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COMPUTER SIMULATION OF ORGANIZED FENCING

ANACAPA SCIENCES, Incorporated
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ABSTRACT

A computer-based model was developed to simulate the organized fencing of stolen goods. The fencing model incorporated the basic components of organized fencing, was driven by dynamics which were consistent with current marketing theory, and provided periodic summary reports of theft, fencing and customer activity. The model was designed to provide the criminal intelligence analyst with a framework for, first, describing organized fencing from available data, and, second, manipulating the components of fencing activity to gain understanding and, ultimately, to make predictions.

The approach consisted of reviewing what was known about organized theft and fencing, using this background to develop a conceptual model, and then refining and programming the model for computer execution. After conducting preliminary computer runs to identify and correct coding errors and computational problems, 13 simulation runs were completed under varying input conditions. Four of these runs are described in this report to illustrate the simulation model and to demonstrate model sensitivity.

Although the project was preliminary in nature and of limited scope, the results suggested that computer simulation is a potentially useful tool for the analysis of organized crime. The development of the model itself forced analysts and specialists to face issues and questions at a greater level of detail than before. Furthermore, simulation runs made with the fencing model illustrated how the dynamics of organized criminal activity might be examined and, consequently, how the results of simulation experiments might aid the development of strategic countermeasures.

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INTRODUCTION

This report describes the development and application of a computer program designed to simulate the criminal activities involved in organized fencing. This report, together with the report, *A Computer-based Program for Criminal Intelligence Analysis* (Harris and Ford, 1975), make up the final report of a project directed toward the systematic identification of law-enforcement intelligence analysis needs, and the development of ways to satisfy those needs with available technology. An earlier report, *Advanced Analysis Aids Requirements and Concepts* (Harris, de Mille, Sjovold, and Ford 1975) described the identification of intelligence analysis needs and presented a set of candidate analysis concepts to be developed to satisfy the needs identified. One sub-set of concepts led to the computer-aided criminal intelligence analysis program described in the companion report. Another sub-set of concepts led to the computer-based simulation of organized fencing described here. In addition to the publication of this report, computer programming was developed and was delivered separately for implementation of the simulation model at the Law Enforcement Consolidated Data Center (LECDC), for further development and use by the Organized Crime and Criminal Intelligence Branch (OCCIB), California Department of Justice, in Sacramento, California.

The project reported here was a preliminary effort to examine the feasibility and usefulness of developing computer-based simulations of organized criminal activity. Both the budget and time available were severely limited; for example, the entire effort was completed in about two months. Consequently, although the effort did result in a working, all-computer simulation of organized fencing, the scope of the project was not sufficient to design and incorporate the human factors engineering required to develop a tool sufficiently refined to be generally useful. However, modifications can be made as the simulation model is tested and used by OCCIB specialists.

NATURE OF COMPUTER SIMULATION

Essentially, simulation consists of playing around with an imitation to find out how the real thing really works; text book definitions, however, are somewhat more elegant. For example, Abelson (1968) defines simulation as the exercise of a flexible imitation of process and outcomes for the purpose of clarifying or explaining the underlying mechanisms involved. In his primer on simulation, Barton (1970) says that simulation is the dynamic execution or manipulation of a model of a real system for some purpose. Others, of course, provide additional definitional variations; however, the components of imitation, manipulation, and comprehension seem to be present in most.

The simulation of organized fencing described in this report employs an all-computer simulation. An all-computer simulation is one wherein the model and the means of manipulating it are entirely contained within a computer system. This is not to say, of course, that all simulations have to be computer based. Many types of simulations do not require a computer at all; in others, there is only a partial role for the computer, such as simulations in which humans and computers interact.

Computer simulations, like other tools and aids, are useful for some purposes but not for others. Since simulations permit the manipulation of variables and the observation of the results of the manipulations, they can be used for conducting experiments. For example, conditions related to organized crime might be varied to determine their impact on the nature and extent of criminal activity. We might find that small changes in Condition A have significantly greater impact than large changes in Condition B. Extrapolation of these results to real life might suggest that certain law-enforcement countermeasures will be more effective than others.

Simulation works best when the analyst knows a great deal about the specific aspects of some type of criminal operation, but needs help in relating the specific details to the overall system. Thus, simulation serves as an aid to organizing information about criminal systems and gaining understanding as to how the systems operate. Naturally, the organization of information and the understanding of the systems puts the analyst in the position to make predictions about what will happen when conditions change.

Simulation, on the other hand, is not very useful in the analysis or investigation of specific cases. Simulation does not provide an effective way of going beyond the present knowledge held by an analyst or investigator. Consequently, simulation would not be effective in selecting targets, in identifying key individuals in organized criminal operations, in assessing the value of evidence, in describing the method of operation employed by a particular criminal group, or in any other supportive capacity to developing inferences or collecting evidence relative to specific cases.

ORGANIZED FENCING

Fencing appears to be a relatively simple, easily understood type of criminal activity. Four types of people are involved--victims, thieves, fences, and customers. Thieves steal from victims, sell the stolen property to fences who in turn funnel it to various customer outlets which sell the goods to the ultimate consumer. However, according to most law enforcement agencies and investigative bodies who have examined the problem, fencing is one of the most under-rated and infrequently prosecuted of all criminal activities (Chamber of Commerce of the United States, 1974). The professional fence, by performing the middleman function, plays a critical role in this system.

In one of the few studies conducted recently to assess the nature and scope of organized fencing, the New Mexico Governor's Organized Crime Prevention Commission (1974), in cooperation with the Albuquerque Police Department, conducted a research project to determine the nature and extent of organized fencing operations in Albuquerque, New Mexico. About 200 fences were identified in Albuquerque. About 180 of these fences were categorized as amateurs who operate small businesses for their primary income; the remaining 20 were classified as professionals for whom fencing was a major source of income, and was practiced with continuity. At the time of the report, types of commodities receiving priority from thieves and fences were jewelry, clothing, television sets, business machines, automobiles, firearms, tools, and various types of mechanical equipment. The professional fences know the market; and what the market wants is quickly communicated to interested thieves. It was not unusual for a fence to communicate his specific needs or even to pinpoint the target to a thief. Furthermore, successful fences develop their own string of thieves through a process of screening and testing. Thieves can be readily dropped by fences because the testimony of a thief against a fence is of limited value; it merely consists of the thief's word against that of the fence. Also, drug addiction gives the fence a valuable advantage; he has little difficulty manipulating an addict who must steal to satisfy his habit.

The New Mexico study concluded that leading fences have the following features:

- well established business covers,
- connecting or alliance with thieves who can be readily used and disposed of,
- penetrations or connections in the criminal justice system,
- availability of legal expertise,
- continuity in conducting illegal transactions,
- excellent networks of sources in the business community,
- expertise in concealing funds and records,
- good systems for insulating themselves from exposure to prosecution, and
- contacts outside of the state.

Probably the most extensive study of a single fence was conducted by Klockars (1974). To complete the study, Klockars regularly visited the fence at his home and his place of business for over a year, meeting customers, friends, and relatives. From the information collected, he described the fence's 25 successful years in buying and selling stolen property. Although this report provides a significant amount of insight into fencing operations, particularly those of a fence like the individual described, it is only marginally helpful in defining organized fencing as a system.

In a preliminary attempt to provide a systems orientation to organized fencing, Roselius and Benton (1971) concluded that legitimate marketing theory can serve as the foundation for building a theory of the distribution of stolen property. They concluded further that such a theory is necessary if law enforcement officials are to make substantial advances in blocking and investigating the traffic in stolen goods. Professional and organized thieves and fences face a formidable marketing task in general, and especially so in the case of large scale cargo thefts. Because the marketing problem is complex, the fence must make an overt attempt to solve it. Once he does, his behavior pattern becomes predictable by use of marketing theory and concepts, providing police agencies an approach to attacking crimes of theft and fencing by attacking their logical marketing practices.

POTENTIAL BENEFITS AND RISKS OF THE PROJECT

Because the simulation project represented a pioneering effort in the area of criminal law enforcement, there were associated risks as well as potential benefits. To become a useful, analytical tool, the organized fencing simulation model must evolve through substantial testing, refinement, and human factors engineering. However, the project budget and time limitation precluded this systematic development. Thus, the primary risk was not one of developing a working simulation, but rather one of advancing far enough to provide the basis for ultimately developing a generally useful tool, and at the same time to provide sufficient assessment of how useful a tool of this type might be if fully developed.

In spite of the risks involved, the project appeared warranted for several reasons. First, the potential benefits were great. Intelligence analysts, particularly those at the State level, are in need of techniques that will aid them in understanding and explaining to others the dynamics of complex criminal activities. Success in other areas had suggested that simulation models might be of help in meeting these needs within law enforcement. Thus, at a minimum, the project could provide a preliminary test of this hypothesis.

Second, the success of law enforcement efforts over the long term appear to depend on the selection of appropriate strategies, as well as the utilization of effective tactics. Emphasis at this time, however, continues to be primarily on tactics. Simulation models which provide the framework for building theory, manipulating models of total criminal systems, and predicting the effects of change might help emphasize and support strategic intelligence.

Finally, the need for more efficient law enforcement training methods is likely to grow as criminal activities become more complex and sophisticated. Traditional classroom methods need to be replaced or supported by "hands-on" training techniques. These techniques are appropriate whether the training objectives are to impart knowledge, develop skills, or modify attitudes. One innovation that might help satisfy this need is the use of computer-based simulations for purposes of demonstration and manipulation under controlled instructional conditions. Although the adaptation of a simulation model for this purpose is outside the scope of the project, the steps taken within the project might help test the feasibility of the concept and might provide a basis for an extension into the training area.

OBJECTIVES AND SCOPE OF THE PROJECT

The primary objective of the project was to develop a basic, working, all-computer simulation of organized fencing. The intent was to encompass the primary entities, events, and relationships that comprise organized fencing at the professional level. Furthermore, it was intended that the simulation be adaptable to the OCCIB/LECDC computer facility in Sacramento.

However, the simulation model produced by the project would not be sufficiently refined for use, generally, by intelligence analysts. The scope of the project was insufficient to design and incorporate the human factors engineering required to develop such a tool. In short, the project was designed to develop a simulation in a specified area of criminal activity, organized fencing, for the purpose of examining the feasibility and potential usefulness of computer simulation to criminal intelligence analysis.

APPROACH

The approach consisted mainly of reviewing what is known about organized theft and fencing, and using this background to develop an all-computer simulation of the main components of organized fencing. When OCCIB decided to initiate the computer simulation of some aspects of organized criminal activity as one of the objectives of the overall project, the specific criminal area had not as yet been selected. However, a rationale for the use of computer simulation, a review of related research, and an outline of the approach to be employed had been completed during the first phase of the project; these results were reported earlier (Harris, deMille, Sjovold, and Ford, 1975).

SELECTION OF ORGANIZED FENCING

Three main criteria were employed during the process which resulted in the selection or organized fencing. The first was the potential impact of the resulting simulation on OCCIB objectives. Several review and planning sessions were conducted by OCCIB analytical and research personnel to review their current operations and objectives in light of the proposed simulation project. As a result, two candidate criminal areas were given the highest priority--organized urban terrorism, and organized fencing. For different reasons--one of public security, the other of economic impact--these areas were being given increasing attention by California law enforcement agencies and, in particular, the California Department of Justice.

The second criterion was the availability of knowledge and data relative to the criminal activity. Since both areas had received recent attention and study, they both had an associated data base. However, neither data base was really complete for purposes of simulation.

It was mainly with respect to the third criterion that organized fencing was selected over organized urban terrorism. That criterion was the extent to which existing knowledge, data, and the nature of the criminal activity yielded to computer simulation. In other words, the extent that simulation could be used to gain an understanding of the criminal activity and, ultimately, to help predict trends and develop countermeasures. A review of the two candidate areas suggested that organized fencing provided the greatest potential for computer simulation. This area was most like a system for which the components, relationships, and operations could be defined and imitated through computer programming. Organized fencing was more like the kinds of systems for which computer simulation had been successful in the past than was organized urban terrorism.

MAJOR PROJECT TASKS

1. *Organized Fencing Review*

Descriptions and data were collected on organized fencing. A review of the literature was completed and interviews were conducted with researchers and analysts who were currently studying organized fencing. Actually, these two avenues of information collection interacted with each other because the literature identified persons to contact, and persons contacted suggested additional documents which might be helpful. Even so, in spite of its lengthy history and its significance as a current problem, relatively little was found to be published on the subject, and few appeared to be actively studying the problem. A literature search was requested from the National Criminal Justice Reference Service; the indexes of the National Technical Information Service were reviewed for the previous three years; and a visit was made to Dr. Ted R. Roselius, and Dr. Douglas Benton at Colorado State University. Drs. Roselius and Benton authored the previously cited report on marketing theory and the fencing of stolen goods under a Law Enforcement Assistance Administration grant, and were, at the time of the visit, completing a study directed toward the development of a marketing model for organized fencing. In addition, Mr. Larry McNeely and Mr. Ken Brown of the Crime Patterns Analysis section, OCCIB, were interviewed. McNeely and Brown were currently studying the problem of fencing in California and were analyzing specific cases of organized fencing.

2. *Development of a Preliminary Model*

Based upon the information collected through literature review and interviews, a preliminary model of organized fencing was developed. The model was developed in five steps. The first step consisted of listing for each major component of the model--victim, thief, fence, and customer--the variables which might need to be incorporated. Second, the events in which these components would engage during theft and fencing activities were defined. Third, preliminary mathematical expressions of the relationships among the components of the model, associated variables, and the events were formulated. Fourth, a flow chart was constructed to depict the flow of computer calculations during a simulation run. The preparation of the flow chart served several purposes: it helped clarify and refine some of the preliminary concepts; it was used as a description of the model during its presentation and review with OCCIB. Finally, a refinement of the flow diagram served as the starting point for programming the simulation model.

3. Refinement of the Simulation Model

The model was refined by the project staff in conjunction with the model review and data input by OCCIB specialists. In meetings at Santa Barbara and Sacramento, the model was presented, discussed, and modifications recommended. In addition, in a joint working session, available information was collected and organized for purposes of model refinement and computer programming. These data were the type that an analyst would use to set up simulation runs. They helped the project staff in designing the simulation with respect to the scope and type of data the model must handle. Finally, thief, fence, and customer structures were refined and detailed; mathematical expressions were made explicit; and event generation and status up-date sequences were refined.

4. Computer Programming

The model was programmed for computer execution. Programs were designed and coded for the CDC 6400 computer at General Research Corporation in Santa Barbara; however, programs were designed with adaptation on OCCIB/LECDC computer facilities in mind.

5. Execution of Preliminary Simulation Runs

Preliminary computer runs were conducted to identify and correct any coding errors and computational problems. Then, when assured that the programming was computationally correct, the simulation was initialized and permitted to run for specified periods of time. At the end of each period, printouts describing system status and flow were obtained and reviewed. Of particular interest were indicators of out-of-balance conditions and trends which did not appear to be realistic. The results were employed to make modifications in both the model and the computer programming.

6. *Sensitivity Testing*

Eight simulation runs, each one year in length, were completed to examine the sensitivity of the simulation model. The cases differed from each other with respect to variables which might affect the obtainable measures of criminal activity, such as theft rate, value of goods stolen per theft, and so on. Results were obtained, charted, and compared as a means of examining the model sensitivity. As a result of this testing, some modifications were made in the model, primarily in the mathematical expressions.

7. *Final Computer Programming*

The computer programming was finalized on the CDC 6400 computer at General Research Corporation in Santa Barbara. To illustrate the simulation model and computer programming in its final form, a series of five different simulation runs were designed and executed. As before, the simulation set up and the parameters employed were changed from run to run to examine the sensitivity of the model. The results of four of the simulations are used later in this report to illustrate the type of results obtainable.

8. *Program Adaptation at OCCIB/LECDC*

Guidance was provided to OCCIB and LECDC personnel in adapting the simulation model for use at the OCCIB/LECDC facilities in Sacramento. The first step of the adaptation was to program the model for execution on the IBM 360 computer at the University of California, Santa Barbara. The IBM 360 computer was considered comparable to LECDC's Spectra 70 computer in Sacramento. The resulting programming and associated materials were then packaged and delivered to LECDC.

FENCING MODEL

The fencing model incorporates the basic components of organized fencing, is driven by dynamics which are consistent with current marketing theory, and reports summary statistics of theft and fencing activity. The major components of the model are: commodity types, thieves, fences, customers, theft events, fencing events, and mathematical expressions of interrelationships. The flow of activity is initiated when a thief steals some amount of a commodity and sells it to his fence. The fence, in turn, sells as much as he can of the stolen goods to the customer who offers the most favorable price. The flow of activity is influenced by many factors, including the risk associated with stealing different types of commodities, the type of thief, the needs of the thief, the market price of the commodity, the time since the last theft by any given thief, the financial resources of the fence, the proportion of market price paid to the thief, the proportion of market price obtained by the fence, the customers turnover rate, the maximum supply of stolen goods each customer will keep on hand, the relative numbers of thieves, fences and customers, and the minimum returns below which the thief will not steal and the fence will not sell.

The model provides the analyst with the framework for, first, describing organized fencing from available data, and, second, manipulating the components of organized fencing to gain understanding and make predictions. This section of the report describes the fencing model in terms of the assumptions upon which it was based, its main components, the input data required, the processing of theft and fencing events, and the summary reporting provided. The components and flow of the fencing model are diagrammed in Figure 1; they will be described in detail in this section of the report.

ASSUMPTIONS

As with any simulation model, particularly one developed where knowledge is incomplete and where a theoretical framework is yet to be formulated, many assumptions are required. A number of the more detailed assumptions will be revealed later in descriptions of theft event and fencing event processing. At the outset, however, a couple of the main assumptions which define the nature and scope of the model are discussed.

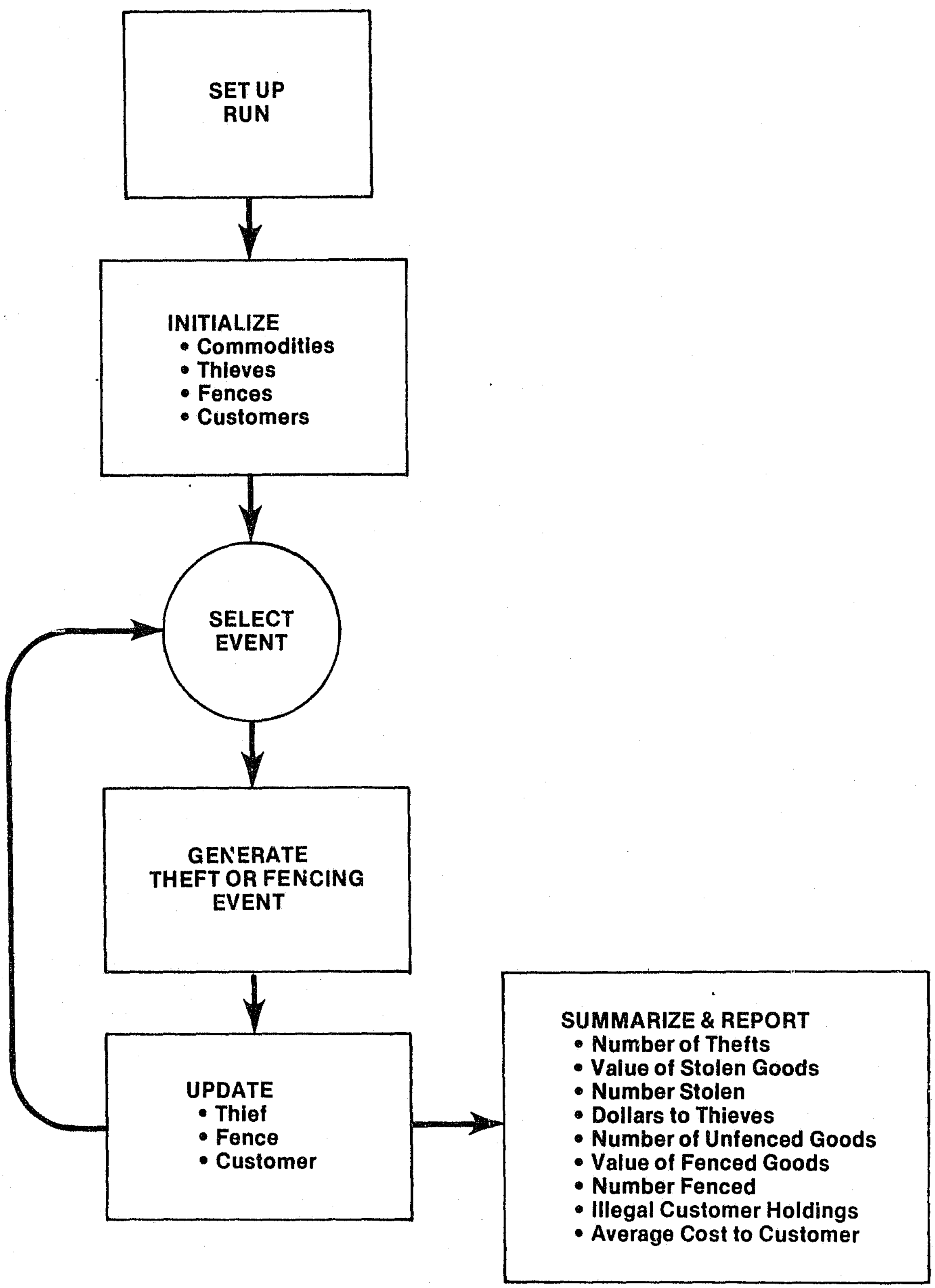

Figure 1. Fencing model operational flow.

Scope of the Model

In attempting to simulate organized fencing, scope is one of the first questions to be faced. How encompassing should the simulation be? Should the focal point be on a single fence and include only those other components that interact with this fence; or should the simulation encompass all the thieves, fences, and customers within a city, county, state, country, or the world? Obviously, it is necessary to draw the line somewhere, if for no other reason than that of practicality.

The assumption made was that the capability to employ appropriate ratios among thieves, fences, and customers be the overriding consideration. The simulation model should incorporate a sufficient number of each to permit the analyst to set up most any fencing simulation with realistic ratios among numbers of thieves, fences, and customers. To this end, estimates were obtained from OCCIB specialists regarding the numbers of thieves, fences, and customers engaging in the traffic of the major commodities being fenced. On the basis of these estimates, then, the simulation model was designed to incorporate as many as 200 thieves, 20 fences, 100 customers, and 10 different commodities. Should the analyst wish to extrapolate summary statistics, such as theft rate, to a particular geographic area, such as the State of California, appropriate multipliers can be used. For example, if the simulation run was conducted at a "scale reduction" of about one-tenth, estimates could be derived for the simulated area by multiplying the statistics by 10.

Level of Fencing

The fencing model was restricted to organized fencing at the professional level. In terms of this restriction, only those fences who devote themselves full-time to the receipt, brokerage, or distribution of stolen goods were included. Thus, the model focuses on only those fences who deal in relatively large volumes of stolen merchandise and whose customers are retailers or wholesalers of the merchandise. Therefore, the type of fence who receives stolen merchandise from thieves, and who mixes stolen goods with legitimate goods in his retail or wholesale outlet is excluded from this model except perhaps as a potential customer of a fence. Thus, the model assumes that any given thief "works for" a specific fence; that the fence distributes stolen goods to customers who are retailers or wholesalers; and that these customers, in turn, sell goods through legitimate or quasi-legitimate channels to the ultimate consumers.

Application of Marketing Theory

The model is based upon the assumption that organized fencing is sufficiently parallel to the distribution of legitimate goods to permit the application of certain aspects of conventional marketing theory. This proposition was studied by Roselius and Benton (1971). They concluded that legitimate marketing theory can serve as the foundation for building a theory for the distribution of stolen property. As thieves, fences, and customers engage in the distribution of stolen goods, they face many of the same problems a legitimate businessman faces as he matches supply and demand. Consequently, they can be expected to use many of the same strategies and procedures in solving these problems. For example, the amount of disequilibrium between the demand for and the supply of particular kinds of stolen goods, as reflected in pricing structures, is likely to have a predicable impact on the behavior of thieves, fences, and customers.

MODEL COMPONENTS

The components of the model are entities, events, and the mathematical relationships among variables which serve to drive the model. The components themselves will be described here; the dynamics of theft and fencing event processing will be described later.

Entities

Each of the 10 possible commodity types, 200 thieves, 20 fences, and 100 customers are defined and described in terms of specified characteristics. The characteristics used to describe these four entities are presented below. Each commodity, thief, fence, or customer can be unique in terms of the values assigned; for example, each of the 200 possible thieves may be described differently in terms of thief characteristics.

COMMODITY TYPE CHARACTERISTICS

- MARKET PRICE (DOLLARS)

  The average retail price paid by consumers for commodities of this type.

- RISK FACTOR

  Estimates of parameters A and B in the expression for theft risk (R):

$$R = \frac{A}{\Delta t + 1} + B$$

  where Δt = time since last theft for a specified thief.

  (The rationale and use of R will be described later.)

- FENCE-CUSTOMER TRANSACTION TIME (DAYS)

  The time required to execute the sale of stolen goods from fence to customer.

- PROPORTION OF MARKET PRICE TO THIEF

  The decimal fraction of the market price typically paid by fence to thief for that commodity type.

- PROPORTION OF MARKET PRICE TO FENCE

  The decimal fraction of the market price typically paid by customer to fence for that commodity type.

FENCE CHARACTERISTICS

- CAPITAL (DOLLARS)

  The financial resources in dollars that the fence has available for his fencing operations.

THIEF CHARACTERISTICS

- THIEF TYPE

  Thieves can be categorized as Type 1 or Type 2, based on amounts typically stolen. Distributions of amounts stolen are constructed from input data for each thief type, and each commodity type. Thus, when a thief is characterized as Type 1 or 2, that distribution is used in the generation of theft events involving that thief.

- DOLLARS NEEDED PER DAY

  The dollar amount per day expended by the thief or, conversely, needed to be obtained by the thief through stealing.

- FENCE NUMBER

  The numerical identification of the fence through which the thief disposes of his stolen goods.

CUSTOMER CHARACTERISTICS

- COMMODITY TYPE (NUMBER)

  The identification number of the commodity type in which that customer deals.

- TURNOVER RATE (TIMES PER YEAR)

  Turnover rate is the measure of the number of times the inventory of stolen goods is sold out and replaced during the year. It is calculated by dividing annual sales by average monthly inventory.

- MAXIMUM SUPPLY (NUMBER OF UNITS)

  The maximum number of stolen goods that the customer will have on hand at any time.

Events

Two types of events are incorporated into the model--theft events and fencing events. The theft event contains two actions: 1) the theft of some amount of one of the commodity types, and 2) the sale of the stolen goods by the thief to his fence. The particular commodity stolen is determined from a consideration of several variables, including the fraction of market price paid to the thief, the risk factor, the distribution of quantity stolen for the designated thief type, and a random factor. The generation and processing of the theft event in terms of these variables will be discussed later.

The fencing event consists of the sale of stolen goods by the fence to a customer. For this event to occur, a fence must have some quantity of unfenced stocks on hand. When this is the case, the fence seeks out that customer which will give him the best price. This price is determined from a consideration of several factors, including the relationship between current supply and maximum supply for each customer, the market price, and the percentage of market price normally paid to the fence. The generation and processing of fencing events will be discussed in greater detail later.

SIMULATION SET-UP AND DATA INPUT

The main analyst activity in using the computer-based fencing model is setting up the simulation run; selecting the numbers of commodity types, thieves, fences, and customers; and specifying the characteristics of each of these entities. When these tasks have been completed and appropriate information entered into the computer, the simulation run can be executed. A copy of the Data Input Form designed for use in these set-up and input tasks is provided in the Appendix.

The simulation run is set up by completing the first six items of the Data Input Form. In item 1, the length of the simulation run is specified by directing the computer to stop the run after the designated number of days. Items 2 and 3 provide a means for obtaining event detail, if desired. Event Detail Reports provide a listing for each commodity type, in the simulation, the last price paid to a fence by a customer for that commodity, and the quantities of each commodity type held by each fence and each customer after the most recent event.

Items 4 and 5 permit the analyst to specify the nature of the simulation outputs. By means of item 4, the analyst can specify the time period, in days, for printing the Periodic Cumulative Summary Report. For example, by requesting a report every seven days the simulation printout will provide a report each seven days for the duration of the run. By means of item 5, the analyst can specify the number of periods to be covered by each Summary Statistics Report. If 26 periods are specified, for example, when the period is seven days, a report covering a total of 182 days will be printed each 182 days, for the duration of the run. The two types of reports are described and illustrated later.

Item 6 permits the analyst to specify a lower bound for the amount of money acceptable to the thief or fence for his goods. This bound is specified by the analyst in terms of a proportion of the Market Price. To understand how this lower bound operates requires defining different levels of a price structure. At the highest level is Market Price, the average amount paid for commodities of this type in legal transactions on the retail market. At the next level down is Illegal Market Price, that price which serves as a basis for calculating the amount paid by fence to thief and the amount paid by customer to fence. It is a function of the supply and demand conditions of illegal trafficking in the commodity type. Finally, the price that is paid by customer to thief during a specific transaction is called Market Cost. Market Cost is a specified proportion of the illegal market price. The amount paid by fence to thief is also a specified proportion of the illegal market price.

To illustrate, then, the effect of establishing a lower bound as a proportion of Market Price, consider an example. Assume that the Market Price is \$500 per unit and that a lower bound of 0.5 of this amount has been established for an acceptable Illegal Market Price. Then, if the proportion of this price paid for goods of this type, by customer to fence is 0.4 and by fence to thief is 0.1, the fence would get $100 per unit and the thief would get $25 per unit at the lower bound. In other words, if the amounts received were less than these amounts, the thief would stop stealing and the fence would stop selling goods of this type.

The remainder of the data input form is employed by the analyst to specify characteristics for commodity types, thief types, fences, and thieves. These characteristics were described earlier. The main task for the analyst is to enter data which will most accurately reflect the organized fencing system under study. Of concern here are the ratios of thieves to fences to customers, of describing the characteristics of the entities most accurately, and, within each entity, providing the most realistic distribution of existing characteristics. The first part of the computer printout for any simulation run provides a complete listing of the simulation run set-up and of the data input for each entity.

THEFT EVENT PROCESSING

A theft event occurs whenever any thief runs out of money. One of the characteristics of each thief in the simulation is the amount of money needed per day. This amount is subtracted each day from each thief's cash on hand. Thus, when the cash on hand reaches zero, the thief is ready to steal some more goods.

In selecting the commodity type to be stolen, the thief examines the likely return from each different commodity type in the simulation run. This return is the thief's percentage of the Illegal Market Price established in the last transaction involving that commodity type. However, as discussed earlier, if the Illegal Market Price drops below a specified proportion of legal market price, the thief will not steal and the fence will not sell goods of that commodity type until the price is raised above that lower bound.

The sequence of calculations and routines involved in processing theft events are outlined in the following paragraphs. The description of these steps will be largely conceptual to nature. Some of the detailed calculations are either sufficiently complex to be beyond the scope of this discussion or have been more appropriately included in the programming package.

1. An oddment is calculated for each commodity type. Oddments are essentially the same things as odds, within the context of probability; however, odds are defined and used only for the case of two events, whereas oddments are defined and used in cases of more than two events. For example, a statement that the odds are 3 to 2 in favor of Event A over Event B means that A will occur 3 times out of 5, and B will occur 2 times out of 5. Similarly, if the oddments for events A, B, and C are determined to be 3, 2, and 5 respectively, the meaning conveyed is that Event A is likely to occur 3 times out of 10, Event B 2 times out of 10, and Event C 5 times out of 10. The oddment for each commodity type is calculated from the expression below.

$$\text{ODDMENT} = (\text{THIEF DISCOUNT})\left(\frac{\text{MARKET CLOSE}}{\text{RISK}}\right)(\text{AVERAGE AMOUNT STOLEN})$$

Where:

THIEF DISCOUNT = Percentage of Market Close paid by fence to thief for the commodity type.

MARKET CLOSE = The Illegal Market Price established in the last fence/customer transaction for the commodity type.

$$\text{RISK} = \frac{A}{\Delta t + 1} + B$$

Where: A and B are coefficients estimated and input by the analyst for the commodity type, and Δt is the time since the last theft committed by the thief.

AVERAGE AMOUNT STOLEN = The estimate put in by the analyst of the average amount of the commodity stolen by a thief of a specified thief type (Type 1 or Type 2).

2. Since an element of chance is involved in the ultimate selection of a commodity type by a thief, a random number is generated and employed along with the oddments in commodity type selection. Thus, although the commodity types with the largest calculated oddments are most likely to

be selected, introduction of the random number makes possible the selection of any commodity type included in the simulation. The selection process is as follows: First, a cumulative distribution is made of the calculated oddments. For example, assuming four commodity types are involved and that their oddments are calculated to be 420, 180, 670, and 80 the cumulative distribution of these oddments would be as shown in the third column below.

COMMODITY TYPE	ODDMENT	CUMULATIVE DISTRIBUTION	RANDOM NUMBER (1050) LESS DISTRIBUTION VALUES
1	420	420	1050 - 420 = 630
2	180	600	1050 - 600 = 450
3	670	1270	1050 - 1270 = -220
4	80	1350	1050 - 1350 = -300

Second, a random number is selected between 0 and the sum of all the oddments, between 0 and 1350 in this case. Third, the number at each level in the cumulative oddment distribution is subtracted from the random number selected. For example, if the random number selected was 1050, the subtraction process would produce the numbers to the right in the fourth column. Note that there is a point in the distribution where subtraction results in a negative number. In this case, the subtraction of 1270 from 1050 resulted in the negative number -220. It is the corresponding commodity type, where the sign changes from positive to negative, Commodity Type 3 in this case, that is selected for the next theft.

3. The amount stolen by the thief is determined conceptually in a somewhat similar manner to the selection of commodity type, but requires mathematics significantly more complex. The process will be described generally here; the mathematics and a detailed description of the methods are presented elsewhere (McGrath and Irving, 1973). From input data supplied by the analyst for average, minimum, and maximum amounts stolen during thefts of the different commodity types, Beta distributions are generated for each thief type (Type 1 and Type 2) for each commodity type. These three numbers are used to define the parameters of the Beta distribution between the minimum and maximum values. The Beta distribution is shaped generally like a normal

curve and is constructed to be tangent to the x axis at the end points of the interval. Constructed in this way, the distribution can be used as a density function from which the number of goods stolen of a particular commodity type by a thief of specified type can be sampled. Thus, in essentially the same manner that commodity types with larger oddments have greater likelihood of being selected, amounts stolen with greater densities on the Beta distribution will have a greater likelihood of being sampled.

4. Having determined what is to be stolen and how much of it will be stolen, the theft is completed and the stolen goods are sold by thief to fence for the calculated amount. Then, the time is calculated for when that thief will have to steal again.

5. If the fence to whom the goods were sold still has unfenced stocks, there will already be a fence event set up for him on the event list and no further action is required. Otherwise, a fence event is set up for this fence to start trying to pass the stolen merchandise along to his customers.

6. With the processing of the theft event, appropriate components of the output array are incremented so that at the end of the correct time period, summary statistics can be produced.

FENCING EVENT PROCESSING

The fencing event consists of the sale of stolen goods by the fence to a customer. A fencing event can occur when a fence has unfenced stocks; it is typically kicked off by the receipt of goods from a thief. The operations which make up the processing of fencing events are described in the following paragraphs.

1. A fencing event is initiated either upon receipt of stolen goods by the fence from a thief or when the fence has stolen goods on hand which have been left over, unfenced, from a previous theft. In fencing any commodity type the fence considers each of his customers, one at a time, to identify the customer who will pay the highest unit price for stolen goods of that type. Of course, the fence rejects all customers who will not pay an amount equal to or greater than the lowest acceptable purchase price as discussed earlier.

2. The price any customer is willing to pay a fence for stolen goods of a specified commodity type is based upon the calculated value called Market Cost. Market Cost is a function of the Market Price for that commodity type, the capacity of the customer to purchase additional stocks, and the fence discount. It is calculated from the expression below.

$$\text{MARKET COST} = (\text{ILLEGAL MARKET PRICE})\ (\text{FENCE DISCOUNT})$$

Where:

$$\text{ILLEGAL MARKET PRICE} = (\text{MARKET PRICE}) \left(\frac{\text{MAXIMUM SUPPLY} - \text{CURRENT SUPPLY}}{\text{MAXIMUM SUPPLY}} \right)$$

in which:

MARKET PRICE = Analyst input estimate of the average retail price paid on the legal market for commodities of that type.

MAXIMUM SUPPLY = Maximum amount of stolen goods of that commodity type that the customer will have on hand at any time.

CURRENT SUPPLY = Supply of stolen goods of the commodity type that the customer has on hand at the time of the calculation.

FENCE DISCOUNT = Proportion of the Illegal Market Price paid by customer to fence for stolen goods of that commodity type.

The expression for Illegal Market Price simply reduces Market Price linearly as a function of the customer's current supply of stolen goods of that commodity type. If the customer has no goods of that type on hand, Illegal Market Price is equal to Market Price, and the fence would be paid his normal percentage of Market Price. However, whenever the customer's current supply is greater than zero, Illegal Market Price will be less than Market Price, going to zero when current supply is equal to maximum supply. At that point the customer will refuse the purchase of any commodity of that type. Of course, as discussed earlier, when Illegal Market Price gets below a level acceptable to the fence, the fence will refuse to sell to the customer.

3. In selling stolen goods to a customer, the fence selects the customer who will pay him the *greatest dollar amount*. Thus, the selection process takes into account the quantity the fence possesses and Market Cost, as well as the quantity which the customer is able and willing to accept. In executing the transaction, the customer pays the fence the designated Market Cost for that commodity type, adding to the fence's cash. Also, the appropriate amount of the commodity is transferred from the fence, adding that amount to the customer's stocks. If the fence still has stock remaining, a future fence event is set up at a later time which is dependent upon the time delay for the type of commodity fenced. If the fence has no remaining stocks, then no future event is scheduled; the fence must wait for action by one of his associated thieves. Finally, if the fence is unable to enter into a transaction because he cannot find a customer willing to pay an acceptable price for his goods, a new event is set up one day later and the processing of the current event is terminated.

4. Customer stocks are reduced in accordance with the annual turnover rates which were put into the simulation by the analyst for each customer. Once each day the customer stocks are reduced by applying a multiplier (less than 1) calculated from the individual turnover rates. Customer stocks, of course, refer only to the stolen goods maintained by the customers, and not to the total customer stocks of the subject commodity type.

SUMMARIZATION AND REPORTING

Two types of summary reports and a status detail report are available as simulation outputs. The types of reports desired, their number and frequency, and their periodicity are established during the simulation run set up. Use of the first five items on the data input form for this purpose was described earlier.

The Periodic Cumulative Event Report provides cumulative statistics on theft activity, fence/customer activity, and customer data. The types of information provided are listed here; examples of reports from a simulation run are shown in the next section of this report.

PERIODIC CUMULATIVE EVENT REPORT
(Information provided for each commodity type)

THEFT STATISTICS
- Number of thefts to date
- Dollar value of thefts to date
- Number of goods stolen to date
- Total dollars received by thieves to date

FENCE/CUSTOMER ACTIVITY
- Average number of unfenced goods on hand
- Dollar value of stolen goods fenced to date
- Number of stolen goods fenced to date

CUSTOMER DATA
- Average number of stolen goods held
- Average market cost

A Summary Statistics Report is provided after each designated number of periods. Stated another way, after a specified number of Periodic Cumulative Event Reports are produced, a Summary Statistics report is provided. This report includes the information listed below for each commodity type.

SUMMARY STATISTICS REPORT
(Information provided for each commodity type)

THEFT RATE PER DAY
AVERAGE VALUE OF GOODS STOLEN PER THEFT
AVERAGE NUMBER OF GOODS STOLEN PER THEFT
AVERAGE DOLLARS RECEIVED BY THIEF PER THEFT
AVERAGE NUMBER OF UNFENCED GOODS CARRIED BY FENCE
AVERAGE VALUE OF STOLEN GOODS FENCED PER DAY
AVERAGE NUMBER OF STOLEN GOODS FENCED PER DAY
AVERAGE NUMBER OF STOLEN GOODS HELD BY CUSTOMERS
AVERAGE MARKET COST

At any specified day in the simulation run, a designated number of Event Detail Reports can be obtained. Each report shows, for each commodity type, the amounts of stolen goods held by both fences and customers after the latest theft or fencing event. In addition, the report shows the clock time of the most recent event, the Illegal Market Price at the close of the last fence-customer transaction (Market Close) for each commodity type, and the two entities (thief, fence or customer) involved in the latest event. Examples of Event Detail Reports are provided in the next section of this report.

SIMULATION RUNS

A total of 13 simulation runs were conducted to examine the operation of the fencing simulation model. Four of these runs are used in this section to illustrate the different simulation outputs and to provide a preliminary demonstration of model sensitivity.

The simulation set-up and most of the input data are the same for each of the four runs. However, the ratios of thieves to fences to customers was varied. Thus, differences found in the Periodic Cumulative Event Reports and in the Summary Statistics Reports reflected the impact of these variations only. The ratios for the four runs were as described below. These

		NUMBER OF:	
RUN	THIEVES	FENCES	CUSTOMERS
1	200	10	40
2	100	10	40
3	200	5	40
4	200	10	20

ratios are roughly comparable to ratios of numbers of thieves, fences, and customers estimated by OCCIB analysts for several different commodity types within the State of California.

RUN SET-UP AND DATA ENTRY

The runs were set up and the data for each run entered in accordance with the requirements of the Data Input Form. The information put in was printed out as one of the products of the simulation run. This printout, as currently formatted, is illustrated on the following five pages in Figure 2. The printout closely parallels the Data Input Form shown in the Appendix.

One of the major limitations of this developmental effort was that there was insufficient time or funds available to design and test printout formats for conformance to human factors engineering principles; printouts were prepared in a manner that would facilitate the computer programming but

```
364.0           SPECIFY CASE TIME, DAYS
  180.0         SPECIFY START OF INTERMEDIATE EVENT DETAIL, DAYS
   10           SPECIFY NUMBER OF EVENTS TO PRINT DETAIL FOR
7.0             SPECIFY DAYS TO BE COVERED IN OUTPUT PERIOD PRINTOUT
26.0            NUMBER OF OUTPUT PERIODS WITHIN SUMMARY REPORT
0.5             FRACTION OF USUAL PRICE WHICH THIEF WILL ACCEPT
    4   NUMBER OF COMMODITY TYPES
150.0     6.         1.         0.25      0.1       0.25      PR,A,B,DT,T-D,F-D
700.0     8.         1.0        0.5       0.1       0.65      PR,A,B,DT,T-D,F-D
200.0     9.         1.0        0.5       0.32      0.80      PR,A,B,DT,T-D,F-D
350.0     8.0        1.0        1.0       0.10      0.65      PR,A,B,DT,T-D,F-D
   40  NUMBER OF CUSTOMERS
          1  2.0     1500.0       COM.TYPE,TURNOVER,MAX.NO.
          1  2.0     1500.0       COM.TYPE,TURNOVER,MAX.NO.
          1  2.0     1500.0       COM.TYPE,TURNOVER,MAX.NO.
          1  2.0     1500.0       COM.TYPE,TURNOVER,MAX.NO.
          1  2.0     1500.0       COM.TYPE,TURNOVER,MAX.NO.
          2  4.0     5.0          COM.TYPE,TURNOVER,MAX.NO.
          2  4.0     5.0          COM.TYPE,TURNOVER,MAX.NO.
          2  4.0     5.0          COM.TYPE,TURNOVER,MAX.NO.
          2  4.0     5.0          COM.TYPE,TURNOVER,MAX.NO.
          2  4.0     5.0          COM.TYPE,TURNOVER,MAX.NO.
          3  52.0    10.0         COM.TYPE,TURNOVER,MAX.NO.
          3  52.0    10.0         COM.TYPE,TURNOVER,MAX.NO.
          3  52.0    10.0         COM.TYPE,TURNOVER,MAX.NO.
          3  52.0    10.0         COM.TYPE,TURNOVER,MAX.NO.
          3  52.0    10.0         COM.TYPE,TURNOVER,MAX.NO.
          4  5.0     25.0         COM.TYPE,TURNOVER,MAX.NO.
          4  5.0     25.0         COM.TYPE,TURNOVER,MAX.NO.
          4  5.0     25.0         COM.TYPE,TURNOVER,MAX.NO.
          4  5.0     25.0         COM.TYPE,TURNOVER,MAX.NO.
          4  5.0     25.0         COM.TYPE,TURNOVER,MAX.NO.
          1  4.0     2000.0       COM.TYPE,TURNOVER,MAX.NO.
          1  4.0     2000.0       COM.TYPE,TURNOVER,MAX.NO.
          1  4.0     2000.0       COM.TYPE,TURNOVER,MAX.NO.
          1  4.0     2000.0       COM.TYPE,TURNOVER,MAX.NO.
          1  4.0     2000.0       COM.TYPE,TURNOVER,MAX.NO.
```

Figure 2. Printout of data input for Run 2.

```
        2   8.0      20.0         COM.TYPE,TURNOVER,MAX.NO.
        2   8.0      20.0         COM.TYPE,TURNOVER,MAX.NO.
        2   8.0      20.0         COM.TYPE,TURNOVER,MAX.NO.
        2   8.0      20.0         COM.TYPE,TURNOVER,MAX.NO.
        2   8.0      20.0         COM.TYPE,TURNOVER,MAX.NO.
        3   104.0    100.0        COM.TYPE,TURNOVER,MAX.NO.
        3   104.0    100.0        COM.TYPE,TURNOVER,MAX.NO.
        3   104.0    100.0        COM.TYPE,TURNOVER,MAX.NO.
        3   104.0    100.0        COM.TYPE,TURNOVER,MAX.NO.
        3   104.0    100.0        COM.TYPE,TURNOVER,MAX.NO.
        4   10.0     50.0         COM.TYPE,TURNOVER,MAX.NO.
        4   10.0     50.0         COM.TYPE,TURNOVER,MAX.NO.
        4   10.0     50.0         COM.TYPE,TURNOVER,MAX.NO.
        4   10.0     50.0         COM.TYPE,TURNOVER,MAX.NO.
        4   10.0     50.0         COM.TYPE,TURNOVER,MAX.NO.
    2  NUMBER OF THIEF TYPES
 3000   100    50    50        QUANTITIES PER THEFT  - TYPE 1
  500    10    20    10     LOW END OF RANGE
 7000  1000   200   100    HIGH END OF RANGE
   15     3     5     3        QUANTITIES PER THEFT  -  TYPE 2
    5     1     1     1    LOW END OF RANGE
   50    10    20    10    HIGH END OF RANGE
   10   NUMBER OF FENCES
400000.0      PRESENT BANKROLL
200000.0      PRESENT BANKROLL
200000.0      PRESENT BANKROLL
100000.0      PRESENT BANKROLL
100000.0      PRESENT BANKROLL
400000.0      PRESENT BANKROLL
200000.0      PRESENT BANKROLL
200000.0      PRESENT BANKROLL
100000.0      PRESENT BANKROLL
100000.0      PRESENT BANKROLL
```

Figure 2. Printout of data input for Run 2 (continued).

100 NUMBER OF THIEVES

1	1000.0	1	TYPE,MONEY NEED, FENCE
1	1000.0	2	TYPE,MONEY NEED, FENCE
1	1000.0	3	TYPE,MONEY NEED, FENCE
1	1000.0	4	TYPE,MONEY NEED, FENCE
1	1000.0	5	TYPE,MONEY NEED, FENCE
2	100.0	1	TYPE,MONEY NEED, FENCE
2	100.0	2	TYPE,MONEY NEED, FENCE
2	100.0	3	TYPE,MONEY NEED, FENCE
2	100.0	4	TYPE,MONEY NEED, FENCE
2	100.0	5	TYPE,MONEY NEED, FENCE
2	100.0	6	TYPE,MONEY NEED, FENCE
2	100.0	7	TYPE,MONEY NEED, FENCE
2	100.0	8	TYPE,MONEY NEED, FENCE
2	100.0	9	TYPE,MONEY NEED, FENCE
2	100.0	10	TYPE,MONEY NEED, FENCE
2	100.0	1	TYPE,MONEY NEED, FENCE
2	100.0	2	TYPE,MONEY NEED, FENCE
2	100.0	3	TYPE,MONEY NEED, FENCE
2	100.0	4	TYPE,MONEY NEED, FENCE
2	100.0	5	TYPE,MONEY NEED, FENCE
2	100.0	6	TYPE,MONEY NEED, FENCE
2	100.0	7	TYPE,MONEY NEED, FENCE
2	100.0	8	TYPE,MONEY NEED, FENCE
2	100.0	9	TYPE,MONEY NEED, FENCE
2	100.0	10	TYPE,MONEY NEED, FENCE
2	75.0	1	TYPE,MONEY NEED, FENCE
2	75.0	2	TYPE,MONEY NEED, FENCE
2	75.0	3	TYPE,MONEY NEED, FENCE
2	75.0	4	TYPE,MONEY NEED, FENCE
2	75.0	5	TYPE,MONEY NEED, FENCE
2	75.0	6	TYPE,MONEY NEED, FENCE
2	75.0	7	TYPE,MONEY NEED, FENCE
2	75.0	8	TYPE,MONEY NEED, FENCE
2	75.0	9	TYPE,MONEY NEED, FENCE
2	75.0	10	TYPE,MONEY NEED, FENCE
2	75.0	1	TYPE,MONEY NEED, FENCE

Figure 2. Printout of data input for Run 2 (continued).

2	75.0	2	TYPE,MONEY NEED, FENCE
2	75.0	3	TYPE,MONEY NEED, FENCE
2	75.0	4	TYPE,MONEY NEED, FENCE
2	75.0	5	TYPE,MONEY NEED, FENCE
2	75.0	6	TYPE,MONEY NEED, FENCE
2	75.0	7	TYPE,MONEY NEED, FENCE
2	75.0	8	TYPE,MONEY NEED, FENCE
2	75.0	9	TYPE,MONEY NEED, FENCE
2	75.0	10	TYPE,MONEY NEED, FENCE
2	75.0	1	TYPE,MONEY NEED, FENCE
2	75.0	2	TYPE,MONEY NEED, FENCE
2	75.0	3	TYPE,MONEY NEED, FENCE
2	75.0	4	TYPE,MONEY NEED, FENCE
2	75.0	5	TYPE,MONEY NEED, FENCE
2	50.0	1	TYPE,MONEY NEED, FENCE
2	50.0	2	TYPE,MONEY NEED, FENCE
2	50.0	3	TYPE,MONEY NEED, FENCE
2	50.0	5	TYPE,MONEY NEED, FENCE
2	50.0	6	TYPE,MONEY NEED, FENCE
2	50.0	7	TYPE,MONEY NEED, FENCE
2	50.0	8	TYPE,MONEY NEED, FENCE
2	50.0	9	TYPE,MONEY NEED, FENCE
2	50.0	10	TYPE,MONEY NEED, FENCE
2	50.0	1	TYPE,MONEY NEED, FENCE
2	50.0	2	TYPE,MONEY NEED, FENCE
2	50.0	3	TYPE,MONEY NEED, FENCE
2	50.0	4	TYPE,MONEY NEED, FENCE
2	50.0	5	TYPE,MONEY NEED, FENCE
2	50.0	6	TYPE,MONEY NEED, FENCE
2	50.0	7	TYPE,MONEY NEED, FENCE
2	50.0	8	TYPE,MONEY NEED, FENCE
2	50.0	9	TYPE,MONEY NEED, FENCE
2	50.0	10	TYPE,MONEY NEED, FENCE
2	50.0	6	TYPE,MONEY NEED, FENCE
2	50.0	7	TYPE,MONEY NEED, FENCE
2	50.0	8	TYPE,MONEY NEED, FENCE

Figure 2. Printout of data input for Run 2 (continued).

2	50.0	9	TYPE,MONEY NEED, FENCE
2	50.0	10	TYPE,MONEY NEED, FENCE
2	25.0	1	TYPE,MONEY NEED, FENCE
2	25.0	2	TYPE,MONEY NEED, FENCE
2	25.0	3	TYPE,MONEY NEED, FENCE
2	25.0	4	TYPE,MONEY NEED, FENCE
2	25.0	5	TYPE,MONEY NEED, FENCE
2	25.0	6	TYPE,MONEY NEED, FENCE
2	25.0	7	TYPE,MONEY NEED, FENCE
2	25.0	8	TYPE,MONEY NEED, FENCE
2	25.0	9	TYPE,MONEY NEED, FENCE
2	25.0	10	TYPE,MONEY NEED, FENCE
2	25.0	1	TYPE,MONEY NEED, FENCE
2	25.0	2	TYPE,MONEY NEED, FENCE
2	25.0	3	TYPE,MONEY NEED, FENCE
2	25.0	4	TYPE,MONEY NEED, FENCE
2	25.0	5	TYPE,MONEY NEED, FENCE
2	25.0	6	TYPE,MONEY NEED, FENCE
2	25.0	7	TYPE,MONEY NEED, FENCE
2	25.0	8	TYPE,MONEY NEED, FENCE
2	25.0	9	TYPE,MONEY NEED, FENCE
2	25.0	10	TYPE,MONEY NEED, FENCE
2	25.0	5	TYPE,MONEY NEED, FENCE
2	25.0	6	TYPE,MONEY NEED, FENCE
2	25.0	7	TYPE,MONEY NEED, FENCE
2	25.0	8	TYPE,MONEY NEED, FENCE
2	25.0	9	TYPE,MONEY NEED, FENCE
2	25.0	10	TYPE,MONEY NEED, FENCE

Figure 2. Printout of data input for Run 2 (continued).

not necessarily analyst use. As a consequence, the clarity of formatting can be improved significantly. The printout of the data input is particularly in need of further development and refinement.

As shown at the top of the first sheet of Figure 2, the simulation was run a total of 364 days; a printout of event detail for 10 events was begun on the 180th day; the number of days to be covered in each Periodic Cumulative Event Report was specified to be 7; and the number of periods to be contained within each Summary Statistics Report was specified to be 26. Therefore, two Summary Statistics Reports were produced during the run--one at day 182, and the other at day 364. Finally, the fraction of Market Price which a thief or fence will accept as the lower-bound basis for proportional payment was specified to be 0.5.

Commodity types and their characteristics are specified on the next four lines--jewelry (Commodity Type 1) on the first line, typewriters (Commodity Type 2) on the second line, firearms (Commodity Type 3) on the third line, and television sets (Commodity Type 4) on the fourth line. The characteristics of each commodity type are provided in the six columns--Market Price, Risk Factor A, Risk Factor B, fence to customer transaction time, fraction of Illegal Market Price paid to thief, and fraction of Illegal Market Price paid to fence.

Risk Factors A and B are estimates made by the analyst for use in the calculation of Risk employed, in turn, in the calculations to determine which commodity type will be stolen during the next theft. Risk is defined by the expression:

$$\text{RISK} = \frac{A}{\Delta t + 1} + B$$

Where: A and B are coefficients estimated and input by the analyst for each commodity type, and Δt is the time since the last theft committed by the thief.

The idea is that some commodities are more risky to steal than others, and that risk dissipates somewhat for any given thief with the passage of time since the thief's last theft. Consequently, values for A and B are selected to reflect the relative risk associated with stealing goods of each type included in the simulation run. As shown on the first sheet of Figure 2, values of A and B were chosen for jewelry so that the maximum risk (when $\Delta t = 0$) would be 7 ($A + B = 6 + 1 = 7$). The values of A and B were chosen for firearms so that maximum risk would be 10 at $\Delta t = 0$, ($A + B = 9 + 1 = 10$). As Δt increases, the Risk factor for each of these commodities would decrease, ultimately, down to a value of 1 in each case; however, the Risk factor for firearms would remain greater than that for jewelry until this minimum value was reached. Of course, values of B need not be the same for all commodity types, as they are in this run, so that commodity types may differ with respect to minimum risk values as well.

The next section of the printout provides the characteristics put in for the 40 customers included in the simulation run. As indicated by the labels to the right of the three columns, Column 1 identifies commodity type; Column 2 provides turnover rate; and Column 3 provides maximum number of stolen goods that the customer will keep on hand at any given time.

In the next section, the two thief types are defined for each of the four commodities. The average, minimum, and maximum numbers of goods stolen per theft of each commodity type is given for each of the two types of thieves. For example, in Column 1 the average number of goods stolen during a jewelry (Commodity Type 1) theft by Thief Type 1 is shown as 3000; the minimum number is 500, and the maximum number is 7000.

In the next section, the initial bankroll for each of the 10 fences included in the simulation model are listed.

Finally, the characteristics of each of the 100 thieves included in the simulation run--thief-type, money needed per day, and associated fence--are presented. Thief-type is in Column 1, money need is in Column 2, and associated fence is in Column 3.

PERIODIC CUMULATIVE EVENT REPORTS

The first five Periodic Cumulative Event Reports printed for Simulation Run 2 are shown in Figure 3. Theft statistics, fence/customer activity, and customer data were accumulated and printed out for each period. Since the

PRESENT TIME (DAYS) IS- 7

COMMODITY TYPE	NUMBER THEFTS	DOLLAR VALUE	NUMBER STOLEN	DOLLARS RECEIVED	AVERAGE UN-FENCED	DOL.VALUE FENCED	NUMBER FENCED	AVE.ILLEG. HOLDINGS	MARKET COST (AVE)
	---THEFT STATISTICS---				---FENCE/CUSTOMER ACTIVITY---			---CUSTOMER DATA---	
1	43	608234	16220	239123	14	586083	16079	1458	18
2	28	56240	124	8527	2	42808	107	9	229
3	77	106986	669	36704	2	87821	645	20	122
4	38	47072	207	6590	1	40564	198	17	157

PRESENT TIME (DAYS) IS- 14

COMMODITY TYPE	NUMBER THEFTS	DOLLAR VALUE	NUMBER STOLEN	DOLLARS RECEIVED	AVERAGE UN-FENCED	DOL.VALUE FENCED	NUMBER FENCED	AVE.ILLEG. HOLDINGS	MARKET COST (AVE)
	---THEFT STATISTICS---				---FENCE/CUSTOMER ACTIVITY---			---CUSTOMER DATA---	
1	6	5346	143	1071	22	1135	60	1322	18
2	3	6275	14	494	2	3213	14	8	204
3	95	127014	794	34377	5	83402	766	24	106
4	26	28204	124	2563	3	13809	103	22	118

PRESENT TIME (DAYS) IS- 21

COMMODITY TYPE	NUMBER THEFTS	DOLLAR VALUE	NUMBER STOLEN	DOLLARS RECEIVED	AVERAGE UN-FENCED	DOL.VALUE FENCED	NUMBER FENCED	AVE.ILLEG. HOLDINGS	MARKET COST (AVE)
	---THEFT STATISTICS---				---FENCE/CUSTOMER ACTIVITY---			---CUSTOMER DATA---	
1	2	1659	44	334	18	1653	88	1204	19
2	5	9872	22	768	2	3187	14	8	235
3	106	145235	908	34196	10	81749	863	23	103
4	11	13114	58	1038	3	6840	59	22	114

PRESENT TIME (DAYS) IS- 28

COMMODITY TYPE	NUMBER THEFTS	DOLLAR VALUE	NUMBER STOLEN	DOLLARS RECEIVED	AVERAGE UN-FENCED	DOL.VALUE FENCED	NUMBER FENCED	AVE.ILLEG. HOLDINGS	MARKET COST (AVE)
	---THEFT STATISTICS---				---FENCE/CUSTOMER ACTIVITY---			---CUSTOMER DATA---	
1	11	11039	294	2215	38	1681	89	1115	19
2	5	8998	20	713	3	2978	13	8	223
3	102	134097	838	33319	8	84176	851	37	73
4	10	10092	44	785	2	6651	58	23	112

PRESENT TIME (DAYS) IS- 35

COMMODITY TYPE	NUMBER THEFTS	DOLLAR VALUE	NUMBER STOLEN	DOLLARS RECEIVED	AVERAGE UN-FENCED	DOL.VALUE FENCED	NUMBER FENCED	AVE.ILLEG. HOLDINGS	MARKET COST (AVE)
	---THEFT STATISTICS---				---FENCE/CUSTOMER ACTIVITY---			---CUSTOMER DATA---	
1	6	167757	4474	33792	404	15418	818	1076	18
2	12	18914	42	1479	5	6166	27	8	224
3	114	137572	860	32390	10	81878	838	21	109
4	13	13699	60	1076	2	6254	54	22	117

Figure 3. First five Periodic Cumulative Event Reports for Run 2.

analyst specified a seven-day report period, information was accumulated and printed out each seven days. After the seventh day, when an output is printed, the slate is wiped clean and all values begin at zero at the beginning of the next period.

The five reports shown in Figure 3 demonstrate some of the dynamics of the simulation model. As a function of the conditions which drive the theft and fencing events, there appears to be substantial variation in measures from period to period. Of course, these five reports cover only the first 35 days of the simulation run, a period of time when conditions are not likely to be as stable as later in the run. However, reports printed at days 168, 175, and 182, shown in Figure 4, still reflect notable periodic differences.

SUMMARY STATISTICS REPORT

As requested for Run 2, Summary Statistics Reports were provided at day 182 and day 364. The report printed at day 182 is shown in Figure 4; it is the fourth report down from the top of the sheet. This report provides summary statistics for the data accumulated during the first 182 days of the simulation run. Average values are calculated from the accumulated data and presented for each commodity type in the Summary Statistics Report. For example, the report in Figure 4 shows that, for jewelry, an average of 1.13 thefts per day took place; that the average value per theft was $9,495; that the average number stolen was 253 units; that the thief received $2,485 on the average per theft, and so on.

Each Summary Statistics Report is based only on the data accumulated for the number of periods specified by the analyst. That is, the report at 182 days is based only on data accumulated during that 182 day period; the report provided at day 364 is based only on data accumulated from day 182 through day 364. If a Summary Statistics Report for the entire 12-month period were required, the analyst would need to combine the two six-month reports.

PRESENT TIME (DAYS) IS- 168

COMMODITY TYPE	THEFT STATISTICS: NUMBER THEFTS	DOLLAR VALUE	NUMBER STOLEN	DOLLARS RECEIVED	FENCE/CUSTOMER ACTIVITY: AVERAGE UN-FENCED	DOL.VALUE FENCED	NUMBER FENCED	CUSTOMER DATA: AVE.ILLEG. HOLDINGS	MARKET COST (AVE)
1	6	5542	148	1113	725	28432	1508	1231	18
2	0	0	0	0	141	0	0	9	182
3	95	207038	1294	46818	93	122894	1253	41	92
4	17	21868	96	1716	15	6862	59	23	112

PRESENT TIME (DAYS) IS- 175

COMMODITY TYPE	THEFT STATISTICS: NUMBER THEFTS	DOLLAR VALUE	NUMBER STOLEN	DOLLARS RECEIVED	FENCE/CUSTOMER ACTIVITY: AVERAGE UN-FENCED	DOL.VALUE FENCED	NUMBER FENCED	CUSTOMER DATA: AVE.ILLEG. HOLDINGS	MARKET COST (AVE)
1	1	872	23	177	622	20067	1054	1220	19
2	0	0	0	0	139	4860	21	9	235
3	59	100439	628	24250	63	88361	921	28	98
4	12	31434	138	2455	21	9112	79	25	113

PRESENT TIME (DAYS) IS- 182

COMMODITY TYPE	THEFT STATISTICS: NUMBER THEFTS	DOLLAR VALUE	NUMBER STOLEN	DOLLARS RECEIVED	FENCE/CUSTOMER ACTIVITY: AVERAGE UN-FENCED	DOL.VALUE FENCED	NUMBER FENCED	CUSTOMER DATA: AVE.ILLEG. HOLDINGS	MARKET COST (AVE)
1	8	116255	3100	23619	729	38634	2030	1312	18
2	5	9702	21	771	138	7291	31	10	177
3	102	234797	1467	53971	97	109637	1132	50	60
4	1	1494	7	116	13	10072	86	28	112

SUMMARY STATISTICS- TIME (DAYS) IS 182

COMMODITY TYPE	THEFT RATE PER DAY	AVE.VALUE PER THEFT	AVE.STOLEN PER THEFT	DOLLARS RE-CEIVED/THEFT	AVERAGE UN-FENCED	VAL.FENCED PER DAY	NUM.FENCED PER DAY	AVE.ILLEG. HOLDINGS	MARKET COST (AVE)
1	1.13	9495	253	2485	375	6192	245	1217	18
2	.94	5314	12	443	82	885	3	9	208
3	13.43	1730	11	406	57	13687	140	31	97
4	1.77	1419	6	122	8	1311	10	23	116

PRESENT TIME (DAYS) IS- 189

COMMODITY TYPE	THEFT STATISTICS: NUMBER THEFTS	DOLLAR VALUE	NUMBER STOLEN	DOLLARS RECEIVED	FENCE/CUSTOMER ACTIVITY: AVERAGE UN-FENCED	DOL.VALUE FENCED	NUMBER FENCED	CUSTOMER DATA: AVE.ILLEG. HOLDINGS	MARKET COST (AVE)
1	0	0	0	0	526	38522	2027	1363	17
2	0	0	0	0	138	0	0	8	214
3	70	141543	885	33477	84	97803	1012	28	110
4	1	13241	58	1036	15	4919	42	24	107

Figure 4. A Summary Statistics Report together with surrounding Periodic Cumulative Event Reports for Run 2.

EVENT DETAIL REPORTS

Examples of Event Detail Reports are shown in Figures 5 and 6. In Figure 5, the status of fence and customer stocks is shown immediately after the transaction involving the sale of stolen goods from thief 72 to fence 7. This event took place at clock time 180.0999.

The Market Cost (price paid to fence) at the most recent fencing event is shown for each commodity type on the first line; commodity type number corresponds to the column. For example, the Market Cost for typewriters (Commodity Number 2), $226.99, is shown in the second column. This is the amount that the customer paid the fence during the last transaction for stolen goods of that commodity type.

The stocks of each commodity type held by fences are listed next in the appropriate columns. Although these numbers are each carried to some number of decimal places, this was done again only to facilitate the computer programming. The amounts of stolen goods shown to be held by each fence should be rounded to the nearest whole number. For example, the number of items of Commodity Type 1 held by the first fence is 3,340, not 3,339.852.

The customer stocks of stolen goods are listed at the bottom of the sheet; however, they are not listed in columns according to commodity types as are the fence stocks. Due to the way that the data were entered for these simulation runs, commodity types are differentiated by rows--Commodity Type 1 in Row 1, Commodity Type 2 in Row 2, Commodity Type 3 in Row 3, and Commodity Type 4 in Row 4. The same sequence is then repeated again in the bottom four lines. As in the case of the fence stocks, these numbers should be rounded to the nearest whole number for purposes of interpretation and data analysis. The first listed customer, for example, holds 1,251 units of Commodity Type 1, not 1,250.629 units.

SIMULATION RUN COMPARISONS

Although the only variations made from run to run were in the ratios among the numbers of thieves, fences, and customers, these differences do provide a basis for comparing simulation runs and therefore, making a preliminary examination of the potential sensitivity of the simulation model.

THIEF	72				
FENCE	7				
*****CLOCK	180.0999				
MKT CLOSE	17.29037	226.9903	97.83953	112.4540	
FNCE STOCK	3339.852	30.95894	85.56953	4.384793	
FNCE STOCK	2427.295	340.9244	118.6960	21.87306	
FNCE STOCK	18.87962	363.6671	6.970390	0.	
FNCE STOCK	933.5266	214.7527	225.6478	3.651330	
FNCE STOCK	0.	292.2741	9.902806	0.	
FNCE STOCK	0.	22.31637	1.469521	0.	
FNCE STOCK	219.3150	66.63804	397.3510	57.41574	
FNCE STOCK	72.62821	19.78826	35.11894	23.51119	
FNCE STOCK	131.9575	20.24085	47.08778	0.	
FNCE STOCK	141.6689	9.182233	21.35809	26.51426	
CUST STOCK	1250.629	901.5626	892.8648	1262.051	1285.207
	3.231913	3.291213	3.291213	3.116500	3.116500
	4.920913	4.920913	4.920913	4.920913	4.920913
	16.60635	12.64242	23.88908	17.77809	20.97374
	1826.201	1077.847	1122.959	1963.965	1729.258
	16.67506	16.07959	17.29258	17.93298	10.02241
	38.85029	62.33000	62.33000	66.79514	40.90193
	41.68765	39.83517	41.68765	26.64960	33.76167

Figure 5. Event Detail Report showing status after the theft event involving Thief 72 and Fence 7, during Run 2.

FENCE	3				
CUSTOMER	34				
*****CLOCK	180.0452				
MKT CLOSE	17.29937	226.9903	97.83953	112.4540	
FNCE STOCK	3339.852	30.95894	85.56953	4.384793	
FNCE STOCK	2427.295	340.9244	118.6960	21.87306	
FNCE STOCK	18.87962	363.6671	0.	0.	
FNCE STOCK	933.5266	214.7527	158.8118	3.651330	
FNCE STOCK	0.	292.2741	9.902806	0.	
FNCE STOCK	0.	22.31637	1.469521	0.	
FNCE STOCK	219.3150	66.63804	388.4573	57.41574	
FNCE STOCK	72.62821	19.78826	35.11894	23.51119	
FNCE STOCK	131.9575	20.24085	47.08778	0.	
FNCE STOCK	141.6689	9.182233	21.35809	26.51426	
CUST STOCK	1250.629	901.5626	892.8648	1262.051	1285.207
	3.231913	3.291213	3.291213	3.116500	3.116500
	4.920913	4.920913	4.920913	4.920913	4.920913
	15.50635	12.64242	23.88908	17.77809	20.97374
	1826.201	1077.847	1122.959	1963.965	1729.258
	16.67506	16.07959	17.29258	17.93298	10.02241
	38.85029	62.33000	62.33000	66.79514	40.90193
	41.68765	39.83517	41.68765	26.64960	33.76167

Figure 6. Event Detail Report showing status after the fencing event involving Fence 3 and Customer 34, during Run 2.

The summary statistics reported in the Summary Statistics Report of day 364 were each charted for the four simulation runs. These charts are presented in figures on the following pages. They are provided here primarily to give the reader some feeling for the kinds of assessments possible through use of the model. There is no implication whatever that these results accurately reflect the characteristics of organized fencing within the State of California or any where else. What they do show, however, is the type of results obtainable with the simulation model as currently configured, and some of the types of experimentation possible by the analyst through manipulation of the model.

Some of the preliminary results are sufficiently interesting to bear further investigation, from two points of view--to learn more about the nature of organized fencing and to learn more about the operation of the simulation model. For example, Figure 7 shows a notable increase in theft rate per day during Run 3. During this run, the number of fences was reduced relative to the number of thieves and number of customers. As shown in Figure 7, theft rate for both firearms and typewriters were substantially greater during this run than during the other runs; the impact on television sets and jewelry was relatively minor, on the other hand.

In Figure 8, Run 2 is shown to have produced a substantial increase in value per theft for typewriters, but to have had relatively little impact on the other commodity types--jewelry, firearms, and television sets. In Run 2 the number of thieves was reduced relative to the numbers of fences and customers. The results shown in Figures 9 and 10 are consistent with those shown in Figure 8. Figure 9 shows that the average number of units stolen per theft was greater in Run 2 for typewriters; Figure 10 shows that amount received per theft by the thief was greater in Run 2 for typewriters.

The impact of reducing the number of fences relative to numbers of thieves and customers in Run 3 was, as shown in Figure 7, to increase the theft rate, particularly for firearms and television sets. As shown in Figure 11, the increase in theft rate combined with the smaller number of fences to result in significantly greater numbers of unfenced goods held by fences in Run 3 than in the other runs. The greatest contrast is between

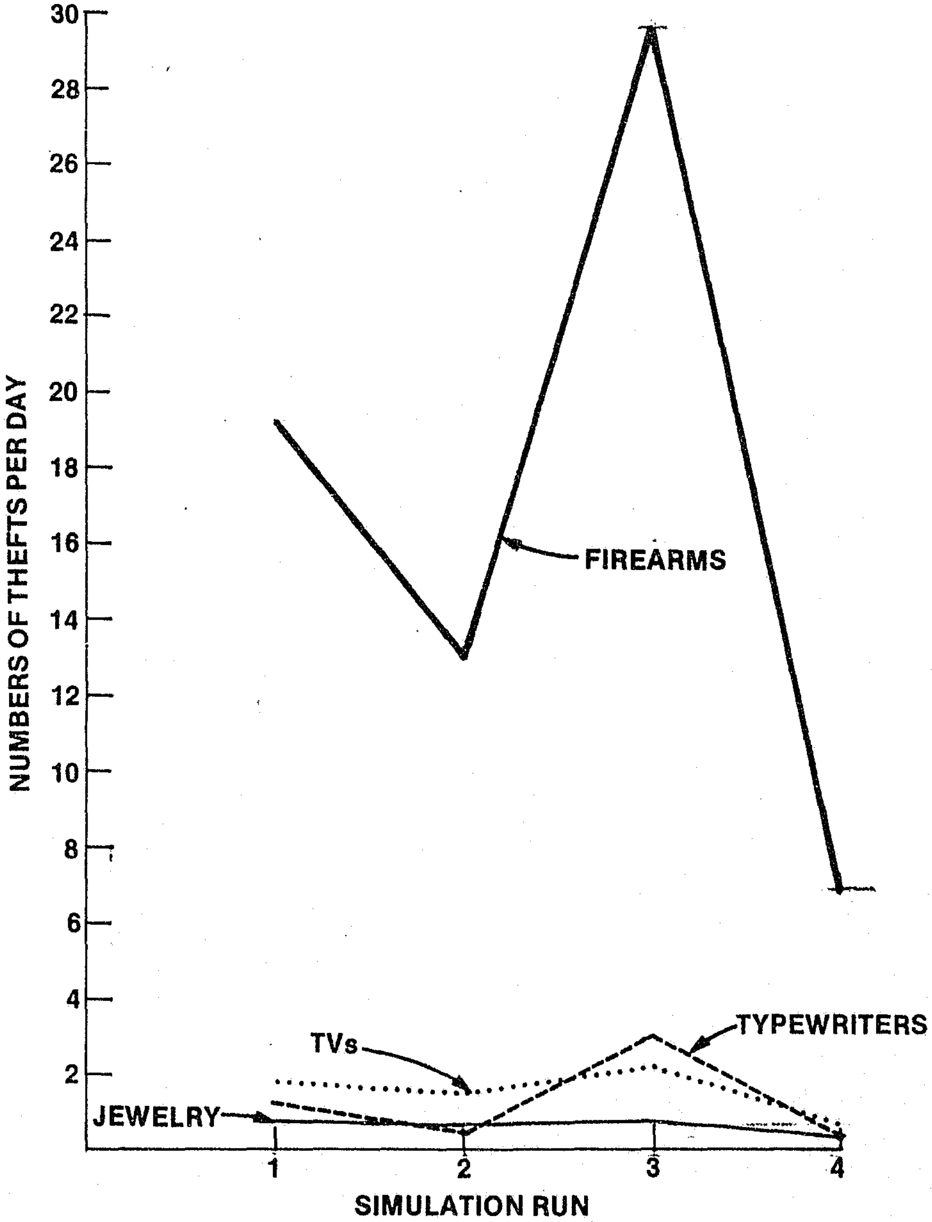

Figure 7. Theft rate by commodity type in each of four simulation runs.

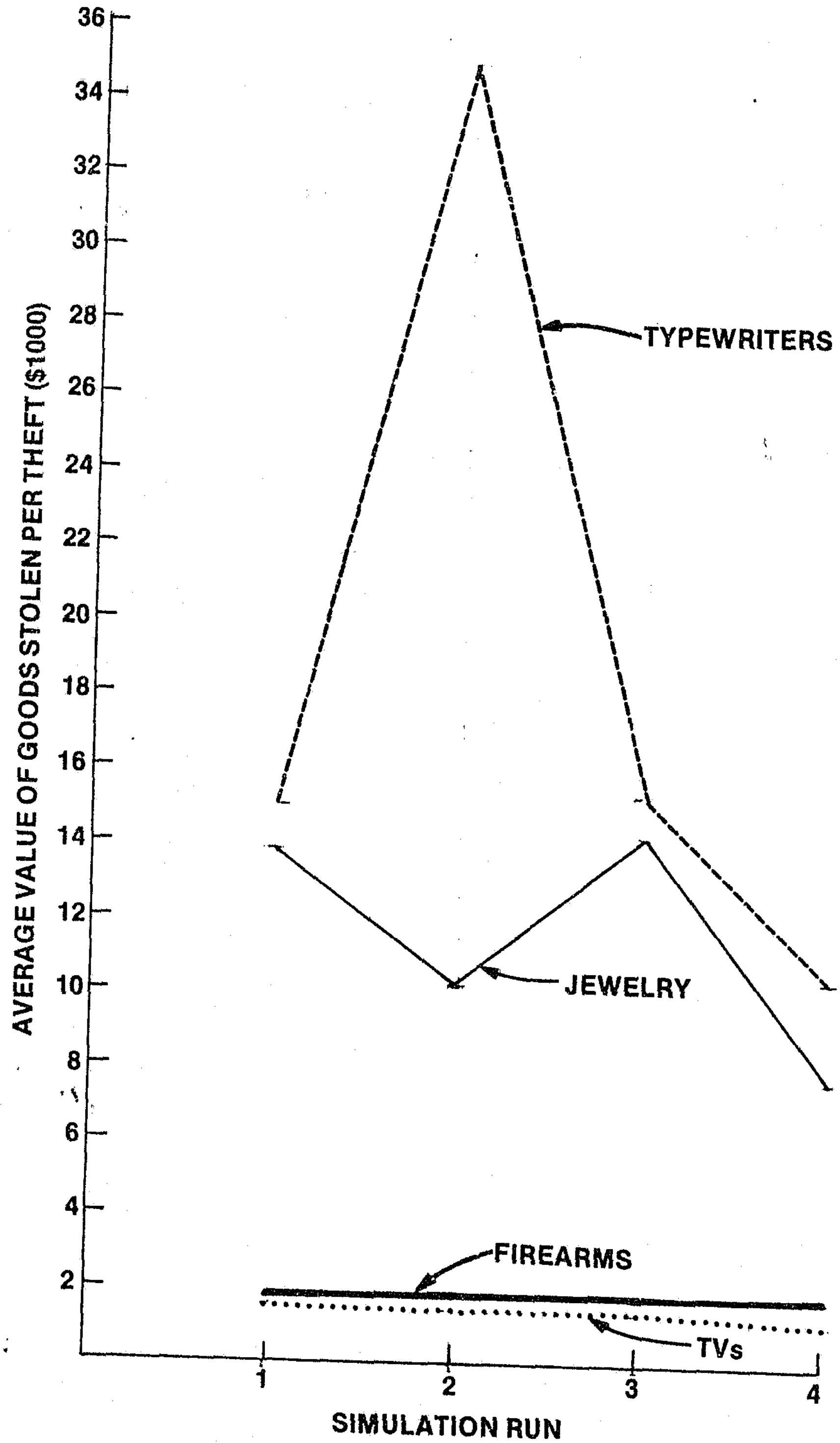

Figure 8. Average theft value by commodity type in each of four simulation runs.

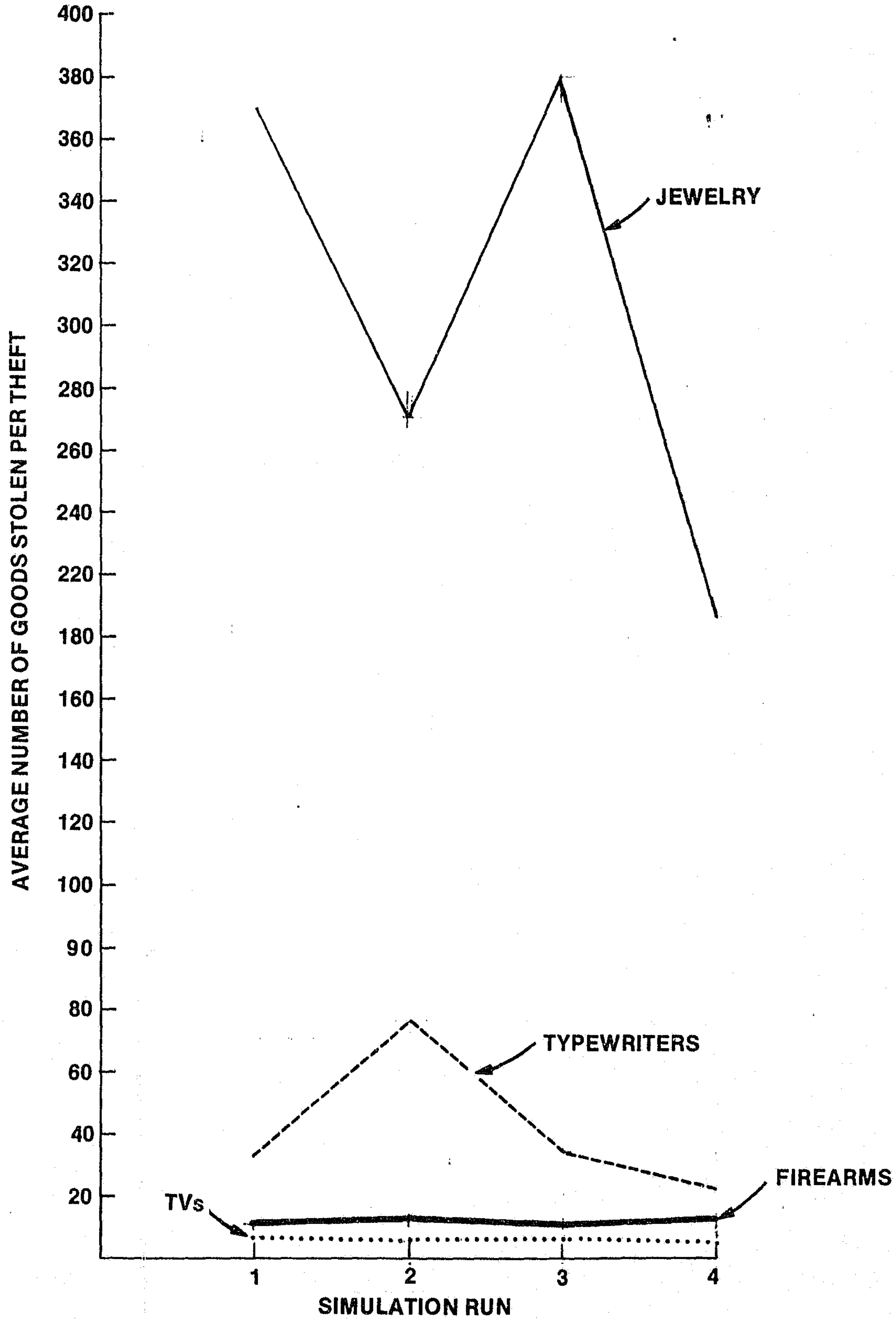

Figure 9. Average number of goods stolen of each commodity type in each of four simulation runs.

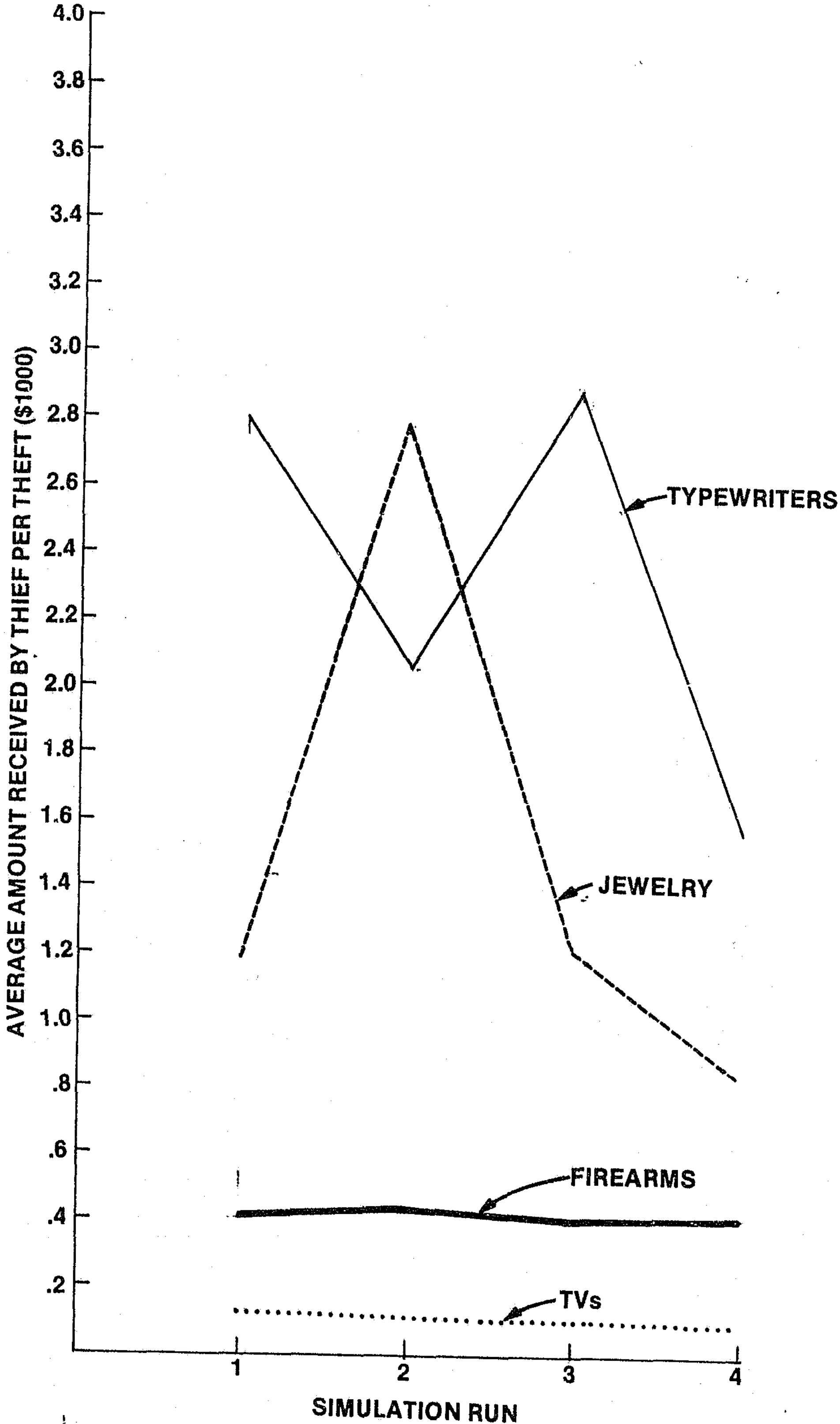

Figure 10. Average amount received per theft by the thief for each commodity type in each of four simulation runs.

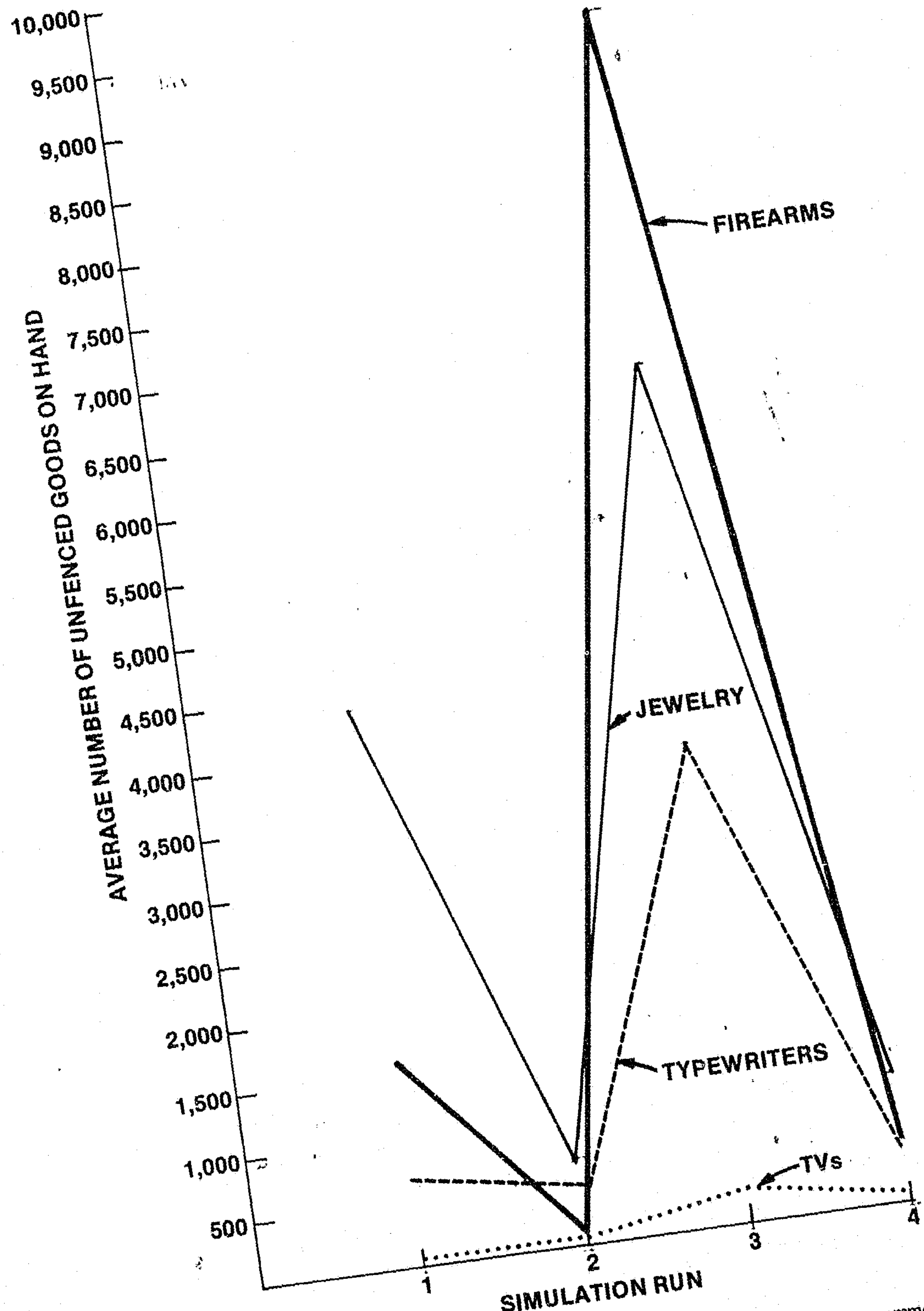

Figure 11. Average number of unfenced goods of each commodity type in each simulation run.

Runs 2 and 3. In Run 2, the reduction in ratio of thieves to fences and customers produced low levels of unfenced goods, whereas in Run 3 the reduction in ratio of fences to thieves and customers produced relatively high levels of unfenced goods.

The results shown in Figure 12 and Figure 13 suggest that reducing the number of customers relative to thieves and fences substantially reduces both the value and the number of stolen goods fenced per day, for each commodity type.

The average number of stolen goods held by customers appeared to be relatively immune to the manipulation of ratios among numbers of thieves, fences and customers. As shown in Figure 14, average holdings of stolen goods were relatively stable over the four simulation runs.

Finally, as shown in Figure 15, there were some slight differences among the different commodity types relative to average Market Cost. For example, highest average Market Cost for typewriters occurred during Runs 1 and 2, and the lowest average Market Cost occurred during Run 3. On the other hand, the lowest average Market Cost for jewelry varied hardly at all.

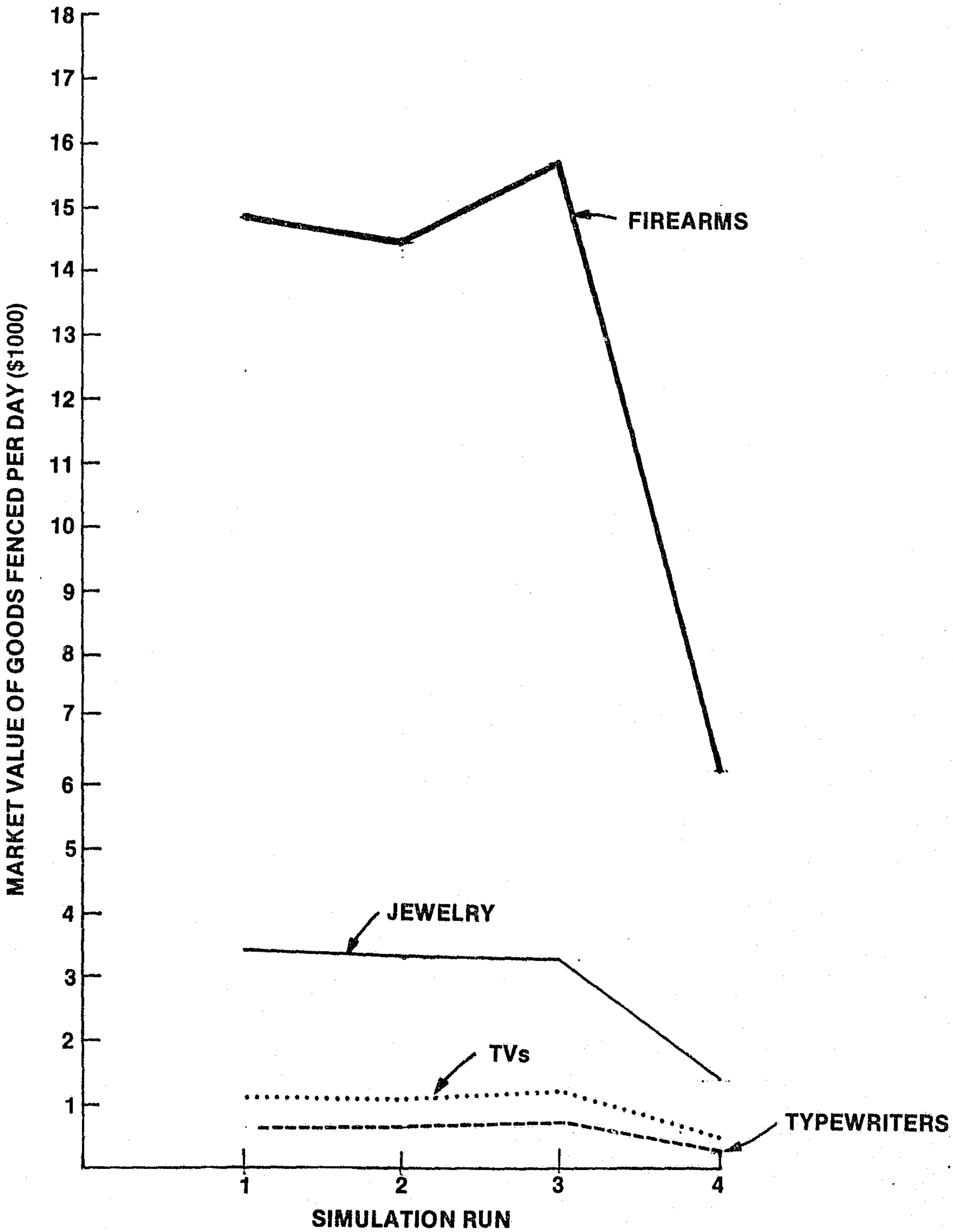

Figure 12. Average value of stolen goods of each commodity type fenced per day in each simulation run.

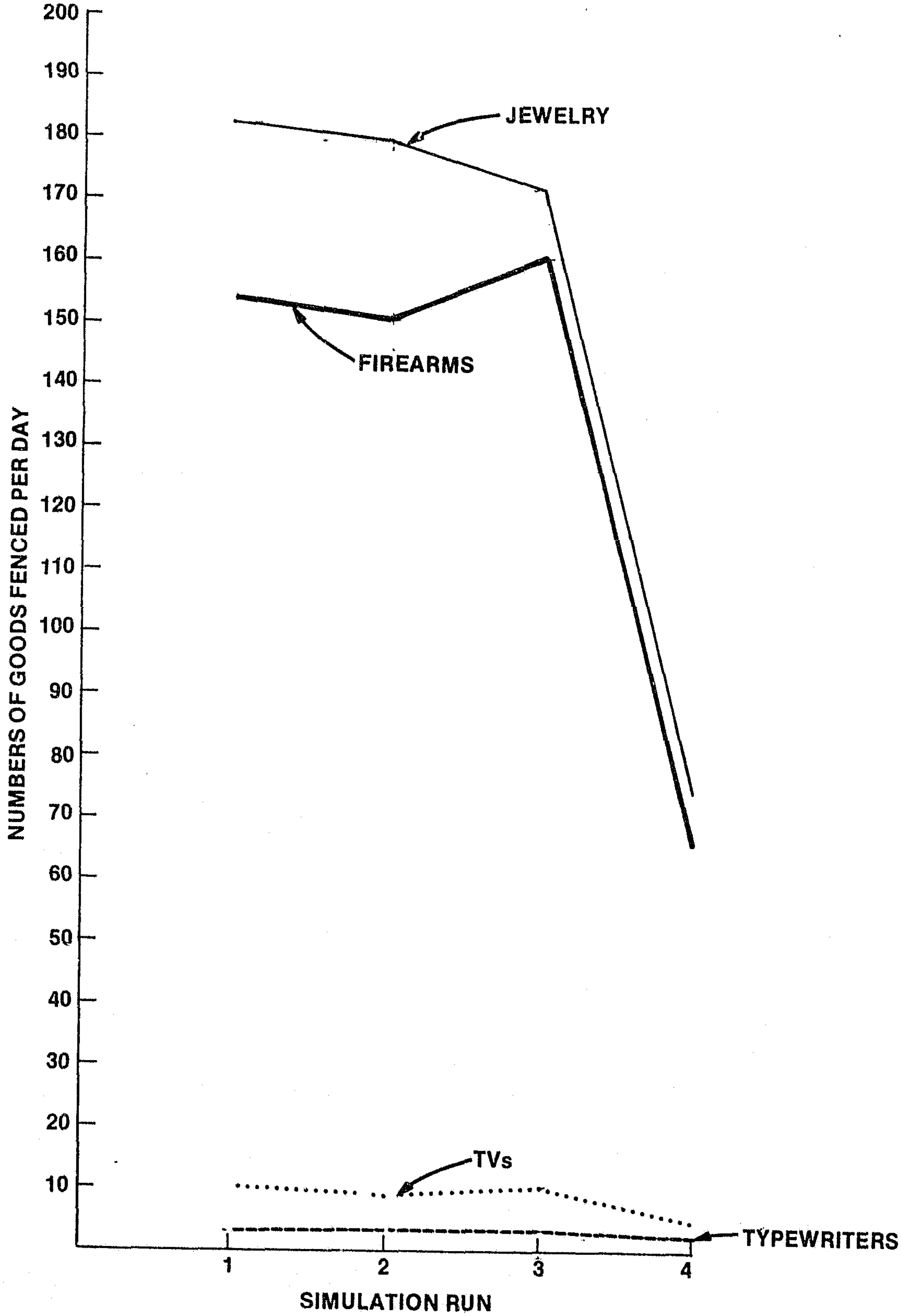

Figure 13. Average number of stolen goods fenced per day of each commodity type in each simulation run.

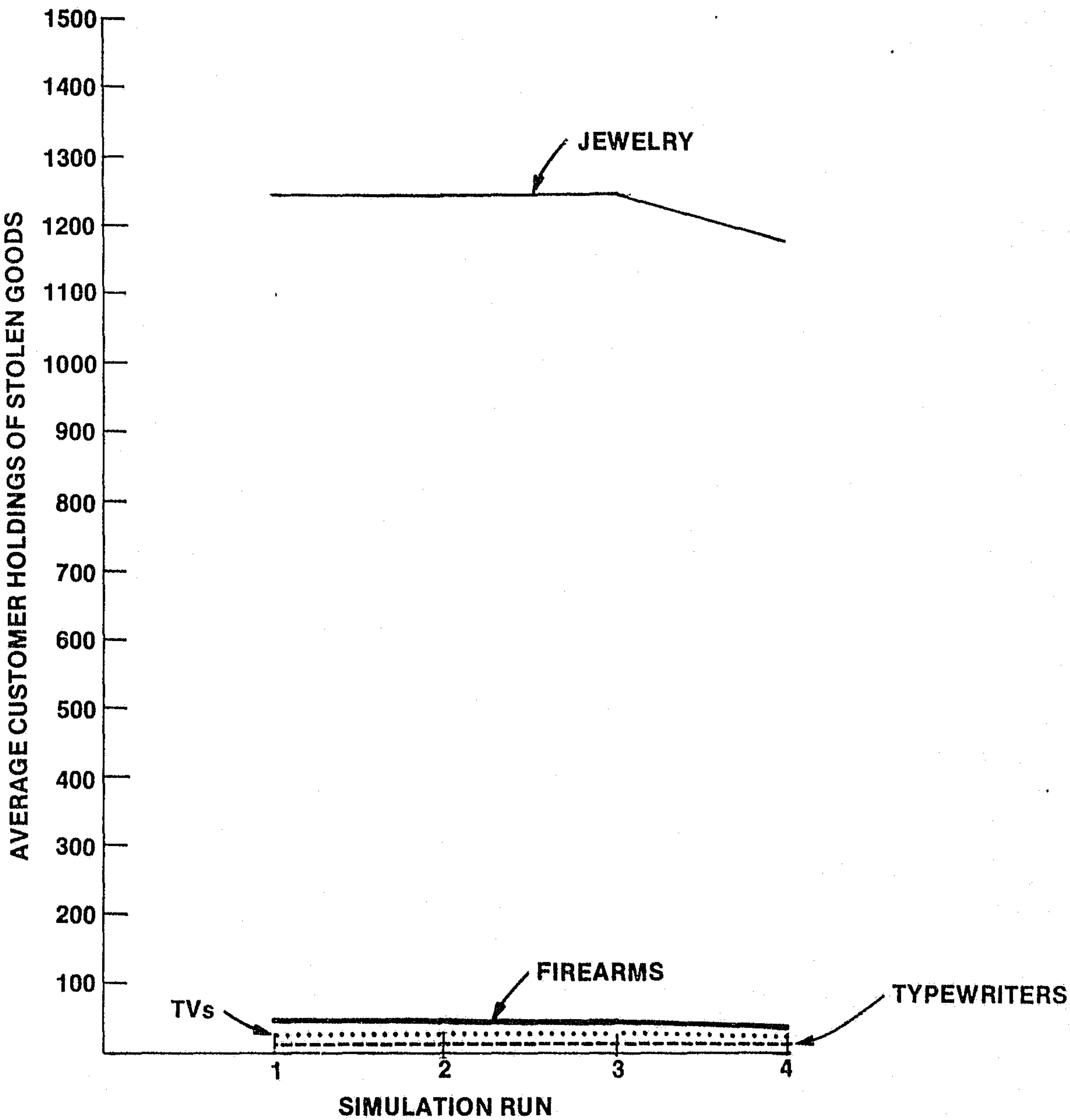

Figure 14. Average number of stolen goods of each commodity type held by customers during each simulation run.

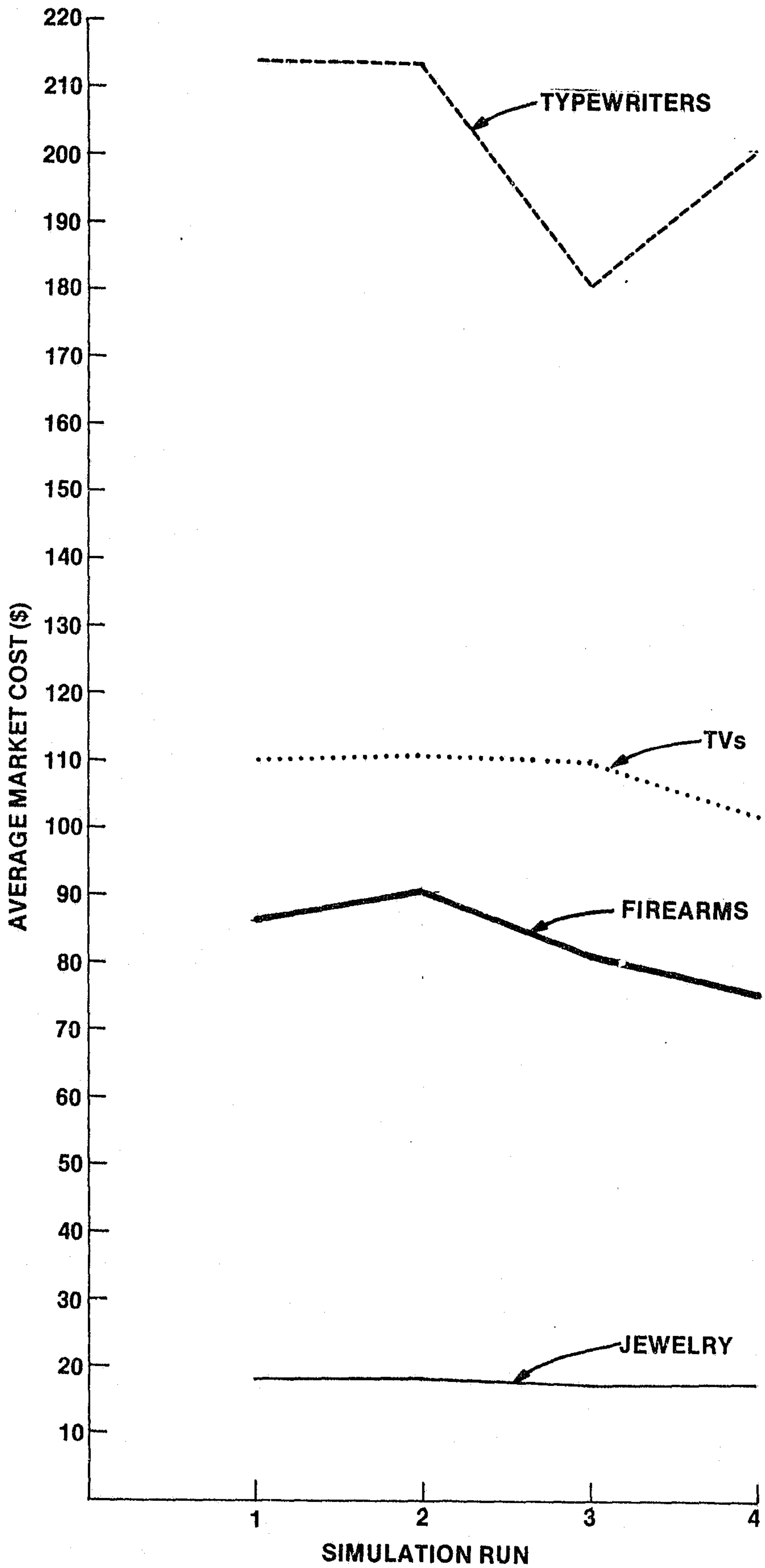

Figure 15. Average Market Cost by commodity type in each of four simulation runs.

CONCLUSIONS

A working, computer-based simulation of organized fencing was developed. The simulation model encompassed the primary entities, events, and relationships that comprise the fencing of stolen goods at the professional level. Furthermore, the model appears to be of sufficient scope and flexibility to enable criminal intelligence analysts to gain an understanding of fencing operations, to provide a framework for building a theory of organized fencing, and to examine the potential impact of strategic countermeasures.

However, although the simulation model is useful in its present form, further testing and refinement are required. At this point, the model has not been subjected to any operational testing involving analytical personnel nor has it been designed in conformance with human factors engineering principles. For example, there are numerous improvements needed in the organization, formatting, and content of both inputs to the model and outputs from simulation runs. Operational testing is likely to reveal the need for additional changes that will enhance the potential of the model.

The results of the project suggest that simulation models are potentially useful tools, in general, for the analysis of organized crime. Although the computer simulation of organized fencing was, admittedly, a project of limited scope, the experience revealed several potential benefits. First, the development process itself forces issues and questions that must be faced and handled at greater levels of detail than they would otherwise. Second, a simulation model provides a framework for organizing what is known about an organized criminal system, and, through manipulation of key variables, a way to develop greater understanding of how the systems might operate. Third, after confidence has been gained that the model adequately reflects the real system, strategic countermeasures can be developed and their impact estimated prior to the expenditure of personnel and equipment resources. Finally, the simulation model appears to have potential as a training aid, providing a means for "hands on" training to facilitate learning about the more complex and sophisticated criminal systems.

REFERENCES

Abelson, R. P. Simulation of social behavior. In G. Lindzey & E. Aronson, *Handbook of social psychology*, 2nd ed., volume 2, 276-356. Reading: Addison-Wesley, 1968.

Barton, R. E. *A primer on simulation and gaming*. Englewood Cliffs: Prentice-Hall, 1970.

Chamber of Commerce of the United States. Handbook on white collar crime. Washington, D.C., 1974.

Governor's Organized Crime Prevention Commission. 1974 annual report and guidelines for a comprehensive plan. Santa Fe, New Mexico, December 1974.

Harris, D. H., de M[illegible]e, R., Sjovold, A. & Ford, L. R. Advanced analysis aids requirements and concepts. Santa Barbara, California: Anacapa Sciences, Inc., Technical Report 189-1, March 1974.

Harris, D. H. & Ford, L. R. A computer-based program for criminal intelligence analysis. Santa Barbara, California: Anacapa Sciences, Inc., Technical Report 189-2, August 1975.

Klockars, C. B. *The professional fence*. New York: The Free Press, 1974.

McGrath, E. J. & Irving, D. C. Techniques for efficient monte carlo simulation. Volume 2: RAN-ETC. La Jolla, California: Science Applications, Inc., March 1973 (AD 762 722).

Roselius, T. & Benton, D. Marketing theory and the fencing of stolen goods. Fort Collins: Colorado State University, August 1971 (PB 207 848).

APPENDIX

ORGANIZED FENCING SIMULATION

DATA INPUT

SIMULATION RUN SET-UP

1. STOP the run after ________ DAYS.
2. Provide EVENT DETAIL starting at DAY ________.
3. Provide EVENT DETAIL for ________ (NUMBER) of events.

   CAUTION Only about two events can be printed out per sheet; therefore, caution should be exercised to avoid getting more printed material than can be used.

4. Print PERIODIC CUMULATIVE EVENT SUMMARY every ________ DAYS.
5. Print SUMMARY STATISTICS every ________ PERIODS.
6. Lowest purchase price acceptable to thief or fence (before discount) is ________ (PROPORTION) of the market price.

COMMODITY DATA

7. Number of COMMODITY TYPES in this run is ________ (MAXIMUM = 10).

COMMODITY TYPE		MARKET PRICE ($)	RISK FACTOR		FENCE-CUSTOMER TRANSACTION TIME (DAYS)	PROPORTION OF MKT PR TO THIEF	PROPORTION OF MKT PR TO FENCE
NO.	NAME		A	B			
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

CUSTOMER DATA

8. Number of CUSTOMERS this run is ________ (MAXIMUM = 100).

CUSTOMER NO.	COMMODITY TYPE NO.	TURNOVER RATE	MAXIMUM SUPPLY (NO.)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			

CUSTOMER NO.	COMMODITY TYPE NO.	TURNOVER RATE	MAXIMUM SUPPLY (NO.)
26			
27			
28			
29			
30			
31			
32			
33			
34			
35			
36			
37			
38			
39			
40			
41			
42			
43			
44			
45			
46			
47			
48			
49			
50			

CUSTOMER DATA (Cont.)

CUSTOMER NO.	COMMODITY TYPE NO.	TURNOVER RATE	MAXIMUM SUPPLY (NO.)
51			
52			
53			
54			
55			
56			
57			
58			
59			
60			
61			
62			
63			
64			
65			
66			
67			
68			
69			
70			
71			
72			
73			
74			
75			

CUSTOMER NO.	COMMODITY TYPE NO.	TURNOVER RATE	MAXIMUM SUPPLY (NO.)
76			
77			
78			
79			
80			
81			
82			
83			
84			
85			
86			
87			
88			
89			
90			
91			
92			
93			
94			
95			
96			
97			
98			
99			
100			

THIEF TYPE DATA

9. Number of THIEF TYPES this run is ________ (1 or 2).

THIEF TYPE		AMOUNT STOLEN PER THEFT				
		COMMODITY TYPE NUMBER				
		1	2	3	4	5
1	AVERAGE					
	MINIMUM					
	MAXIMUM					
2	AVERAGE					
	MINIMUM					
	MAXIMUM					

THIEF TYPE		AMOUNT STOLEN PER THEFT				
		COMMODITY TYPE NUMBER				
		6	7	8	9	10
1	AVERAGE					
	MINIMUM					
	MAXIMUM					
2	AVERAGE					
	MINIMUM					
	MAXIMUM					

FENCE DATA

10. NUMBER OF FENCES this run is ________ (MAXIMUM = 20).

FENCE NO.	1	2	3	4
CAPITAL ($)				

FENCE NO.	5	6	7	8
CAPITAL ($)				

FENCE NO.	9	10	11	12
CAPITAL ($)				

FENCE NO.	13	14	15	16
CAPITAL ($)				

FENCE NO.	17	18	19	20
CAPITAL ($)				

THIEF DATA

11. Number of THIEVES this run is _______ (MAXIMUM = 200).

THIEF NO.	TYPE (1 or 2)	$ NEED PER DAY	FENCE NO.
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			

THIEF NO.	TYPE (1 or 2)	$ NEED PER DAY	FENCE NO.
26			
27			
28			
29			
30			
31			
32			
33			
34			
35			
36			
37			
38			
39			
40			
41			
42			
43			
44			
45			
46			
47			
48			
49			
50			

THIEF DATA (Cont.)

THIEF NO.	TYPE (1 or 2)	$ NEED PER DAY	FENCE NO.
51			
52			
53			
54			
55			
56			
57			
58			
59			
60			
61			
62			
63			
64			
65			
66			
67			
68			
69			
70			
71			
72			
73			
74			
75			

THIEF NO.	TYPE (1 or 2)	$ NEED PER DAY	FENCE NO.
76			
77			
78			
79			
80			
81			
82			
83			
84			
85			
86			
87			
88			
89			
90			
91			
92			
93			
94			
95			
96			
97			
98			
99			
100			

THIEF DATA (Cont.)

THIEF NO.	TYPE (1 or 2)	$ NEED PER DAY	FENCE NO.
101			
102			
103			
104			
105			
106			
107			
108			
109			
110			
111			
112			
113			
114			
115			
116			
117			
118			
119			
120			
121			
122			
123			
124			
125			

THIEF NO.	TYPE (1 or 2)	$ NEED PER DAY	FENCE NO.
126			
127			
128			
129			
130			
131			
132			
133			
134			
135			
136			
137			
138			
139			
140			
141			
142			
143			
144			
145			
146			
147			
148			
149			
150			

THIEF DATA (Cont.)

THIEF NO.	TYPE (1 or 2)	$ NEED PER DAY	FENCE NO.
151			
152			
153			
154			
155			
156			
157			
158			
159			
160			
161			
162			
163			
164			
165			
166			
167			
168			
169			
170			
171			
172			
173			
174			
175			

THIEF NO.	TYPE (1 or 2)	$ NEED PER DAY	FENCE NO.
176			
177			
178			
179			
180			
181			
182			
183			
184			
185			
186			
187			
188			
189			
190			
191			
192			
193			
194			
195			
196			
197			
198			
199			
200			

END