within the criminal justice are considered to be in one of five 'stocks'; they can move to other stocks or out of the system. The numbers of persons moving in and out of the stocks are determined by the model's parameters. The five stocks consist of four court stocks and one prison stock. Persons awaiting determination of court cases are assumed to be in one of the four court stocks, two for the Local Court and two for the District Court – for both jurisdictions there are two stocks in order to distinguish between persons in custody (on remand) and persons not in custody.

A central issue in the development of any simulation model is the need to obtain reliable and stable estimates of its parameters. In the present case parameter estimates were, as far as possible, based on data over a five-year period. For most parameters the estimates were found to be reasonably stable over time.

The model's validity was tested by comparing observed stock values with those predicted by the model, over the last two years of the period from which data were used for parameter estimation. The results of this exercise show that the model performs reasonably well, indicating that the model's structure can be considered, within limitations, to be a valid representation of the criminal justice system.

Sensitivity testing of the parameters shows that the predicted remand population is most sensitive to the initial values for the court stocks, whereas the sentenced prisoner population is most sensitive to the parameter which determines departures from prison.

Three example simulations are presented to illustrate use of the model. The first concerns the effect on the total prison population of an increase in the number of persons brought to court on criminal charges. The second concerns the effect on the remand population of a change in the proportion of persons refused bail. The third concerns the effect on the sentenced prisoner population of a change in sentencing practices. The results of these simulations show that policy changes do not always produce the effects which might be expected.

The report concludes by acknowledging that the model is by no means a perfect representation of the criminal justice system but that, used with care and judgement, it could be a useful tool in policy impact analysis. Further development of the model is possible but is probably only desirable if the present model proves to be useful and if the quality and range of data on criminal justice functioning can be improved.

INTRODUCTION

Between June 1998 and June 1999, the prison population in New South Wales (NSW) grew from about 6,400 to 7,200, following a five-year period during which it had remained quite stable, with an average 6,300 prisoners. This growth was entirely unexpected but appeared to result partly from changes in policing policy designed to reduce crime. The dramatic effect of this policy change highlighted the lack of any facility for assessing the effect of changes in criminal justice or law enforcement policy on the operation of the criminal justice system. As a result, the NSW Treasury asked the NSW Bureau of Crime Statistics and Research (BOCSAR) to develop a computer model which could be used to simulate the effects of changes to law enforcement or criminal justice resources or policy.

The purpose of this report is to describe and document the progress which has been made to date in developing such a model. We begin by explaining some of the background considerations which motivated the particular model developed by BOCSAR. We then describe the model and the data required to build it and run simulations. Following this we describe the data sources from which the required data were drawn. The next section describes how the model parameters were estimated and examines the stability of the estimates over time. Results of validity testing and sensitivity testing are presented in the following two sections. The penultimate section illustrates the utility of the model by describing the results of some sample simulations. Implications for implementation and future development of the model are then discussed.

BACKGROUND TO MODEL DEVELOPMENT

Court and prison administrators have long appreciated the vulnerability of their agencies to changes in levels of police activity. When arrest rates rise without warning the downstream effect is often court and prison congestion. Without some facility for tracking the effect of changes in the number of people arrested, there is little that can be done to prevent this occurring. Governments can appoint additional judges but this expedient only serves to reduce congestion if there are sufficient courts to place them in. Prison administrators face an even more stark choice. Prison congestion can only be eased by building new prisons or letting prisoners out earlier than normal. The first option is very expensive and the second is fraught with political risk.

Increased arrest rates are perhaps the most common but are certainly not the only source of court and prison congestion. Policy changes within the criminal justice system can produce court and prison congestion just as surely as an increase in arrest rates. Changes to the range of offences which must be heard before a judge and jury (as opposed to being dealt with summarily, by a magistrate), for example, can increase court congestion even if arrest rates do not rise. The same effect can issue from changes in the relative proportions of defendants pleading guilty or not guilty. More restrictive bail conditions or a growth in court delay, on the other hand, can significantly increase the size of the remand population. Likewise, tougher sentencing policies can increase the size of the sentenced prisoner population.

During the 1970s recognition of the need for early warning of court and prison congestion stimulated interest in building computer simulation models of the criminal justice system (Nagel 1977). The simulation models which have been developed are all designed to mimic the flow of cases through various stages of the criminal justice system (eg. arrest, remand, trial, imprisonment). They do this, essentially, by making assumptions about the proportions of cases which currently pass through various stages of the criminal justice system during particular time periods. Policy simulations are carried out by changing these assumptions and seeing how this affects the flow of cases through the simulated justice system. A change to bail policy, for example, can be explored by changing the proportion of people granted bail in the model and comparing the effects (say) on people in custody before and after the change.

Early attempts at simulation model building were designed to represent the operation of the justice system in very considerable detail. In its original formulation, for example, the JUSSIM model, developed by the United States Justice Department, simulated the effect of police resources on the flow of individuals into the courts, the flow of individuals, distinguished by crime type, age and sex, through the courts, the flow of individuals from the courts to prison and the flow of recidivists released from prison back into the courts (Chaiken et al. 1977). A similar approach was adopted by the Home Office in Britain (Morgan 1985). Some model builders have sought to achieve even more exacting goals. The DOTSIM model, for example, was designed to simulate the flow of individual cases (rather than groups of cases) though the justice system (Chaiken et al. 1977).

In general, the more detailed a model's representation of the justice system, the greater the range of policy simulations it can be used to conduct. A model which describes the relationship between police resources and arrest rates, for example, can be used to simulate the effect of changes to police resources. One where the user simply scripts the input to the justice system cannot. A model which tracks individual cases through the justice system can be used to examine the effect on court waiting times whereas one which simply tracks the flow of groups of cases cannot. A model which attaches costs to each stage of processing can be used to calculate the cost of changes to policies affecting the flow of individuals through the justice system whereas one which simply models those flows without costing them cannot.

Unfortunately, the increase in power which comes from making simulation models more complex comes at a price. The wider the range of policy questions a model is expected to answer, the more assumptions the model designer must embed in the model about the operation of the criminal justice system. The more complex the model, moreover, the greater the range of parameters in the model which must be estimated to conduct simulations. The trouble with making more assumptions is that, when there is little or no evidence to support them, the results from simulations using the unsupported assumptions are open to debate. The trouble with increasing the number of model parameters which must be estimated is that it becomes more difficult, time consuming and expensive to obtain the data required to estimate those parameters.

The magnitude of these problems became all too clear to BOCSAR during its first attempt to develop and implement a simulation model of the NSW criminal justice system during the early 1990s. The model was intended to be capable of answering a wide range of policy questions. To this end the design of the model was extremely complex. It simulated the passage of individual cases through the criminal justice system by assigning probabilities to the likelihood of a given case passing from one processing stage to another within the system. Random numbers were then used to determine the actual number of cases passing from stage to stage in a particular time period. Individual cases were distinguished according to their offence type and plea and whether the defendant was remanded in custody. The outcomes of court processing where also modelled in considerable detail (e.g. whether adjourned, whether convicted, penalty type and amount).

This approach to model development certainly resulted in a powerful tool. For example, the model could identify the effect of an increase in arrest rates, for any one of a large number of different offences, on average court delay or the likelihood of the prison population exceeding a certain level. Unfortunately the model also required the estimation of a very large number of parameters. The number of parameters required just for the Local Court module of the model exceeded five hundred. To make matters worse, the data required to estimate model parameters were not all readily available, making updating of the parameters and maintenance of the model an extremely laborious task. In some cases the data required to estimate parameters were not routinely collected and original research projects had to be instigated to collect the required data. This made collection of the data for the model parameters quite expensive.

The complexity of the model also highlighted another problem. Few criminal justice agencies employ large numbers of people trained in data analysis, computer simulation or empirical research. In fact the end users of a criminal justice simulation model are more likely to have been trained in law and / or justice administration rather than in statistics. Their knowledge of the criminal justice system, *qua* system, is largely derived from experience. For this reason they are naturally reluctant to rely on a complex computer system to obtain answers to questions which they view as more reliably and more transparently answered on the basis of their experience. Not surprisingly, in the circumstances, the first simulation model developed by BOCSAR was infrequently used. This fact, and the expense and effort involved in maintaining the model, eventually led to its abandonment as a planning tool.

A detailed simulation model of the NSW District Court subsequently met a similar fate. The model, developed in BOCSAR by Crettenden, Packer and Macalpine (1993), was designed to allow court administrators to explore the effects (on court backlogs, court delay, the amount of court time used each month, the age of the pending caseload and the number of cases finalised each month) of changes to 13 different aspects of District Court operations. As with the criminal justice model, simulation was conducted on a case by case basis so that by repeatedly running the model with the same parameter settings court administrators were to determine the likelihood (for example) that delay or court backlogs would exceed certain pre-ordained values. As with the criminal justice model, this power came at a price. The model was extremely complex to use and expensive to maintain and, largely as a result, was never adopted as a management tool by court administrators.

The failure to implement these earlier simulation models exerted a strong influence on the current authors' approach to developing a simulation model of the criminal justice system. To avoid the problems just described we resolved (a) to develop the simplest possible model capable of performing useful policy analysis (b) to model only the aggregate flow of cases through the criminal justice system (not individual cases) (c) to design a model whose parameters could largely if not entirely be obtained from existing data collections (d) to make the model as user-friendly as possible and (e) as much as possible, to limit the assumptions made by the model to those supported by empirical evidence. Following discussions with criminal justice agency personnel, several general questions were identified as both as recurring and central enough to function as design constraints on the model to be developed. These were:

1. What are the potential effects of an increase in arrest rates?
2. What are the potential effects of changes to bail policy?
3. What are the potential effects of changes in court backlogs?
4. What are the potential effects of programs designed to divert people from court or prison?
5. What are the potential effects of changes to sentencing practice?

The ensuing sections of this report describe the development of a model designed to answer these kinds of general questions within the constraints (a) to (e) described above.

DESCRIPTION OF THE MODEL

The model is a simple stock and flow model of the NSW criminal justice system. It includes only the two major court jurisdictions in NSW, the Local Court and the District Court. The Children's Court and the Supreme Court are not modelled.

For the model the entry point to the criminal justice system is police action taken against an individual for an alleged criminal offence. New entrants to the criminal justice system are those persons entering the system as a result of a police process, namely being formally charged, or being brought to court by means of a Court Attendance Notice or summons. Other means of entering the court system, for example, contesting a minor traffic fine or applying for an Apprehended Violence Order, are excluded from the model. The new entrants to the system form the input to the model.

It is assumed that, at any one time, a person in the system must be in one of five different 'stocks':

- *Local Court custody* – the stock of persons in custody awaiting a Local Court determination or a committal to the District Court;
- *Local Court bail* – the stock of persons on bail awaiting a Local Court determination or a committal to the District Court (for these persons bail may have been granted, or dismissed, or not considered – for convenience all these conditions are referred to as 'on bail' throughout this report);
- *District Court custody* – the stock of persons in custody awaiting a District Court determination;
- *District Court bail* – the stock of persons on bail awaiting a District Court determination;
- *Prison* – the stock of sentenced prisoners (persons in prison serving a sentence).

The model allows the following flows into stocks, between stocks or out of the system:

- persons formally charged can enter either *Local Court custody* or *Local Court bail*;
- persons brought to court by means of a Court Attendance Notice or summons can only enter *Local Court bail*;
- persons in *Local Court custody* can have their court case finalised without an imprisonment penalty being imposed (an exit from the system) or with an imprisonment penalty being imposed (a flow to *Prison*); they can also move to *Local Court bail* (a change in bail status) or be committed to the District Court (a flow to *District Court custody*);
- persons in *Local Court bail* can have their court case finalised without an imprisonment penalty being imposed (an exit from the system) or with an imprisonment penalty being imposed (a flow to *Prison*); they can also be committed to the District Court (a flow to *District Court bail*);
- persons in *District Court custody* can have their court case finalised without an imprisonment penalty being imposed (an exit from the system) or with an imprisonment penalty being imposed (a flow to *Prison*);
- persons in *District Court bail* can have their court case finalised without an imprisonment penalty being imposed (an exit from the system) or with an imprisonment penalty being imposed (a flow to *Prison*);
- persons in *Prison* can only move out of the system.

This is a restricted set of flows compared with what can and does actually occur in the NSW criminal justice system. For example, the model does not specifically model appeals. The model only allows entry to prison as a result of a conviction in the Local or District Court. It is assumed that, once committed to the District Court, a person's bail status cannot change. It is also assumed in the model that, once a person is granted bail in the Local Court, that person cannot be remanded in custody, even if committed to the District Court. These restrictions simplify the model but, we hope, have little effect on the model's ability to simulate the criminal justice system. There is, however, one assumption for which an adjustment factor is included in the model. This assumption is that those awaiting a court case determination are either on remand or not in prison at all. We know that this assumption is incorrect because, in reality, many of the people awaiting court determinations are already in prison serving sentences for prior convictions. If these people receive another prison sentence, their stay in prison can be increased but they are not 'new entrants' to prison and do not therefore increase the prison population. The model deals with this problem by using a parameter to adjust for the numbers of entrants to prison.

We can depict this model diagrammatically and its operation can be written as a set of five equations describing how the stocks change from one month to the next. But first we need to define some measures. We present these definitions in Figure 1.

Using these measures we can depict the model diagrammatically as shown in Figure 2. In the figure the boxes represent stocks and the arrows represent flows, with the arrowheads indicating the flow direction.

Figure 1: Definitions of variables used in the model

$A(t)$ = number of persons formally charged in month t

$S(t)$ = number of persons issued a Court Attendance Notice or summons in month t

$L1(t)$ = number of persons in *Local Court custody* in month t

$L2(t)$ = number of persons in *Local Court bail* in month t

$D1(t)$ = number of persons in *District Court custody* in month t

$D2(t)$ = number of persons in *District Court bail* in month t

$P(t)$ = number of sentenced prisoners in prison in month t

$Q1(t)$ = number of persons in *Local Court custody* whose cases are finalised in month t

$Q2(t)$ = number of persons in *Local Court bail* whose cases are finalised in month t

$Q3(t)$ = number of persons in *District Court custody* whose cases are finalised in month t

$Q4(t)$ = number of persons in *District Court bail* whose cases are finalised in month t

a = proportion of persons formally charged who are placed in custody

b = proportion of persons in custody given a prison sentence by the Local Court

c = proportion of persons formally charged who are placed in custody and who are committed to the District Court

d = proportion of persons formally charged who are placed on bail and who are committed to the District Court

e = proportion of persons on bail given a prison sentence by the Local Court

f = proportion of persons in custody given a prison sentence by the District Court

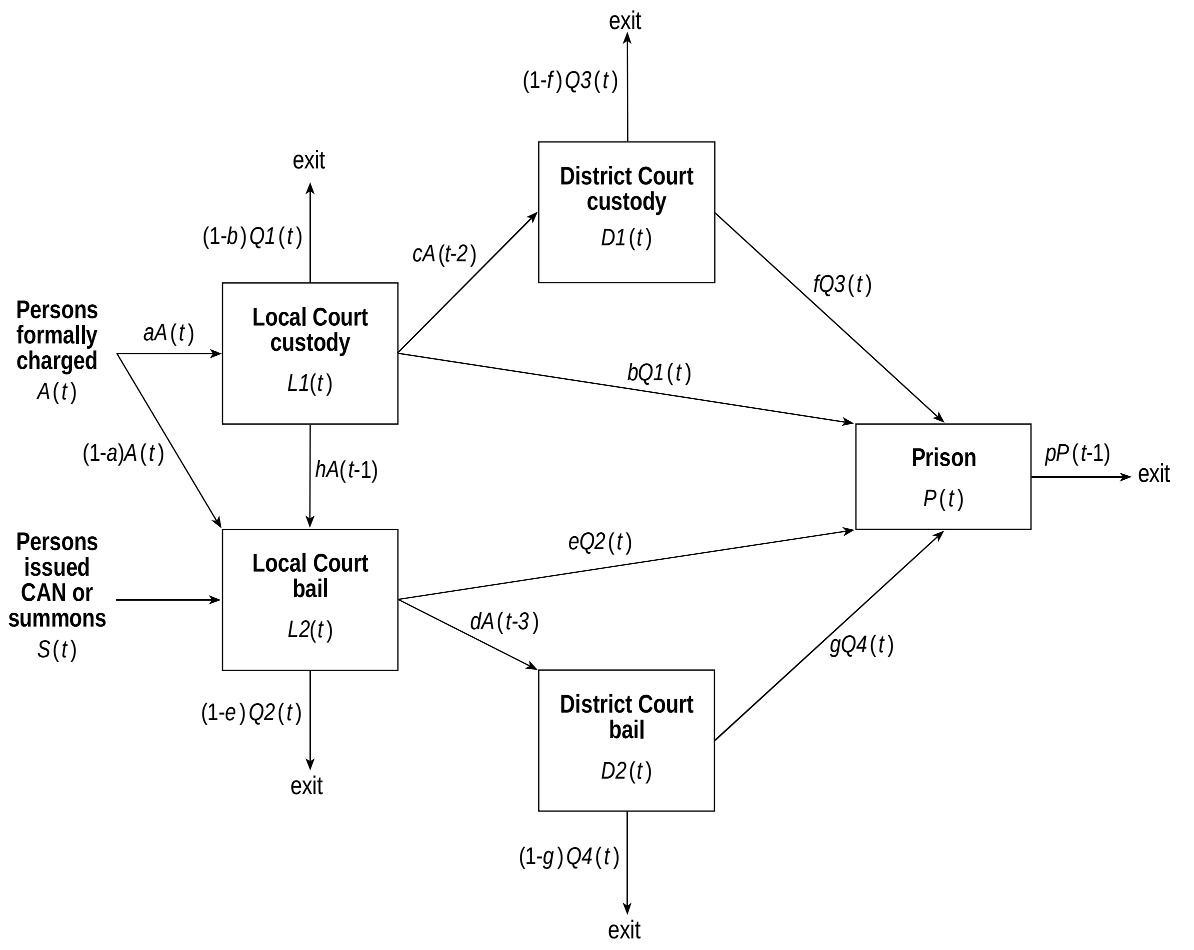
g = proportion of persons on bail given a prison sentence by the District Court

h = proportion of persons formally charged who move from *Local Court custody* to *Local Court bail*

j = adjustment factor applied to the numbers of persons sentenced to prison to determine the number of new entrants to the sentenced prisoner population

p = proportion of the sentenced prisoner population who are discharged from prison each month.

Figure 2: Stock and flow model of the NSW criminal justice system



The changes in the stocks from one month to the next are as follows:

$$L1(t) = L1(t-1) - Q1(t) + aA(t) - cA(t-2) - hA(t-1) \tag{1}$$

$$L2(t) = L2(t-1) - Q2(t) + (1-a)A(t) + S(t) - dA(t-3) + hA(t-1) \tag{2}$$

$$D1(t) = D1(t-1) - Q3(t) + cA(t-2) \tag{3}$$

$$D2(t) = D2(t-1) - Q4(t) + dA(t-3) \tag{4}$$

$$P(t) = P(t-1) + j[bQ1(t) + eQ2(t) + fQ3(t) + gQ4(t)] - pP(t-1) \tag{5}$$

Each of these equations states that the stock in a specified month is equal to the stock in the previous month, minus the number of departures in the specified month, plus the number of new arrivals in the specified month. Take, for example, equation (1) for *Local Court custody*. The number of new arrivals in the specified month is the proportion *a* of persons formally charged that month. There are, however, three ways in which a person can depart from *Local Court custody* so there are three terms in the equation to represent the departures: the number of persons whose cases are finalised ($Q1(t)$), the number of persons who are committed to the District Court ($cA(t-2)$) and the number of persons who move to *Local Court bail* because of a change in bail status ($hA(t-1)$).

Some comment is necessary here to explain why there are time period lags in the last two of these terms. First, we know, from the database of finalised criminal matters maintained by BOCSAR, that the median time from arrest to committal for custody cases is two months. It is therefore assumed in the model that a person spends two months in *Local Court custody* before being committed to the District Court. The number of persons committed to the District Court is then the proportion *c* of persons formally charged two months prior to the specified month. (Note that these departures from *Local Court custody* are the new arrivals to *District Court custody* in equation (3) above.)

Second, the NSW Department of Corrective Services estimate that more than two-thirds of unsentenced inmates stay in prison (on remand) less than one month. It is therefore assumed in the model that those whose bail status changes from custody to bail only stay one month in custody. The number of persons who depart *Local Court custody* for *Local Court bail* is then the proportion *h* of persons formally charged one month earlier than the specified month. (Note that these departures from *Local Court custody* become new arrivals to *Local Court bail* in equation (2) above.)

One further point to note is that in equation (2) the departures from *Local Court bail* as a result of committal to the District Court (and hence the new arrivals to *District Court bail* in equation (4)) are estimated as the proportion *d* of persons formally charged three months prior to the specified month. The reason for the three-month lag is that we know, again from the BOCSAR database of finalised criminal matters, that the median time from arrest to committal for bail cases is three months.

In equation (5) the arrivals are persons sentenced to prison, multiplied by the adjustment factor *j*, and the departures are estimated to be a proportion *p* of the sentenced prisoner population in the previous month. (Note that this is a very crude way of estimating departures from prison which could easily be replaced by estimates generated by some other procedure.)

To simulate the criminal justice system using this model, calculations for stocks can be made for any number of time periods using equations (1) to (5). However, in order to do this, the following data are required for substitution into these equations:

- estimates of the parameters a, b, c, d, e, f, g, h, j and p;
- input values for all $A(t)$ and $S(t)$ for all t for which the model is to produce estimates;
- estimates of the numbers of persons whose cases are finalised (which we hereafter refer to as 'finalisations'), $Q1(t)$, $Q2(t)$, $Q3(t)$, and $Q4(t)$, for all t for which the model is to produce estimates;
- initial values for all the stocks, that is $L1(1)$, $L2(1)$, $D1(1)$, $D2(1)$ and $P(1)$.

In a simulation each of these data items can be either assigned a hypothetical value or given a value reflecting current conditions. For example, the parameter *a* determines how many of the new entrants to the criminal justice system will be held on remand. In a simulation the user of the model can choose to use a value for *a* which reflects current practice (that is, a value estimated from recent data) or a value which reflects a change in the proportion remanded in custody. The latter would be appropriate if the user's purpose is to simulate changes in bail procedures.

It is because the user can change the values of parameters, inputs and court finalisations that the model has the potential to be used for simulating a number of different scenarios.

For example:

- the effect of additional police could be simulated by increasing the inputs $A(t)$ and $S(t)$;
- the effect of changes in bail procedures could be simulated by changing the parameter a (and possibly parameters c and d because changing the profile of those on remand could affect the proportion sentenced to prison);
- the effect of changes in sentencing could be simulated by changing the parameter p, (alternatively, the number of prisoners discharged each month could be specified by the user); and
- the effect of additional judges or magistrates could be simulated by increasing the numbers of finalisations from the relevant courts.

While it is possible for the user to specify the court finalisations in each time period, we have included in our model a method for determining the finalisations from within the model. We have assumed that, within limits, the *input* to the courts is a predictor of the *output* from the courts. This assumption is based on the data in Figures 3 and 4. The figures show quarterly 'inputs' to and 'outputs' from the NSW Local and District Courts for the period July 1994 to June 1998. Quarterly rather than monthly data are presented because the court vacation months of January and July tend to have much lower numbers of matters finalised. The model is not designed to predict this type of variability from month to month, but to 'even it out' over the whole year.

Figure 3: Quarterly input and output, NSW Local Court, July 1994 to June 1998

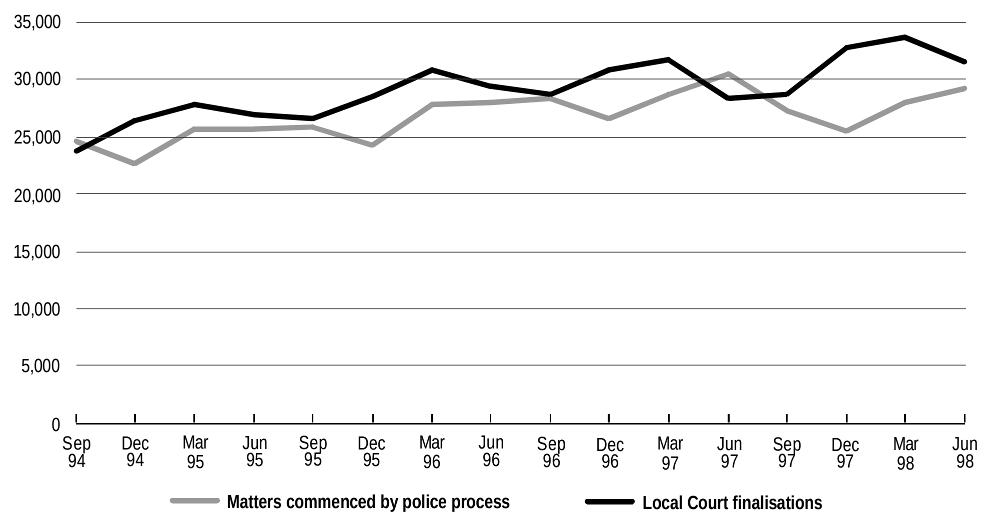
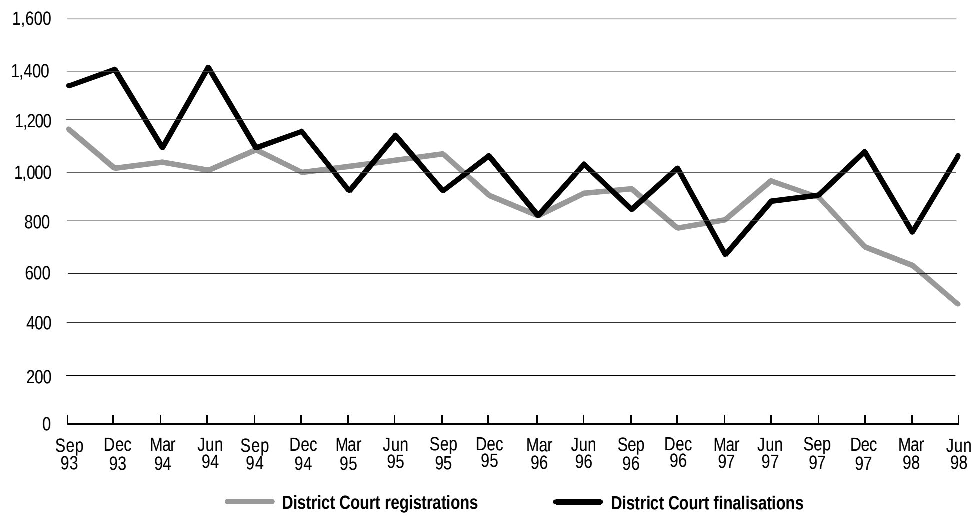


Figure 3 presents data for the Local Court and Figure 4 for the District Court. For the District Court the input are the numbers of cases registered and the output are the numbers of persons whose cases were finalised. For the Local Court the input are the total numbers of persons either formally charged or brought to court by means of a Court Attendance Notice or summons minus the District Court input; the output are the numbers of persons whose cases were finalised by the Local Court.

Figure 4: Quarterly input and output, NSW District Court, July 1993 to June 1998



Given that Figure 3 and Figure 4 demonstrate a close relationship between court input and court output, it seemed sensible to assume such a relationship in the model. However, it did not seem sensible to assume an unbounded relationship between input and output. To take an extreme example, if no new cases were registered in a particular period it is not likely that the courts would stop hearing cases for a similar length of time. At the other extreme, if double the usual number of cases were registered in a particular period the courts would probably not be able to respond by doubling the number of cases completed.

We have therefore allowed the user to set minimum and maximum bounds for the numbers of court finalisations in any one month. We calculate the number of finalisations in a month as being equal to the number of new entrants to the relevant stock in the previous month, unless that number falls outside the minimum and maximum bounds specified by the user. Where the number of new entrants in the previous month is less than the minimum bound for the number of finalisations, the number of finalisations is set equal either to that minimum bound or to the total stock, whichever is the smaller. Where the number of new entrants in the previous month is greater than the maximum bound for the number of finalisations, the number of finalisations is set equal either to that maximum bound or to the total stock, whichever is the smaller.

Note that the user could set the upper and lower bounds for finalisations on the basis of recent history, for example, by using recent observed minimum and maximum values, or by assessing the lower and upper limits of court capacity in some other way, for example, basing them on the number of judicial officers and the minimum and maximum numbers of cases each could dispose of.

DATA SOURCES

To build the model we needed data both to estimate the parameters and to run simulations. In this section we review the sources of data available. First we consider the input data. Input to the model is assumed to be by police process only. That is, the only entrants to the modelled criminal justice system are persons who first appear in the courts as a result of a formal charge, a Court Attendance Notice or a summons. The best source of these data in NSW is the Charge Management System operated by the NSW Police Service. However this system was not fully operational until mid-1998. As a proxy measure, to build the model we used data obtained from the Computerised Operational Policing System (COPS). All criminal incidents reported to or detected by police are recorded in this system. The system includes a Person of Interest file in which action taken against persons of interest is recorded. Data from COPS are available for each month from April 1994 onwards.

Next we consider the stocks. Initial estimates of the five stocks are required to run a simulation. It would also be useful to have monthly stock data, for comparison with model predictions, to test the model's predictive ability. Unfortunately the only stock for which there are readily available monthly data is the sentenced prisoner population (available from the NSW Department of Corrective Services). For the Local Courts the only data available are the total number of matters on hand before the Courts. This total cannot be disaggregated by bail status and includes matters not covered by the model because they did not commence by police process (Apprehended Violence Order applications, for example). For the District Court, monthly data are available on the total stock, that is, the total pending caseload. (This stock measure is a count of cases rather than persons but as there are, on average, only 1.05 persons per case we have used this measure as a proxy count of total persons in the District Court bail and custody stocks.) Again the data are not available disaggregated by bail status. One extra piece of information that is available (from the NSW Department of Corrective Services) is the monthly remand population. This population is the sum of two stocks used in the model, namely *L1* and *D1*. Hence, given an estimate of the proportion of the remand population awaiting a District Court hearing, it is possible to obtain separate estimates of both *L1* and *D1* and therefore of *D2* because the sum of *D1* and *D2* is known.

We turn now to the data required to estimate the parameters used in the model. These data are monthly numbers of each of the following: remand receptions, persons formally charged, persons registered in the Local Court who are placed in custody, persons registered in the District Court who are placed in custody, persons registered in the District Court who are placed on bail, the numbers of persons whose cases are finalised in both the Local and District Courts, separately for persons in custody and persons on bail, and the numbers of persons given a prison sentence, again for both the Local and District Courts, separately for persons in custody and persons on bail.

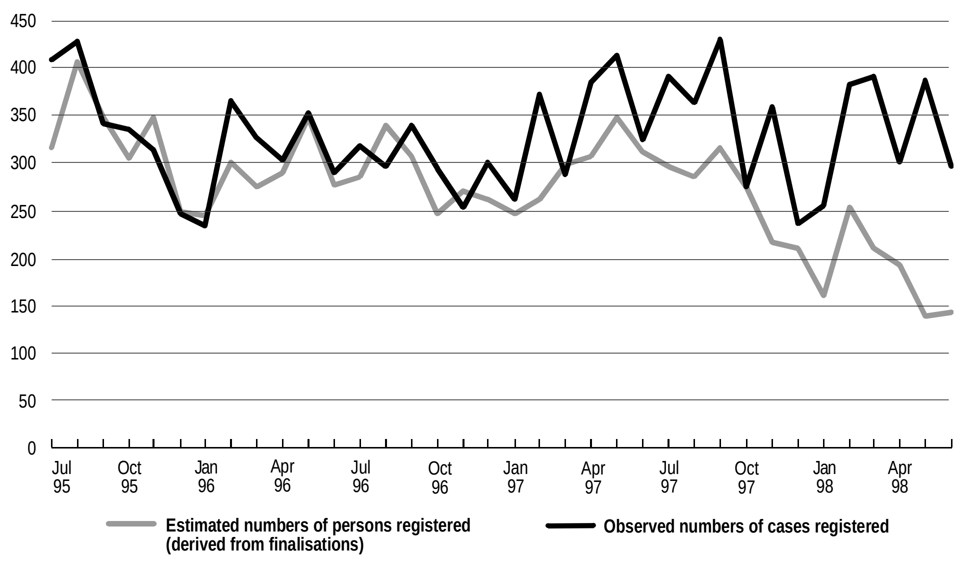
The NSW Department of Corrective Services has records on monthly remand receptions. We have already discussed the source of information on persons charged. Finalisation data by jurisdiction and custody status are available from the BOCSAR database of finalised criminal court appearances as are the data on numbers of persons given prison sentences.

Court registration data are more problematic. Data are available for the total number of cases registered each month in the District Court but not disaggregated by custody status. No data are available for Local Court registrations for reasons similar to those which apply to the Local Court stock.

To estimate the parameters for the model it was therefore necessary to find an alternative method of obtaining registration data. The source we used was the BOCSAR database of finalised criminal court appearances. Court cases are not recorded in this database until they are finalised. However, the date of registration and the custody status at finalisation are both recorded for each case. It is therefore possible to crosstabulate persons according to both their custody status at case finalisation and their month of case registration. If it can be assumed that the custody status at finalisation reflects the custody status at registration, then the numbers of persons whose cases are registered each month can be determined from such a tabulation. There is one significant drawback with this method of determining registrations. Because cases are only recorded after they are finalised, the more recent the date of registration the more likely is the method to result in undercounting. For example, if a period of two years elapses between a case's date of registration and its date of finalisation, then the case would not be counted as registered by this method unless the data were extracted at least two years after registration. The undercounting is likely to be more of a problem for bail registrations than for custody registrations because the delay between the registration and finalisation of cases involving persons on bail is longer (cases involving persons on remand are given priority in the District Court).

The undercounting is illustrated in Figure 5 which shows the total numbers of *persons* registered estimated via the method just described, that is, derived from the database of finalised cases, and the observed numbers of registered *cases* obtained from the District Court, for the period July 1995 to June 1998. The figure shows that there is good agreement between the two data series in the early months but an increasing discrepancy towards the end of the period.

Figure 5: Observed cases registered and estimated persons registered NSW District Court, July 1995 to June 1998



PARAMETER ESTIMATES AND ASSESSMENT OF STABILITY

In this section, we describe how estimates were obtained for each of the parameters *a, b, c, d, e, f, g, h, j* and *p* and how their stability was assessed. By stability we mean the robustness of the estimates over time. Five years of monthly data, from July 1993 to June 1998, where available, were used to estimate the parameters and check their stability. The stability of the estimates was assessed by comparing annual estimates of the parameters for each of the five years.

Parameter *a*: proportion of persons formally charged who are placed in custody

The first flow parameter to be estimated for the model is the proportion of persons formally charged who are placed in custody (thereby moving into the stock measure *L1*). Estimation of the parameter relies on accurate charge information being available. The relative split between charge matters and Court Attendance Notice and summons matters, as shown in Figure 6, has not been stable over the five-year period.

Figure 6: Persons entering the NSW criminal justice system, July 1994 to June 1998

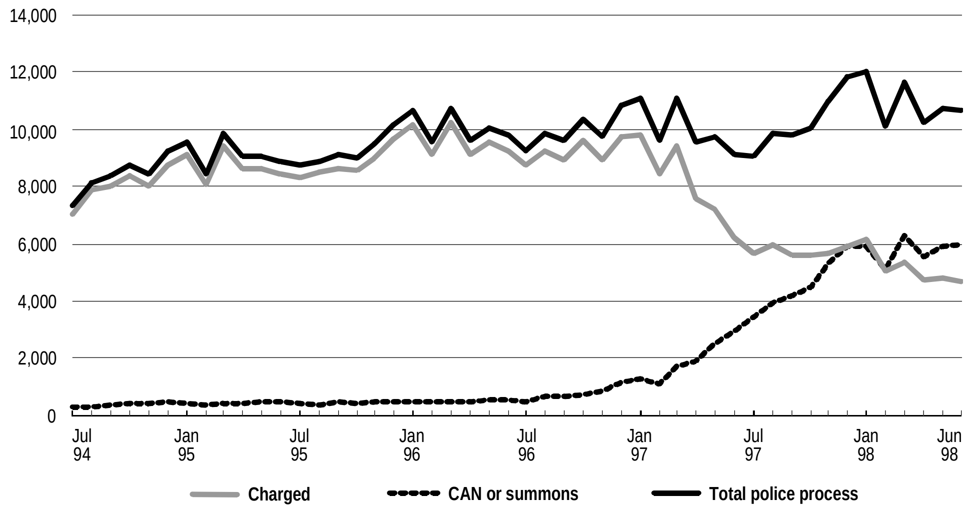
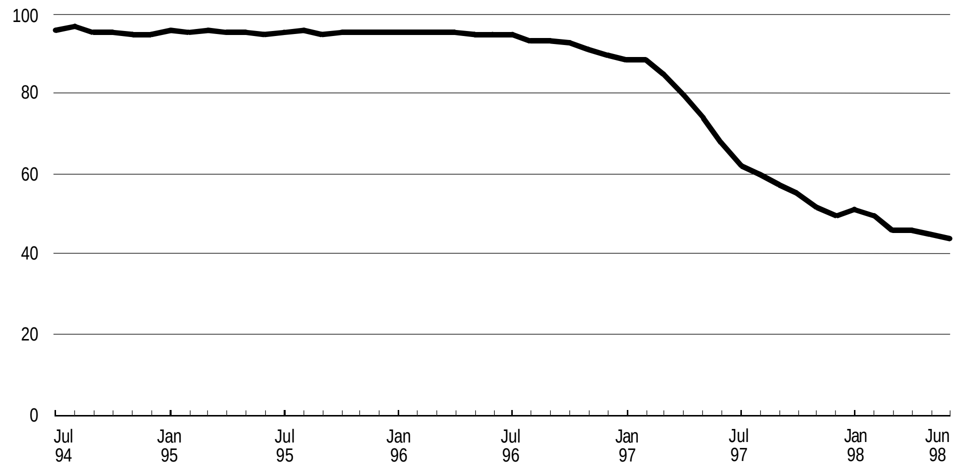


Figure 7 shows the numbers of persons formally charged as a percentage of total police process. It is clear that in 1994 about 95 per cent of police matters commenced by charge but by 1998 the proportion was closer to 40 per cent. More recent data indicate that, in 1999, only about 40 per cent of police matters were entering the Local Court sector by formal charge, and that this proportion has stabilised. If actual data were used to estimate the proportion of persons formally charged who entered custody, this proportion would show a rapid increase as policing policy changed over time. By splitting the total number of arrests retrospectively according to current practice (i.e. 40% charge, 60% Court Attendance Notice or summons), however, a relatively stable estimate of the parameter can be made.

Figure 7: Persons charged as a percentage of total police process entrants to the NSW criminal justice system, July 1994 to June 1998



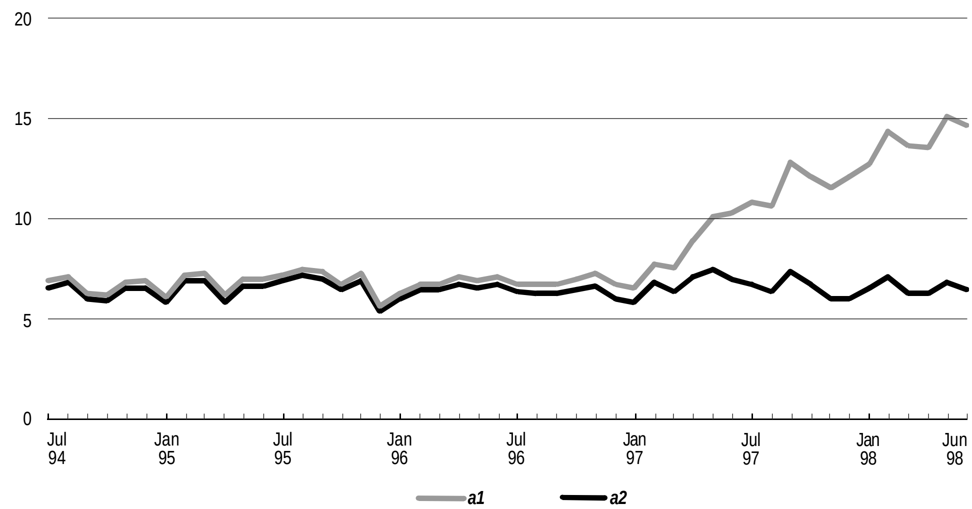
It is assumed that all persons entering remand do so from the Local Court immediately at first appearance for a charge. The proportion of persons who are formally charged by police, and who are placed into custody each month (the flow parameter, *a*) is therefore calculated using remand reception data and police charge data. Remand receptions data, by month, were provided by the Department of Corrective Services.

Figure 8 shows the results of two methods used to calculate *a*. The number of persons entering remand each month is calculated as a proportion of:

- actual numbers of persons charged (*a1*)
- persons charged determined as 40 per cent of total police process (*a2*).

The figure shows the monthly estimates of *a1* and *a2* from July 1994 to June 1998.

Figure 8: Monthly estimates of parameter *a*, using two methods, July 1994 to June 1998



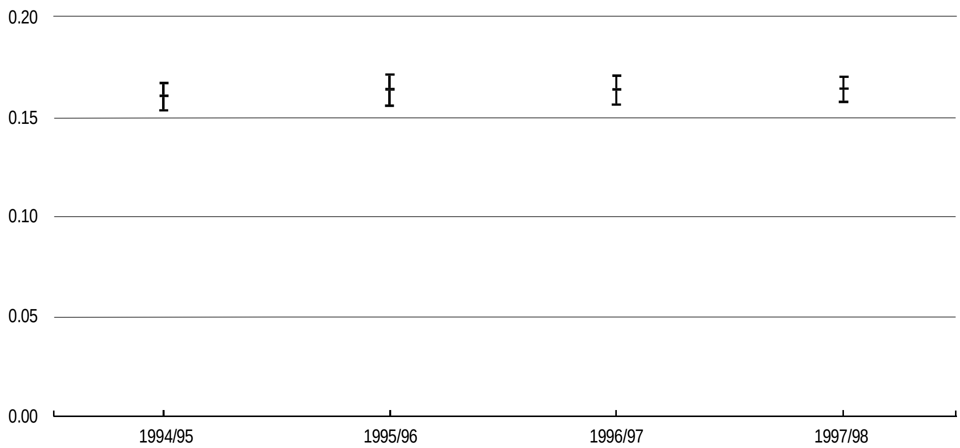
It is clear from Figure 8 that, because of the change in police practice, the flow parameter estimate using actual charge data is not stable (see the line *a1*). The alternative method results in an estimate which is more stable over time. For this method it is assumed that the more recent estimate of the proportional number of charges is appropriate, that is, that 40 per cent of all police process entrants to the Local Court do so by formal charge. Applying this proportion to total police process data, we therefore generate retrospectively an artificial count of the number of charged persons entering the criminal justice system.

Clearly, because of its stability, *a2* should be the parameter estimate used in the model. Table 1 shows the mean, standard deviation and 95 per cent confidence interval of the calculated monthly estimates. From Table 1 we see that about 16 per cent of all persons charged enter remand. The small standard deviation and the narrow range of the confidence interval show that the estimate is relatively stable over the time period. Further evidence of this stability is shown in Figure 9 which graphs the mean and 95 per cent confidence intervals for the four 12-month periods ending June, between July 1994 and June 1998.

Table 1: Proportion of persons formally charged who are placed in custody

Parameter description	*Mean*	*Standard deviation*	*95% confidence interval*
Proportion of persons charged entering remand	0.163	0.011	0.160 — 0.166

Figure 9: Annual means and 95% confidence intervals for estimates of parameter *a*, July 1994 to June 1998



Parameter *b*: proportion of persons in custody given a prison sentence by the Local Court

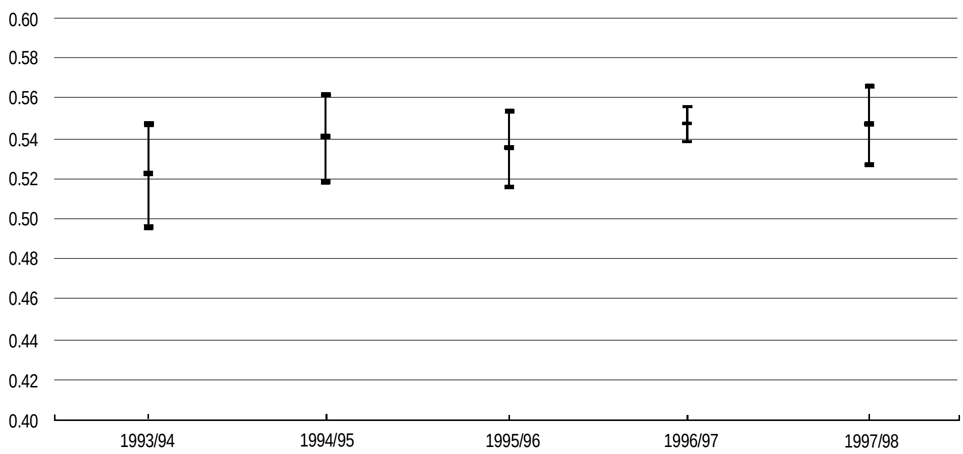
The parameter *b* is estimated by dividing the number of persons in custody given a prison sentence at case finalisation in the Local Court, by the total number of persons in custody whose cases are finalised in the Local Court. Monthly data for both numerator and denominator are available from the BOCSAR database of finalised criminal court cases.

Table 2 shows the mean, standard deviation and 95 per cent confidence intervals for the three model parameters relating to the Local Courts sector of the model. For the parameter *b* these statistics are based on monthly estimates calculated for each month from July 1993 to June 1998. Table 2 shows that the average proportion of persons in custody who are subsequently imprisoned by the Local Court is about 54 per cent. Figure 10 shows means and confidence intervals for each of the five 12-month periods of the time period used to estimate the parameter. It is clear that the mean proportion of persons in custody who are imprisoned is relatively stable with a mean at around 0.54 each year.

Table 2: CJS model parameters estimated for Local Courts sector

Parameter description		*Mean*	*Standard deviation*	*95% confidence interval*
Proportion of persons in custody given a prison sentence	*b*	0.538	0.032	0.530 — 0.546
Proportion of persons on bail given a prison sentence	*e*	0.026	0.002	0.025 — 0.026
Proportion of persons formally charged who move from custody to bail	*h*	0.029	0.014	0.025 — 0.033

Figure 10: Annual means and 95% confidence intervals for estimates of parameter *b*, July 1993 to June 1998



Parameter *c*: proportion of persons formally charged who are placed in custody and who are committed to the District Court

In the model it is assumed that a proportion *c* of those who are formally charged and placed in custody are committed to the District Court two months later. The parameter *c* can therefore be estimated by dividing the numbers of persons newly registered in custody in the District Court by the number of persons formally charged two months earlier.

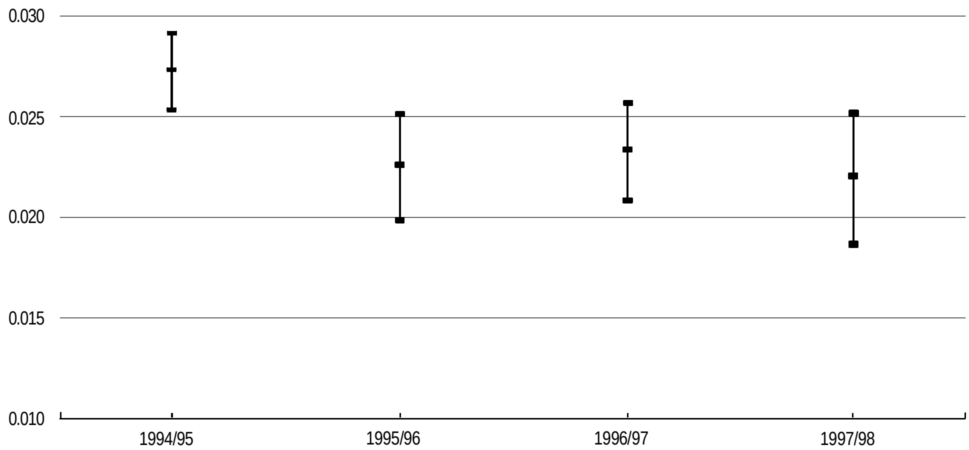
The only source of information on bail status at registration in the District Court is the BOCSAR database of finalised cases, as described earlier. The monthly numbers of persons whose cases were registered in custody each month were derived from the data recorded in this database (on the assumption that the custody status at finalisation is the same as at registration). Being based on finalised cases, the parameter estimates which are based on these data are less reliable towards the end of the time series (in 1998 and possibly 1997 - see Figure 11 which shows the estimates and their 95% confidence intervals based on 12-month periods).

Table 3 shows the mean, standard deviation and 95 per cent confidence intervals for the four model parameters relating to the District Court sector of the model. For the parameter *c* the statistics are based on data from July 1994 to June 1998. It can be seen that approximately 2 per cent of persons formally charged by police and who are remanded in custody are committed to the District Court two months later. Recalculation of this proportion omitting the most recent and less reliable data for the 12 months ending June 1998 results in an identical estimated mean of 0.024 (with the standard deviation also unchanged).

Table 3: CJS model parameters estimated for District Court sector

Parameter description		*Mean*	*Standard deviation*	*95% confidence interval*
Proportion of persons formally charged who are placed in custody and committed to the District Court	*c*	0.024	0.004	0.022 — 0.025
Proportion of persons formally charged who are placed on bail and committed to the District Court	*d*	0.052	0.018	0.047 — 0.057
Proportion of persons in custody given a prison sentence by the District Court	*f*	0.812	0.057	0.797 — 0.827
Proportion of persons on bail given a prison sentence by the District Court	*g*	0.262	0.046	0.250 — 0.274

Figure 11: Annual means and 95% confidence intervals for estimates of parameter *c*, July 1994 to June 1998



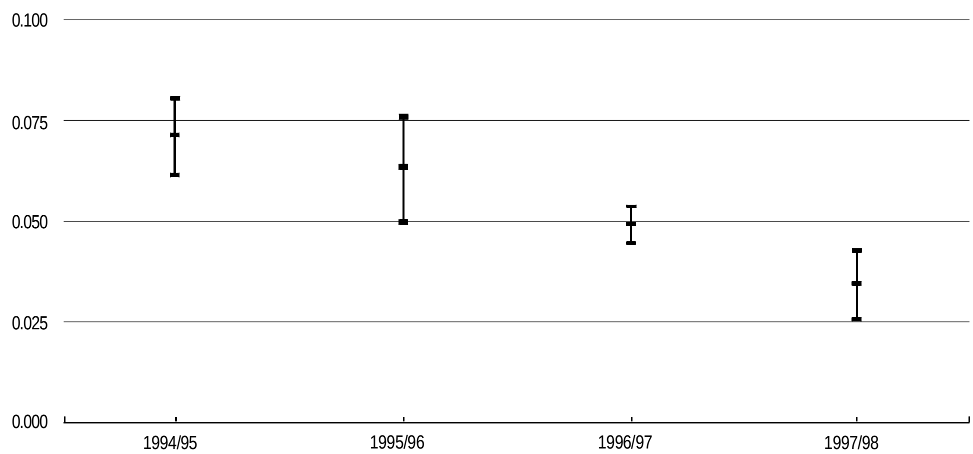
Parameter *d*: proportion of persons formally charged who are placed on bail and who are committed to the District Court

In the model it is assumed that a proportion *d* of those who are formally charged and *not* placed in custody are committed to the District Court three months later. The parameter *d* can therefore be estimated by dividing the numbers of persons newly registered on bail in the District Court by the number of persons formally charged three months earlier.

As noted above, the only source of information on bail status at registration in the District Court is the BOCSAR database of finalised cases. The monthly numbers of cases registered on bail each month were derived from the data recorded in this database (on the assumption that those on bail at finalisation were on bail at registration).

Table 3 shows the mean, standard deviation and 95 per cent confidence interval for the monthly estimates of *d* based on data from July 1994 to June 1998. The mean is 0.052 indicating that approximately 5 per cent of persons formally charged by police and who are on bail are committed to the District Court three months later. Figure 12 shows the annual mean estimates to be decreasing over time. Recalculation of the mean omitting the most recent and less reliable data (the 12 months to June 1998) results in a re-estimated mean of 0.059 (standard deviation = 0.014). The value of 0.052 was used for validity testing of the model.

Figure 12: Annual means and 95% confidence intervals for estimates of parameter *d*, July 1994 to June 1998

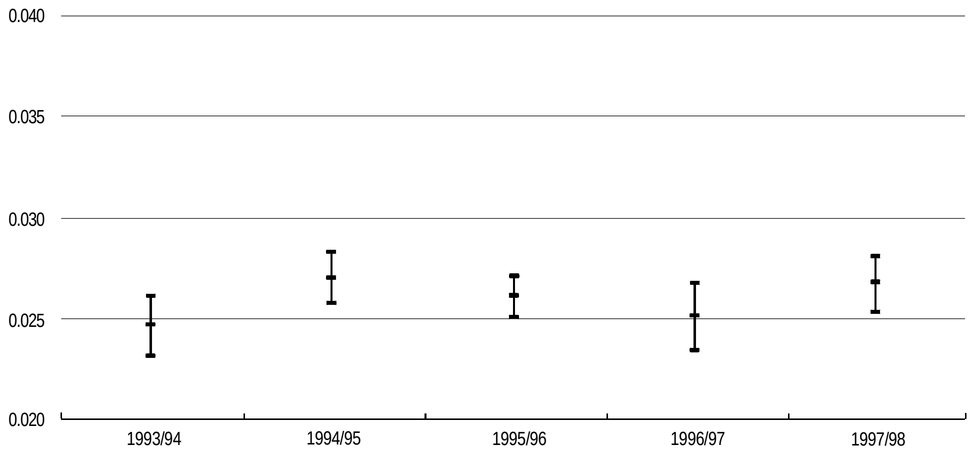


Parameter *e*: proportion of persons on bail given a prison sentence by the Local Court

The parameter *e* is estimated by dividing the number of persons on bail given a prison sentence at case finalisation in the Local Court by the total number of persons whose cases are finalised on bail in the Local Court. The mean, standard deviation and 95 per cent confidence interval of the monthly estimates of *e* for the period July 1993 to June 1998 are shown in Table 2. The mean is 0.026 indicating that around 3 per cent of those on bail at case finalisation in the Local Court are given a prison sentence.

Figure 13 shows that the mean proportion of persons on bail who are imprisoned each year is relatively stable at a value of around 0.026.

Figure 13: Annual means and 95% confidence intervals for estimates of parameter *e*, July 1993 to June 1998



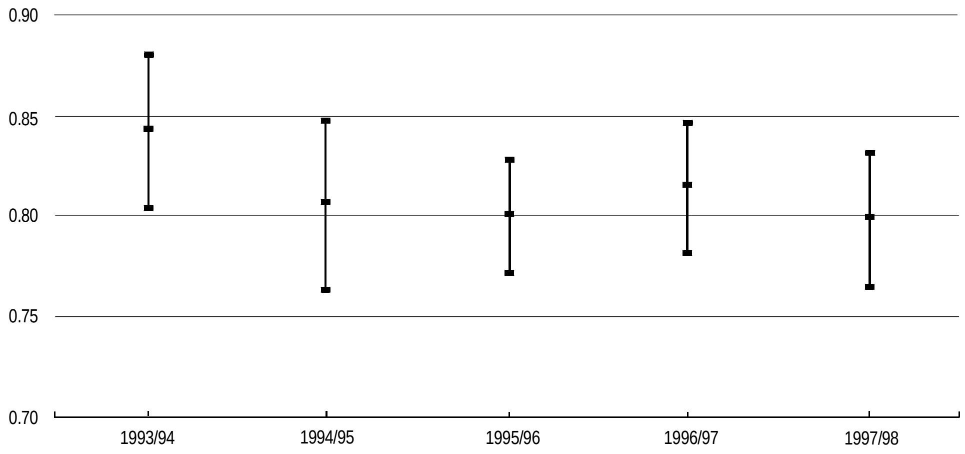
Parameter *f*: proportion of persons in custody given a prison sentence by the District Court

The parameter *f* is estimated by dividing the number of persons in custody given a prison sentence at case finalisation in the District Court, by the total number of person in custody whose cases are finalised in the District Court.

The mean, standard deviation and 95 per cent confidence interval of the monthly estimates of *f* for the period July 1993 to June 1998 are shown in Table 3. The mean is 0.812 indicating that around 81 per cent of those in custody when their case is finalised in the District Court are given a prison sentence.

Figure 14 shows that the mean proportion of persons in custody who are imprisoned each year is relatively stable across the five years, but shows wide variation, as evidenced by the large confidence intervals, within each 12-month period. The large variation is probably due to the fact that the number of custody cases finalised each year is quite small (about 100 persons per year).

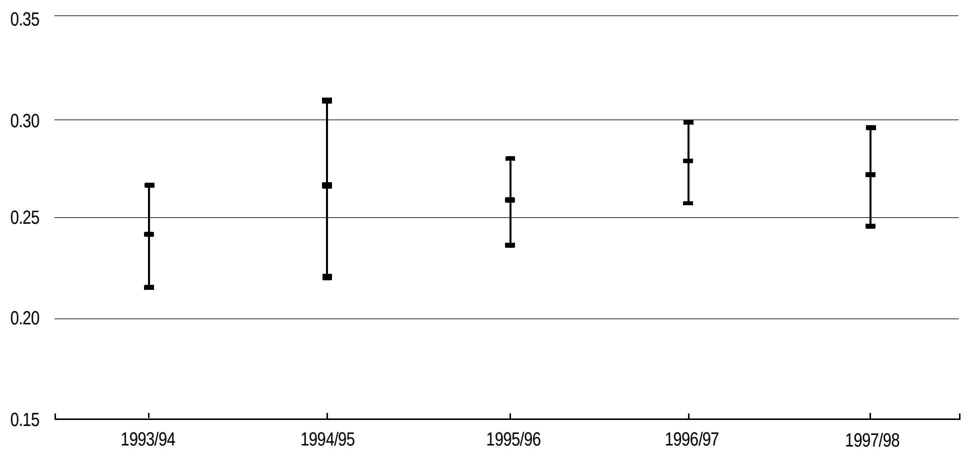
Figure 14: Annual means and 95% confidence intervals for estimates of parameter *f*, July 1993 to June 1998



Parameter *g*: proportion of persons on bail given a prison sentence by the District Court

The parameter *g* is estimated by dividing the number of persons on bail given a prison sentence at case finalisation in the District Court, by the total number of persons who are on bail when their cases are finalised in the District Court. The mean, standard deviation and 95 per cent confidence interval of the monthly estimates of *g* for the period July 1993 to June 1998 are shown in Table 3. The mean is 0.262 indicating that around 26 per cent of persons on bail at case finalisation in the District Court are given a prison sentence. Figure 15 shows that the mean proportion of persons on bail who are imprisoned each year is relatively stable. However, the variation within the 12-month periods is relatively large.

Figure 15: Annual means and 95% confidence intervals for estimates of parameter *g*, July 1993 to June 1998



Parameter *h*: proportion of persons formally charged who move from Local Court custody to Local Court bail

Figure 16 shows the time series of total number of persons registered in custody each month as derived from the BOCSAR database of finalised criminal court cases assuming that bail status at finalisation reflects bail status at registration. (Note that District Court registrations are lagged by two months for this exercise to take account of the committal process.) Figure 16 also shows the time series of remand receptions as recorded by the Department of Corrective Services. It is clear that remand receptions are generally greater than the estimated custody registrations. We assume that the discrepancy between these two series is due to a change in bail status between registration and finalisation for some of those who are initially remanded in custody. We estimate the parameter *h* from the difference between the two series divided by the numbers of persons formally charged in the previous month. The mean, standard deviation and 95 per cent confidence interval of the monthly estimates of *h* for the period July 1994 to June 1998 are shown in Table 2.

Figure 16: Persons registered in custody and remand receptions, July 1993 to June 1998

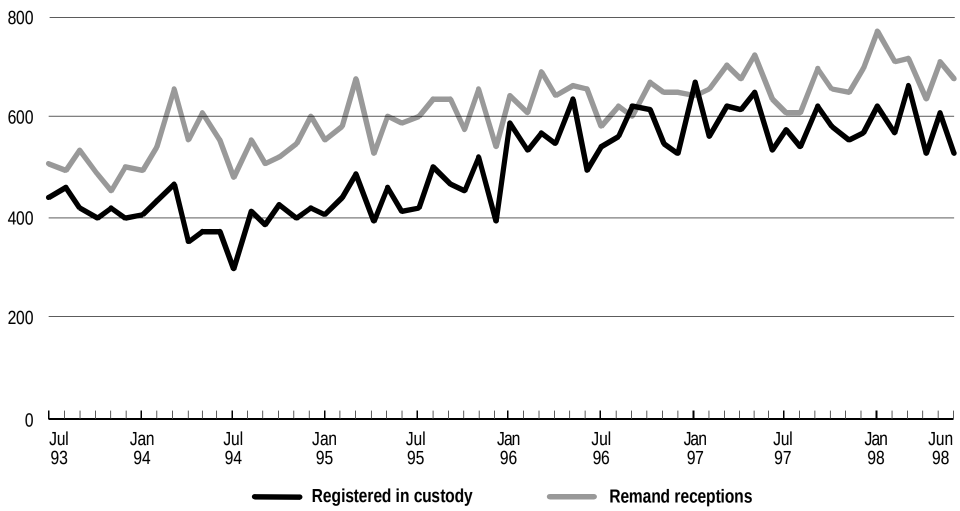
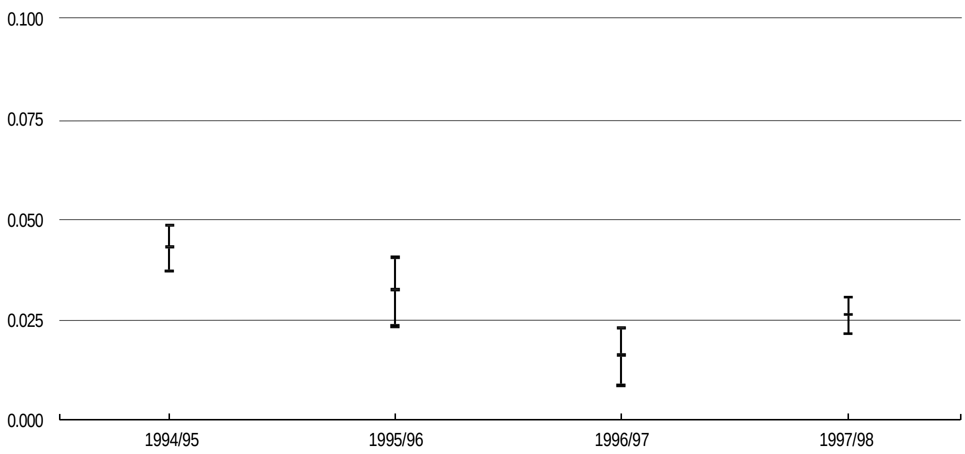


Figure 17 shows the means and 95 per cent confidence intervals for each of the four 12-month periods. The means vary between about 0.02 and 0.04.

Figure 17: Annual means and 95% confidence intervals for estimates of parameter *h*, July 1994 to June 1998



Parameter *j*: adjustment factor applied to the numbers of persons sentenced to prison to determine the number of new entrants to the sentenced prisoner population

We noted when describing the model that it includes an adjustment factor to allow for the fact that some of those who appear before the courts are already in prison serving sentences for previous convictions. Figure 18 shows the monthly numbers of sentenced prisoner receptions as recorded by the Department of Corrective Services and the monthly numbers of persons sentenced to prison as recorded in the BOCSAR database of finalised criminal court cases. We assume that the difference between the series is due to the fact that some of those sentenced by courts do not become new entrants to prison because they are already there and use this fact to estimate the parameter *j*. Monthly estimates of *j* were obtained by dividing sentenced prisoner receptions by the number of persons sentenced to prison each month.

Figure 18: Sentenced prisoner receptions and persons sentenced to prison, July 1993 to June 1998

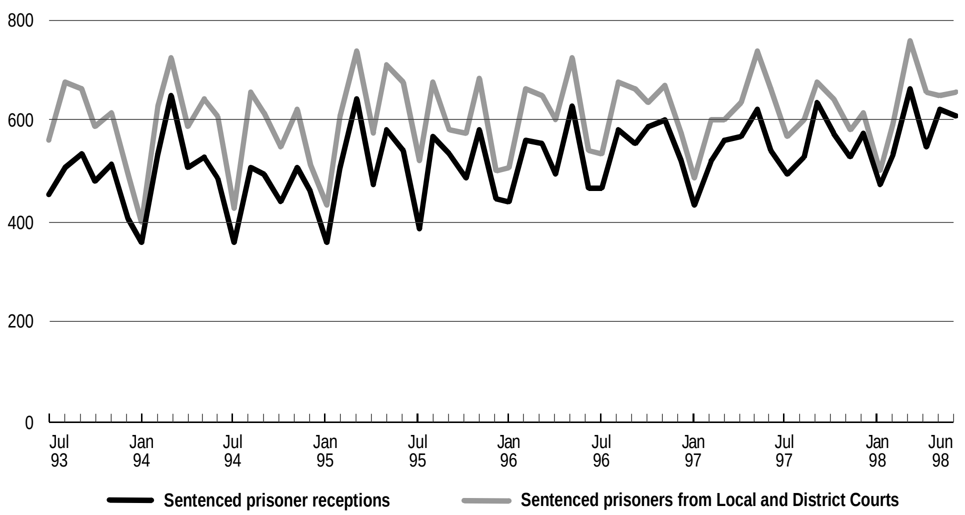
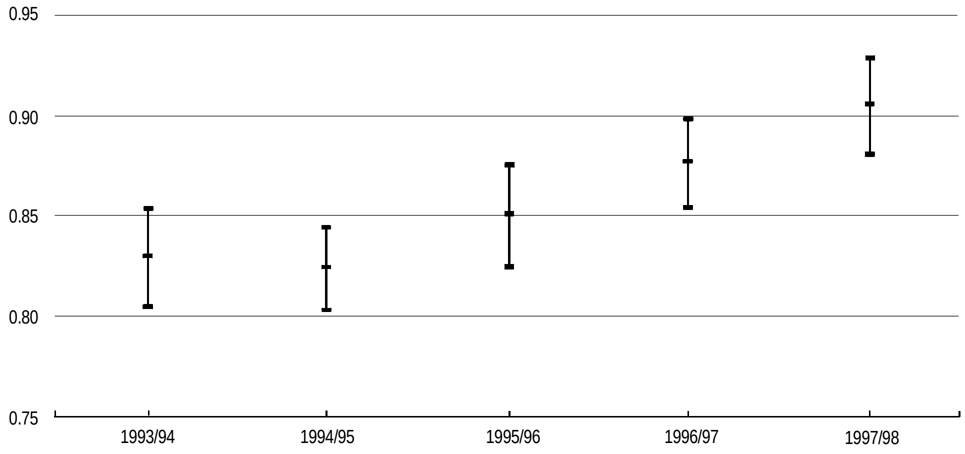


Table 4: CJS model parameters estimated for prison sector

Parameter description		*Mean*	*Standard deviation*	*95% confidence interval*
Proportion of sentenced prisoners received as new sentenced prisoner receptions	*j*	0.857	0.048	0.844 — 0.869
Proportion of sentenced prisoners discharged	*p*	0.096	0.012	0.092 — 0.099

Table 4 shows the mean, standard deviation and 95 per cent confidence intervals for the two model parameters relating to the prison sector of the model. Approximately 86 per cent of persons recorded as sentenced to a period of imprisonment in the BOCSAR database, are also recorded by the Department of Corrective Services as sentenced prisoner receptions. Figure 19 shows that the annual mean of this proportion has been steadily increasing over the time period varying between about 80 per cent and 90 per cent.

Figure 19: Annual means and 95% confidence intervals for estimates of parameter *j*, July 1993 to June 1998

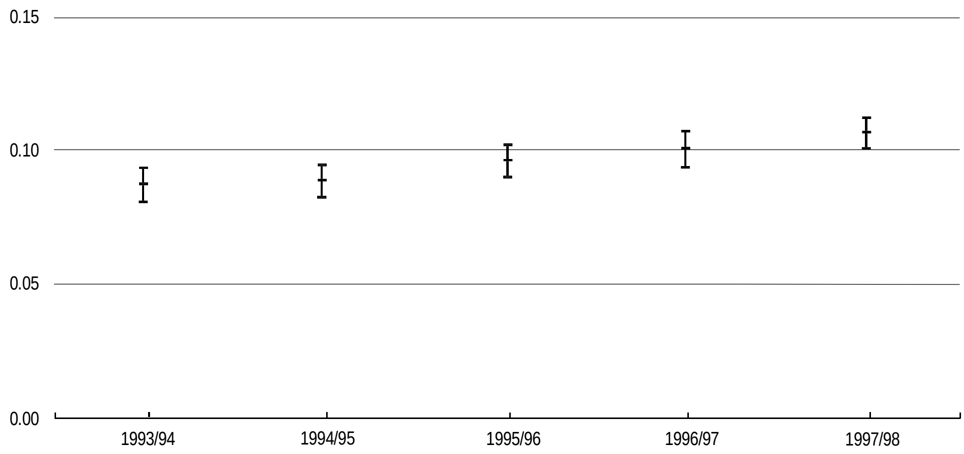


Parameter *p*: proportion of sentenced prisoners discharged

The parameter *p* is estimated as the number of sentenced prisoners discharged divided by the number in the prison population. The number of persons discharged from prison each month is calculated as a direct proportion of the sentenced prisoner population. The Department of Corrective Services provided monthly data for both the sentenced prisoner population and sentenced prisoner receptions. The numbers of sentenced prisoners discharged were derived from these two series (given that this month's population is calculated by adding prisoners received and subtracting prisoners discharged from last month's population).

From Table 4 it can be seen that, on average, about 10 per cent of the sentenced prison population is discharged each month. Figure 20 shows the mean estimates and 95 per cent confidence intervals for each of the five 12-month periods between July 1993 and June 1998. It is clear that the estimate has been increasing over time.

Figure 20: Annual means and 95% confidence intervals for estimates of parameter *p*, July 1993 to June 1998



VALIDITY TESTING

Running a simulation using the model involves calculating values of the stocks in successive time periods using equations (1) to (5) (see page 8). To test the validity of the model we used data for the period July 1996 to June 1998 (the final two years of the period from which data were used for parameter estimation). We compared values of stocks and flows predicted by the model with observed values over this time period. The validity testing exercise was therefore designed more as a test of the model's structure than of its ability to predict into the future.

The data required to run a simulation are estimates of the parameters a, b, c, d, e, f, g, h, j and p; input values for $A(t)$ and $S(t)$ for each month; estimated finalisations ($Q1(t)$, $Q2(t)$, $Q3(t)$, and $Q4(t)$) for each month; and initial values for all the stocks, that is $L1(1)$, $L2(1)$, $D1(1)$, $D2(1)$ and $P(1)$.

We used the parameter estimates obtained as a result of the estimation process just described. Their values were $a = 0.163$, $b = 0.538$, $c = 0.024$, $d = 0.052$, $e = 0.026$, $f = 0.812$, $g = 0.262$, $h = 0.029$, $j = 0.857$, $p = 0.096$. As input data we used the observed 'total police process' numbers for each of the months July 1996 to June 1998. The number of persons entering the criminal justice system each month as a result of being formally charged, $A(t)$, was estimated as 40 per cent of 'total police process' and the numbers of persons entering the system each month as a result of a Court Attendance Notice or summons, $S(t)$, was estimated as 60 per cent of 'total police process'.

The finalisations were calculated in the manner described earlier (at the end of the section 'Description of the model') with the user-specified minimum and maximum values being set as the *observed* minimum and maximum values over the 24-month period, for each of the court stocks.

The only remaining data required were the initial values for each stock. This was straightforward for the sentenced prisoner population (being the observed value in July 1996) but more difficult for the court stocks. For the District Court there are data for the whole stock, but not broken down by custody status. For the Local Court there are no stock data available (that is, no counts of only those criminal matters which were commenced by police). The remand population is, however, known. The sum of *Local Court custody* ($L1$) and *District Court custody* ($D1$) should equal the remand population. Further, the Department of Corrective Services estimate that the proportion of the remand population who are awaiting a Local Court hearing is about 0.6 (Thompson, B., 2000, pers. comm., 8 June). From these two pieces of information we were able to determine initial values for both $L1$ and $D1$. We were then able to calculate an initial value for $D2$, *District Court bail* (equal to total District Court stock minus $D1$). Finally, we estimated that the proportion of the total local Court stock in custody was about 5.5 per cent and used this fact to estimate the bail stock (given the custody stock already estimated). This last estimation was again based on data for finalised cases drawn from the BOCSAR database.[1] The initial values for the five stocks were:

Local Court custody:	$L1(1)$	=	487
Local Court bail:	$L2(1)$	=	8,368
District Court custody:	$D1(1)$	=	325
District Court bail:	$D2(1)$	=	2,187
Sentenced prisoner population:	$P(1)$	=	5,433

The results of the validity testing are presented in Figures 21 to 28 which show comparisons of observed data with predictions from the model. Figure 21 shows total District Court registrations and Figure 22 shows total District Court stocks. Neither shows the data disaggregated by custody status, because there are no observed data for comparison.

The first notable feature of Figure 21 is that the predicted values are much less variable than the observed values. This is not surprising because there is no attempt to model seasonality – in the model the parameters are applied consistently each month, and the month to month variation in predicted values arises only from the variation in the monthly input. It is also clear from Figure 21 that the predicted values are of the same order of magnitude as the observed values. Over the period simulated the total number of registrations predicted is less than the total number of registrations observed, the difference being 6 per cent of the observed total.

Figure 21: District Court registrations, October 1996 to June 1998

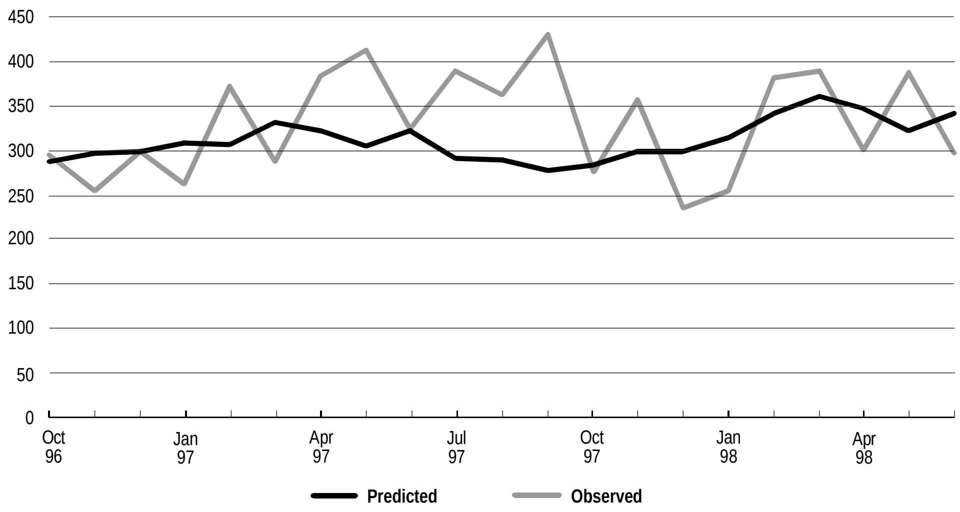
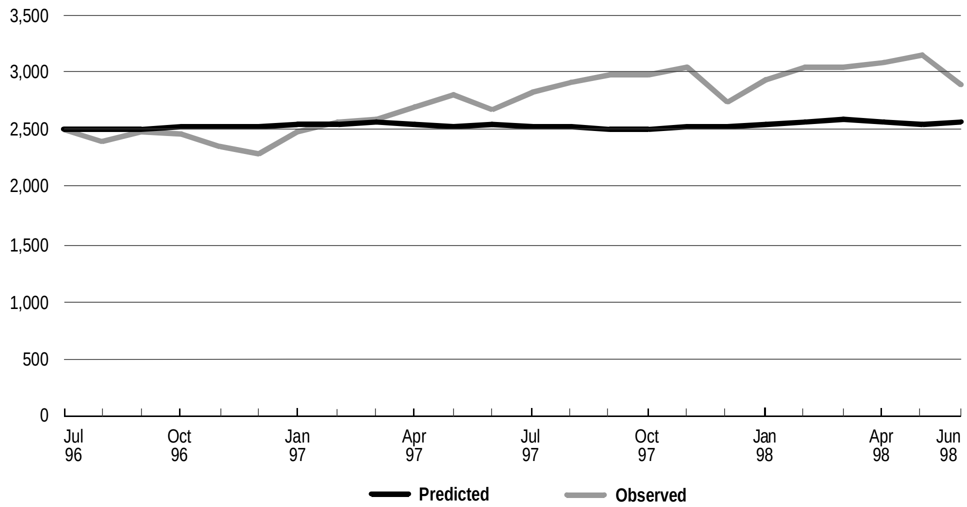


Figure 22 shows that the predicted District Court stock stayed relatively stable whereas the observed stock increased over the two-year time period. The difference is quite large at the end of the period, with the predicted stock being 2,572 and the observed stock being 2,887 in June 1998, a difference of 11 per cent (of the observed stock).[2]

There are no observed registration or stock data for comparison with predicted values in the Local Court. It is worth noting, however, that the predicted registrations are relatively stable but the predicted Local Court stock increases steadily from about 9,000 to about 15,000 over the two-year period.

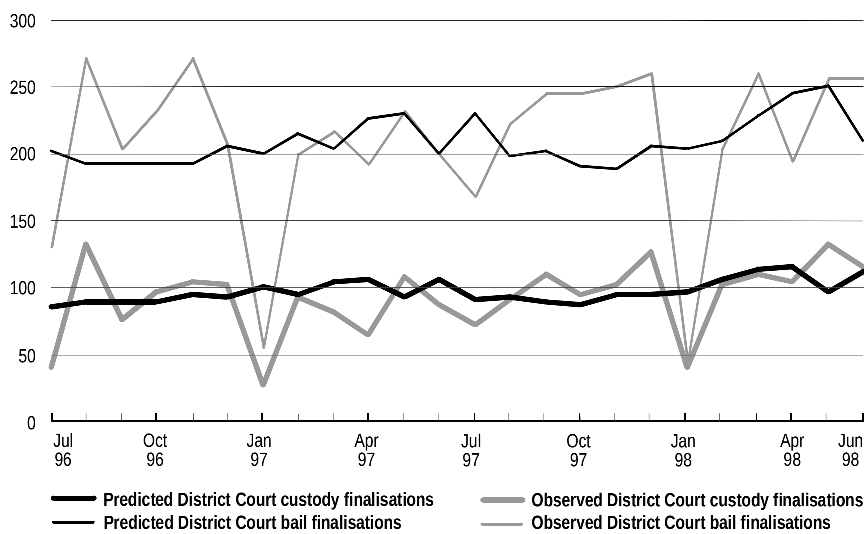
Figure 22: Predicted and observed total District Court stock, July 1996 to June 1998



Figures 23 to 25 show finalisations. Figure 23 is for the District Court and shows both bail and custody finalisations. Because of the difference in scale, bail and custody finalisations in the Local Court are shown in separate figures (Figures 24 and 25).

Figure 23 shows that the predicted and observed finalisations are of similar magnitude. Again the predicted values are evenly spread over the period, whereas the effects of the January court vacation are quite marked in the observed data. Over the full two-year period, the total predicted custody finalisations are 6 per cent fewer than the observed values, whereas for bail finalisations, the predicted values differ from the observed values by less than 0.2 per cent.

Figure 23: District Court finalisations, July 1996 to June 1998



Figures 24 and 25 show that there is fairly close agreement between predicted and observed Local Court finalisations. Over the full two-year period the total predicted finalisations differ from the observed finalisations by about 4 per cent. There are fewer predicted than observed custody finalisations but more predicted than observed bail finalisations.

Figure 24: Local Court custody finalisations, July 1996 to June 1998

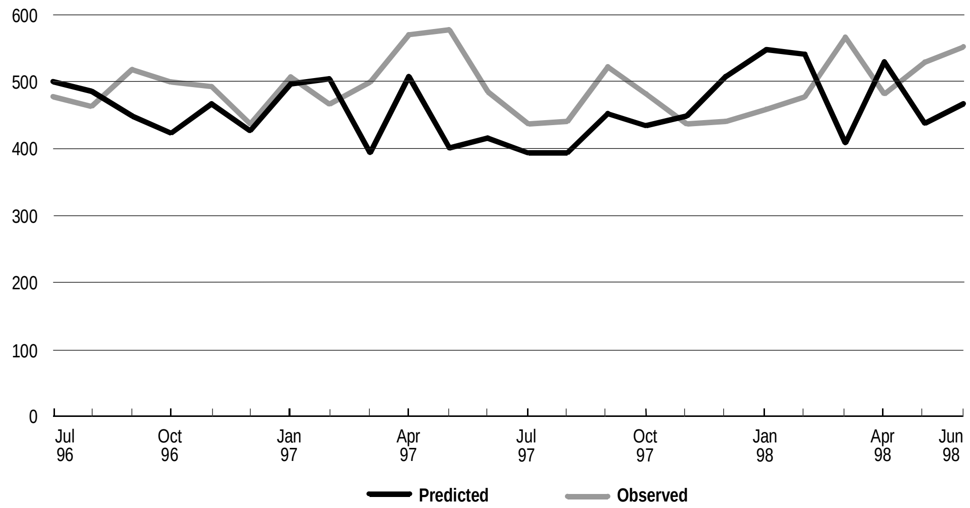
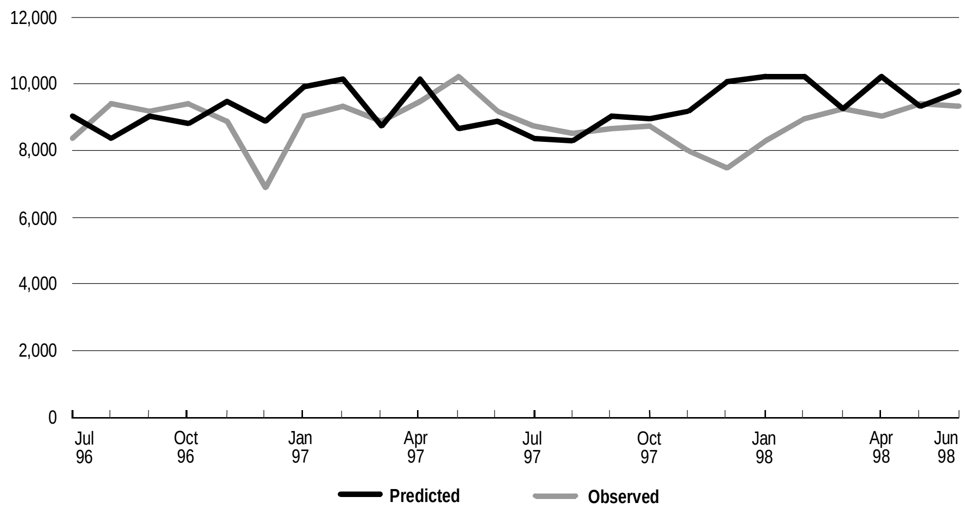


Figure 25: Local Court bail finalisations, July 1996 to June 1998



Figures 26 and 27 show the remand and sentenced prisoner populations, respectively. It can be seen that there is a greater relative discrepancy between the predicted and observed remand population than between the predicted and observed sentenced prisoner population. The predicted remand population in June 1998 is less than the observed remand population by 24 per cent, whereas the predicted sentenced prisoner population is 5 per cent greater than the observed population. Figure 28 shows the total prisoner population (that is, the total of the remand and sentenced prisoner populations). There is less than 0.1 per cent difference between the observed and predicted values in June 1998, with the predicted prison population being 6,446 and the observed being 6,440.

Figure 26: Remand population, July 1996 to June 1998

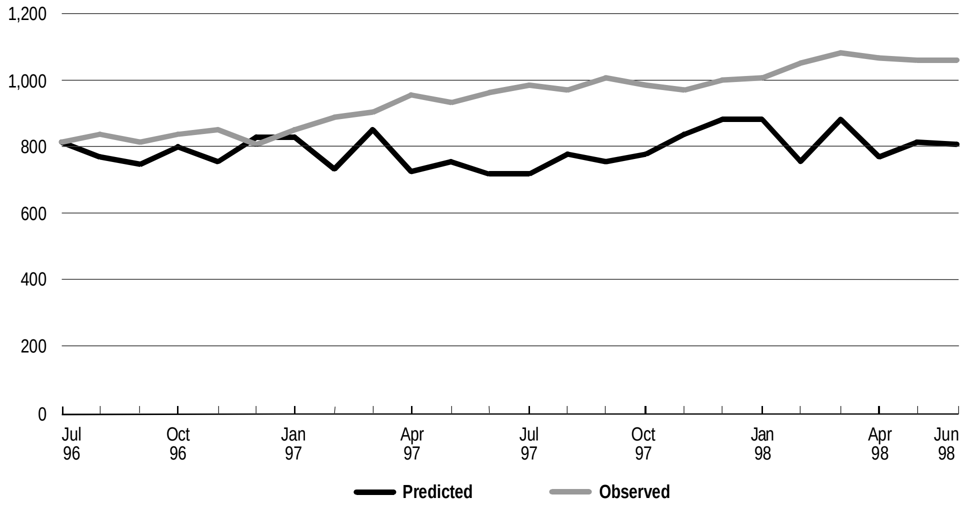


Figure 27: Sentenced prisoner population, July 1996 to June 1998

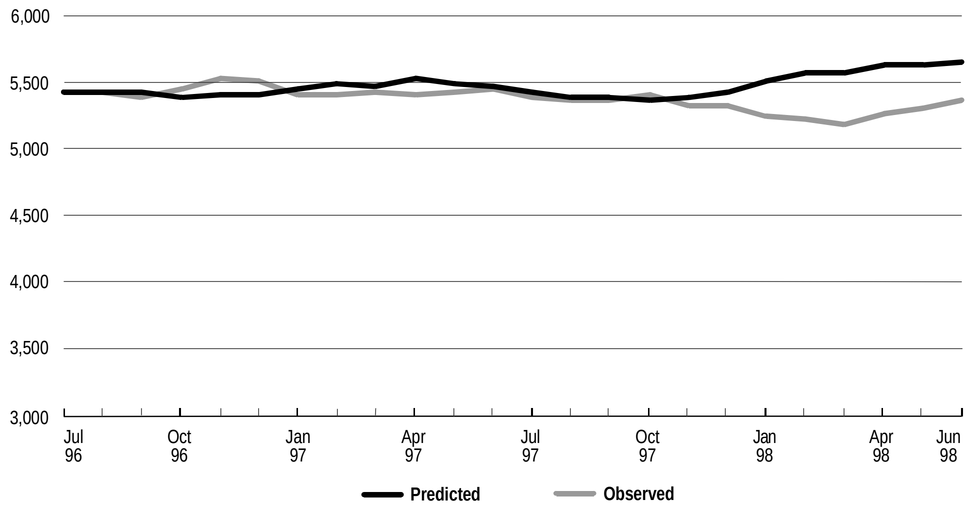
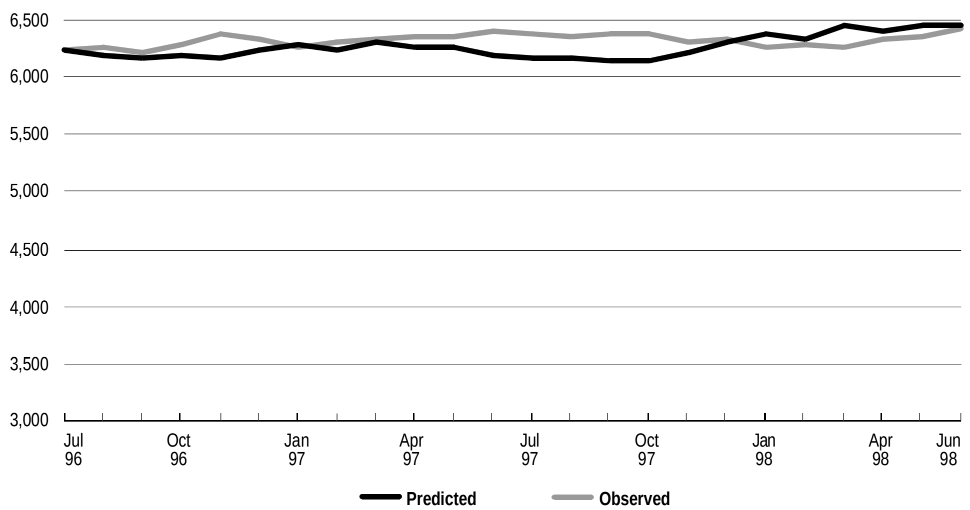


Figure 28: Total prison population (remand and sentenced prisoners), July 1996 to June 1998



SENSITIVITY TESTING

The aim of sensitivity testing is to determine the extent to which the model's predictions are sensitive to the values of the parameters. Our approach to sensitivity testing was to vary one parameter at a time while holding all other parameter values (and other user-specified inputs) constant, then to run a simulation and compare the output with that from the base model simulation. The base model is the same as that used for validity testing. We only examine two output measures, the remand population and the sentenced prisoner population, these being the two most important measures which we wish to predict. Sensitivity was tested for the parameters *a, b, c, d, e, f, g, h, j* and *p* and also for changes in initial court stocks and changes in the maximum number of finalisations.

For each of the parameters *a, b, c, d, e, f, g, h, j* and *p* the values were varied by substituting the minimum and maximum bounds of their 95 per cent confidence limits.

To test the sensitivity of changing initial stock values, the proportion of the remand population awaiting a Local Court hearing (which was set at 60 per cent for validity testing, based on the Department of Corrective Services estimate) was set at a minimum of 55 per cent and a maximum of 65 per cent.[3] These percentages were then applied to the observed remand population to obtain new initial *custody* stocks for both the Local and District Courts. New initial values for *bail* stocks were then calculated by applying the same restrictions as used for determining initial stocks described above (namely, setting the sum of the initial values for District Court bail and custody stocks equal to the total observed District Court stock and assuming that 5.5 per cent of the Local Court stock were in custody).

To test the sensitivity of changing the maximum bounds for the court finalisations, the maximum values of Local Court finalisations and the maximum values of District Court finalisations were separately increased by 10 per cent.

The results are summarised in Table 5. The first two rows show the observed values and the base model predictions, respectively, for the sentenced prisoner and remand prisoner populations in June 1998. Each row thereafter shows the new predicted values resulting from the change to the base model indicated in the first column. The differences between (1) the predicted value and the observed value, and (2) the predicted value and the base model value, are shown as percentages of the observed and base model values respectively. The first of these percentage difference measures is shown for interest but it is the second which measures sensitivity. Where it is impossible for the change to have an effect on the remand population (for example, parameters which determine the proportion of finalisations receiving a prison sentence) no data are presented for the remand population.

It is clear from Table 5 that, compared with the base model, the predictions do not vary a great deal in response to parameter changes. The remand population is most sensitive to the changes in initial stock values, whereas the sentenced prisoner population is most sensitive to the values of *p* (the proportion of the sentenced prisoner population who are discharged from prison each month).

Table 5: Parameter sensitivity

	Sentenced prisoner population			Remand prisoner population		
	June 1998 value	*% difference from observed*	*% difference from base*	*June 1998 value*	*% difference from observed*	*% difference from base*
Observed	5380			1060		
Base model	5639	4.8		807	-23.9	
a = 0.160	5587	3.8	-0.9	794	-25.1	-1.6
a = 0.166	5691	5.8	0.9	820	-22.7	1.6
b = 0.530	5609	4.3	-0.5			
b = 0.546	5669	5.4	0.5			
c = 0.022	5620	4.5	-0.3	814	-23.2	0.9
c = 0.025	5648	5.0	0.2	803	-24.2	-0.5
d = 0.047	5598	4.1	-0.7			
d = 0.057	5679	5.5	0.7			
e = 0.025	5562	3.4	-1.4			
e = 0.026	5639	4.8	0.0			
f = 0.797	5627	4.6	-0.2			
f = 0.827	5651	5.0	0.2			
g = 0.250	5618	4.4	-0.4			
g = 0.274	5660	5.2	0.4			
h = 0.025	5711	6.1	1.3	824	-22.2	2.1
h = 0.033	5567	3.5	-1.3	790	-25.5	-2.1
j = 0.844	5561	3.4	-1.4			
j = 0.869	5710	6.1	1.3			
p = 0.092	5851	8.8	3.8			
p = 0.099	5488	2.0	-2.7			
55% of remand in LC	5635	4.7	-0.1	847	-20.1	5.0
65% of remand in LC	5641	4.9	0.0	766	-27.7	-5.1
Increase maximum LC finalisations by 10%	5665	5.3	0.5	807	-23.9	0.0
Increase maximum DC finalisations by 10%	5639	4.8	0.0	807	-23.9	0.0

EXAMPLE SIMULATIONS

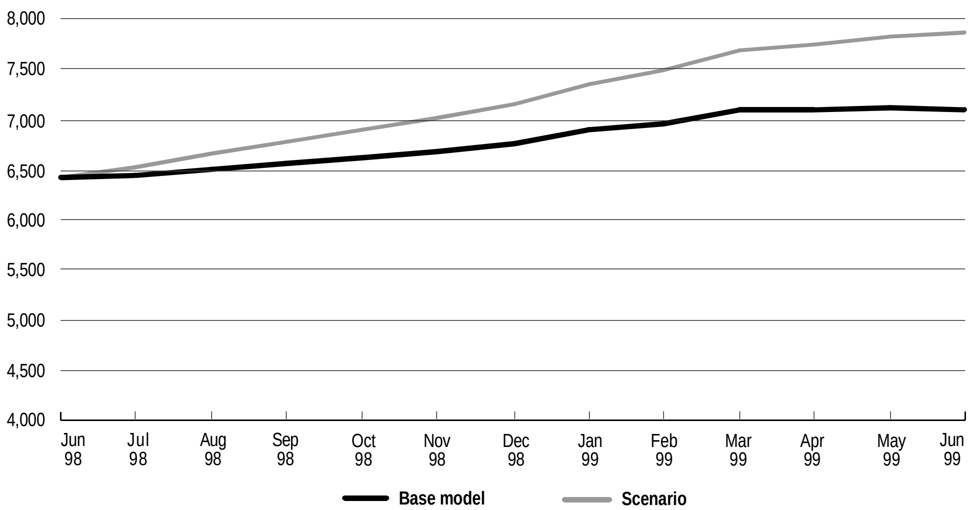
To demonstrate how this model could be used to simulate policy changes we present three example simulations. In the first, we examine the effect on the total prison population of increasing the numbers of persons brought to court. In the second, we examine the effect on the remand population of changing the proportion of persons who are remanded in custody. In the third, we examine the effect on the sentenced prisoner population of changing sentencing practices.

The example simulations are run for 12 months only, from July 1998 to June 1999. The data used for building the model were all drawn from time periods prior to July 1998. Hence these example simulations are projections into the 'future' from the model's point of view.

June 1998 was used as the starting point for the new base model used in these simulations. Initial stock values for June 1998 were determined in the same manner as they were for the validity testing exercise (but using the June 1998 observed values). The actual observed inputs (persons formally charged or given a Court Attendance Notice or summons) were used in the simulation base model and all scenario models except for the scenario where an increased input was simulated.

In practice it would be sensible to check the parameter estimates using the most recent data before performing any simulations. We therefore checked the estimates of each of the parameters *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *j* and *p*, using data from the two years immediately prior to the simulation period, that is, using observed data for July 1996 to June 1998. For three of the parameters (*j*, *h* and *p*), the new estimates were well outside the 95 per cent confidence limits shown earlier. The new estimates for these parameters were used for the example simulations presented here.[4]

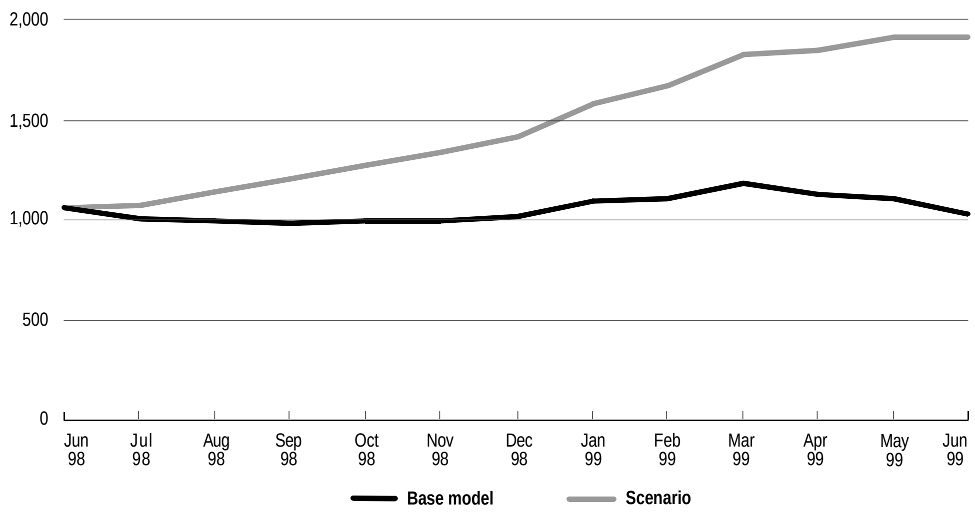
Figure 29: Prison population resulting from simulation of increased input to courts, June 1998 to June 1999



For the first example simulation we assumed that the numbers of persons entering the criminal justice system, by formal charge, Court Attendance Notice or summons, was increased by 10 per cent. Such a change could result, for example, from an increase in police numbers or a change in policing policy. Figure 29 shows the total remand plus sentenced prisoner population for the twelve months of the simulation period for both the new base model and the 'scenario' being simulated. Compared with the base model there is an 11 per cent increase in the total prison population after twelve months of increased input to the criminal justice system.

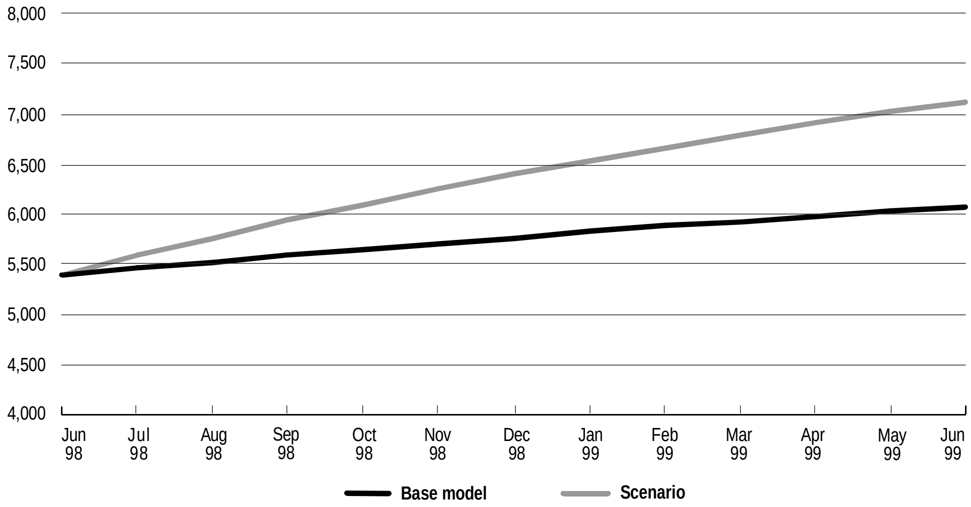
For the second example simulation we assumed that the bail procedures were changed such that the chance of a person (formally charged with an offence) being remanded in custody was increased by 10 per cent. The parameter *a* measures the proportion of persons, formally charged, who enter the Local Court custody stock. The value of this parameter was changed from 0.163 to 0.179. Figure 30 shows the remand population for the twelve months of the simulation period for the base model and the scenario. It is clear that the change in bail procedures results in a growth in the remand population. By June 1999 the remand population predicted by the scenario model is nearly double the remand population predicted by the base model.

Figure 30: Remand population resulting from simulation of changes in bail procedures, June 1998 to June 1999



For the third example simulation we assumed that sentencing practices were changed such that the average prison sentence was increased by one month. To simulate this effect we changed the proportion p of persons exiting prison from 0.103 to 0.080.[5] Figure 31 shows the sentenced prisoner population for the twelve months of the simulation period for both the base model and the scenario model. Increasing the average sentence by one month has the effect of increasing the sentenced prisoner population by 17 per cent within twelve months.

Figure 31: Sentenced prisoner population resulting from simulation of changes in sentencing practices, June 1998 to June 1999



DISCUSSION

In summary, we have shown that it is possible to build a model which has a simple structure and reasonable predictive performance. The model was developed without the aid of additional resources and using simple spreadsheet software. Most although not all of the data required by the model are readily available. The fact that a useful model can be developed within these constraints should prompt others in Australia contemplating development of a criminal justice simulation model to think carefully before developing large and complex simulation models of the criminal justice system. It remains to be seen whether our second attempt at model development proves more useful to criminal justice administrators than our first.

That said, there are certainly problems with our model. First, despite the relatively small number of parameters, some of the data required for parameter estimation are not available in NSW. Second, the model is by no means a perfect predictive tool. Its predictive performance is not good for some measures. It is worth considering each of these problems in more detail.

The greatest deficiency in the available court data for NSW is the lack of information on the custody status of persons registered and awaiting case determination in the NSW criminal courts. Information on custody status is not available either at the time of registration or at any time thereafter, until the case is finalised. For NSW Local Courts the problem is greater, because it is not possible to disaggregate either registration or stock data by whether the case was initialised by a formal charge, a summons, a Court Attendance Notice or some other means.

The lack of data leads to further problems. In attempting to estimate court registrations and stock by custody status we have had to rely on finalisation data and, in so doing, assume that custody status at finalisation is the same as at registration, an assumption which is clearly not true and which we acknowledge to be untrue in our estimation of the parameter h (the proportion of persons who change their custody status). Clearly then the parameter estimation for this model could be improved with better data and hopefully this would lead to a better performing model.

Over the two-year period used for in the model validation exercise the model performed quite well in predicting the total prison population. While the predicted total prison population is close to the observed population, its individual components (remand and sentenced prisoner populations) are not. There is a substantial discrepancy between the observed and predicted remand population at the end of the two-year validation period.

Another flaw in the model's predictive ability is the prediction of the Local Court stock. There were no observed data for comparison; nevertheless the model's predictions of an ever-increasing stock is unlikely to be correct.

The stock measures are affected by the numbers of new entrants and the numbers of finalisations. It is possible that our method for determining court finalisations is too crude. In the model we have assumed that finalisations are related to registrations. It is possible that they are related, not to registrations but to stock, or in some way related to both. This is an area worthy of further investigation.

A major drawback of this model is that it is not possible to predict the amount of time a case spends in the criminal justice system.

Despite the model's flaws, however, it is a tool which can be used for policy simulations if used with care and knowledge of the model's limitations. To be useful, of course, the model would need to be maintained. By this we mean that the parameter values, their variation and trends over time should be checked and, if necessary, the estimates updated on a regular basis. Ideally this maintenance should be the responsibility of one agency and this agency should also have responsibility for communicating updated parameter values to all users of the model.

Clearly using the model for policy simulations would require informed judgement on the part of the user because it is up to the user to determine what effect a proposed policy change is likely to have on the model's parameter values. In most instances it would probably be appropriate to run simulations for a range of different parameter values, i.e. to put minimum and maximum bounds on the new values for the parameters. Determining how a parameter's value might change could in some cases involve some analysis on the part of the user. For example, suppose that the maximum penalty for a specific offence were to be changed. To determine how the parameter p would be affected would require a knowledge of the proportion of people likely to be affected by the change in the maximum penalty.

There is, of course, scope for developing the model further. It is our view, however, that it would be preferable to refine the parameter values on the basis of better data before adding to the complexity of the model's structure.

Putting this point to one side, there are several areas where the model could usefully be developed. One of the less plausible assumptions of the model, as it stands, is that the outputs from the courts are a simple function of their input (see page 10) subject to certain fixed maximum and minimum bounds specified by the model user (see page 11). Although the first part of this assumption is consistent with Figures 3 and 4, the general idea that courts are insensitive to the size of their backlogs is implausible. In practice the output of the courts is likely to increase as the workload grows and then gradually slow (rather than simply level off at a fixed maximum value) as courts reach the upper limit of their capacity. A more realistic model would include more empirically well-founded assumptions about the true relationship between court inputs, backlogs and outputs.

Incorporation of separate flows for defendants pleading 'guilty' and 'not guilty' would also greatly improve the utility of the model. At present the effect of a change to the guilty plea rate can only be modelled by making assumptions (outside the model) about how changes in the plea rate would influence the parameters governing court output and prison input. The parameters reflecting court output and prison input can then be changed to examine to examine the effect of plea rate changes. This is a very clumsy way of proceeding. Changes to guilty plea rates can have a dramatic effect on court backlogs and on the size of the prison population (because defendants pleading guilty generally get shorter sentences). Governments can enact policies which influence the likelihood of pleading guilty. It would obviously be preferable if administrators could simulate the effect of such policies directly.

The model could also usefully be developed in the correctional area. At present there is no explicit modelling of Parole Board releases or revocations. Nor is there any explicit modelling of returns to prison for non-compliance with periodic detention orders. Nor, indeed, is there any modelling of flows into and out of community corrections. The overall prison population is likely to be quite sensitive to flows in and out of prison as a result of Parole Board decisions or policy affecting the treatment of individuals who breach their periodic detention orders. On the other hand, modeling of community correctional flows is important because, while it is much less expensive to place a person on a community correctional order than in prison, the large number of people on community correctional orders at any given time generates a significant call on public resources.

A final area where the model would benefit from development is in modeling the relationship between police resources and arrest rates. We have left this area until last, not because we regard it as unimportant, but because we have real doubts about whether there is a determinate relationship between police resources and input to the criminal justice system. Major changes to arrest rates can and often do take place without any change in police resources. Two obvious examples of this are the dramatic increase in arrest rates for offensive behaviour which occurred following changes to the Summary Offences Act in 1988 (Bonney 1989) and the very strong growth in arrest rates which occurred following introduction of crime and operation review panels by the NSW Police Service. We suggest that the empirical relationship between arrest rates and police resources be thoroughly investigated prior to inclusion of a police resources module within the current model.

NOTES

1 A stock estimate for a sample month can be obtained by counting persons with cases registered in or before the specified month and finalised after the specified month. Using the bail status at finalisation the stock can be split into its bail and custody components and the proportion of persons in custody calculated. It should be noted that this method is not ideal for estimating the absolute values of stocks because the same individual may be involved in a number of different court cases (and therefore be counted more than once by this procedure) and because the method uses retrospective data about cases which have been finalised (and therefore excludes any cases still in the stock at the time of data extraction).

2 Note that the discrepancy is in fact a little more than this percentage indicates because the observed data are cases whereas the predicted data are persons.

3 The Department of Corrective Services estimated the proportion of remand prisoners who were awaiting a Local Court hearing in four sample months. The estimates ranged between 56 per cent and 65 per cent.

4 The new estimated values were $j = 0.891$, $h = 0.021$, $p = 0.103$.

5 It can be shown that, in stable conditions, the prison population is equal to the number of prisoner receptions per month multiplied by their length of stay in months. The average length of a prison sentence can therefore be estimated by dividing the population by the number of receptions. For the base model (with $p = 0.103$) the estimated length of stay in prison (averaged over the twelve months simulated) was 8.9 months. For the scenario model (with $p = 0.080$) it was 9.9 months.

REFERENCES

Bonney, R. 1989, *NSW Summary Offences Act 1988*, NSW Bureau of Crime Statistics and Research, Sydney.

Chaiken, J., Crabill, T., Holliday, L. P., Jaquette, D. L., Lawless, M. L. & Quade, E. A. 1977, 'Summary of operational criminal justice models' in Nagel, S. S. 1977, *Modeling the Criminal Justice System*, Sage Publications Inc., Beverly Hills, California.

Crettenden, I., Packer, J. & Macalpine, S. 1993, *A Computer Simulation Model of the District Criminal Court of New South Wales*, NSW Bureau of Crime Statistics and Research, Sydney.

Morgan, P. M. 1985, 'Modelling the criminal justice system' *in* D. Moxon (ed.) Managing Criminal Justice, London, HMSO, pp. 29-45.

Nagel, S. S. 1977, *Modeling the Criminal Justice System*, Sage Publications Inc., Beverly Hills, California.