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ECONOMIC DECISION ANALYSIS APPLIED TO RELATED CASES IN LITIGATION

by

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ABSTRACT

Quantitative analysis and decision analysis have both been applied to the evaluation of legal problems. A common example is the application of these theories to questions concerning whether to litigate an issue, or if settlement is preferable, determining the value of the case for settlement purposes. Using a decision tree format and simple Bayesian probability theory, each option for the case as diagrammed on a decision tree can be given an expected value and the case itself then given an expected value. This value gives a starting point for determining the amount of money to be spent on discovery and preparation for the case, or as a starting point for settlement negotiations. This system works well for an independent case, that is, one which is self-contained. All the necessary parties are represented, all the pertinent facts are contained within the instant fact situation itself, and no other case has a weighty influence on the outcome of this case. There is in law, however, another kind of case which is not independent.

Because of the doctrine of collateral estoppel, some cases are either extremely prejudiced by, or solely determined by, the outcome of some other case. If an issue already determined in one case is sufficiently similar to the issue sought to be litigated in a subsequent case, litigation of that issue in the following case can be prevented or estopped because of the prior determination. This situation arises when a common fact situation affects multiple plaintiffs or defendants. The importance of the first case to be tried then is greater than its sole expected value. Some method is necessary to quantify the importance of the first case when its determination will affect one or more subsequent cases. A method to quantify this kind of value is the subject of this thesis.

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Chapter 1

LITERATURE REVIEW

This chapter reviews literature on decision analysis, and on quantitative analysis and decision analysis as applied to the legal profession. For persons not familiar with decision theory, most particularly decision trees, a brief summary of pertinent articles is presented. The following section will examine literature applying decision analysis to the legal profession.

1.1 Decision Analysis

Since nearly every action taken by an individual or an organization is the result of making a choice among a number of alternatives, considerable effort has been made to develop selection processes which will help the selector best satisfy goals. The selection processes range from doing things by habit, by intuition, or by formal analytic models or processes. The choice of process is largely dependent on the immediate goal, any known constraints, and the perceived consequences of each alternative. However it is accomplished, whenever choices are available, a decision

must be made.

Decision analysis is a formalized framework of processes available to decision makers. The purpose of decision analysis is to aid in determining which alternative will maximize gain (or minimize loss). Decision theory does not make decisions for the decision maker. It is important because it provides a structure for analyzing a decision, clarifies alternatives and their consequences, and identifies the most sensitive components of the decision. In fact, the backbone of decision theory is the taking of a problem, breaking it into component parts, analyzing each piece, and then putting pieces back together so that the overall problem can be seen more clearly.

1.2 Decision Trees

The use of decision trees is a particular area of decision theory. Trees were one of the earliest forms of decision theory. In its most basic form, decision trees are little more than a sketch showing the interrelationships among alternatives. In the early 1960s, the use of decision trees became more formalized, and probability theory was combined with the skeleton framework. In 1964, decision trees were termed a "recent development," and were

characterized as having "tremendous potential" as a decision-making tool. "The decision tree can clarify for management, as can no other analytical tool that I know of, the choices, risks, objectives, monetary gains, and information needs involved in a ... problem" (Magee, 1964). Using investment alternatives as an example, Magee laid out the basic methodology of decision trees including the rollback procedure for determining the expected value of each option. He also included the concept and methodology of discounting cash flows to achieve the most realistic expected values.

Building upon the framework laid by Magee, Hammond (1967) introduced the concept of adding risk-taking attitudes to the analysis already provided by the basic decision tree. His point was that the highest expected value is not always the most important criteria to consider in choosing among alternatives. The option with the highest expected value may also include some probability of a large loss. An individual or a company may prefer to choose an option with a slightly lower expected value and a lower exposure to loss. This "preference theory" can be incorporated into decision tree analysis by defining risk attitudes and creating preference curves for the decision maker. Hammond also discussed the zero illusion and its

implications for decision makers. The zero illusion is a particular form of preference graph showing a steep drop off in willingness to accept risk when there is a possibility that the asset position (or whatever criterion is used) may go negative (Figure 1.1). The zero illusion illustrates very conservative behavior around the zero point, and less conservatism for options which could be slightly positive or slightly negative.

In the 1970s, emphasis was placed on distinguishing between risk and uncertainty in analyzing decisions. Risk is defined as that situation in which one or more outcomes or states of nature are possible. A probability of occurrence is assigned to each possibility (Parsons, 1972b). Uncertainty is defined as the situation in which the probability of occurrence of possible outcomes cannot be ascertained, or when the confidence associated with any probabilities assigned is so low as to be meaningless (Parsons, 1972c). At least one commentator has stated that the distinction between risk and uncertainty is not critical (Rudawsky, n.d.). Rudawsky places the emphasis on the causal relationship between the two: risk is the consequential effect of possible uncertain outcomes. Parsons (1972b,c,d,e) worked with matrices and developed formulas for using known, unknown, and partially known

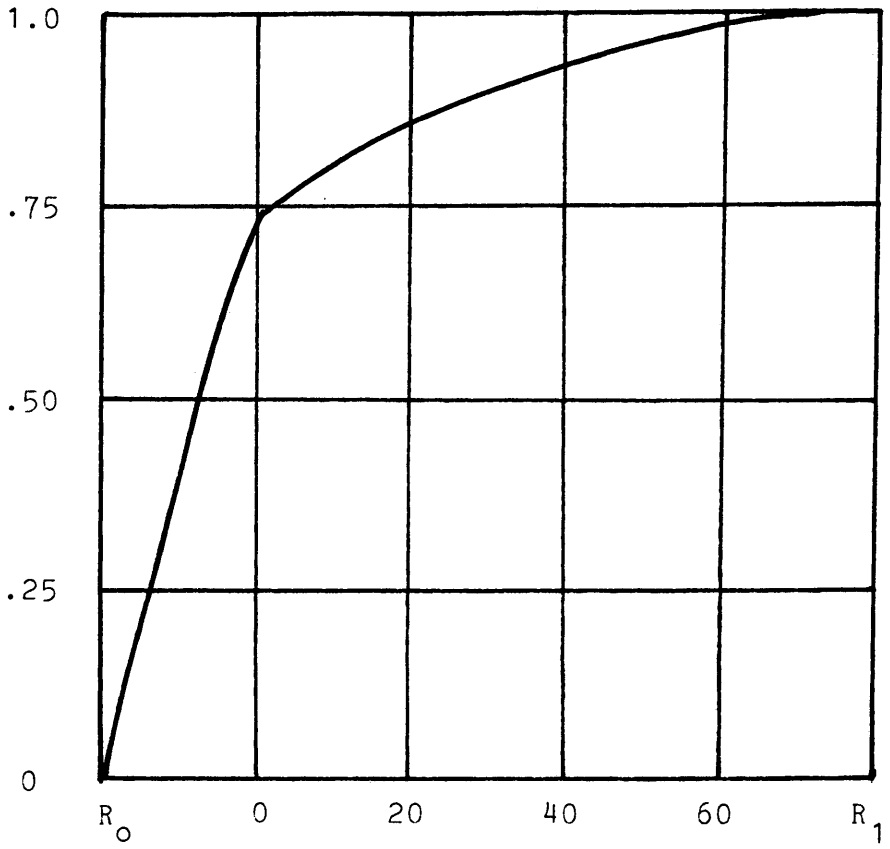

Figure 1.1

Preference Curve Illustrating Zero Illusion

probabilities in analyzing problems. Even after this work on clarification, however, the application of risk and uncertainty to decision trees did not change materially.

It was also in the 1970s that articles appeared supporting the advent of decision theory and decision trees, but noting their non-use or inapplicability to real world problems (Conrath, 1973). Conrath describes an informal experiment with a group of top managers. In each problem, the data were presented in several different forms and the decisions reached were compared. The decisions varied depending on how the data were presented, different presentations creating different emphases of the data. The article also pointed out the difficulty for many managers in appraising risk in terms of a probability range rather than a point estimate. In addition, the managers were acutely aware of the imprecision of their data. For this reason, they were reluctant to use a sophisticated model when the data rarely warranted such sophistication. The transition between theory and practical application continues to be a major focus for decision analysis research.

An interesting observation in tracing the literature of decision trees is that their use seems to be forgotten

and then revived at regular intervals. As mentioned, Magee in 1964 wrote a comprehensive article describing the use of decision trees for management. In 1973, in an administrative management periodical, decision trees were described and heralded as a new and wonderful tool (Mali, 1973). In 1978, an article appeared in an accounting periodical showing the application of decision trees to tax problems as though it were a new concept (Vanecek, 1978). This continued in other systems journals (Cronin, 1979; CPA Journal, 1982), and in 1982 decision trees were applied to the real estate management field as an innovation in analysis (Goodheim, 1982). Eighteen years after Magee's article appeared in the Harvard Business Review, that periodical again published an article showing that business managers were beginning to use decision analysis on a regular basis and described decision trees as one of three primary methods employed (Ulvila and Brown, 1982). The next section will review the literature applying quantitative analysis and decision analysis to legal problems.

1.3 Application of Quantitative Methods To Legal Problems

Some articles which show quantitative analysis of

legal problems do not use decision analysis. A summary of both types of articles is included in this review. A comprehensive article detailing the analysis of settlement versus going to trial appeared in 1969 (Friedman, 1969). This article did not use decision trees or any other method of decision analysis, but instead, presented a straight algebraic evaluation of a lawsuit from both the plaintiff's and defendant's points of view, and described the conditions under which settlement was possible and thus preferable to litigation.

The article requires only the basic economic assumptions, that is, that both parties are motivated by economic goals and wish to maximize gains and minimize losses, that both parties are willing to make decisions based on probability estimates, and that all factors relevant to settlement must be quantifiable in dollars. Briefly, if a plaintiff is sure of defendant's liability, plaintiff's recovery will be his damage award minus his costs, and if offered a settlement, he will not settle for less than that amount. If one defendant is also sure of his liability, his estimated cost will be the amount of the damage award plus his costs, and he will not pay more than that in settlement. Mathematically, this type of settlement is written as follows:

D_d = defendant's estimate of the amount of plaintiff's award;

D_p = plaintiff's estimate of his award;

C_d = defendant's estimated litigation costs;

C_p = plaintiff's estimated litigation costs; and

X = amount of ultimate settlement.

Therefore, rational parties will settle if

$$D_d + C_d \geq X \geq D_p - C_p, \qquad (1.1)$$

and will not settle if

$$D_d + C_d < D_p - C_p. \qquad (1.2)$$

The settlement range or bargaining span is shown by

$$(D_d + C_d) - (D_p - C_p) \geq 0. \qquad (1.3)$$

Continuing in this vein, Friedman considered the

situation where the losing party must pay the winner's litigation costs and the effect of that situation upon the bargaining span. He also considers the effect of mitigation, an evaluation of future damages, and a mathematical evaluation of injunctions versus damage awards. In 1972, a slightly different approach was taken by Tersine and Johnston.

Tersine and Johnston attempted to determine a breakeven number. Breakeven is defined as the point at which a client is ambivalent about accepting a settlement or going to trial. This number was derived from a standardized mode, and beta curves. The article contains no proofs, explanations, or justification for its method, and is not useful for the practitioner. The next article in the history of quantitative analysis applied to the legal profession discusses the applicability of Bayesian probability theory to legal problems.

Weeks (1975) discussed the appropriate and inappropriate applications of probability theory to the legal profession. Although not strictly included in the definition of decision analysis, pure Bayesian probability theory in several instances has been used in different contexts in the legal process. There are only a few such

examples, and they have been included here for a complete literature review. Over the years, plaintiffs' attorneys and prosecutors have attempted to win several civil and criminal cases by the use of statistics. The prosecution in a robbery case attempted to prove that the defendants had in fact committed the crime because the probability of another similar pair of defendants being in that area at the same time was 1 in 12 million. The courts will not allow statistics to be used in such fashion. Such a conviction would be based upon speculation and not upon observation (Weeks, 1975). Weeks then showed, however, how probability theory could be used by the practicing attorney to evaluate a settlement figure, or to value the helpfulness or harmfulness of a potential witness to his case. The article contains a good general explanation of Bayesian theory, an explanation simplistic enough for even non-mathematically oriented attorneys to understand.

In 1979 more recognition of worthy uses of statistics in litigation appeared (Curtis and Wilson, 1979). Statistics were used in anti-trust cases to establish relevant markets and market share. Statistical presentations were also used in deceptive advertising cases and trademark infringement cases (Curtis and Wilson, 1979), and statistics have been critical in analyzing employment

discrimination cases (Wilson and Curtis, 1979). Finally, Wilson and Curtis concluded by using an additional example where statistics were used to show that the lower average egg production in a fully integrated production facility was the result of a genetic flaw in the breeder flock at the time the flock was purchased. The difference in egg laying was shown to be significant at the .001 level and damages were awarded based on the national mean and the particular deviation. The next advance was in modeling. Jensen and Horvitz (1979) built a model showing the decision-making process of a judicial opinion and then attempted to use coefficient correlation to determine the most critical inputs. The article lacks persuasion, and does not present a tool that is readily useful for the practitioner.

Although he did not cite Weeks, Greenberg (1976) built upon the foundation laid by Weeks. Greenberg, however, concentrated on incorporating the time value of money into quantitative analyses of settlement values. The courts have in fact used discounting in computing damages for many years (Greenberg, 1976). The first mention of applying decision analysis by diagramming decisions with several options by decision trees was made by Greenberg. He included an example which showed how attorneys could give a

quantitative evaluation of a settlement position other than by using indefinite words. The lack of quantifying opinions was by this time beginning to be a recurring complaint against attorneys, but no further particular attention was paid to this problem until 1979.

Responding to complaints voiced at a conference (A Businessman's View of Lawyers, 1978), Vagts (1979) wrote a readable article describing the uses of statistics and the general reluctance of lawyers to employ quantitative techniques. This article pointed out some reasons for this reluctance, showing possible conflicts between the lawyers' Code of Professional Responsibility and the questions asking for quantitative responses. This article is quite thought-provoking regarding these possible conflicts, but resolution should be possible.

The application of decision analysis to the legal profession continued to be directed primarily to decisions regarding whether to settle or go to court. Bodily (1981) wrote an excellent article using a specific case example to show the financial savings to be gained by using decision analysis. As is common, the only parties who won in Bodily's initial example were the attorneys. Decision analysis of the problem brought a relatively prompt

settlement and saved many dollars in legal fees. An additional benefit of timely resolution which Bodily points out is the fact that both companies involved in the lawsuit had to issue annual reports and financial statements for several consecutive years showing this potentially large unresolved suit. One company felt that reporting a large unresolved lawsuit for several consecutive years was a deciding factor in its being refused a major loan. Bodily's article lists several good criteria for deciding when to implement decision analysis, and explains the value of effective use of top level executives from several departments when performing such analysis.

Although he did not use decision analysis, Nagel (1982) wrote on lawyer decision making and threshold analysis. His emphasis was in finding breakeven points for the number of hours an attorney should devote to a case, the breakeven amount of money for settlement purposes, and an attorney's breakeven fee, to cite a few examples. His approach uses simple algebra and elementary graphing. He uses good examples to show threshold analysis (breakeven point) with one, two, or three unknown variables.

Nagel had previously written on decision analysis itself and its application to the legal profession (Nagel

and Neef, 1979; Nagel, 1983). His application has been to system-wide parts of the profession, for example, jury selection, and to cost-benefit analysis of requiring bond, versus freeing defendants on their own recognizance. His primary focus has been in criminal law although each book contains a section on applying his method of analysis to civil cases.

Although the acceptance of decision analysis by the legal profession has been slow, the methods have been presented in seminar form in recent years by Litigation Risk Analysis (TM) headed by Marc Victor (1982). Victor has focused on decision tree analysis and on presenting the necessary probability theory in such a fashion that attorneys would not shy away from its use. His first pitch is the oft repeated experiment where several persons are asked to assign their assessment of appropriate probabilities to a series of statements such as "very likely," "a good chance," etc. The variance is always astounding. Therefore, he introduces a visual aid to assist the attorney in learning to think in quantitative terms. At least one large natural gas company has instituted such litigation risk analysis on a company-wide basis and is pleased with the result (Brown, 1983). As is often mentioned with decision tree analysis, a large part

of the benefit is the focus on critical sub-issues and the assistance it gives in general organization of the problem into a manageable form (Victor, 1982).

Another large company employs an in-house program which uses probability theory in assessing the value of cases (Haggarty, 1982). A particular advantage for this company is that they are involved in an area of law (medical insurance defense) where a sufficient body of data are available to generate objective probabilities. Haggerty's paper seems to present a very favorable reaction to the success of the program.

Most recently, a general article on quantitative analysis for the attorney appeared (Greenberg, 1983) which focuses on the necessity of using time value of money concepts. Although every article surveyed refers to discounting, several practitioners continue not to take the time value of money into account when assessing the value of a case. With this pointed focus, perhaps the neglect of this important concept will be remedied. The next chapter explains the legal problem to be solved by this thesis and the legal theory necessary to understand the problem.

Chapter 2

WHY DEVELOP ECONOMIC DECISION ANALYSIS OF RELATED CASES?

Today's courts are faced with a geometric increase in the amount of litigation from just a few years ago. Litigation is supposed to be a last resort; that is, parties should go to trial only if no other resolution of the conflict is possible. This would help conserve judicial and personal resources. Another way to conserve would be to avoid re-litigation of already determined issues.

2.1 Analysis of Independent Cases

The thrust of the literature to date has been on aiding parties and their lawyers in negotiating a settlement rather than going to trial. This is accomplished by determining the expected value of each side, and seeing if there is a range of dollars within which settlement could be reached. Because this type of analysis is not utilized as frequently as it should be, there continues to be too much litigation. Case evaluation to date, however, has focused on what is termed here the independent case, a case which is isolated in its

circumstances and effects. No other parties than those captioned are affected by its resolution, and all variables to be considered in determining the value of the case are determinable from the facts and figures ascertainable from the instant case. There is another type of case, however, which is not independent. This second type of case is the focus of this thesis. Some legal theory is necessary as preliminary material.

2.2 Analysis of Related Cases

In law there is a doctrine called collateral estoppel. In essence, this doctrine holds that any fact or issue which has been litigated and which has had a final judgment issued upon it cannot be re-litigated in a later case.

> Where there is a second action between the same parties, or their privies, who are bound by a judgment rendered in a prior suit, but the second action involves a different claim, case or demand, the judgment in the first suit operates as a collateral estoppel as to, but only as to, those matters or points which were in issue or controverted and upon the determination of which the initial judgment necessarily depended (Moore's Federal Practice, para. 0.441[2], at 3777 [2d ed. 1980]).

The basis of this doctrine is both practical and

philosophical. Theoretically, a final judgment by any court in the land is entitled to full faith and credit by any other jurisdiction. Thus the resolution by one court of a particular issue is in fact final and binding upon other courts. Re-litigation would be redundant. From a practical point of view, re-litigation of a finally resolved issue would be a waste of judicial resources as well as the resources of the parties. There is a corollary legal doctrine, however, which must be distinguished from collateral estoppel.

Res judicata is a doctrine which prevents re-litigation of a claim of action which has already been tried and determined. For example, an automobile accident may lead to several different causes of action, personal injury and property damage being the most obvious two. Collateral estoppel applies to an issue, or question of fact, such as, was party B negligent? The resolution of one issue, negligence, could determine both claims of action from the above example of the auto accident. Collateral estoppel is often referred to as issue preclusion to more clearly differentiate it from res judicata which operates upon claims of action. There are several stringent requirements for invoking collateral estoppel, however, so that its use is not as widespread as the definition might

lead one to believe.

A counterforce to the doctrine of collateral estoppel is the strong American tradition that every citizen is entitled to due process, or his day in court. Thus, collateral estoppel used to be invoked only when the parties were exactly the same. Thus if parties A and B had been to court and had received a final judgment, then, for collateral estoppel to be applied in a subsequent litigation, A and B must again be the parties. This mutuality of parties made the application of collateral estoppel very limited. In 1942, however, the Supreme Court relaxed this exact mutuality requirement (Kroll, 1979). Faced with increasing numbers of trials and also faced with cases in which several plaintiffs were affected by basically the same set of circumstances, the Court reasoned that if there was a nexus between the original party and the new party, collateral estoppel could still be fairly applied. The court, faced with a motion to apply collateral estoppel, must weigh the right of a party to his day in court against the prospect of re-litigating an already determined issue. This does assume that the issue in question is the same in both instances.

Besides the requirement of mutuality of parties, or a

nexus between parties, collateral estoppel also requires that the issue in question must be identical to the prior issue, must have been fully and actually litigated, and the issue must have been necessary to the prior judgment (Kempkes, 1981-82). These conditions are to insure that the defense had the opportunity to prepare its case or defense and is not being bound on an issue it did not have the opportunity or incentive to pursue. Some factors considered are not particularly legal in nature. If the requested damages in the former case were minimal, a defendant might not have been motivated to prepare the best defense. It would be unfair then to bind the defendant in a subsequent litigation with potentially substantial damages when it had not fully litigated the question in the former case. Also, and of importance to this thesis, if the defendant did not know that another case could arise where collateral estoppel might be invoked, again he might not have fully defended the issue in the former action. It is not just defendants who are affected by this doctrine.

So far only offensive collateral estoppel has been discussed. The offensive use is when a new plaintiff in an action uses a judgment from a prior action against the same defendant. When a defendant uses a prior judgment against a new plaintiff, it is called defensive collateral estoppel.

It is this application which runs up against the right of due process by depriving a party of his day in court because the doctrine would be applied against a new plaintiff. In much of the recent increase in multi-party litigation coming to court, there are usually many different plaintiffs, but the defendants remain the same. Thus, the use of defensive estoppel would deprive the new and different plaintiffs of their opportunity to be heard. In 1971, however, the Supreme Court permitted the defensive assertion of collateral estoppel for reasons of fairness and practicality.

> Application of collateral estoppel conserves judicial time and resources, protects a litigant from the unnecessary expense and potential harassment of repetitive litigation, and avoids conflicting rights and duties that could result from inconsistent judgments (Polick, 1980).

Finally, there is a last possibility to be considered. It is possible for a situation to arise where both parties have a case they feel is determinant. This situation could arise when a prior court refused to allow collateral estoppel to be invoked, and tried the subsequent case on its merits. This would create two judgments. In the asbestos-related cases today, there are tens of judgments on each side because the early courts were

hesitant to apply either offensive or defensive collateral estoppel. The rule in the case of conflicting judgments is to allow the new case to be tried on its merits and neither side wins by collateral estoppel because the current court will not second guess the prior courts. "We decline the invitation to decide which case was the better tried, in which case the evidence more truly presented the facts, and which 'full and fair opportunity' by defendant resulted in the 'correct' decision." (State Farm Fire & Casualty Company v. Century Home Components, Inc., 550 P2d 1185, Oregon 1976). Thus, conflicting judgments are handled by the courts as if there were no controlling judgments on either side.

When the asbestos-related cases first began appearing in court, no one really knew the magnitude the litigation would later assume. Thus, when the early cases were heard, the courts did not foresee the mass of litigation and did not consider the use of collateral estoppel to prevent repetitious litigation. Now, the number of cases is in the thousands, but the courts have a number of conflicting earlier judgments and are therefore essentially prevented from invoking collateral estoppel on either side. Partly because of the asbestos situation, the use of offensive and defensive collateral estoppel is predicted to increase to

prevent new situations with the problems caused by multiple conflicting judgments (Brosseau, 1983).

2.3 Why the Use of Collateral Estoppel Will Increase

Whatever the underlying reasons, the total amount of litigation has increased enormously in recent years. Another recent phenomena is the awareness of the number of persons who can be affected by a particular set of circumstances, for example, black lung disease, or asbestos-related diseases, or the very recent activity in personal injury suits by sand and gravel workers for lung diseases. In each of these instances, there are factors which are common to all potential plaintiffs. The use of collateral estoppel is one way to prevent duplicative litigation on the common issues. The problem to be resolved by this thesis is now described.

2.4 The Problem

When faced with a lawsuit, the defendant must first determine whether it is an independent case or whether it is the first of a number of related cases. As of April 1982, 16,000 asbestos-related lawsuits had been filed and

400 to 500 new suits each month were predicted (Gunn, 1982). When Mansville Corporation decided to seek refuge under Chapter XI of the bankruptcy code, it made note of a study estimating that 52,000 asbestos suits could be filed against it. When such a company must plan its defense of the first case, the case gains importance beyond its own potential damages in the helpful or harmful precedent the judgment may create. One attorney stated that he assumes he has an unlimited budget to use when planning his initial defense. To date, no quantitative method has been developed for evaluating the monetary value of a potentially precedent setting lawsuit, or the expected value of a collection of related cases. This thesis will develop such a quantitative model.

Chapters 3, 4, and 5 will describe the quantitative method developed to solve the problem of evaluating precedent setting cases. Chapter 6 will apply the method to two hypothetical problems in the minerals field.

Chapter 3

DEVELOPMENT OF ASSUMPTIONS, NOTATION, AND PROBABILITIES

This chapter develops the four basic assumptions based upon the legal theory discussed in Chapter 2. The bulk of this chapter develops the notation necessary to combine the legal theory, decision tree analysis, and probability theory. The last section of the chapter expresses the equations developed in the middle section in general polynomial form and as a function of a particular variable.

3.1 Assumptions for the Model

Four assumptions concerning the applicable cases must be made for the model developed in this thesis. The first assumption is that the cases are sufficiently related so that collateral estoppel is a possibility; if not, this model is not applicable. This assumption relates to the portion of the discussion in Chapter 2 concerning independent cases versus cases where the use of collateral estoppel is possible. This assumption can be written

$$P(o_{ij}) \neq 0, \qquad (3.1a)$$

$$P(d_{ij}) \neq 0, \qquad (3.1b)$$

$$\forall \; i < j,$$

where

$P(o_{ij})$ is the probability of the event that the decision in offensive case i estopped case j,

and

$P(d_{ij})$ is the probability of the event that the decision in defensive case i estopped case j.

The second assumption is that if collateral estoppel is not applied and a case is brought to trial on the merits, the probability of winning or losing any one case is equal to the probability of winning or losing any of the other cases. This assumption is based on Bernoulli's principle of insufficient reason. That is, in the absence of any information to the contrary, one should assume that all states of nature are equally likely. Here, this means that the likelihood of winning or losing is equally likely. If there were any reason to assume otherwise, such as a significantly different fact set, then that case would

not be sufficiently related to the others to be included in the pool of cases being considered. Therefore, the probability of winning or losing any one case on the merits is the same as the probability of winning or losing any other case on the merits. This does not say the probability of winning is 0.5 and of losing is 0.5. It says only that whatever the probability of winning one case is, the probability of winning any other case in the pool is the same. Also, the conditions of win or lose are mutually exclusive so that the probability of winning and the probability of losing must sum to 1. This second assumption can be written

$$P(M_i) = P(M_j), \forall \text{ i and j}, \qquad (3.2)$$

where

$P(M_i)$ is the probability of the event that case i will be won on the merits.

Since the probabilities of winning on the merits is the same for all cases i = 1,2,..., the subscript can be omitted.

Also, we have

$$P(M) + P(M') = 1 \qquad (3.3)$$

where

$P(M)$ = the probability of the event that the current case will be won on the merits, and

$P(M')$ = the probability of the event that the current case will be lost on the merits.

The third assumption is that within each pool of cases (one offense, one defense), the probability of a judgment in any one of the cases being determinant when applied to another case in the pool is the same for all cases in that pool. In theory, a judgment from any court of competent jurisdiction is of equal validity as a judgment of any other court and such a judgment is binding upon any other court through the Full Faith and Credit Clause of the Constitution. In practice, a judgment from a state court of New York or California might be more persuasive than a judgment from another jurisdiction because of the general reputation of the bar concerned. This practical consideration can be incorporated within the model. The probability assigned by the counsel to his chances of collateral estoppel being invoked will reflect his consideration of the jurisdictions from which his potential

determinant judgments arise. This third assumption can be stated mathematically as

$$P(o_{ij}) = P(o_{km}) \;\forall\; i < j,\ k < m, \tag{3.4a}$$

$$P(d_{ij}) = P(d_{km}) \;\forall\; i < j,\ k < m. \tag{3.4b}$$

Because of Equations (3.4a) and (3.4b), the subscripts can be dropped, and $P(o_{ij})$ will be denoted by $P(o)$, and likewise $P(d_{ij})$ will be denoted by $P(d)$.

Thus

$P(o)$ = the probability of the event that the decision in a prior offensive case will estop the current case, and

$P(d)$ = the probability of the event that the decision in a prior defensive case will estop the current case.

The fourth assumption is that the plaintiff and

defendant have different pools of cases and may have different probabilities of collateral estoppel being invoked. This assumption is based on the fact that courts are more reticent about invoking defensive collateral estoppel than they are offensive estoppel. When defensive collateral estoppel is invoked, its effect is to deprive a plaintiff of his day in court and since that is such a strong American tradition, defensive collateral estoppel is simply not seen in practice as often as offensive collateral estoppel. Thus, the plaintiff and defendant are each looking at different likelihoods that they will be collaterally estopped. Included in defendant's considerations are those cases which may not in fact be invoked formally by the courts. The presence of those cases is never forgotten, however. This was referred to in the discussion in Chapter 2 when it was mentioned that at least one defense counsel treated any such case as if he had an unlimited budget with which to defend because of the possibility of estoppel. Basically, this means that this doctrine is in fact considered and considered quite seriously in the defense's evaluation even though its formal application until recently has been limited. This assumption can be stated mathematically as

$$P(o) \neq P(d), \text{ and} \tag{3.5a}$$

$$P[O_{i+1} \mid (i,r)] \neq P[D_{i+1} \mid (i,r)], \tag{3.5b}$$

where

$P(o)$ is defined following Equation (3.4a);

$P(d)$ is defined following Equation (3.4b);

$P[O_{i+1} \mid (i,r)]$ = the probability of the event that the offense has at least one determinant case in its pool which will estop the current case (i+1) given that state (i,r) has occurred (state (i,r) has occurred means that i cases have been concluded and r of them have been won by the defense); and

$P[D_{i+1} \mid (i,r)]$ = the probability of the event that the defense has at least one determinant case in its pool which will estop the current case (i+1) given that state (i,r) has occurred.

The important distinction being made here is that P(o) and P(d) refer to individual cases, and $P[O_{i+1} \mid (i,r)]$ and $P[D_{i+1} \mid (i,r)]$ refer to the totality of the cases in the

pool.

3.2 Pertinent Probabilities

When a case comes to counsel's attention (remember the assumption is that collateral estoppel is possible), there are four immediate possibilities. Both plaintiff and defendant could have a determinant decision in their pool, neither plaintiff nor defendant has a determinant case, or plaintiff has one and defendant doesn't or vice versa. This can be pictured as illustrated in Figure 3.1. The effect of this figure is that the counsel can see the situations where he will be going to trial on the merits, or whether one side should win by reason of collateral estoppel. The "O" shows the situation when the offense or plaintiff should win by collateral estoppel, that is, he has a determinant case and the defense doesn't. The "D" shows the opposite situation. Defense has a determinant case and the offense doesn't and therefore the defendant should win. The situations when the case will go to trial are those where both parties have a determinant decision and where neither party has a determinant judgment and are represented by "T." This refers to the discussion in Chapter 2 where the possibility of both parties having a determinant case was discussed.

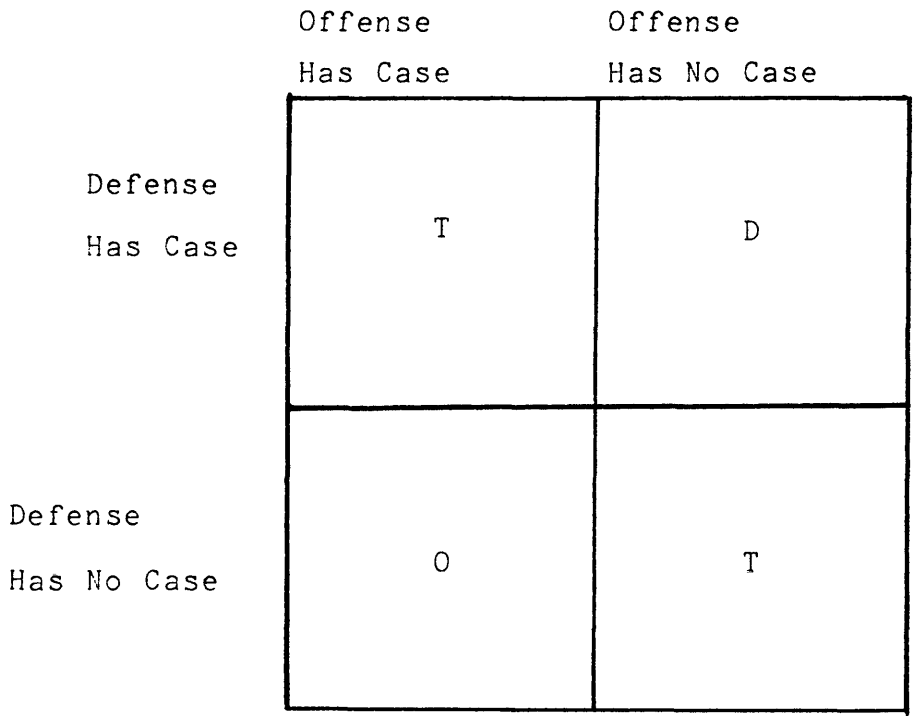

Figure 3.1

Visualization of When Trial Will Occur

and When Case Will Be Won By Collateral Estoppel

Assume that defense counsel has a pool consisting of n cases. For the (i+1)th case, where (i+1) $\leq$ n and where r of the preceeding i cases have been won by the defense (0 $\leq$ r $\leq$ i) the set of at least one of the r preceeding cases being determinant and the set of none of the cases being determinant are complements of each other, the complement set being denoted by a prime ('), and their probabilities must sum to 1. Since 1 - P(d) is the probability that any one case is not determinant, the collective probability of no case being determinant $P[D'_{i+1}|(i,r)]$ is a joint probability of r independent events happening together. This can be written as

$$P[D'_{i+1}|(i,r)] = \prod_{j=1}^{r} (1 - P(d)), \quad (3.6)$$

or

$$P[D'_{i+1}|(i,r)] = [1 - P(d)]^{r}, \quad (3.7)$$

where

$P[D'_{i+1} \mid (i,r)]$ is read as the probability of the event that defensive collateral estoppel will not estop case (i+1) given that state (i,r) has occurred.

The set of at least one case being determinant is the complement of the set of no cases being determinant because any case in the pool either is or is not determinant, therefore, the conditions are mutually exclusive and the probabilities of each set must sum to 1. This can be expressed mathematically as follows:

$$P[D_{i+1} \mid (i,r)] + P[D'_{i+1} \mid (i,r)] = 1, \text{ or} \qquad (3.8)$$

$$P[D_{i+1} \mid (i,r)] = 1 - P[D'_{i+1} \mid (i,r)]. \qquad (3.9)$$

Substituting from Equation (3.7) into Equation (3.9) gives

$$P[D_{i+1} \mid (i,r)] = 1 - [1 - P(d)]^{r}. \qquad (3.10)$$

Since r of the i preceeding cases were won by the defense, (i-r) were therefore won by the offense. By an analysis parallel to the above, we obtain

$$P[O_{i+1} \mid (i,r)] = 1 - [1 - P(o)]^{i-r}, \qquad (3.11a)$$

and

$$P[O'_{i+1} \mid (i,r)] = [1 - P(o)]^{i-r}, \qquad (3.11b)$$

where

$P[O_{i+1} \mid (i,r)]$ = the probability that the offense has a case which will estop case (i+1) given that state (i,r) has occurred.

Knowing the probability that collateral estoppel might be invoked on either side, counsel can calculate the probability of going to trial on the (i+1) case given that state (i,r) has occurred, $P[T_{i+1}|(i,r)]$. This probability of going to trial is equal to the joint probability of neither offensive nor defensive collateral estoppel being invoked, $P[O'_{i+1}|(i,r)]P[D'_{i+1}|(i,r)]$ plus the joint probability of both sides having a determinant case, $P[O_{i+1}|(i,r)]\ P[D_{i+1}|(i,r)]$, which can be expressed in equation form as

$$P[T_{i+1}|(i,r)] = P[O'_{i+1}|(i,r)]P[D'_{i+1}|(i,r)] + P[O_{i+1}|(i,r)]P[D_{i+1}|(i,r)]. \quad (3.12)$$

This is illustrated in Figure 3.2. The area outside both circles is equivalent to neither side having a determinant case and therefore the case would go to trial, this is represented by the first term on the right hand side of Equation (3.12). The circles represent the determinant case or cases of the plaintiff and the

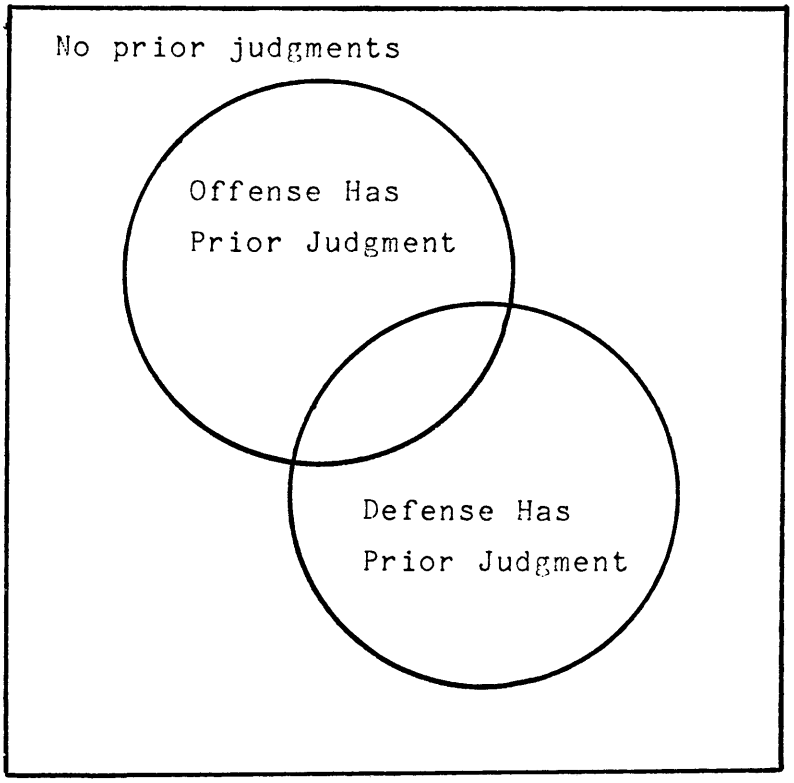

Figure 3.2

Second Visualization of When Trial Will Occur and

When Case Will Be Won By Collateral Estoppel

defendant. When both sides have a determinant case, the current lawsuit (i+1) will go to trial just as if there were no determinant case at all, this is represented by the second term on the right hand side of Equation (3.12). This situation is shown in Figure 3.2 by the intersection of the two circles. The intersection and the area outside the circles then represents the probability of going to trial and the non-intersecting portions of the circles represent the probability that one side or the other should win by collateral estoppel.

Defense counsel can now also compute the probability of winning the (i+1)th case, $P[W_{i+1}|(i,r)]$, assuming r of the preceeding i cases were won by the defense. The probability of winning the (i+1)th case is equal to the probability of going to trial multiplied by the probability of winning on the merits plus the probability defensive collateral estoppel will apply multiplied by the probability that offensive collateral estoppel will not apply. This can be written

$$P[W_{i+1} \mid (i,r)] = P(M)P[T_{i+1} \mid (i,r)] + P[D_{i+1} \mid (i,r)]P[O'_{i+1} \mid (i,r)]. \quad (3.13)$$

Similarly,

$$P[L_{i+1} \mid (i,r)] = P(M')P[T_{i+1} \mid (i,r)] + P[O_{i+1} \mid (i,r)]P[D'_{i+1} \mid (i,r)], \quad (3.14)$$

where

$P[W_{i+1} \mid (i,r)]$ = probability of the event of winning case (i+1) given that state (i,r) has occurred,

$P[L_{i+1} \mid (i,r)]$ = probability of the event of losing case (i+1) given that state (i,r) has occurred, and

$P(M)$ = the probability of winning any case on its merits at trial.

But, when $r < 0$, and when $r > i$, then

$$P[W_{i+1} \mid (i,r)] = 0, \quad (3.15a)$$

$$P[L_{i+1} \mid (i,r)] = 0. \quad (3.15b)$$

There are always two sides in any lawsuit, the plaintiff and the defendant. For a complete analysis then, there should be a probability of winning and losing calculated for each side, $P[WO_{i+1}|(i,r)]$ and $P[WD_{i+1}|(i,r)]$; O for the offense and D for the defense, as an example. Since the most likely occurrence for this kind of analysis would arise when a mining company or manufacturer is the defendant in pending actions, the remainder of the analysis will be presented from the defendant's point of view and the subscript D to denote defense will be assumed, i.e., $P[WD_{i+1}|(i,r)] = P[W_{i+1}|(i,r)]$.

If a decision tree were drawn to represent the related cases being analyzed, it would be too cumbersome to use because the tree's branches increase at a rate of 2^n. For simplification, the typical decision tree, Fig. 3.3a can be drawn as in Fig 3.3b. Since there are two ways that the state (2,1) can be reached, (and the importance is in the number of the case (i) and the number of wins (r), not the method by which that state is reached), the two branches resulting in (2,1) are reduced to one. This will cut the number of calculations significantly, which will save computer time when the program is introduced later in Chapter 6.

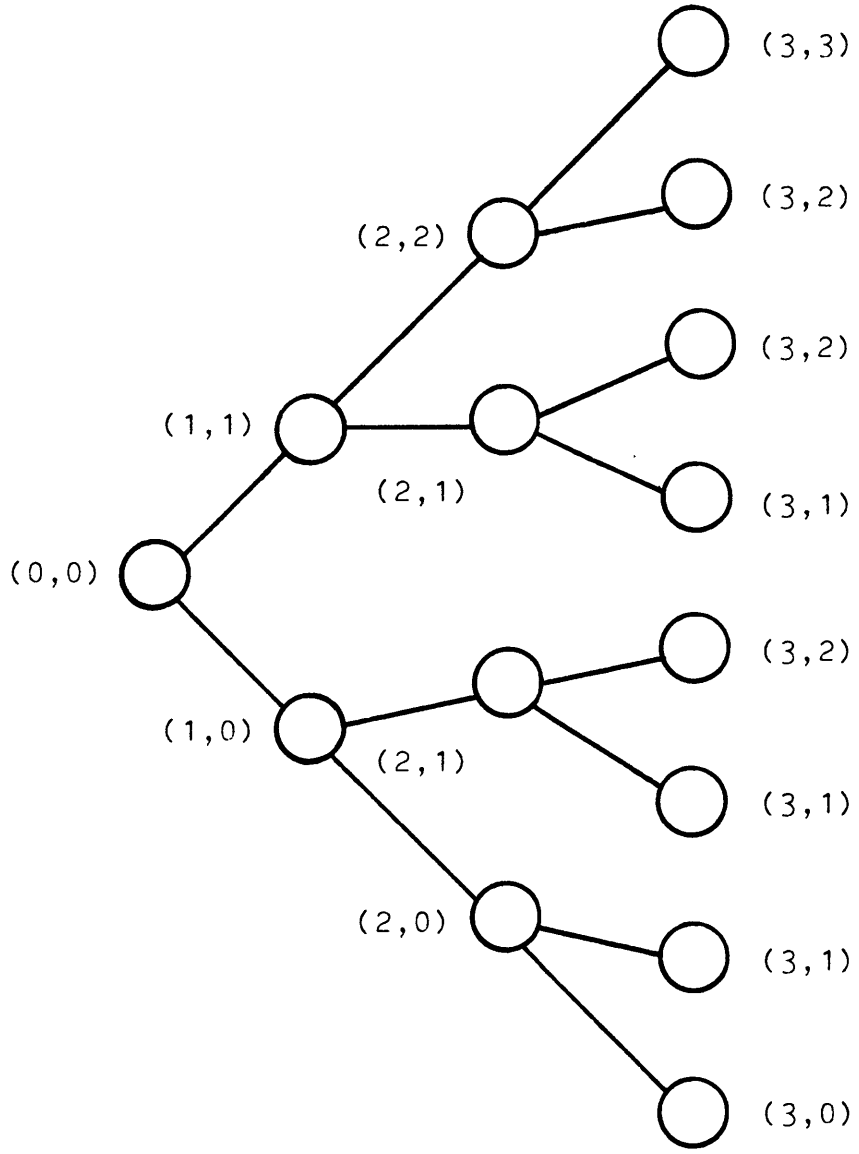

Figure 3.3a

Typical Decision Tree

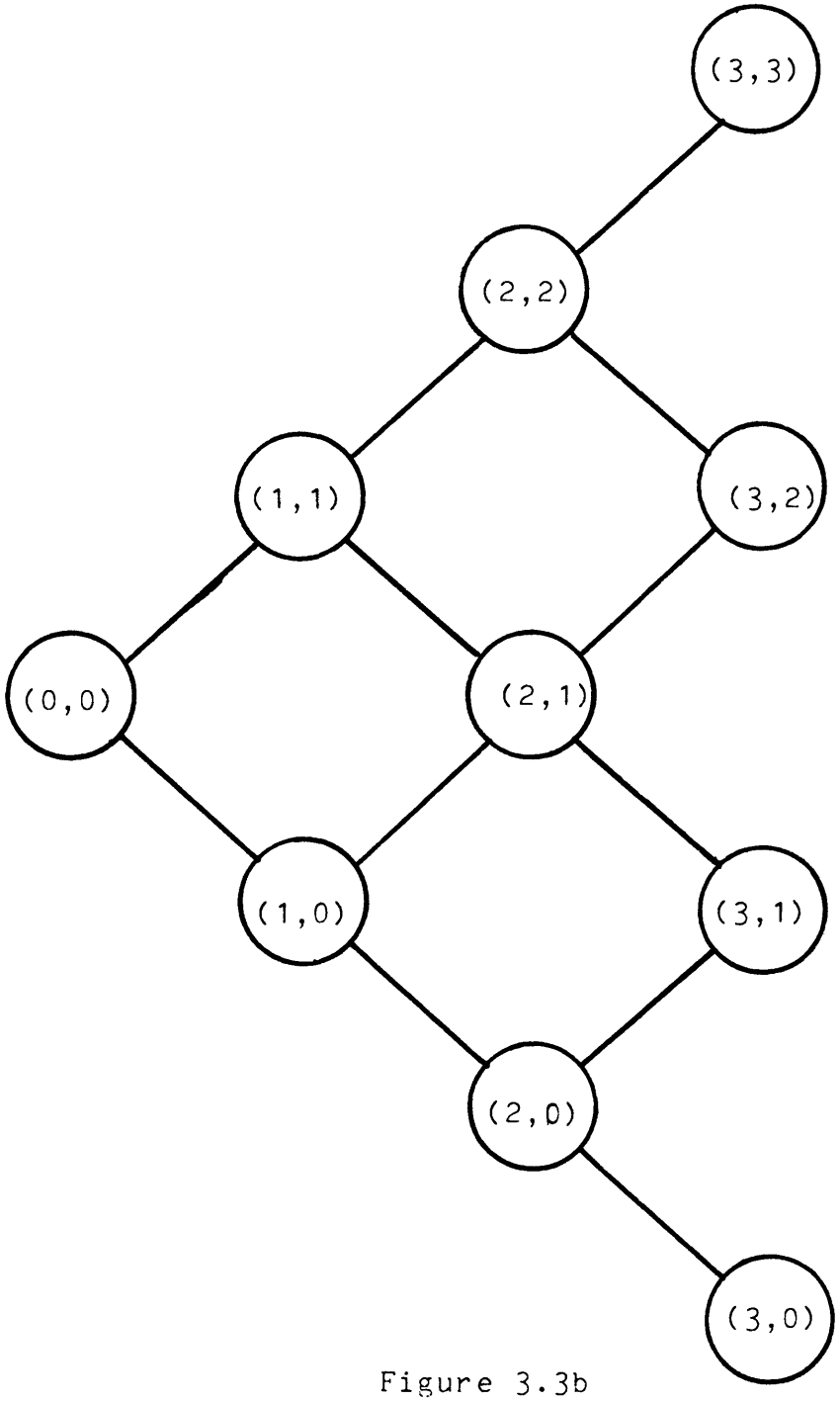

Figure 3.3b

Simplified Decision Tree

So far, a method of evaluating the probability of winning or losing case (i+1) given (i,r) has been developed. On the tree diagram, this is shown by node (i,r) and the probability of winning is the probability associated with the branch showing that the case was won, that is, the branch leading to (i+1,r+1). To illustrate, if counsel wished to know the probability of winning the third case if one of the two prior cases had been won, $P[W_3|(2,1)]$, counsel would find node (2,1) and ascertain the probability associated with the branch leading to state (3,2).

There is another evaluation counsel might wish to make. This would be the probability of some node (i,r) occurring. To evaluate the occurrence of any case (i,r), the only pertinent cases are the two cases immediately preceeding it. This concept is the same as the simplification made in the decision tree, Figure 3.3b. As an example, counsel might want to calculate the probability of case (10,8) occurring (the 10th case being concluded with 8 of the prior 10 cases being won). There are only two ways to get to (10,8), being at (9,8) and losing, or, being at (9,7) and winning. There are many ways to get to (9,8) and (9,7), but those are the only two ways to reach (10,8). The probability of (i,r) occurring is written

$$P(i,r) = P(i-1,r)P[L_i \mid (i-1,r)] + P(i-1,r-1)P[W_i \mid (i-1,r-1)], \quad (3.16)$$

where

$P(i,r)$ = the probability of event (i,r) occurring,

$P[L_i \mid (i-1,r)]$ = the probability of the event that case i is lost given that the state $(i-1,r)$ has occurred, and

$P[W_i \mid (i-1,r-1)]$ = the probability of the event that case i is won given that the state $(i-1,r-1)$ has occurred.

The unconditional probability of winning any case $(i+1)$ can be determined using the above information. The probability of winning case $(i+1)$ would be the summation of the joint probabilities of the $(i+1)$ prior nodes. Those probabilities are the probability of being at any particular prior state times the conditional probability of winning given that that state had occurred. This can be

written as

$$P(W_{i+1}) = \sum_{r=0}^{i} P(i,r)P[W_{i+1}|(i,r)]. \qquad (3.17)$$

The probability of losing is of course the complement of $P(W_{i+1})$ or $P(W'_{i+1})$. By parallel reasoning, this is written as

$$P(L_{i+1}) = \sum_{r=0}^{i} P(i,r)P[L_{i+1}|(i,r)]. \qquad (3.18)$$

To illustrate this, consider the probability of winning case 2:

$$P(W_2) = P(1,0)P[W_2 \mid (1,0)] + P(1,1)P[W_2 \mid (1,1)]. \quad (3.19)$$

One way to think of these cumulative probabilities is to picture a decision tree drawn for the (i+1)th case. To compute the probability of winning case (i+1), one would sum up all the branches pointing in an upwards direction from node (i,r) because they represent all the possible ways of reaching winning cases. For example, on Figure 3.3b this would be the branch leading from (1,1) to (2,2) and the branch from (2,1) leading to (3,2) and similar branches showing that the prior case had been won. Conversely, the summation of all the downward branches from node (i,r) encompasses all the ways of getting to losing cases. In Figure 3.3b, this would be the branch leading from (1,0) to (2,0) and the branch from (2,1) leading to (3,1), etc.

By examining Figure 3.3b, which is a decision tree drawn to represent this analysis, it can be seen that the cases represented by the interior nodes are those with which lawyers are most concerned because they represent the situations in which some of the prior cases have been won and some lost. This makes predicting the next outcome more uncertain. By interior nodes are meant the nodes

representing cases such as (2,1) and (3,2). The cases along the top and bottom edges are not so difficult. Those cases are (2,2) or (3,0) as examples. They represent the situations where the prior cases have either all been won or all been lost. Since Equation (3.16) is designed to represent any arbitrary case, some nonsensical results occur when the edge cases are evaluated. It is possible to obtain results such as (0,-1) or (5,6) which are impossible states since ($0 \leq r \leq i$) by definition. Three special rules are used to evaluate the probability of the occurrence of edge cases just as was done in Equations (3.15a,b). Equation (3.16) is repeated below.

$$P(i,r) = P(i-1,r)P[L_i \mid (i-1,r)] + P(i-1,r-1)P[W_i \mid (i-1,r-1)] \qquad (3.16)$$

and the special rules are added:

$$P(0,0) = 1, \qquad (3.20)$$

$$\text{if } r > i, \text{ then } P(i,r) = 0, \text{ and} \qquad (3.21)$$

$$\text{if } r < 0, \text{ then } P(i,r) = 0. \qquad (3.22)$$

Some examples of edge cases are

$$P(1,0) = P(0,0)P[L_1 | (0,0)] + P(0,-1)P[W_1 | (0,-1)]. \quad (3.23a)$$

But since $P[W_1 | (0,-1)]$ and $P(0,-1)$ are impossible states, using Equations (3.15a) and (3.22) the following results

$$P(1,0) = 1 \times P[L_1 | (0,0)] + 0 \times 0 \quad (3.23b)$$

$$= P[L_1 | (0,0)] \quad (3.23c)$$

which makes sense, because if no other cases have been tried, the probability of losing the first case should be the probability of losing case 1.

As an additional example consider calculating P(3,3) using Equation (3.16):

$$P(3,3) = P(2,3)P[L_3 | (2,3)] + P(2,2)P[W_3 | (2,2)]. \quad (3.24a)$$

Since it is impossible to have the state (2,3), using Equations (3.15b) and (3.21) this simplifies to

$$P(3,3) = 0 \times 0 + P(2,2)P[W_3 | 2(,2)] \quad (3.24b)$$

$$= P(2,2)P[W_3 | (2,2)], \quad (3.24c)$$

which again makes sense, since the probability of ever getting to the position of having tried and won three cases (3,3) is solely dependent upon having been at (1,1) and (2,2).

As a final example of calculating the probabilities of edge cases consider P(3,0):

$$P(3,0) = P(2,0)P[L_3 | (2,0)] + P(2,-1)P[W_3 | (2,-1)]. \quad (3.25a)$$

Again using Equations (3.15a) and (3.22)

$$P(3,0) = P(2,0)P[L_3 | (2,0)] + 0 \times 0 \quad (3.25b)$$

$$= P(2,0)P[L_3 | (2,0)], \quad (3.25c)$$

which is logical for a bottom edge case. With these rules for evaluating Equation (3.16), one can now turn to combining any n cases and ascertain an expected value for all n related cases.

3.3 Calculation of Expected Values

The expected value of related cases applicable to this model is the summation of the probabilities of losing cases 1 through n times the expected amount of the damages plus the costs of litigation. This is written

$$EV = \sum_{i=1}^{n} [A_i P(L_i) + C_{t_i}], \qquad (3.26)$$

where

EV = expected value of all n cases,

A_i = expected award (or damages) for case i,

$P(L_i)$ = probability of losing case i

C_{t_i} = costs of trial of any individual case.

It is assumed that C_{t_i} is the same for all cases

and thus C_{t_i} will be denoted by C_t.

A small digression is necessary here to discuss litigation costs and awards or damages. A distinction is going to be made between two types of litigation costs. The defense is going to be faced with a decision as to how much money to put into preparation, etc., to fight the first case; the proper amount to pay for this will be developed in Chapters 4 and 5. Much of this initial work, however, will be used in later cases as well as the first case. Any models developed, or engineering studies made, would be available for all later cases and would not need to be duplicated. These costs will be denoted as C_p. A second kind of cost is that cost associated with the defense of any case. Once the studies are done and determinations are made from the initial litigation cost, it is assumed here that the cost to defend each case i is approximately the same. This cost will be denoted by C_t as in Equation (3.26).

Equation (3.26) is the first time that A_i for damages or awards has appeared. The reason for this is that A_i will vary for each case. Once liability or the lack thereof is established, it is the same for all individuals involved. This is the basis for considering "related" cases. In the example of a mining disaster, if a manufacturer or the mining company is liable for the

injuries of one party, one or the other is also almost automatically liable for the injuries of another party. The damages themselves, however, may vary greatly. The amount paid for a broken leg is not the same as that due for the loss of a leg, or a death, etc. Therefore, each case must have its own Ai to be used in the computation of the overall expected value.

Equation (3.26) looks at first glance to be an expected value equation for any case, but the computation of $P(L_i)$ depends upon previous cases, so Equation (3.26) is specific for cases for which collateral estoppel is possible. This equation for expected value can be adjusted to account for the time value of money as explained below.

Equation (3.26) contains the term A_i which is specific for any case i. Since some parameters of these cases are being estimated on an individual basis, it is easy to include a time estimate as well for when the damages would most likely have to be paid. This time estimate (t) is used in conjunction with the discount factor (d) to adjust Equation (3.26) to account for the time value of money. This would be written as follows for an individual case and for the overall expected value:

$$PEV_i = [A_i P(L_i) + C_t](1 + d)^{-t_i}, \qquad (3.27)$$

and

$$PEV = \sum_{i=1}^{n} [A_i P(L_i) + C_{t_i}](1 + d)^{-t_i}. \qquad (3.28)$$

Where

PEV_i = present expected value for case i, that is, the expected value adjusted for time value of money;

PEV = present expected value of all n cases, that is, expected value adjusted for time value of money;

d = discount factor; and

t_i = time in future when damages for case i will be paid.

Equation (3.28) ends the derivation of the expected value of n related cases for these costs. A major break in the development of the model occurs here. The remainder of this chapter will take the equations derived above and show analytically that they all reduce to polynomials in terms

of P(M). Chapter 4 will develop a formula to evaluate the appropriate amount of money to be spent on initial preparation costs, C_p, and then show that those equations also reduce to polynomials in terms of P(M). Chapter 5 will then use the equations from Chapters 3 and 4 and will show the reader how to optimize C_p.

3.4 Development of General Polynomial Form

For purposes of the optimization developed in Chapter 5, the equations derived in Sections 3.1, 3.2, and 3.3 must be expressed as functions of P(M). Appendix A shows the algebraic details of how Equations (3.12), (3.13), (3.14), (3.16), (3.17), (3.18), (3.26), (3.27), and (3.28) can be expressed as functions of P(M) and the parameters P(o) and P(d).

The terms P(o) and P(d) from Equation (3.4) are the attorney's estimate of the chances of any case being collaterally estopped. Although these estimates are formed by the attorney, the terms are essentially constant inasmuch as the attorney can do little to change or affect those probabilities. Since P(o) and P(d) can be treated as constants, Equations (3.6) through (3.11b) are also

constants because they are only complements and/or summations of P(o) and P(d) (see Appendix A).

The original of Equations (3.12), (3.13), and (3.14) and the equivalent forms developed in Appendix A are repeated below.

Equation (3.12)

$$P[T_{i+1}|(i,r)] = P[O'_{i+1}|(i,r)]P[D'_{i+1}|(i,r)] + P[O_{i+1}|(i,r)]P[D_{i+1}|(i,r)]. \quad (3.12)$$

The equivalent form is

$$P[T_{i+1}|(i,r)] = [1-P(o)]^{i-r}[1-P(d)]^{r} + \{1-[1-P(o)]^{i-r}\}\{1-[1-P(d)]^{r}\}. \quad (A.1)$$

Equation (A.1) expresses $P[T_{i+1}|(i,r)]$ in terms of the parameters P(o) and P(d).

Equation (3.13)

$$P[W_{i+1} \mid (i,r)] = P(M)P[T_{i+1} \mid (i,r)] + P[D_{i+1} \mid (i,r)]P[O'_{i+1} \mid (i,r)]. \quad (3.13)$$

The equivalent form is

$$P[W_{i+1} \mid (i,r)] = P(M)\left(P[O'_{i+1} \mid (i,r)]P[D'_{i+1} \mid (i,r)] + P[O_{i+1} \mid (i,r)]P[D_{i+1} \mid (i,r)]\right) + P[D_{i+1} \mid (i,r)]P[O'_{i+1} \mid (i,r)]. \quad (A.2)$$

Equation (A.2) shows $P[W_{i+1} \mid (i,r)]$ in terms of P(M), P(o) and P(d).

Equation (3.14)

$$P[L_{i+1} \mid (i,r)] = P(M')P[T_{i+1} \mid (i,r)] + P[O_{i+1} \mid (i,r)]P[D'_{i+1} \mid (i,r)]. \quad (3.14)$$

Its equivalent form is

$$P[L_{i+1} \mid (i,r)] = P(M')\Big(P[O'_{i+1} \mid (i,r)]P[D'_{i+1} \mid (i,r)] + P[O_{i+1} \mid (i,r)]P[D_{i+1} \mid (i,r)]\Big) + P[O_{i+1} \mid (i,r)]P[D'_{i+1} \mid (i,r)]. \quad (A.3)$$

Equation (A.3) expresses $P[L_{i+1} \mid (i,r)]$ as a function of P(M), P(o), and P(d).

Having the form of all the parts of Equation (3.16) allows one to show that for any (i,r), Equation (3.16) is an ith order polynomial of P(M). First, consider the case where i = 1, which gives (1,r). Since by definition r is the number of prior cases won, r must equal either 0 or 1. The states (1,0) and (1,1) will be taken one at a time, but in each case a polynomial of degree 1 in P(M) results.

For P(1,0), Equation (3.16) becomes

$$P(i,r) = P(i-1,r)P(L_i \mid (i-1,r)] + P(i-1,r-1)P[W_i \mid (i-1,r-1)] \qquad (3.16)$$

$$P(1,0) = P(0,0)P[L_1 \mid (0,0)] + P(0,-1)P[L_1 \mid (0,-1)]$$

$$= 1 \times P[L_1 \mid (0,0)] + 0 \times 0$$

$$= P[L_1 \mid (0,0)],$$

which by Equation (A.3) is a linear function of P(M). Similarly, for P(1,1),

$$P(1,1) = P(0,1)P[L_1 \mid (0,1)] + P(0,0)P[W_1 \mid (0,0)]$$

$$= 0 \times P[L_1 \mid (0,0)] + 1 \times P[W_1 \mid (0,0)]$$

$$= P[W_1 \mid (0,0)],$$

which is defined by Equation (A.2) which shows P(i,r) as a linear function of P(M) which again is equivalent to a

polynomial of degree 1. The conclusion is that for the two possible cases when i = 1, (1,0) and (1,1), the results are also polynomials of degree 1.

Next, assume that any P(i-1,r) is a polynomial of degree (i-1). The terms P(i-1,r) and P(i-1,r-1) are polynomials of degree (i-1) by assumption. The terms $P[L_{i+1}|(i-1,r)]$ and $P[W_{i+1}|(i-1,r-1)]$ are linear functions by Equations (A.2) and (A.3). The products of those $P(i-1,r)P[L_{i+1}|(i-1,r)]$ and $P(i-1,r-1)P[W_{i+1}|(i-1,r-1)]$ are polynomials of degree i and their sum, which is P(i,r) is a polynomial of degree i. The conclusion from the above two paragraphs is that for any i, P(i,r) is a polynomial of degree i.

Now that the polynomial form of P(i,r) has been established, Equations (3.17) and (3.18) are fairly straightforward. The details are shown in Appendix A and the original and final forms are repeated below.

Equation (3.17)

$$P(W_{i+1}) = \sum_{r=0}^{i} P(i,r)P[W_{i+1} \mid (i,r)], \qquad (3.17)$$

and after the substitutions,

$$P(W_{i+1}) = \sum_{r=0}^{i} P(i,r)\left[P(M)\left(P[O'_{i+1} \mid (i,r)]P[D'_{i+1} \mid (i,r)] + P[O_{i+1} \mid (i,r)]P[D_{i+1} \mid (i,r)]\right) + P[D_{i+1} \mid (i,r)]P[O'_{i+1} \mid (i,r)]\right]. \qquad (A.4)$$

Equation (3.18)

$$P(L_{i+1}) = \sum_{r=0}^{i} P(i,r)P[L_{i+1} \mid (i,r)],$$

and after the substitutions

$$P(L_{i+1}) = \sum_{r=0}^{i} P(i,r)\Big[\big(P[O'_{i+1}\,|(i,r)]P[D_{i+1}\,|(i,r)] + P[O_{i+1}\,|(i,r)]P[D_{i+1}\,|(i,r)] + P[O_{i+1}\,|(i,r)]P[D'_{i+1}\,|(i,r)]\big) - P(M)\big(P[O'_{i+1}\,|(i,r)]P[D'_{i+1}\,|(i,r)] + P[O_{i+1}\,|(i,r)]P[D_{i+1}\,|(i,r)]\big)\Big]. \quad (A.5)$$

Equations (3.26), (3.27), and (3.28) calculate the expected value of case i and n related cases. The original equation of Equation (3.26) is repeated below. The terms of Equations (3.26), (3.27), and (3.28) have the same components and so only one set of substitutions is necessary. The final equivalent form of Equation (3.26) is repeated below, the details for all three equations are in Appendix A.

Equation (3.26)

$$EV = \sum_{i=1}^{n} [A_i P(L_i) + C_{t_i}].$$

Equation (3.26)

$$EV = \sum_{i=1}^{n} [A_i \Big[P(i,r) \Big(\Big(P[O'_{i+1} | (i,r)] P[D'_{i+1} | (i,r)]$$

$$+ P[O_{i+1} | (i,r)] P[D_{i+1} | (i,r)]$$

$$+ P[O_{i+1} | (i,r)] P[D'_{i+1} | (i,r)] \Big)$$

$$- P(M) \Big(P[O'_{i+1} | (i,r)] P[D'_{i+1} | (i,t)]$$

$$+ P[O_{i+1} | (i,r)] P[D_{i+1} | (i,r)] \Big) \Big) \Big] + C_{t_i} . \quad (A.6)$$

The next chapter will develop a formula for evaluating initial preparation costs C_p, and will show that those formulas are also polynomials of P(M). The information from this chapter and the next will be combined in Chapter 5 where a method is developed for evaluating the C_p which will give the lowest total expected value, TEV.

Chapter 4

GENERAL PREPARATION COSTS

This chapter considers the costs incurred in general preparation of the defense of case 1 of n related cases. These costs produce results that are common to or provide information useful to all the related cases, not just the first case (Kimble and Leshee, 1979). These costs C_p are distinguished from C_t or those costs which are incurred in the actual defense of an individual case. As examples, in the asbestos cases, the general preparation costs would include the earliest medical studies which determined that asbestos was in fact harmful to humans. Those studies, once completed, are applicable to any case regarding similar injuries. For a mine explosion, the re-creation of the mine environment leading to or prior to the explosion would be applicable to each and every suit regarding injuries sustained during the explosion. The point is that the simulation of the mine environment would not be repeated for each case; once done, the results are used in each related case.

The optimum amount to be spent on these general

preparation costs is the ultimate question to be answered in Chapter 5. By optimum is meant that amount of general preparation which leads to the lowest total expected costs. This chapter will focus on the components of these preparation costs and the effect that varying the amount spent on general preparation has on the probability of winning a case.

Prior research in the area has approached this problem from the personal injury plaintiff's point of view. The plaintiff examines how the amount of his potential award will increase with increased effort in preparing the case. The defense point of view would be the opposite, i.e., how low can the damages be kept by increasing efforts in defending the action. Intuitively, one can see how a graph of this would be approximately S-shaped if the potential damages are plotted on the vertical axis and the hours spent in preparation were plotted on the horizontal axis (Nagel, 1982b; Figure 4.1). If zero hours are spent preparing the case, the likelihood of receiving any award is also zero. But the very first few hours spent also result in only a zero or extremely low chance of maximizing the damage award because the results of just a few hours of preparation are not sufficient by themselves to significantly increase the probability of success. After

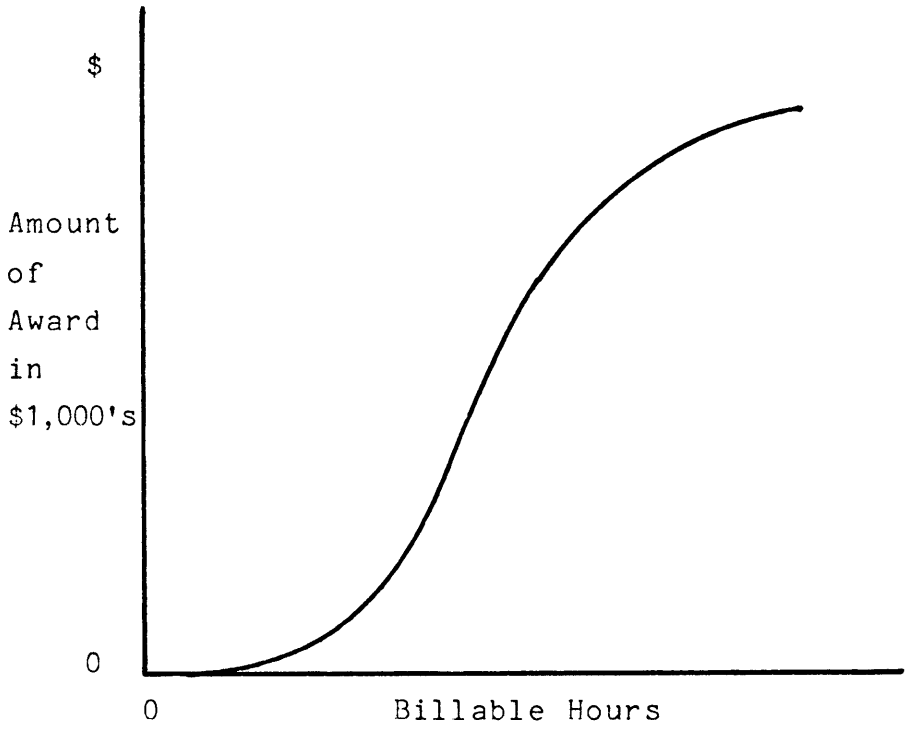

Figure 4.1

Relationship Between Amount of Award

and Hours of Preparation

some initial few hours, however, the increase in award with each additional hour rises very quickly until some optimum number of hours worked is reached. The marginal return of each additional hour after that decreases although the potential return does continue to rise slowly.

There are more factors involved in increasing one's chances of success than just hours of attorney's time. Clermont and Currivan (1978) says that "various and substantial" costs will occur during the course of a case. These costs include expenses of investigation and experts. The variable C_p as used in this thesis includes these expenses as well as attorney time used in preparation. Although the inclusion of other costs as well as hours shifts the S-shaped curve, Clermont and Currivan state that there is no alteration to any conclusions drawn from a curve which includes the extra costs and one which includes just hours of attorney time. Thus, the horizontal scale of Figure 4.1 which has heretofore been hours of billable time will be re-labeled as C_p to include all costs of preparation.

Although research has concentrated on approaching this type of analysis from the personal injury plaintiff's point of view resulting in figures like Figure 4.1, the same

analysis applies to other areas of concern. From a prosecutor's point of view, the vertical scale of Figure 4.1 could be replaced by the probability of conviction. For the mining company defendant in a personal injury action, there could be a question of liability, so the vertical scale of Figure 4.1 would be replaced by the probability of succeeding on the merits at trial and defeating the claim of liability. The same intuitive reasoning which results in an S-shaped curve applies in all these situations. The chance of a prosecutor getting a conviction and the chance of a defendant defeating a claim of liability will be zero with zero hours and dollars of preparation, will increase slowly and then will show large marginal returns for each additional dollar of general preparation added. The vertical axis then will be replaced with the probability of succeeding on the merits at trial, P(M), shown in Figure 4.2. Now that the graph has been re-labeled to reflect the concerns of this paper, the analysis turns to determining points on the curve.

At the outset of any investigation, some areas of research are obvious while others do not become apparent until later in the preparation process. At the outset, counsel will know the nature of the pending action, and will have finished his initial legal research which will

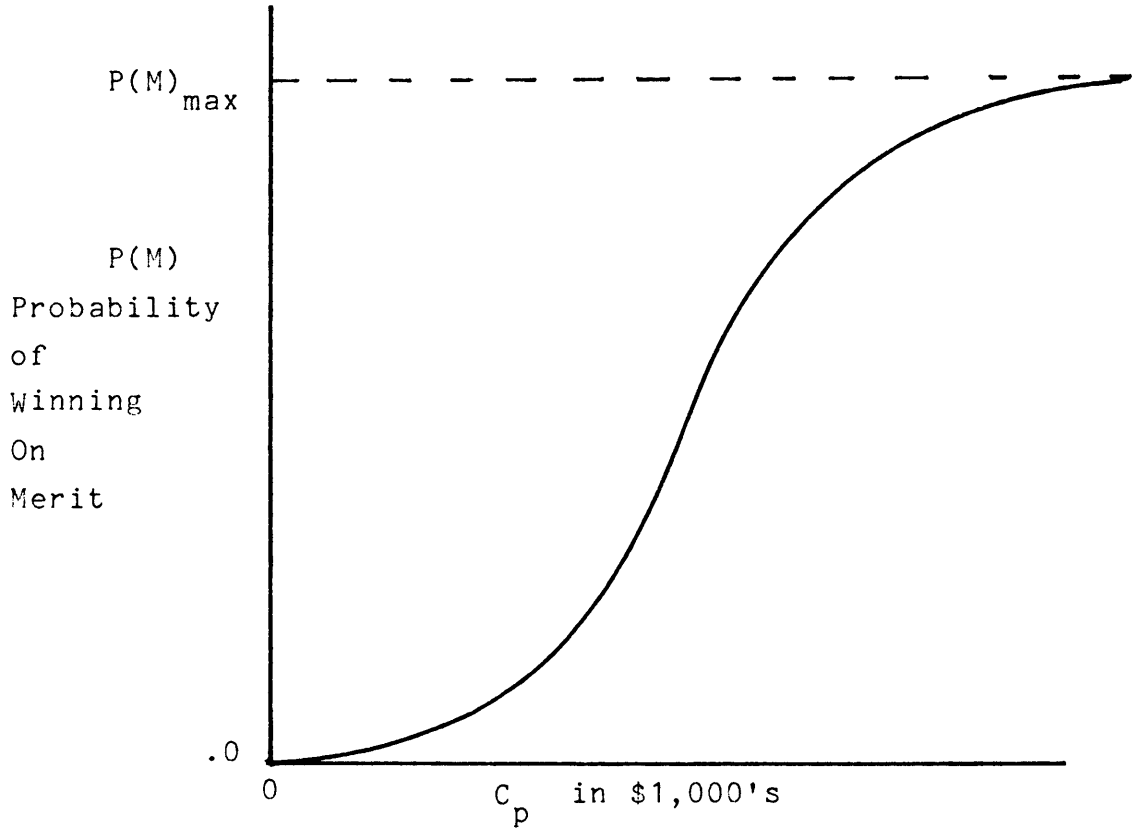

Figure 4.2

Relationship Beween Dollars of General Preparation

and Probability of Winning On Merit

have shown him the applicable legal rules and tests, available defenses, etc. Now with the help of a separate decision tree or some similar analysis tool, counsel can begin to see which elements in this case are going to be most crucial, which facts would be most helpful to the defense if they could be determined. Counsel then must make some additional subjective estimates. If $400,000 is spent on preparation, what are the chances of success likely to be? If $600,000 or $800,000 is spent, how does the chance of success change? These points then can be used to determine the specific equation of the S-curve. Once the equation is determined then one has P(M) expressed as a function of C_p, as shown in Figure 4.2. It is important to remember that this S-curve is not necessarily going to top out or flatten out near the 1.0 probability of winning. In some cases, regardless of the amount of money spent in preparation, the chances of winning or decreasing an award may never exceed 0.5 or 0.3 or 0.7, for example. Therefore, the curve must be read as flattening out and terminating at $P(M)_{max}$ which is the maximum value of the probability of winning on the merits as estimated by counsel. To parallel Chapter 3 however, the curve should show C_p as a function of P(M). By reversing positions on the axes, this same curve can be drawn to show C_p as a

function of P(M), as shown in Figure 4.3.

The curve in Figure 4.3 can be represented by a cubic of the form $aP(M)^3 + bP(M)^2 + dP(M) + e = C_p$. Note that e=0 since this curve passes through the origin. If zero hours of general preparation is done, the probability of winning is also certainly zero. Counsel can estimate $P(M)_{max}$ and another point on the curve, and the dollars necessary to be spent on general preparation costs associated with those chances of winning, and the S-curve can then be drawn. The program ESTOP (discussed in Chapter 6), specifically, subroutine INPINF, takes the two points estimated by counsel and the program estimates a third point. This point is forced to be an inflection point so that the curve is S-shaped and the second derivative at that inflection point is always positive. Counsel will now have three equations with three unknowns, a, b, and d, estimated with the aid of the program ESTOP, and these unknowns can then be determined.

Mathematically, it is possible for a cubic formulation to result in an illogical result. That is, the curve could pass through the same Y-coordinate several times. That would mean that the same dollars of preparation could result in three different P(M)'s. This situation would

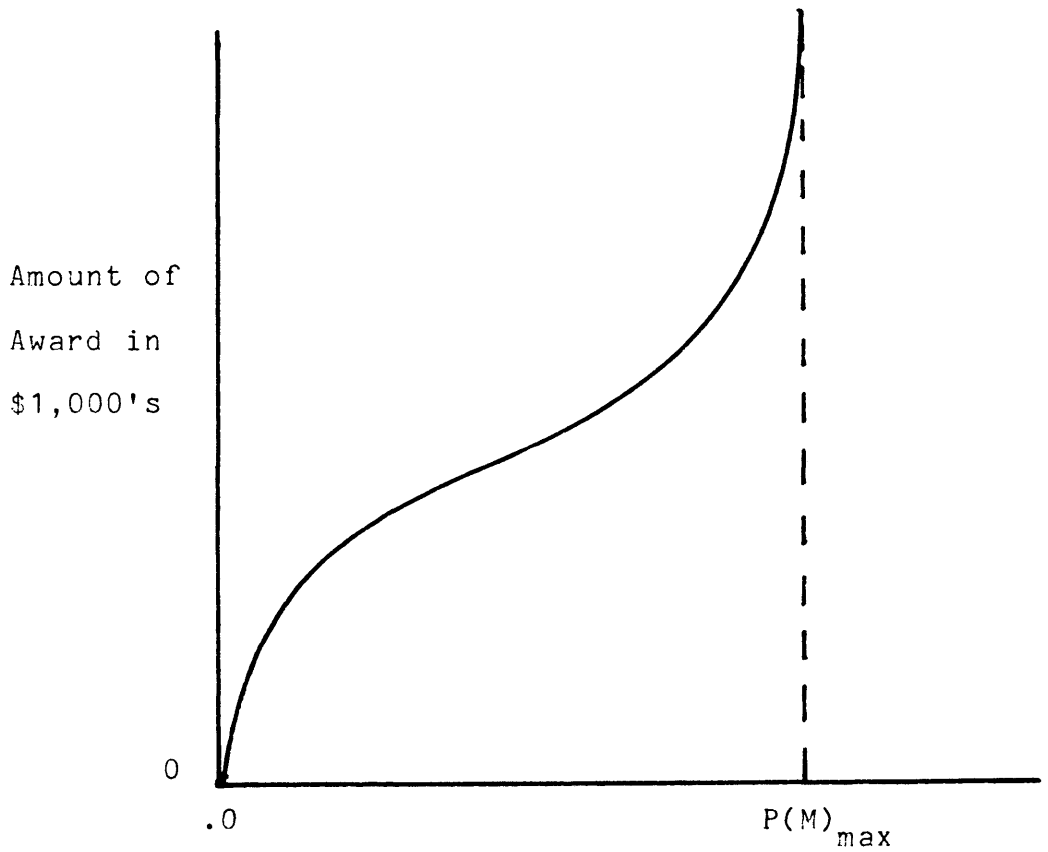

Figure 4.3

Relationship Between Probability of Winning On the Merits and Dollars of General Preparation

make no legal, economic, or common sense. In that case, the program ESTOP must be programmed to fit an equation of a form different than a cubic. For purposes of this paper, only the general cubic form will be considered.

The next chapter will combine the cubic equation derived above and the equations from Chapter 3 to determine the optimum amount of money that should be spent on general preparation costs, C_p.

Chapter 5

OPTIMIZING GENERAL PREPARATION COSTS

In Chapter 3, Equation (3.28) was developed to calculate the expected value adjusted for the time value of money for n related cases. Chapter 4 developed the relationship between $P(M)_{max}$, the highest probability of winning on the merits that can be reached, and the amount of attorney hours and other preparation work, C_p, expended. This chapter will develop the optimum amount to be spent on C_p.

When counsel gets his first one or several of n related cases, he must determine how much money to spend defending such case(s). Just as the costs of defending an individual suit, C_t, and the general preparation costs C_p, are costs to be considered, so also are the potential losses to the company in terms of damages awarded against it. This expected value was developed in Equation (3.28). The sum of these costs are the total costs of the n cases. This can be written

$$TC = C_p + PEV. \qquad (5.1)$$

where:

TC = Total cost;

C_p = General preparation costs; and

PEV = Present expected value of n cases.

The thrust of this chapter is to determine C_p, the amount of money to be spent on general preparation costs to minimize total expected value. The reason this number is desired is that it is economically the most efficient amount to spend. This can be established using basic economic principles. In economics, maximum efficiency is reached at the point where marginal cost (MC) equals marginal benefit (MB),

$$MC = MB. \qquad (5.2)$$

The C_p function developed in Chapter 4 represents costs of preparation in terms of P(M). The expected value

function, although it represents dollars paid out, in fact represents benefits because it shows reduced costs. A reduced cost is equivalent to money saved, or a benefit to the company. That C_p is an economically efficient point will be established logically. C_p increases as P(M) increases, that is, as additional money is spent on general preparation, the chances of winning on the merits at trial also increase (up to a point). Similarly, PEV decreases as P(M) increases. As the chances of winning at trial are increased, the total in increased savings to the company increases, or the PEV decreases. In this analysis then, the equivalent statement of marginal cost equals marginal benefit represents the efficient point.

$$MC = MB,$$

$$dC_p/dP(M) = - [dPEV/dP(M)]. \quad (5.3)$$

Equation (5.3) is the derivative of the C_p function with respect to P(M) set equal to the derivative of the PEV function with respect to P(M). This is the equivalent of the first order condition which establishes the economically efficient point.

$$dC_p/P(M) + dPEV/P(M) = 0,$$

is the equivalent of

$$dTC/dP(M) = 0, \qquad (5.4)$$

or the first order condition of the total cost function.

When this equation is solved, the value of $P^*(M)$ is determined which gives the least total cost. Then, the PEV function is evaluated using $P^*(M)$ and PEV^* which is the optimum minimum value is determined. Similarly, the C_p function is evaluated at $P^*(M)$ and C_p^* is determined. This C_p^* is the efficient amount to allocate to general preparation at this point in time. Thus, when counsel is first confronted with n related cases, he can establish some optimum amount to allocate to preparation.

At later points in the progress of the cases, re-evaluation will certainly need to occur. If some critical fact is established during initial preparation, favorable or unfavorable, the initial estimates of P(o), P(d) or $P(M)_{max}$ will change, and the calculations would be run again. Also, when litigation actually begins, C_p is then a sunk cost and $P^*(M)$ is then more or less fixed and

must be estimated by counsel. This final estimate of $P^*(M)$ will be shown as $P(\hat{M})$. A fine tuning process can now occur. With $P(\hat{M})$ estimated, $\hat{EV}$ can be calculated by evaluating EV at $P(\hat{M})$ and this amount, $\hat{EV}$, is the final estimate of what the n related cases should cost.

At this point several decisions can be made based upon these figures. If an offer is made to settle a case out of court, the case in question can be removed from the pool and the calculations run again. The difference in the original $\hat{EV}$ and the $\hat{EV}'$ ($\hat{EV}$ without the case pending settlement) represents the amount for which counsel should be willing to negotiate a settlement.

Counsel can also run computations with varying combinations of cases from the pool. A large potential award can be pulled out, the computations run and the results compared. Counsel may find that it is advantageous to settle a large case before any precedents have been set. Basically, these are rudimentary sensitivity studies of the model to help counsel determine the most influential variables.

Chapter 6 will present two hypothetical cases to illustrate this method of analysis for related cases.

Chapter 6

APPLICATIONS OF THE METHOD

To illustrate the application of this method, a hypothetical problem will be used. Assume that a company owned pickup truck overturns while exiting an open pit barite mining operation. Three miners were in the truck, Mr. Jones broke his leg, Mr. Smith lost a hand, and Mr. Brown was killed. Three suits are filed against the company alledging liability and claiming damages of $10,000, $75,000, and $350,000 respectively. After some preliminary research, counsel estimates that the probability of offensive collateral estoppel, P(o) is 0.5, and the probability of defensive collateral estoppel, P(d) is 0.1. The best counsel estimates that could be done at trial is a 0.6 probability of winning on the merits.

When the company's attorney first receives the three suits, counsel would like to know the expected potential loss to the company, how much general preparation should be done, i.e., how many dollars should be expended for general preparation, and how much the expected loss can be minimized by general preparation.

Appendix B contains the computer program designed to solve this problem, ESTOP. Appendix C contains the input data files, example program execution, and the report generated for the example problem detailed above where n=3. This output includes the computation of all the intermediate calculations needed to reach the EV function for n=3, and the calculation of the C_p function. As can be readily seen, the calculations are not difficult, but are numerous and repetitive. This method of analysis without a computer is not practical. The program ESTOP prints a graph of the C_p function versus P(M). This graph is generated from the points estimated by counsel as discussed in Chapter 4. ESTOP also generates a graph of the total cost function plotted against the P(M) estimates. As will be shown, the graphs contain all the information critical to the attorney's analysis. The full output for other examples will be included to show the details of the calculations only for completeness of this thesis. For the practitioner, only the graphs need to be generated.

Figures 6.1 and 6.2 show the graphs resulting from the example problem detailed above. Figure 6.1 is the graph of the general preparation costs function, C_p. The dashed vertical line represents $P(M)_{max}$ as estimated by counsel. Figure 6.2 is the graph of total expected costs (EV plus

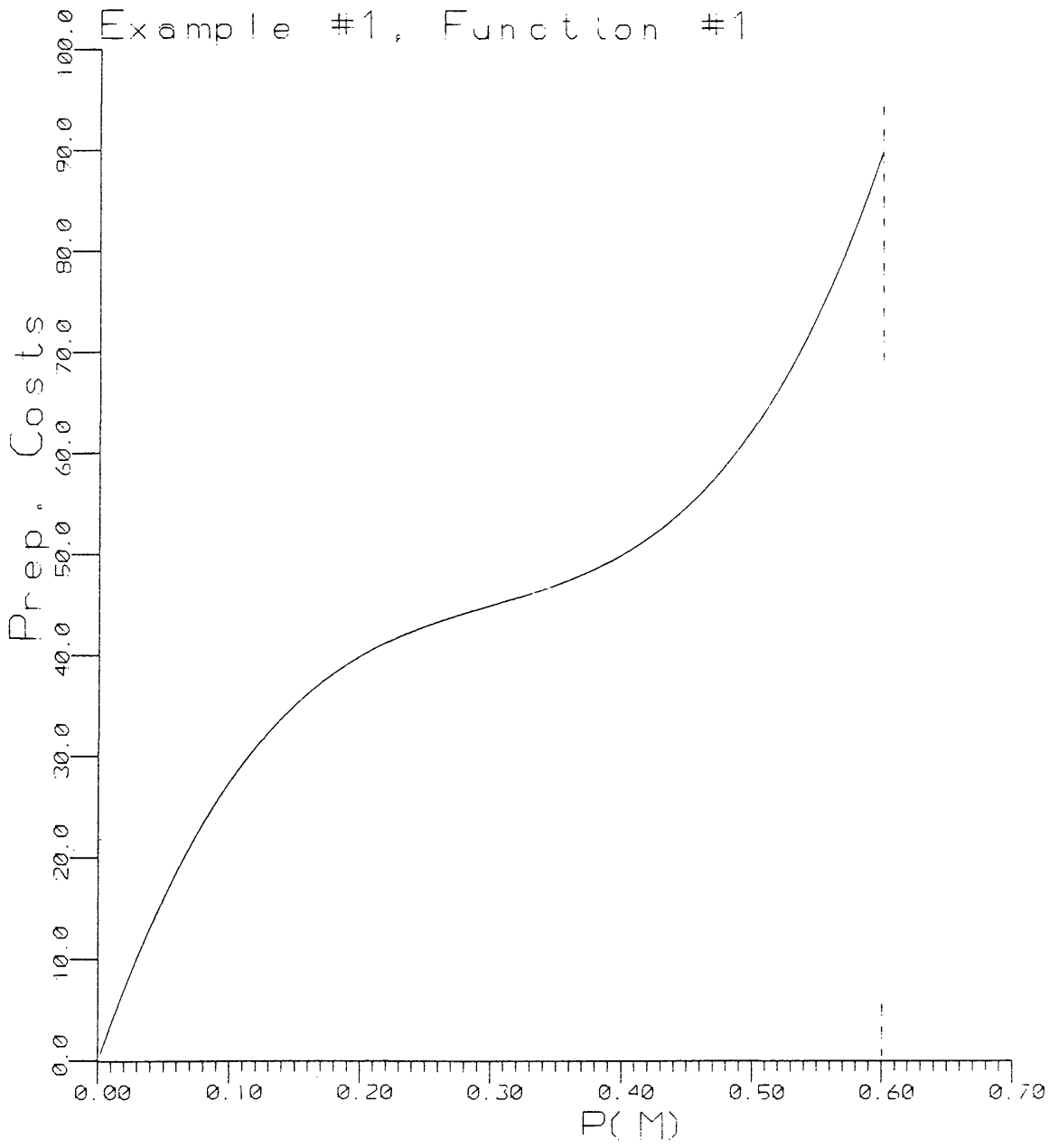

Figure 6.1

Preparation Cost Function for Example 1, n=3

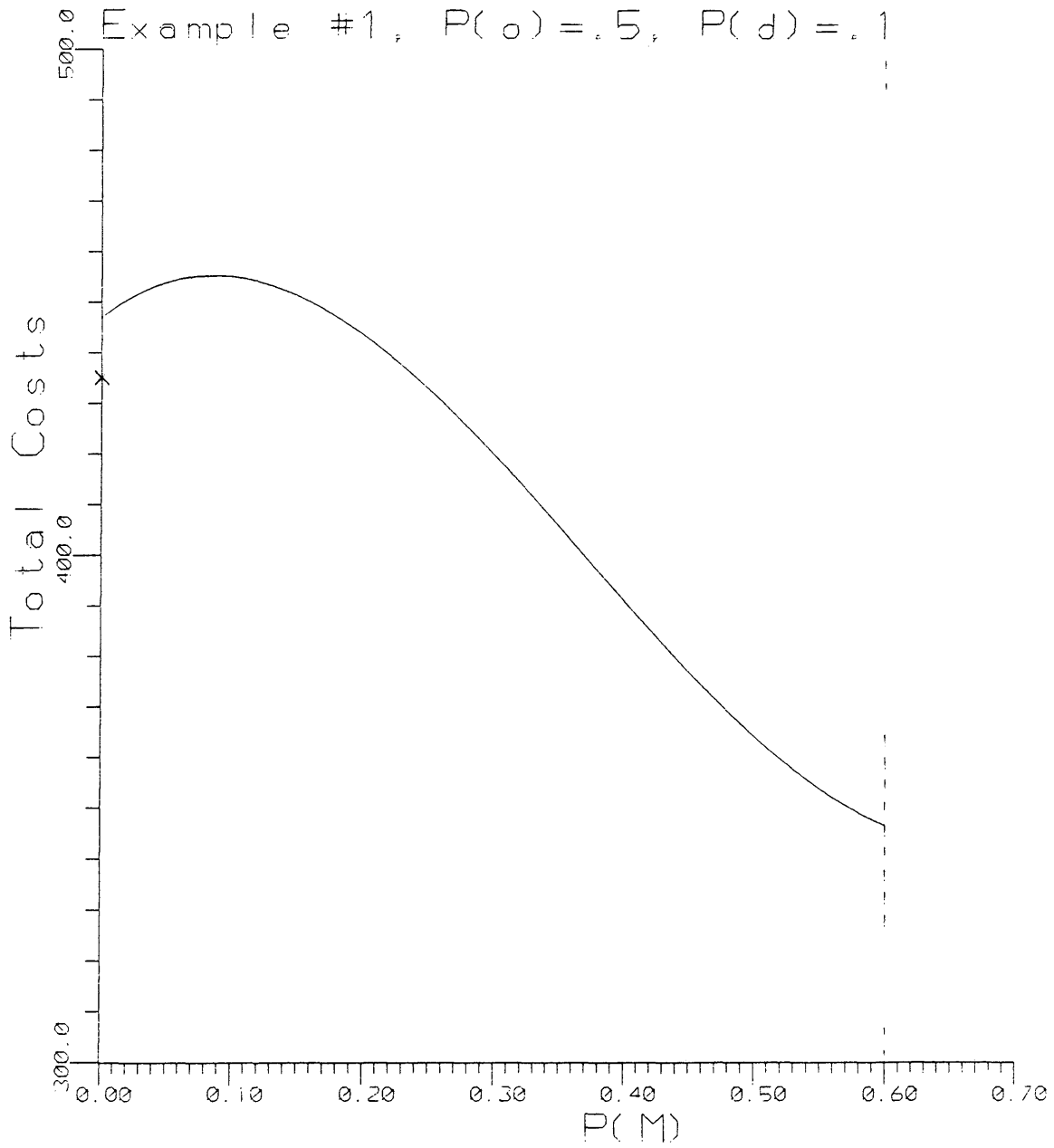

Figure 6.2

Total Cost v. Probability of Winning On Merit

for Example 1, n=3

C_p) versus P(M). Again, the vertical dashed line is $P(M)_{max}$. The total amount of awards requested is shown on the vertical axis by a small x on Figure 6.2. This is the amount the company would pay if it did no preparation, did not defend the actions, and just paid the requested awards. The amount of the awards plus the fixed costs of C_t is the (0,TC) point on the vertical axis. The attorney can tell from inspection how much total costs are expected to be at any P(M) by reading the graph. There are three general categories of results to be read from the graph of TC versus P(M).

The minimum point on the graph can be above the x representing the total awards. This would mean that preparation should not be done, the cases not defended, and the awards should be paid. The minimum point could be below x and to the left of $P(M)_{max}$. This represents the point where marginal cost equals marginal benefits, and is designated as $P^*(M)$. At that point, the associated amount of general preparation, C_p, will yield the lowest possible expected loss to the company. The amount of C_p is determined by ascertaining the P(M) associated with the low point, P*(M), and looking at the graph of C_p versus P(M) to determine the associated dollars of preparation. The third possibility is that the minimum point is to the right of

$P(M)_{max}$. This means that a higher P(M) than the $P(M)_{max}$ estimated by counsel must be possible in order to minimize total expected costs. In that case, the point where the curve crosses $P(M)_{max}$ (the vertical dashed line) is used. If that point is below the x representing total awards, then the amount of preparation dollars associated with $P(M)_{max}$ should be expended for the lowest achievable total expected cost.

In Figure 6.2 it can be seen that the lowest point is to the right of $P(M)_{max}$, the third general category of results, so the point of $P(M)_{max}$ is used. Expected costs can be minimized by spending $90,000 on general preparation ($90,000 is found from Figure 6.1). The advantage of this method of analysis is summarized by the following results. If this analysis were not done, counsel could spend more or less than $90,000 on preparation and therefore not minimize total expected costs. By knowing the point where marginal cost equals marginal benefit, counsel has held the company's losses to the lowest possible dollar amount, $350,000. If no preparation were done, the company loss could amount to the total of the awards plus the costs of going to trial if the actions were defended, $447,000, an amount higher than the minimum calculated. This is a savings to the mining company of $93,000.

By changing $P(M)_{max}$ from 0.6 to 0.3, and making associated changes to the C_p function as shown in Figure 6.3, the curve shown in Figure 6.4 results. This shows that the minimum point on the curve is now above the x on the vertical axis, the first general category of results. Thus, counsel learns before expending any money on general preparation that it is less expensive to pay these suits immediately rather than incur fixed costs, C_t, and preparation costs, C_p. This is an important piece of information and creates immediate savings. The only expense to the company is the time to run the program which is trivial.

Figures 6.5, 6.6, and 6.7, contain the results from a final set of examples. Assuming that 10 men were injured or killed in a mine explosion, two runs were made using ESTOP. P(o), P(d), and P(M) were chosen to represent a pro-defense and then a pro-offense point of view. Figure 6.5 is the preparation cost function. Figure 6.6 shows a pro-offense probability of collateral estoppel, and shows that the minimum EV is above the small x. The requested amounts should be paid. Figure 6.7 shows a pro-defense probability of collateral estoppel. In this instance, the

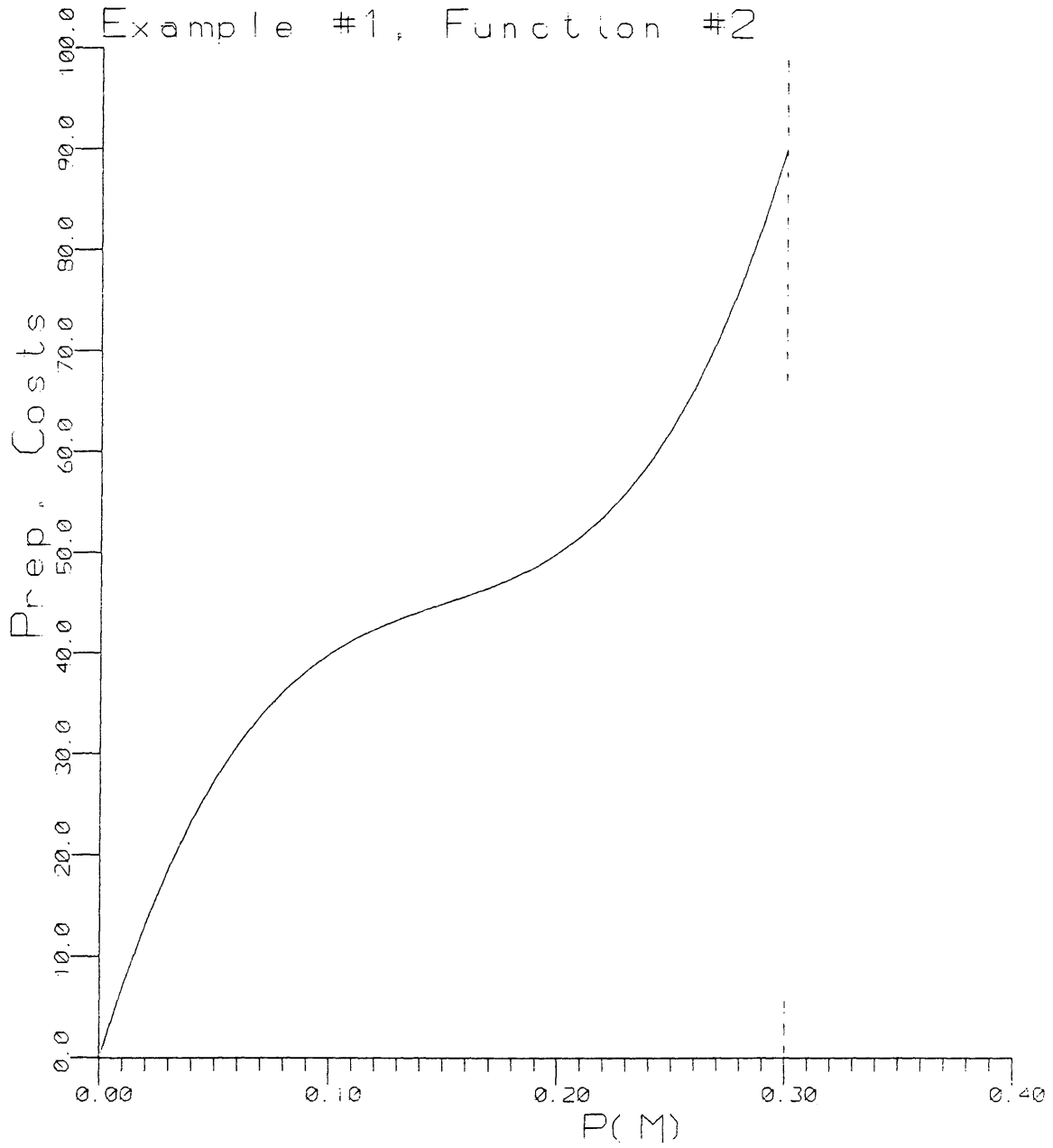

Figure 6.3

Preparation Cost Function for Example 1a, n=3

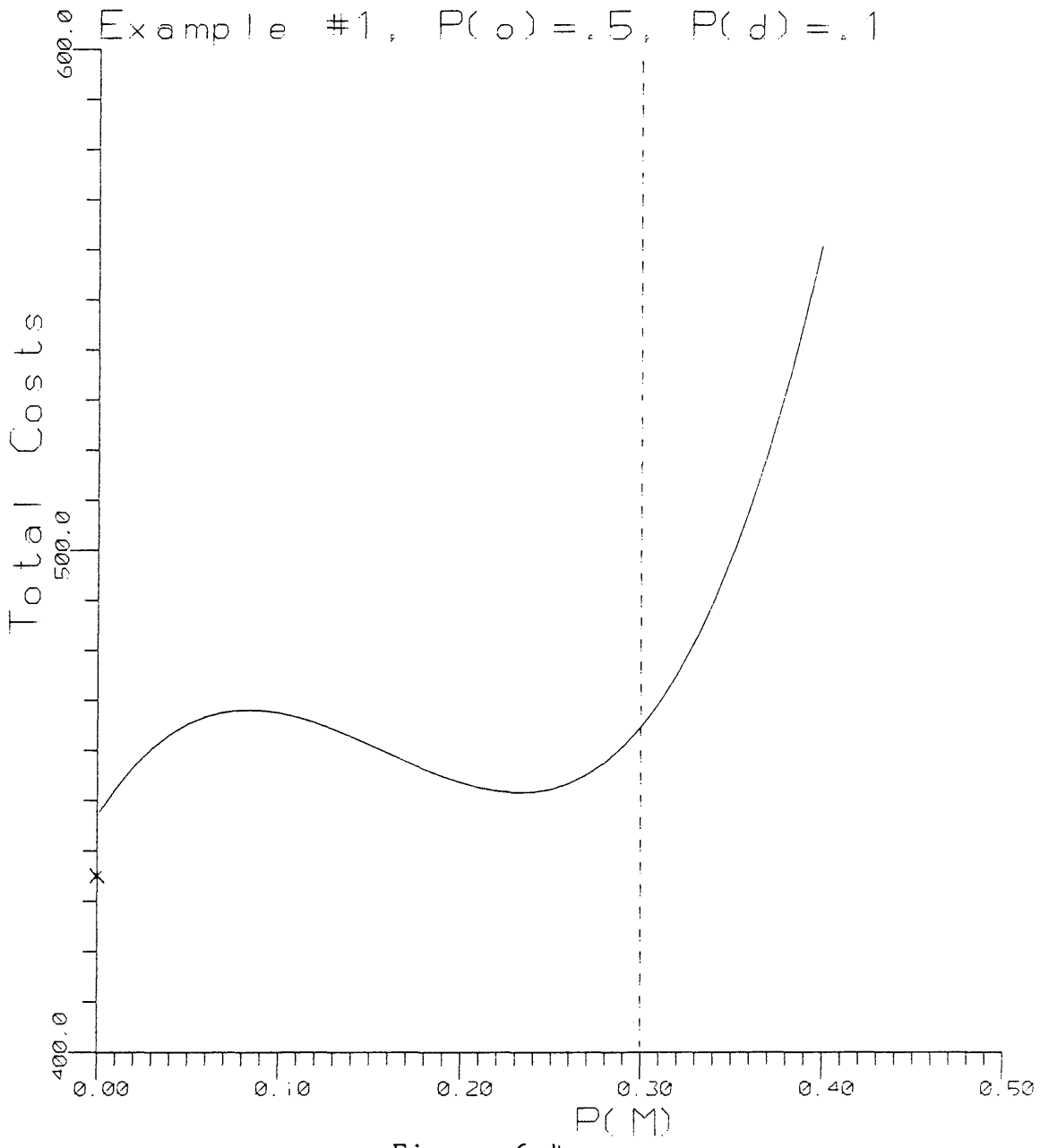

Figure 6.4

Total Cost v. Probability of Winning On Merit

for Example 1a, n=3

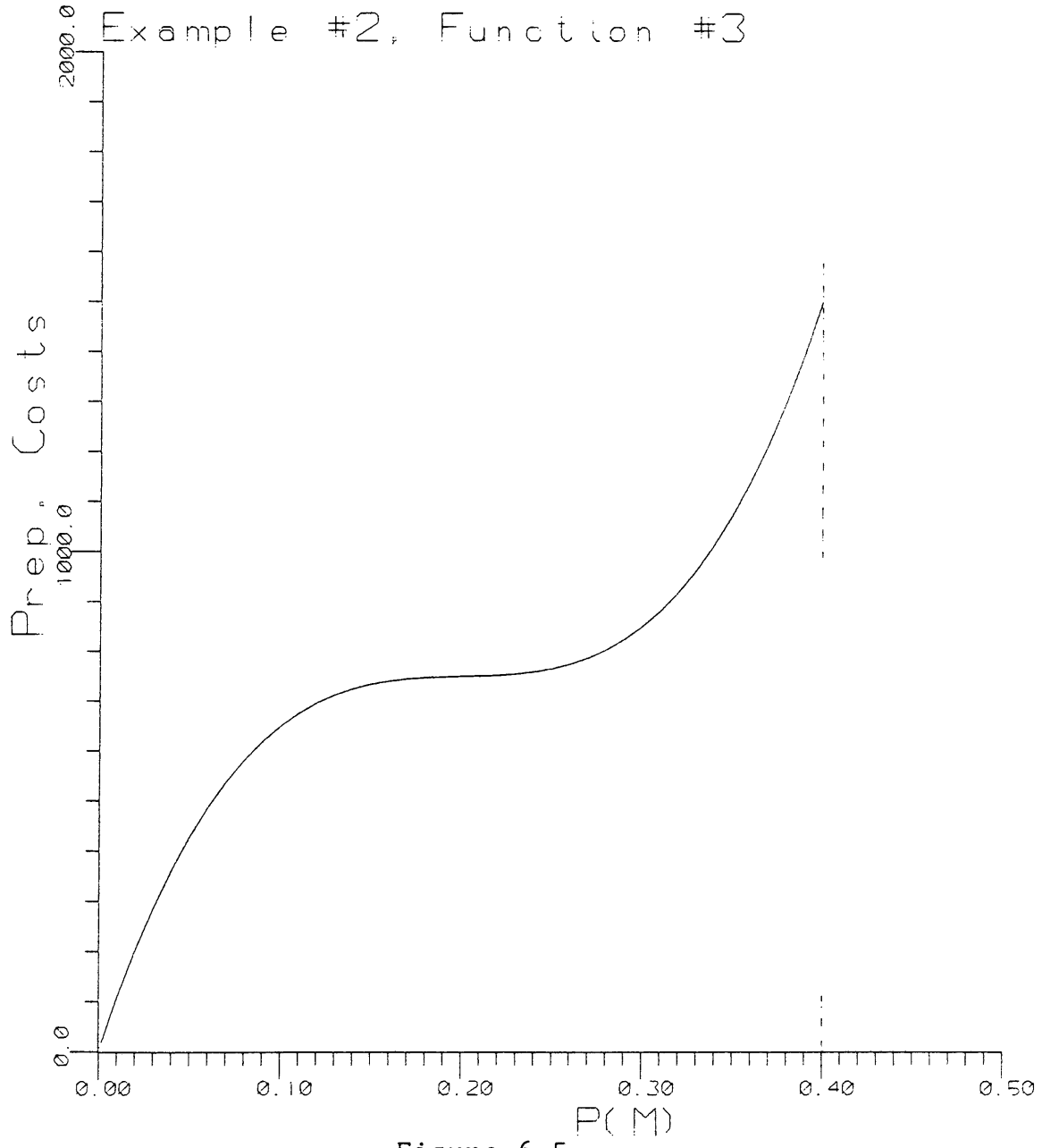

Figure 6.5

Preparation Cost Function for Example 2, n=10

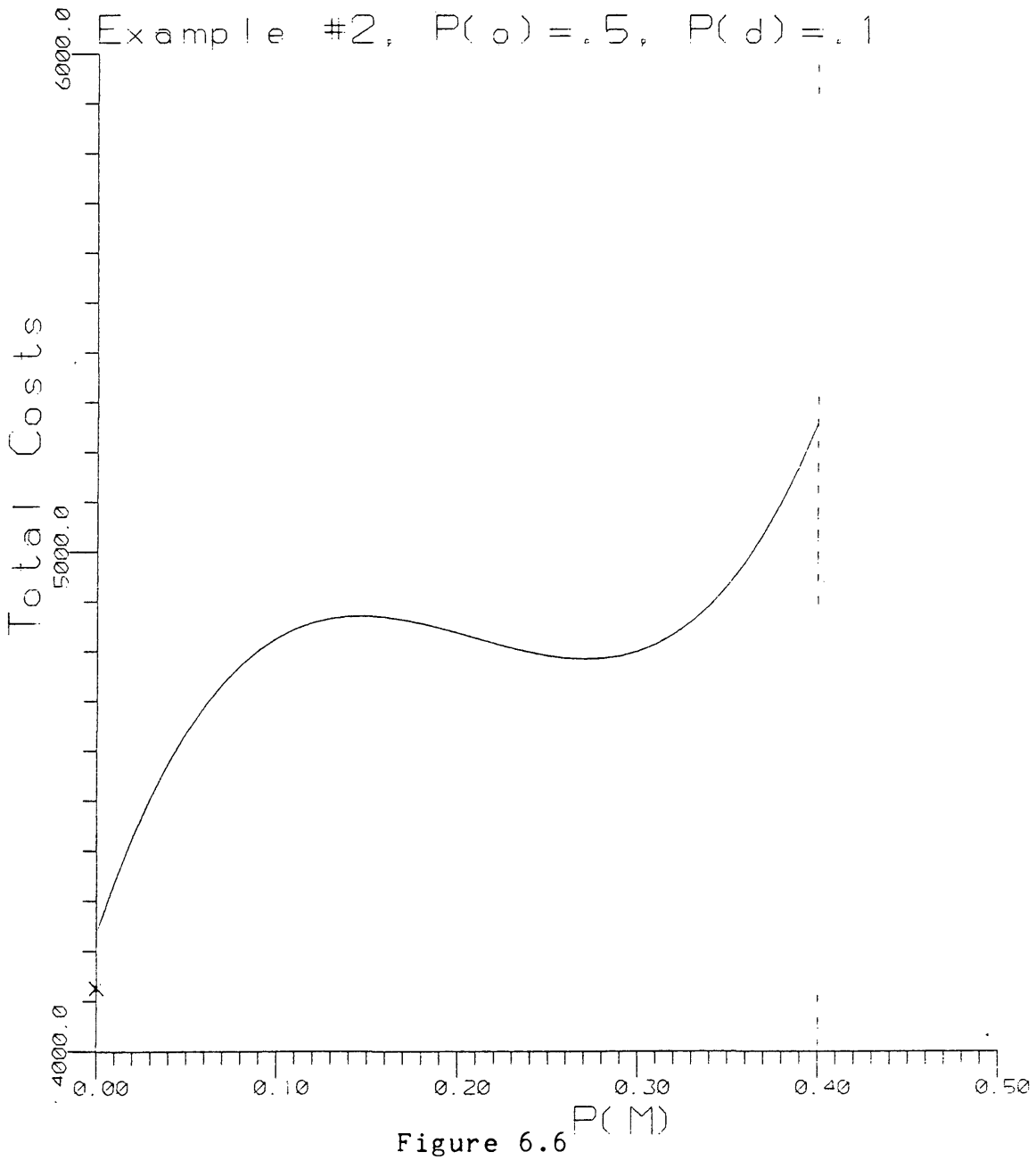

Figure 6.6

Total Cost v. Probability of Winning On Merit

for Example 2, n=10

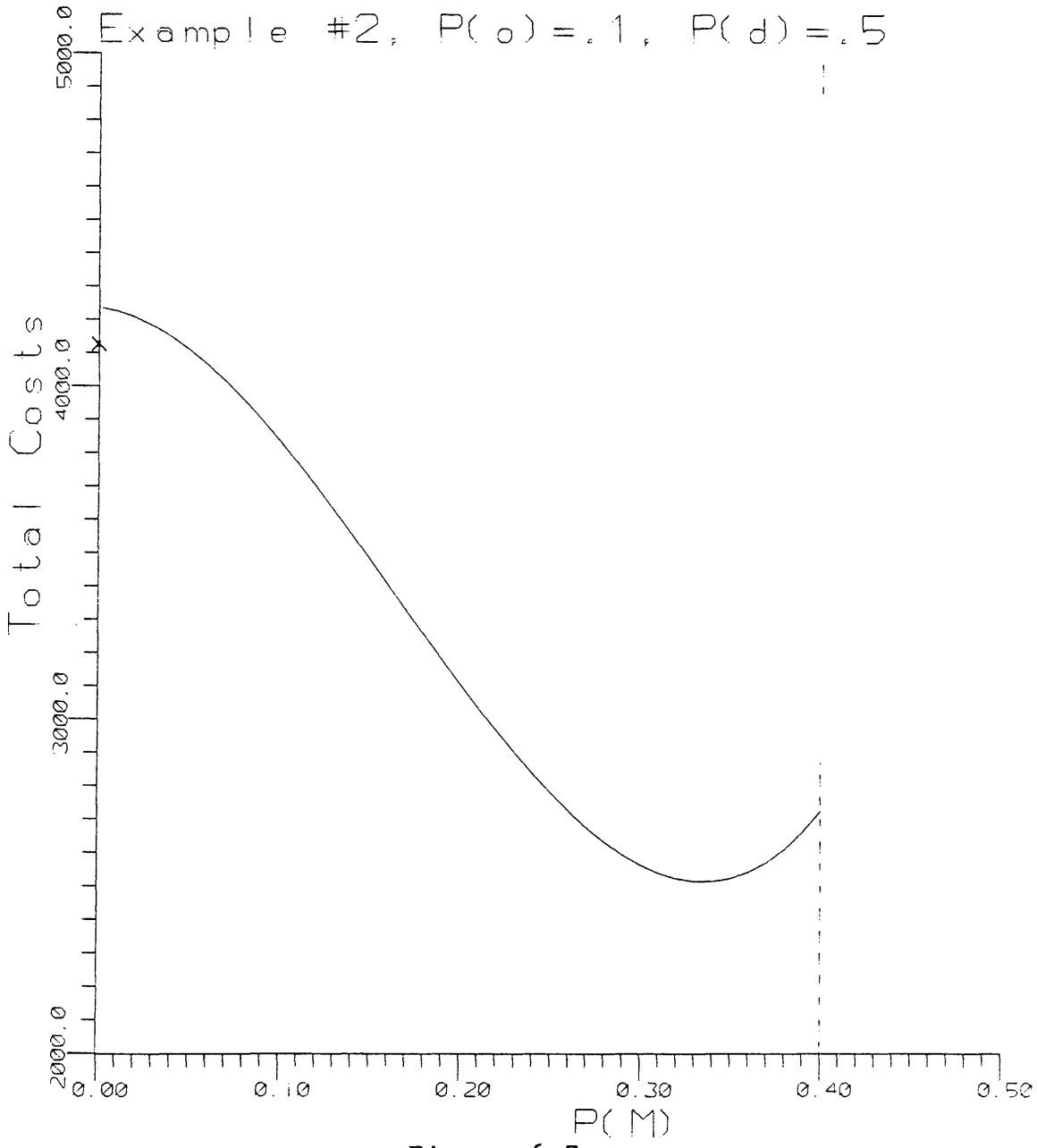

Figure 6.7

Total Cost v. Probability of Winning On Merit

for Example 2a, n=10

company could save $1,620,000 of the amount just requested in total awards by investing $1,000,000 in general preparation, and, would need only a 0.33 probability of winning on the merits to accomplish this savings.

The next chapter includes a brief summary of this thesis and some suggestions for further research.

Chapter 7

SUMMARY AND SUGGESTIONS FOR FURTHER RESEARCH

This thesis began with a review of prior literature in the area of decision analysis and the law. Several quantitative methods of analysis had previously been developed to evaluate settlement versus litigation alternatives. Some decision analysis has also been developed and applied to system-wide concerns within the legal field. No prior work has been done regarding evaluation of related cases.

Chapter 3 began with the development of four basic assumptions derived from the discussion of the legal theory underlying collateral estoppel in Chapter 2. The assumptions are:

1. The n cases being considered are related to each other and collateral estoppel is possible.

$$P(o) \neq 0, \qquad (3.1a)$$

$$P(d) \neq 0. \qquad (3.1b)$$

2. The second assumption is that if collateral estoppel is not invoked, the probability of winning on the merits at trial is the same for all n related cases.

$$P(M_i) = P(M_j), \forall \text{ i and j.} \quad (3.2)$$

Also, since winning and losing are mutually exclusive, the probabilities of the events of winning on the merits and losing on the merits must sum to 1.

$$P(M) + P(M') = 1. \quad (3.3)$$

3. The third assumption is that within each pool of cases (one offense, one defense), the probability of a judgment in any one case being used to invoke collateral estoppel is the same for all cases within that pool. The basis for this is the Full Faith and Credit Clause of the Constitution which states that any state should uphold a final judgment from any other state.

$$P(o_{ij}) = P(o_{km}), \forall\ i < j, k < m; \qquad (3.4a)$$

$$P(d_{ij}) = P(d_{km}), \forall\ i < j, k < m. \qquad (3.4b)$$

The fourth assumption is that the plaintiff and defendant have different probabilities of collateral estoppel being invoked. The courts are generally more reluctant to invoke defensive collateral estoppel because its effect is to deprive a new plaintiff of his day in court.

$$P(o) \neq P(d), \text{ and} \qquad (3.5a)$$

$$P[O_{i+1} \mid (i,r)] \neq P[D_{i+1} \mid (i,r)]. \qquad (3.5b)$$

With these assumptions, the various probabilities of winning or losing case (i+1) given state (i,r) and the probabilities of winning or losing case i were developed. The probability of state (i,r) was also developed. Finally, the expected value of a single case and of all n cases was determined.

Chapter 4 developed the relationship between general preparation costs, C_p, and the probability of succeeding on the merits. This relationship can be represented by an S-shaped curve which can be estimated by a cubic equation. An explanation of how defense counsel could estimate several points on the curve and determine the coefficients was also provided.

Chapter 5 showed how the optimum amount to spend on general preparation C_p can be determined. This optimum amount is the economically efficient point which corresponds to marginal cost equalling marginal benefit. It is important to remember that although expected value is a cost in that it is the amount of awards that can be expected to be paid, it is a benefit to the company because it represents savings by minimizing that expected value.

Chapter 6 showed two small representative problems with three and ten related cases and detailed the computations developed in earlier chapters. The primary interest in related cases being illustrated by the difference in expected value of any of the cases individually and the expected value calculated taking into consideration the relatedness of the cases.

A final point should be made regarding the limitations

on the use of collateral estoppel and therefore this particular method of analysis. Collateral estoppel applies only to issues or facts, not the the way those facts or issues are then resolved or interpreted by the law. An example should help. Mr. Brown and Mr. Smith litigated the issue of who owned the surface rights and who owned the mineral estate. The court in jurisdiction A ruled that Mr. Brown owned the mineral rights and Mr. Smith owned the surface rights. In jurisdiction A, the existence of the fact of ownership of the mineral estate meant that Mr. Brown could employ surface mining techniques even though that would temporarily destroy Mr. Smith's surface estate. These men also own a parcel of land in jurisdiction B. Mr. Brown could ask the court to apply offensive collateral estoppel since he has a judgment determining ownership of the surface versus mineral estates under an identical deed from jurisdiction A. The court in jurisdiction B could in fact invoke collateral estoppel and affix the mineral estate ownership in Mr. Brown and the surface estate ownership in Mr. Smith. However, in jurisdiction B, ownership of the mineral estate does not include the right to employ surface mining techniques if it produces significant damage to the surface estate. Thus, the fact or issue is identical in both jurisdictions, Mr. Brown owns

the mineral estate. The consequences of the existence of ownership, however, is a matter of substantitive law and is unique to each jurisdiction. Collateral estoppel can be very broad in some respects, but it is also quite limited because of the varying statutory construction and interpretation of law in different jurisdictions. Caution must be used when choosing appropriate related cases upon which to apply this analysis.

Further research in this area would include such topics as sensitivity studies of the unknowns P(o), P(d), and P(M). That is, if counsel had an additional $10,000 to spend, would counsel prefer to "buy" additional P(M) or additional P(d)? Studies could also be done to determine the relative effect of settling very large cases, or settling many early cases, upon the expected value of the n cases. It may also be possible to determine some number n', this would be the minimum number of cases necessary to consider implementing this related analysis. This method could also be altered to consider such intangible costs to the company as lost management time and similar resources. With such additional research, this method should prove to be a valuable tool for a minerals firm involved in related cases in litigation.

REFERENCE LIST

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APPENDIX A

Development of General Polynomial Form

Equations (3.6 - 3.11b) are repeated below to show that they are all in terms of P(M) and the parameters P(o) and P(d):

(3.6)

$$P[D'_{i+1} \mid (i,r)] = \prod_{j=1}^{r} (1 - P(d)),$$

(3.7)

$$P[D'_{i+1} \mid (i,r)] = [1 - P(d)]^{r},$$

(3.8)

$$P[D_{i+1} \mid (i,r)] + P[D'_{i+1} \mid (i,r)] = 1,$$

(3.9)

$$P[D_{i+1} \mid (i,r)] = 1 - P[D'_{i+1} \mid (i,r)],$$

(3.10)

$$P[D_{i+1} \mid (i,r)] = 1 - [1 - P(d)]^{r},$$

(3.11a)

$$P[O_{i+1} \mid (i,r)] = 1 - [1 - P(o)]^{i-r}, \text{ and}$$

(3.11b)

$$P[O'_{i+1} \mid (i,r)] = [1 - P(o)]^{i-r}.$$

Equations (3.12), (3.13), and (3.14) can be reduced to equivalent forms in terms of P(M) and P(o) and P(d) with a few substitutions as shown below.

Starting with Equation (3.12) which is repeated below for the reader's convenience,

(3.12)

$$P[T_{i+1} \mid (i,r)] = P[O'_{i+1} \mid (i,r)]P[D'_{i+1} \mid (i,r)] + P[O_{i+1} \mid (i,r)]P[D_{i+1} \mid (i,r)],$$

substituting from Equation (3.11b), yields

$$P[T_{i+1} \mid (i,r)] = [1-P(o)]^{i-r} P[D'_{i+1} \mid (i,r)] + P[O_{i+1} \mid (i,r)]P[D_{i+1} \mid (i,r)], \text{ and}$$

substituting from Equation (3.7) gives

$$P[T_{i+1} \mid (i,r)] = [1-P(o)]^{i-r} [1-P(d)]^{r} + P[O_{i+1} \mid (i,r)]P[D_{i+1} \mid (i,r)].$$

Substituting from (3.11a) gives

$$P[T_{i+1} \mid (i,r)] = [1-P(o)]^{i-r} [1-P(d)]^{r} + \{1-[1-P(o)]^{r}\}P[D_{i+1} \mid (i,r)], \text{ and}$$

substituting from (3.10) yields the final result

$$P[T_{i+1}|(i,r)] = [1-P(o)]^{i-r}[1-P(d)]^{r} + \{1-[1-P(o)]^{i-r}\}\{1-[1-P(d)]^{r}\}, \quad (A.1)$$

which expresses $P[T_{i+1}|(i,r)]$ in terms of the parameters P(o) and P(d).

A similar procedure is followed for Equation (3.13).

(3.13)

$$P[W_{i+1}|(i,r)] = P(M)P[T_{i+1}|(i,r)] + P[D_{i+1}|(i,r)]P[O'_{i+1}|(i,r)],$$

substituting from Equation (3.12)

$$P[W_{i+1}|(i,r) = P(M)\left(P[O'_{i+1}|(i,r)]P[D'_{i+1}|(i,r)] + P[O_{i+1}|(i,r)]P[D_{i+1}|(i,r)]\right) + P[D_{i+1}|(i,r)]P[O'_{i+1}|(i,r)], \quad (A.2)$$

and each of these terms has been shown to be expressible in terms of the parameters P(o) and P(d).

Equation (3.14) is repeated and a similar procedure is followed.

(3.14)

$$P[L_{i+1} \mid (i,r)] = P(M')P[T_{i+1} \mid (i,r)] + P[O_{i+1} \mid (i,r)]P[D'_{i+1} \mid (i,r)],$$

substituting from Equation (3.12) yields

$$P[L_{i+1} \mid (i,r)] = P(M')\Big(P[O'_{i+1} \mid (i,r)]P[D'_{i+1} \mid (i,r)] + P[O_{i+1} \mid (i,r)]P[D_{i+1} \mid (i,r)]\Big) + P[O_{i+1} \mid (i,r)]P[D'_{i+1} \mid (i,r)],$$

substituting for P(M') gives

$$P[L_{i+1} \mid (i,r)] = [1 - P(M)]\Big(P[O'_{i+1} \mid (i,r)]P[D'_{i+1} \mid (i,r)] + P[O_{i+1} \mid (i,r)]P[D_{i+1} \mid (i,r)]\Big) + P[O_{i+1} \mid (i,r)]P[D'_{i+1} \mid (i,r)],$$

Rearranging terms and signs yields

$$P[L_{i+1} \mid (i,r)] = \{P[O'_{i+1} \mid (i,r)]P[D'_{i+1} \mid (i,r)]$$
$$+ P[O_{i+1} \mid (i,r)]P[D_{i+1} \mid (i,r)]$$
$$+ P[O'_{i+1} \mid (i,r)]P[D_{i+1} \mid (i,r)]\}$$
$$- P(M)(P[O'_{i+1} \mid (i,r)]P[D'_{i+1} \mid (i,r)$$
$$P[O_{i+1} \mid (i,r)]P[D_{i+1} \mid (i,r)]), \quad (A.3)$$

and each of these terms was expressed in terms of P(o) and P(d) in the derivation of Equation (A.1) above.

Equation (3.17) uses the induction proof in the text for the reduction of Equation (3.16), P(i,r), and the following substitution,

(3.17)

$$P(W_{i+1}) = \sum_{r=0}^{i} P(i,r)P[W_{i+1} \mid (i,r),$$

substituting from Equation (A.2) yields

$$P(W_{i+1}) = \sum_{r=0}^{i} P(i,r)\left[P(M)\left(P[O'_{i+1}\,|(i,r)]P[D'_{i+1}\,|(i,r)] + P[O_{i+1}\,|(i,r)]P[D_{i+1}\,|(i,r)]\right) + P[D_{i+1}\,|(i,r)]P[O'_{i+1}\,|(i,r)]\right]. \qquad (A.4)$$

From the text we know that P(i,r) is a function of P(M), and from the appendix we know that the terms following P(M) are also functions of the parameters P(o) and P(d), so Equation (3.17) is a function of P(M) and the parameters P(o) and P(d).

Equation (3.18) is repeated and Equation (A.3) is substituted.

(3.18)

$$P(L_{i+1}) = \sum_{r=0}^{i} P(i,r)P[L_{i+1}\,|(i,r)],$$

substituting Equation (A.3) yields

$$P(L_{i+1}) = \sum_{r=0}^{i} P(i,r)\Big[\big(P[O'_{i+1}|(i,r)]P[D'_{i+1}|(i,r)] + P[O_{i+1}|(i,r)]P[D_{i+1}|(i,r)] + P[O_{i+1}|(i,r)]P[D'_{i+1}|(i,r)]\big) - P(M)\big(P[O'_{i+1}|(i,r)]P[D'_{i+1}|(i,r)] + P[O_{i+1}|(i,r)]P[D_{i+1}|(i,r)]\big)\Big], \quad (A.5)$$

which shows $P(L_{i+1})$ in terms of P(M), P(i,r) which is a function of P(M) (from the text), and the remaining terms which have been defined in terms of P(M) previously in this appendix. Therefore, Equation (3.18) is a function of P(M) and the parameters P(o) and P(d).

The remaining three equations are the expected value equations. Again, the original equation will be reproduced and the substitutions made.

(3.26)

$$EV = \sum_{i=1}^{n} [A_i P(L_i) + C_{t_i}],$$

substituting Equation (A.5) gives

$$EV = \sum_{i=1}^{n} [A_i [P(i,r)((P[O'_{i+1}|(i,r)P[D'_{i+1}|(i,r)] + P[O_{i+1}|(i,r)]P[D_{i+1}|(i,r)] + P[O_{i+1}|(i,r)]P[D'_{i+1}|(i,r)]) - P(M)(P[O'_{i+1}|(i,r)]P[D'_{i+1}|(i,t)] + P[O_{i+1}|(i,r)]P[D_{i+1}|(i,r)]))] + C_{t_i}, \quad (A.6)$$

which shows Equation (3.26) expressed in terms of P(M) and the parameters P(o) and P(d), and the constants A_i and

C_{t_i}. The terms within Equation (A.6) having been expressed in terms of P(o) and P(d) and P(M) above in this appendix. The multiplication of a term by one or more constants does not change the functional form of the equation, so the inclusion of A_i and C_{t_i} does not change the functional form of Equation (3.26). Therefore, Equation (3.26) is expressible in terms of P(M) and P(o) and P(d).

Again, a similar procedure of repeating the original equation and making substitutions is followed for Equation (3.27).

(3.27)

$$PEV_i = [A_i P(L_i) + C_t](1 + d)^{-t_i},$$

substituting from Equation (A.4) yields Equation (A.6) immediately above with the multiplication by $(1+d)^{-t_i}$, which is a constant, multiplying the first term originally seen in Equation (3.26). Since the terms in Equation (3.26) can be expressed in terms of P(M), P(o), and P(d), the multiplication of those terms by a constant does not change their functional form, therefore, Equation (3.27) can be

expressed in terms of P(M), P(o), P(d).

Equation (3.28) is only a summation of many Equations (3.27) so the terms are not altered in any manner. Since Equation (3.27) can be expressed in terms of P(M) and P(o) and P(d), therefore, so can Equation (3.28) be expressed in the same way,

(3.28)

$$PEV = \sum_{i=1}^{n} [A_i P(L_i) + C_t](1 + d)^{-t_i}.$$

APPENDIX B

Computer Program for Expected Value Calculations

```
C
C                        ***** C O M M O N *****
C
C             THIS FILE CONTAINS THE FREQUENTLY ACCESSED COMMONS THAT
C          ARE USED BY THE ESTOPPEL EVALUATION SOFTWARE.
C

           REAL PO, PD, PMMAX
           REAL POLYPM
           REAL PEV, PCOSTS
           REAL TEMP1, TEMP2
           REAL ACOSTS, CCOSTS, TFCOST

           INTEGER MXPOLY, MXTERM
           INTEGER NTERMS, PEVTRM, PCTERM
           INTEGER NCASES
           INTEGER CASFIL, PRPFIL, RPTFIL

C          DEFINE MAXIMUM NUMBER OF POLYNOMIALS WE CAN STORE

           PARAMETER (MXPOLY=100)

C          DEFINE MAXIMUM NUMBER OF TERMS IN A POLYNOMIAL

           PARAMETER (MXTERM=MXPOLY+1)

C          THIS COMMON HOLDS INFORMATION ABOUT THE POLYNOMIALS IN "P(M)"
C          NOTE THAT THE POLYNOMIALS ARE STORED BY COLUMN!

           COMMON /POLYS/ POLYPM(MXTERM,MXPOLY), NTERMS(MXPOLY)

C          THIS COMMON HOLDS THE EXPECTED VALUE POLYNOMIAL IN "P(M)" AND
C          THE PREPARATION COST CUBIC, ALSO IN "P(M)"

           COMMON /COSTS/ PEV(MXTERM), PEVTRM, PCOSTS(4), PCTERM,
          $               ACOSTS(MXTERM), CCOSTS(MXTERM), TFCOST

           COMMON /TEMPS/ TEMP1(MXTERM), TEMP2(MXTERM)

           COMMON /PROBS/ PO, PD, PMMAX

           COMMON /CASES/ NCASES

           COMMON /FILES/ CASFIL, PRPFIL, RPTFIL
```

```
C
C                       ***** E S T O P *****
C
C                       BY WAYNE WALL, CSM, NOV 1983
C
C            THIS PROGRAM IS A DRIVER FOR THE ESTOPPEL EVALUATION
C       ROUTINES USED IN ANN RHIAN'S THESIS.
C
        IMPLICIT REAL (A-Z)

        INCLUDE 'COMMON'

        INTEGER TRMINP, TRMOUT, I, R
        INTEGER IPREV
        INTEGER POLY, TERM
        INTEGER CASE

        CHARACTER GDEV*5, GFILE*10, ANSWER*1

        LOGICAL EOF, IERR

        DIMENSION PL(MXTERM)

C       PERFORM INITIALIZATION BY CLEARING OUT ALL THE POLYNOMIALS IN "P(M)"

        DO 20 POLY = 1, MXPOLY

                NTERMS(POLY) = 1

                DO 10 TERM = 1, MXTERM

                        POLYPM(POLY,TERM) = 0.0

10              CONTINUE

20      CONTINUE

C       ALSO CLEAR OUT ALL OTHER POLYNOMIALS

        DO 30 TERM = 1, MXTERM

                PEV(TERM)   = 0.0
                TEMP1(TERM) = 0.0
                TEMP2(TERM) = 0.0

30      CONTINUE

        PEVTRM = 1

C       ALSO CLEAR OUT THE PREPARATION COST CUBIC

        PCTERM = 4

        DO 40 TERM = 1, PCTERM

                PCOSTS(TERM) = 0.0

40      CONTINUE
```

```
C       ASSOCIATE LOGICAL UNIT NUMBERS WITH USER'S TERMINAL

        TRMINP = 1
        TRMOUT = 2

        CALL OPNTRM(TRMINP,TRMOUT)

C       PROMPT THE USER FOR THE PROBABILITY OF THE EVENT THAT THE OFFENSE HAS
C       AT LEAST ONE DETERMINANT CASE IN ITS POOL WHICH WILL ESTOP EACH CASE.

        CALL PROMPT
     $  ('Enter probability offense has a prior estoppel case P(o): ')

        READ (TRMINP,*) PO

C       PROMPT THE USER FOR THE PROBABILITY OF THE EVENT THAT THE DEFENSE HAS
C       AT LEAST ONE DETERMINANT CASE IN ITS POOL WHICH WILL ESTOP EACH CASE.

        CALL PROMPT
     $  ('Enter probability defense has a prior estoppel case P(d): ')

        READ (TRMINP,*) PD

C       ASSOCIATE LOGICAL UNIT NUMBERS WITH CASE INFORMATION FILE AND
C       THE DISCOVERY COST INFORMATION FILE

        CASFIL = 3
        PRPFIL = 4
        RPTFIL = 5

        CALL OPNINS(CASFIL,'Enter name of case information file: ')
        CALL OPNINS
     $  (PRPFIL,'Enter name of preparation cost info file: ')

C       ASSOCIATE LOGICAL UNIT NUMBER WITH A REPORT FILE

        CALL OPNOTS(RPTFIL,'Enter name of file to contain report: ')

C       NOW INPUT THE CASE INFORMATION AND THE PREPARATION COST INFORMATION

        CALL INPINF
```

```
C       COMPUTE THE EXPECTED VALUE AS A FUNCTION OF "P(M)" FOR ALL
C       POSSIBLE STATES.

C       SETUP P(0,0) INTO POLYPM

        POLYPM(1,1) = 1.0
        NTERMS(1) = 1

        DO 600 I = 1, NCASES

                CASE = I

C               OUTPUT THE P(I-1,R) VALUES TO REPORT FILE

                DO 100 POLY = 1, CASE

                WRITE (RPTFIL,50) CASE-1, POLY-1
50              FORMAT(1X,'P(',I2,',',I2,') = ',$)

                CALL POLYOT(RPTFIL,POLYPM(1,POLY),NTERMS(POLY))

100             CONTINUE

                WRITE (RPTFIL,*)

C               NOW COMPUTE THE P(L) VALUE FOR THIS CASE

                DO 200 TERM = 1, CASE + 1

                        PL(TERM) = 0.0

200             CONTINUE

                DO 400 R = 1, CASE

                        DO 250 TERM = 1, NTERMS(R)

                                TEMP1(TERM) = POLYPM(TERM,R)

250                     CONTINUE

                        CALL PBLOSE (CASE-1,R-1,AL,BL)

                        CALL MULLIN (TEMP1,NTERMS(R),AL,BL)

                        DO 300 TERM = 1, NTERMS(R) + 1

                        PL(TERM) = PL(TERM) + TEMP1(TERM)

300                     CONTINUE

400             CONTINUE
```

```
C               NOW OUTPUT THE PL(CASE) VALUE TO THE REPORT FILE

                WRITE (RPTFIL,410) CASE
410             FORMAT(1X,'PL(',I2,')   = ',$)

                CALL POLYOT (RPTFIL,PL,CASE+1)

                WRITE (RPTFIL,*)

C               COMPUTE THE P(I,R) VALUES FOR THIS CASE

                CALL COMPIR(CASE)

C               NOW UPDATE THE RUNNING EXPECTED VALUE SUM

                DO 500 TERM = 1, CASE + 1

                PEV(TERM) = PEV(TERM) + ACOSTS(CASE) * PL(TERM)

500             CONTINUE

                PEV(1) = PEV(1) + CCOSTS(CASE)

600     CONTINUE

C       OUTPUT THE EXPECTED VALUE EXPRESSION

        WRITE (RPTFIL,610)
610     FORMAT(1X,'PEV      = ',$)

        CALL POLYOT (RPTFIL,PEV,NCASES+1)
```

```
C       PROMPT USER FOR THE PLOTTING DEVICE

        CALL PROMPT('Enter name of plotting device: ')
        CALL INPLIN(TRMINP,GDEV,EOF)

        CALL PROMPT('Shall I plot the preparation cost function? ')
        CALL INPLIN(TRMINP,ANSWER,EOF)

        IF ( (ANSWER .EQ. 'Y') .OR. (ANSWER .EQ. 'y') ) THEN

                CALL PLOTIT(GDEV,PCOSTS,PCTERM,-1.0,'Prep. Costs')

        ENDIF

C       ADD THE PREPARATION COSTS AND THE PEV TO GET THE TOTAL COST FUNCTION

        DO 700 TERM = 1, PCTERM

                PEV(TERM) = PEV(TERM) + PCOSTS(TERM)

700     CONTINUE

        WRITE (TRMOUT,*) 'I will now plot the Total Cost function...'

        CALL PLOTIT (GDEV,PEV,NCASES+1,TFCOST,'Total Costs')

        STOP
        END
```

```
C
C                       ***** I N P I N F *****
C
C       INPINF: ROUTINE TO INPUT INFORMATION ABOUT CASES AND PREPARATION COSTS.
C
C       USAGE:  CALL INPINF
C
        SUBROUTINE INPINF

        IMPLICIT INTEGER (A-Z)

        INCLUDE 'COMMON'

        COMMON /USRLUN/ USERIN, USEROT

        REAL A(3,3), X(3), B(3)

C       FIRST INPUT THE NUMBER OF CASES TO BE CONSIDERED

        READ (CASFIL,*) NCASES

        IF ( NCASES .GT. MXPOLY ) THEN

                CALL FATAL ('Too many cases for program to handle!')

        ENDIF

        WRITE (RPTFIL,10) PO, PD, NCASES
10      FORMAT(1X,'Probability of offensive estoppel = ',F6.3,/
     $         1X,'Probability of defensive estoppel = ',F6.3,/
     $         1X,'Number of cases                   = ',I6,//,
     $         1X,'    Awards      Fixed Costs',/)

C       NOW INPUT THE AWARD COSTS AND THE FIXED COSTS FOR EACH CASE

        DO 100 CASE = 1, NCASES

                READ (CASFIL,*) ACOSTS(CASE), CCOSTS(CASE)
                WRITE (RPTFIL,50) ACOSTS(CASE), CCOSTS(CASE)
50              FORMAT(1X,2F12.3)

                TFCOST = TFCOST + CCOSTS(CASE)

100     CONTINUE

        WRITE (RPTFIL,110) TFCOST
        WRITE (USEROT,110) TFCOST
110     FORMAT(/,1X,'Total fixed litigation costs     = ',F12.3,/)
```

```
C       NOW INPUT THE MAXIMUM POINT ON THE PREPARATION COST CURVE

        READ (PRPFIL,*) A(1,1), B(1)

C       NOW INPUT ANOTHER POINT ON THE PREPARATION CURVE NEAR FIRST "BEND"

        READ (PRPFIL,*) A(3,1), B(3)

C       FILL IN THE COEFFICIENT MATRIX FOR THESE TWO POINTS

        A(1,2) = A(1,1) ** 2
        A(1,3) = A(1,1) ** 3
        A(3,2) = A(3,1) ** 2
        A(3,3) = A(3,1) ** 3

C       NOW ADD THIRD POINT SO CURVE IS "S" SHAPED

        A(2,1) = 0.0
        A(2,2) = 2.0
        A(2,3) = 3.0 * A(1,1)
        B(2)   = 0.0

        PMMAX = A(1,1)

C       NOW SOLVE FOR THE COEFFICENTS OF THE PREPARATION COST CUBIC

        CALL LINEQN (A,X,B,3,3,IERR)

        IF ( IERR .NE. 0 ) CALL FATAL('Cannot fit cubic to data!')

C       COPY COEFFICIENTS INTO "PCOSTS"

        PCOSTS(1) = 0.0

        DO 400 ITEM = 2, PCTERM

                PCOSTS(ITEM) = X(ITEM-1)

400     CONTINUE

C       OUTPUT THE PREPARATION COST FUNCTION

        WRITE (RPTFIL,410)
410     FORMAT(1X,'Prep Cost= ',$)

        CALL POLYOT (RPTFIL,PCOSTS,PCTERM)

        WRITE (RPTFIL,*)

        RETURN
        END
```

```
C
C                       ***** C O M P I R *****
C
C                       BY WAYNE WALL, CSM, NOV 1983
C
C       COMPIR: ROUTINE TO COMPUTE THE POLYNOMIALS IN "P(M)" WHICH DESCRIBE
C               THE PROBABILITY OF REACHING ALL STATES P(I,R) FOR A GIVEN
C               VALUE OF "I".  IT IS ASSUMED THAT THE POLYNOMIALS DESCRIBING
C               THE PROBABILITIES OF THE PREVIOUS STATE ARE ALREADY STORED
C               IN COMMON.
C
C       USAGE:  CALL COMPIR (I)
C
C       WHERE:  I       ;IS THE STATE WE ARE INTERESTED IN
C

        SUBROUTINE COMPIR (I)

        IMPLICIT REAL (A-Z)

        INCLUDE 'COMMON'

        INTEGER I
        INTEGER IPREV
        INTEGER POLY, TERM
        INTEGER R

C       CALCULATIONS FOR THIS STATE WILL BE IN TERMS OF THE PREVIOUS STATE

        IPREV = I - 1

C       SET "TEMP2" INITIALLY TO P(IPREV,-1) (WHICH IS = 0.0)

        DO 10 TERM = 1, NTERMS(1)

                TEMP2(TERM) = 0.0

10      CONTINUE

C       ALSO ACTIVATE P(IPREV,I), WHICH IS ALREADY ZERO

        NTERMS(I+1) = NTERMS(1)
```

```
C       NOW COMPUTE THE POLYNOMIALS FOR THIS STATE "I", IN TERMS OF
C       THOSE FOR THE PREVIOUS STATES.

        DO 500 R = 1, I + 1

C       COPY PREVIOUS STATE'S POLYNOMIAL INTO "TEMP1"

        DO 100 TERM = 1, NTERMS(R)

                TEMP1(TERM) = POLYPM(TERM,R)

100     CONTINUE

C       NOW GET THE COEFFICENTS FOR PROBABILITY OF WINNING AND LOSING
C       AT THE PREVIOUS STATE

        CALL PBWIN  (IPREV,R-2,AW,BW)
        CALL PBLOSE (IPREV,R-1,AL,BL)

C       MULTIPLY "TEMP1" TIMES THE PROBABILITY OF LOSING

        CALL MULLIN (TEMP1,NTERMS(R),AL,BL)

C       MULTIPLY "TEMP2" TIMES THE PROBABILITY OF WINNING

        CALL MULLIN (TEMP2,NTERMS(R),AW,BW)

C       NOW ADD "TEMP2" TO "TEMP1"

        DO 200 TERM = 1, NTERMS(R) + 1

                TEMP1(TERM) = TEMP1(TERM) + TEMP2(TERM)

200     CONTINUE

C       NOW COPY "TEMP1" INTO POLYPM AS NEW PROBABILITY EXPRESSION, WHILE
C       AT THE SAME TIME MOVING OLD STATE'S POLYPM VALUE INTO "TEMP2"
C       PRIOR TO NEXT ITERATION.

        DO 300 TERM = 1, NTERMS(R) + 1

                TEMP2(TERM) = POLYPM(TERM,R)
                POLYPM(TERM,R) = TEMP1(TERM)

300     CONTINUE

        NTERMS(R) = NTERMS(R) + 1

500     CONTINUE

        RETURN
        END
```

```
C
C                       ***** P B W I N *****
C
C                       BY WAYNE WALL, CSM, NOV 1983
C
C       PBWIN:  FUNCTION TO CALCULATE THE COEFFICIENTS OF THE POLYNOMIAL
C               A * P(M) + B, WHICH DETERMINES THE PROBABILITY OF THE EVENT
C               OF WINNING A CASE GIVEN THAT STATE (I,R) HAS OCCURED.
C
C       USAGE:  CALL PBWIN (I,R,A,B)
C
C       WHERE:  I       ;THE TOTAL NUMBER OF CASES LITIGATED.
C               R       ;IS THE NUMBER OF CASES LITIGATED THAT HAVE BEEN WON BY
C                       ;THE DEFENSE.
C               A       ;(RETURNED) THE COEFFICENT OF P(M)
C               B       ;(RETURNED) THE CONSTANT TERM
C
        SUBROUTINE PBWIN (I,R,A,B)

        IMPLICIT REAL (A-Z)

        INTEGER I, R

        INCLUDE 'COMMON'

C       IF R < 0, OR R > I, THEN PROBABILITY OF WINNING = 0

        IF ( (R .LT. 0) .OR. (R .GT. I) ) THEN

                A = 0.0
                B = 0.0

                RETURN

        ENDIF

C       FIRST CALCULATE THE PROBABILITY THAT THE OFFENSE HAS A CASE THAT DOES
C       ESTOP.  PROBABILITY THAT THEY DON'T IS (1.0 - PROBABILITY THEY DO).

        POFF  = PBOFF(PO,I,R)
        POFFP = 1.0 - POFF

C       NOW CALCULATE THE PROBABILITY THAT THE DEFENSE HAS A CASE THAT DOES
C       ESTOP.  PROBABILITY THAT THEY DON'T IS (1.0 - PROBABILITY THEY DO).

        PDEF  = PBDEF(PD,I,R)
        PDEFP = 1.0 - PDEF

        CALCULATE "A", THE COEFFICIENT OF "P(M)"

        A = POFF * PDEF + POFFP * PDEFP

        CALCULATE "B", THE CONSTANT TERM

        B = PDEF * POFFP

        RETURN
        END
```

```
C
C                       ***** P B L O S E *****
C
C                       BY WAYNE WALL, CSM, NOV 1983
C
C       PBLOSE: FUNCTION TO CALCULATE THE COEFFICIENTS OF THE POLYNOMIAL
C               A * P(M) + B, WHICH DETERMINES THE PROBABILITY OF THE EVENT
C               OF LOSING A CASE GIVEN THAT STATE (I,R) HAS OCCURED.
C
C       USAGE:  CALL PBLOSE (I,R,A,B)
C
C       WHERE:  I       ;THE TOTAL NUMBER OF CASES LITIGATED.
C               R       ;IS THE NUMBER OF CASES LITIGATED THAT HAVE BEEN WON BY
C                       ;THE DEFENSE.
C               A       ;(RETURNED) THE COEFFICENT OF P(M)
C               B       ;(RETURNED) THE CONSTANT TERM
C
C       NOTE:   THIS ROUTINE TAKES ADVANTAGE OF THE FACT THAT THE PROBABILITY
C               OF WINNING + PROBABILITY OF LOSING MUST SUM TO 1.0
C

        SUBROUTINE PBLOSE (I,R,A,B)

        IMPLICIT REAL (A-Z)

        INTEGER I, R

        INCLUDE 'COMMON'

C       IF R < 0, OR R > I, THEN PROB OF LOSING = 0.0

        IF ( (R .LT. 0) .OR. (R .GT. I) ) THEN

                A = 0.0
                B = 0.0

                RETURN

        ENDIF

C       CALCULATE THE COEFFCIENTS OF THE EXPRESSION DEFINING THE PROBABILITY
C       OF WINNING.

        CALL PBWIN (I,R,AW,BW)

C       NOW THE COEFFICIENTS OF THE EXPRESSION DEFINING THE PROBABILITY OF
C       LOSING MUST BE SUCH THAT THE SUM OF THE TWO EXPRESSIONS = 1.0

        A = - AW
        B = 1.0 - BW

        RETURN
        END
```

```
C
C                       ***** P B D E F *****
C
C                       BY WAYNE WALL, CSM, NOV 1983
C
C       PBDEF:  FUNCTION TO CALCULATE THE PROBABILITY OF THE EVENT THAT THE
C               DEFENSE HAS AT LEAST ONE DETERMINANT CASE IN ITS POOL WHICH
C               WILL ESTOP THE CURRENT CASE GIVEN THAT STATE (I,R) HAS
C               OCCURRED.
C
C       USAGE:  VALUE = PBDEF(PD,I,R)
C
C       WHERE:  PD      ;IS THE PROBABILITY OF THE EVENT THAT THE DECISION IN
C                       ;A PRIOR DEFENSIVE CASE WILL ESTOP THE CURRENT CASE.
C               I       ;THE TOTAL NUMBER OF CASES LITIGATED.
C               R       ;THE NUMBER OF CASES LITIGATED THAT THE DEFENSE
C                       ;HAS WON.
C

        REAL FUNCTION PBDEF(PD,I,R)

        IMPLICIT REAL (A-Z)

        INTEGER I, R

        IF ( (R .LT. 0) .OR. (R .GT. I) ) THEN

                PBDEF = 0.0

        ELSE

                PBDEF = 1.0 - (1.0 - PD) ** R

        ENDIF

        RETURN
        END
```

```
C
C                    ***** P B O F F *****
C
C                    BY WAYNE WALL, CSM, NOV 1983
C
C       PBOFF:  FUNCTION TO CALCULATE THE PROBABILITY OF THE EVENT THAT THE
C               OFFENSE HAS AT LEAST ONE DETERMINANT CASE IN ITS POOL WHICH
C               WILL ESTOP THE CURRENT CASE GIVEN THAT STATE (I,R) HAS
C               OCCURRED.
C
C       USAGE:  VALUE = PBOFF(PO,I,R)
C
C       WHERE:  PO      ;IS THE PROBABILITY OF THE EVENT THAT THE DECISION IN
C                       ;A PRIOR OFFENSIVE CASE WILL ESTOP THE CURRENT CASE.
C               I       ;THE TOTAL NUMBER OF CASES LITIGATED.
C               R       ;THE NUMBER OF CASES LITIGATED THAT THE DEFENSE
C                       ;HAS WON.
C

      REAL FUNCTION PBOFF(PO,I,R)

      IMPLICIT REAL (A-Z)

      INTEGER I, R

      IF ( (R .LT. 0) .OR. (R .GT. I) ) THEN

              PBOFF = 0.0

      ELSE

              PBOFF = 1.0 - (1.0 - PO) ** (I-R)

      ENDIF

      RETURN
      END
```

```
C                              ***** L I N E Q N *****
C
C                              BY: CYNTHIA KRAVER      MAY 13,1983
C
C       LINEQN: THIS SUBROUTINE SOLVES A SET OF LINEAR EQUATIONS BY GAUSS
C               ELIMINATION.  A * X = B
C
C       USAGE:  CALL LINEQN(A,X,B,MROWA,NUMEQ,IERR)
C
C       WHERE:  A               ;THE ARRAY CONTAINING THE COEFFICIENTS
C               X               ;THE SOLUTION ARRAY
C               B               ;THE RIGHT HAND SIDE OF THE EQUATIONS
C               MROWA           ;THE MAXIMUM ROW DIMENSION OF THE A ARRAY
C               NUMEQ           ;THE NUMBER OF EQUATIONS TO BE SOLVED
C               IERR            ;THE ERROR CODE(RETURNED)
C
C       NOTE:   ERROR CODES ARE:
C                       0       ;ALL OK
C                       1       ;SINGULAR


        SUBROUTINE LINEQN(A,X,B,MROWA,NUMEQ,IERR)

        DIMENSION A(MROWA,NUMEQ) , X(NUMEQ) , B(NUMEQ)

        INTEGER ROW , COL

C       ASSUME ALL OK

        IERR = 0

        IF ( NUMEQ .LE. 1 ) GOTO 75

C       FORWARD SUBSTITUTION

        NUM = NUMEQ - 1

        DO 40 COL = 1 , NUM

            MCOL = COL + 1
```

```
C           CHECK TO SEE IF THE ARRAY HAS A ZERO DIAGONAL ELEMENT
            CHECK = ABS(A(COL,COL))
            IF(CHECK .GT. 0.0) GOTO 15
                DO 13 MROW = MCOL , NUMEQ
                    CHECK = ABS(A(MROW,COL))
                    IF(CHECK .LE. 0.0) GOTO 13
C                       FOUND A NON-ZERO ROW ELEMENT
                        DO 12 ICOL = 1 , NUMEQ
                            TEMP = A(MROW,ICOL)
                            A(MROW,ICOL) = A(COL,ICOL)
                            A(COL,ICOL) = TEMP
12                      CONTINUE
                        TEMP = B(MROW)
                        B(MROW) = B(COL)
                        B(COL) = TEMP
                        GOTO 15
13              CONTINUE
C       HERE IF SINGULAR
                IERR = 1
                RETURN

15          DO 30 ROW = MCOL , NUMEQ
                IF( A(ROW,COL) .EQ. 0.0 ) GOTO 30
                CONST = - A(ROW,COL) / A(COL,COL)
                    DO 20 ICOL = MCOL , NUMEQ
                        A(ROW,ICOL) = A(ROW,ICOL) + CONST * A(COL,ICOL)
20                  CONTINUE
                B(ROW) = B(ROW) + CONST * B(COL)
30          CONTINUE
40      CONTINUE
```

```
      IF( A(NUMEQ,NUMEQ) .NE. 0.0 ) GOTO 50
C         HERE IF THE LAST DIAGONAL MAKES ARRAY SINGULAR
          IERR = 1
          RETURN
C     BACK SUBSTITUTION
50    DO 70 ICOL = 2 , NUMEQ
          COL = NUMEQ + 2 - ICOL
          MCOL = COL - 1
          DO 60 ROW = 1 , MCOL
              CONST = - A(ROW,COL) / A(COL,COL)
              B(ROW) = B(ROW) + CONST * B(COL)
60        CONTINUE
70    CONTINUE
C     SUBSCRIPT INTO THE X ARRAY USING THE INDEXES AND
C     DIVIDE BY DIAGONAL ELEMENTS
75    DO 80 ROW = 1 , NUMEQ
          X(ROW) = B(ROW) / A(ROW,ROW)
80    CONTINUE
      RETURN
      END
```

```
C
C                       ***** M U L L I N *****
C
C                       BY WAYNE WALL, CSM, NOV 1983
C
C       MULLIN: ROUTINE TO MULTIPLY A POLYNOMIAL TIMES A LINEAR TERM.
C
C       USAGE:  CALL MULLIN (COEFF,NUMTRM,A,B)
C
C       WHERE:  COEFF   ;IS AN ARRAY OF COEFFICIENTS OF THE POLYNOMIAL
C               NUMTRM  ;IS THE NUMBER OF TERMS IN THE POLYNOMIAL
C               A,B     ;ARE COEFFS OF LINEAR TERM "B + A * X"
C
        SUBROUTINE MULLIN (COEFF,NUMTRM,A,B)
        IMPLICIT REAL (A-Z)
        INCLUDE 'COMMON'
        INTEGER TERM, NUMTRM, NEWTRM
        DIMENSION COEFF(*)
        DIMENSION TEMP(MXTERM)
C       MULTIPLY THE POLYNOMIAL TIMES THE CONSTANT TERM "B", STORING
C       THE RESULT INTO A TEMPORARY POLYNOMIAL
        DO 10 TERM = 1, NUMTRM
                TEMP(TERM) = B * COEFF(TERM)
10      CONTINUE
C       NEW POLYNOMIAL WILL HAVE ONE MORE TERM SO ZERO IT NOW
        NEWTRM = NUMTRM + 1
        TEMP(NEWTRM) = 0.0
C       NOW MULTIPLY THROUGH BY "A" AND ADD THE RESULTS TO PROPER TERMS
        DO 20 TERM = 1, NUMTRM
                TEMP(TERM+1) = TEMP(TERM+1) + A * COEFF(TERM)
20      CONTINUE
C       NOW COPY THE NEW POLYNOMIAL BACK OVER THE OLD ONE
        DO 30 TERM = 1, NEWTRM
                COEFF(TERM) = TEMP(TERM)
30      CONTINUE
        RETURN
        END
```

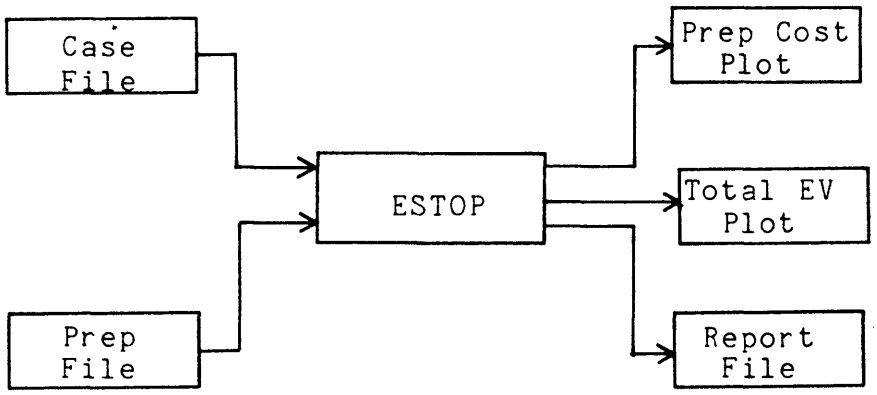
```
C
C                       ***** P O L Y O T *****
C
C                       BY WAYNE WALL, CSM, NOV 1983
C
C       POLYOT: ROUTINE TO OUTPUT A POLYNOMIAL TO SOME DEVICE.
C
C       USAGE:  CALL POLYOT (LUN,COEFF,NUMTRM)
C
C       WHERE:  LUN     ;IS THE LOGICAL UNIT NUMBER TO OUTPUT TO
C               COEFF   ;IS AN ARRAY OF COEFFICIENTS
C               NUMTRM  ;IS THE NUMBER OF TERMS IN THE POLYNOMIAL
C
C       NOTE:   THE POLYNOMIAL IS OF THE FORM:
C               C0 + C1 * P(M)^1 + C2 * P(M)^2 + ... + CN * P(M)^N
C

        SUBROUTINE POLYOT (LUN,COEFF,NUMTRM)

        IMPLICIT REAL (A-Z)

        INTEGER LUN, NUMTRM, TERM

        DIMENSION COEFF(*)

C       IF THERE ARE NO TERMS, THEN RETURN

        IF ( NUMTRM .LE. 0 ) RETURN

C       OUTPUT COEFFICIENTS C0, C1, C2, ..., CN

        IF ( NUMTRM .LE. 6 ) THEN

                WRITE (LUN,100) (COEFF(TERM), TERM=1,NUMTRM)
100             FORMAT(1X,6(1X,F9.2))

                RETURN

        ELSE
                WRITE (LUN,100) (COEFF(TERM), TERM=1,6)

        ENDIF

C       OUTPUT REST OF COEFFICIENTS

        WRITE (LUN,200) (COEFF(TERM), TERM=7, NUMTRM)
200     FORMAT(1000(13X,6(1X,F9.2),/))

        RETURN
        END
```

```
C
C                       ***** P L O T I T *****
C
C                       BY WAYNE WALL, CSM, NOV 1983
C
C       PLOTIT: ROUTINE TO PLOT A POLYNOMIAL IN "P(M)" OVER THE RANGE 0.0 - 1.0
C
C       USAGE:  CALL PLOTIT (GDEV,COEFF,NUMTRM,FCOSTS,YTITLE)
C
C       WHERE:  GDEV    ;HOLDS THE NAME OF THE DEVICE TO PLOT ON
C               COEFF   ;HOLDS THE COEFFICIENTS OF THE POLYNOMIAL IN "P(M)"
C               NUMTRM  ;THE NUMBER OF TERMS IN THE POLYNOMIAL
C               FCOSTS  ;THE TOTAL FIXED COSTS (<0.0 MEANS DON'T PLOT THEM)
C               YTITLE  ;HOLDS THE TITLE FOR THE Y AXIS
C

        SUBROUTINE PLOTIT (GDEV,COEFF,NUMTRM,FCOSTS,YTITLE)

        IMPLICIT INTEGER (A-Z)

        PARAMETER (BLUE=1, BLACK=2, RED=3)

        INCLUDE 'GRFCOM'

        INCLUDE 'COMMON'

        COMMON /USRLUN/ USERIN, USEROT

        CHARACTER GDEV*(*), YTITLE*(*), GFILE*10, PTITLE*30

        REAL COEFF(*), XVAL(100), YVAL(100)
        REAL PM, FCOSTS, X, Y, X1, Y1

        LOGICAL EOF, IERR

C       PROMPT USER FOR THE NAME FOR THE PLOT FILE

        CALL PROMPT('Enter name for plot file: ')
        CALL INPLIN(USERIN,GFILE,EOF)

C       PROMPT THE USER FOR A TITLE FOR THE PLOT

        CALL PROMPT('Enter a title for the plot: ')
        CALL INPLIN(USERIN,PTITLE,EOF)

        CALL GIPLOT (GDEV,GFILE,IERR)

        IF ( IERR ) CALL FATAL ('Error from GIPLOT!')

C       SET PEN COLORS AND AXIS LENGTHS.  (FLAG=0 MEANS SOLID LINE)

        FLAG = 0
        XCOLOR = BLACK
        YCOLOR = BLACK
        TCOLOR = BLUE
        LCOLOR = BLUE
        XLEN = 8.0
```

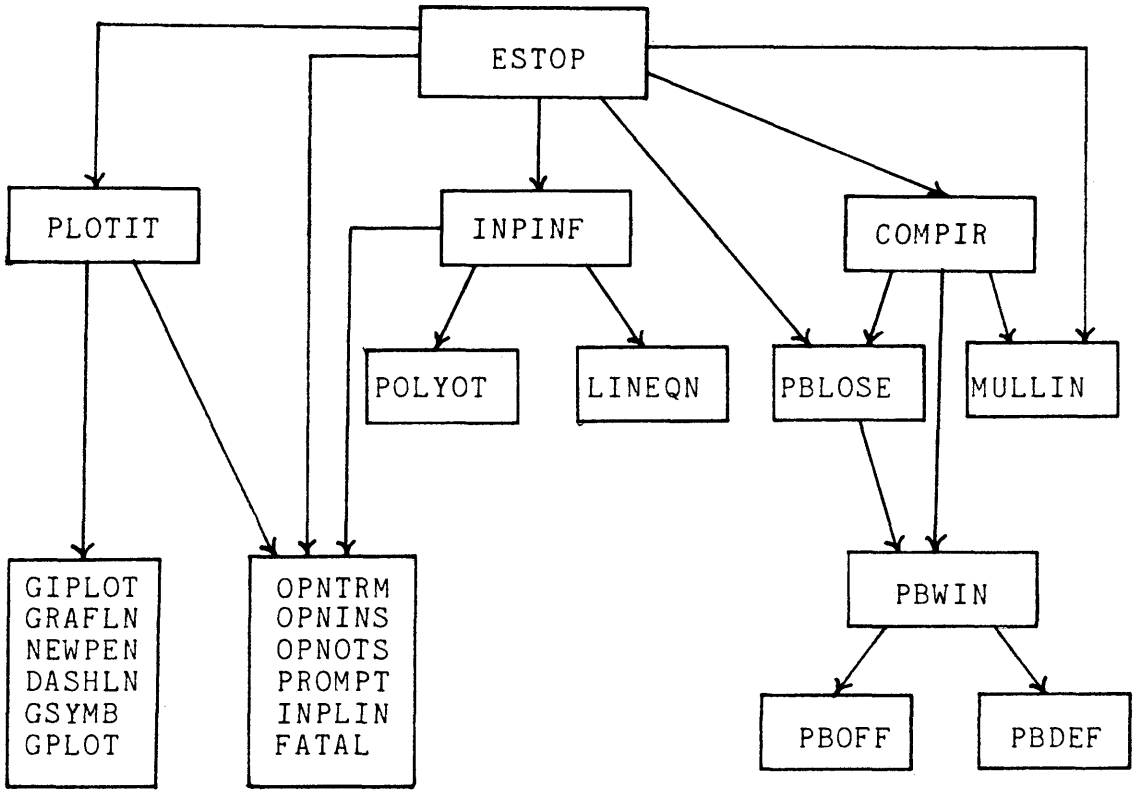
```
C       NOW GENERATE THE DATA POINTS TO BE PLOTTED
        PM = 0.0
        DO 100 ITEM = 1, 100
        XVAL(ITEM) = PM
        YVAL(ITEM) = COEFF(1)
                DO 50 TERM = 2, NUMTRM
                YVAL(ITEM) = YVAL(ITEM) +
     $                       COEFF(TERM) * PM ** (TERM-1)
50              CONTINUE
        IF ( PM .GT. PMMAX ) GO TO 150
        PM = PM + .01
100     CONTINUE
        ITEM = 100
C       PLOT THE GRAPH
150     CALL GRAFLN(XVAL,YVAL,ITEM,'P(M)',YTITLE,PTITLE)
C       NOW DRAW VERTICAL LINE AT P(M)max FOR DECISION MAKING PURPOSES
        X = X0 + (PMMAX-XFSTVL) * XSCAFC
        Y = Y0
        X1 = X
        Y1 = Y0 + YLEN
        CALL NEWPEN(RED)
        CALL DASHLN (X,Y,X1,Y1,.1)
C       IF FCOSTS ARE >= 0.0, THEN MARK TOTAL AWARDS FOR DECISION MAKING
        IF ( FCOSTS .GE. 0.0 ) THEN
                X = X0
                Y = Y0 + ((YVAL(1)-FCOSTS)-YFSTVL) * YSCAFC
                CALL GSYMB (X,Y,.2,' ',0.0,4)
        ENDIF
        CALL GPLOT (0.0,0.0,999)
        RETURN
        END
```

APPENDIX C

Information Flow, Program Structure, Input Data Files and Example Executions



Information Flow



Program Structure

Input Data Files

```
.TYPE CASE1.DAT
3
10,4
75,4
350,4
;The first line of a case file contains the number of cases which follow.
;Then each subsequent line contains two values for each of the cases.
;The first value is the amount of the award that must be paid if the
;defense loses and the second value is the fixed trial costs.


.TYPE PREP1.DAT
.6,90
.2,40
;There are two points specified in a preparation cost file.
;The first pair is the maximum P(M) and the cost of achieving it.
;The second pair is a P(M) and the cost of achieving it that is near the
;left hand "knee" of the S-shaped preparation cost curve.


.TYPE PREP2.DAT
.3,90
.1,40
;There are two points specified in a preparation cost file.
;The first pair is the maximum P(M) and the cost of achieving it.
;The second pair is a P(M) and the cost of achieving it that is near the
;left hand "knee" of the S-shaped preparation cost curve.


.TYPE CASE2.DAT
10
100,11
200,11
225,11
300,11
350,11
375,11
425,11
500,11
750,11
900,11
;The first line of a case file contains the number of cases which follow.
;Then each subsequent line contains two values for each of the cases.
;The first value is the amount of the award that must be paid if the
;defense loses and the second value is the fixed trial costs.


.TYPE PREP3.DAT
.4,1500
.1,650
;There are two points specified in a preparation cost file.
;The first pair is the maximum P(M) and the cost of achieving it.
;The second pair is a P(M) and the cost of achieving it that is near the
;left hand "knee" of the S-shaped preparation cost curve.
```

Example Executions

```
.RUN ESTOP

Enter probability offense has a prior estoppel case P(o): .5
Enter probability defense has a prior estoppel case P(d): .1
Enter name of case information file: CASE1.DAT
Enter name of preparation cost info file: PREP1.DAT
Enter name of file to contain report: REP1.dat

Total fixed litigation costs     =       12.000

Enter name of plotting device: PLOT
Shall I plot the preparation cost function? Y
Enter name for plot file:
Enter a title for the plot: Example #1, Function #1
I will now plot the Total Cost function...
Enter name for plot file:
Enter a title for the plot: Example #1, P(o)=.5, P(d)=.1
CPU time 1.41   Elapsed time 1:32.82

EXIT

.TYPE REP1.DAT
 Probability of offensive estoppel =  0.500
 Probability of defensive estoppel =  0.100
 Number of cases                   =      3

     Awards      Fixed Costs

       10.000        4.000
       75.000        4.000
      350.000        4.000

 Total fixed litigation costs     =       12.000

 Prep Cost=         0.00    375.00  -1125.00   1250.00

 P( 0, 0) =         1.00

 PL( 1)   =         1.00     -1.00

 P( 1, 0) =         1.00     -1.00
 P( 1, 1) =         0.00      1.00

 PL( 2)   =         1.00     -0.60     -0.40

 P( 2, 0) =         1.00     -1.50      0.50
 P( 2, 1) =         0.00      1.40     -1.40
 P( 2, 2) =         0.00      0.10      0.90

 PL( 3)   =         1.00     -0.34     -0.51     -0.15

 PEV      =       447.00   -173.65   -207.45    -53.90
```

```
.RUN ESTOP

Enter probability offense has a prior estoppel case P(o): .5
Enter probability defense has a prior estoppel case P(d): .1
Enter name of case information file: CASE1.DAT
Enter name of preparation cost info file: PREP2.DAT
Enter name of file to contain report: REP2.DAT

Total fixed litigation costs     =       12.000

Enter name of plotting device: PLOT
Shall I plot the preparation cost function? Y
Enter name for plot file:
Enter a title for the plot: Example #1, Function #2
I will now plot the Total Cost function...
Enter name for plot file:
Enter a title for the plot: Example #1, P(o)=.5, P(d)=.1
CPU time 1.37   Elapsed time 1:18.20

EXIT

.TYPE REP2.DAT
 Probability of offensive estoppel =  0.500
 Probability of defensive estoppel =  0.100
 Number of cases                   =      3

     Awards      Fixed Costs

      10.000        4.000
      75.000        4.000
     350.000        4.000

 Total fixed litigation costs     =       12.000

 Prep Cost=         0.00    750.00  -4500.00  10000.00

 P( 0, 0) =         1.00

 PL( 1)   =         1.00     -1.00

 P( 1, 0) =         1.00     -1.00
 P( 1, 1) =         0.00      1.00

 PL( 2)   =         1.00     -0.60     -0.40

 P( 2, 0) =         1.00     -1.50      0.50
 P( 2, 1) =         0.00      1.40     -1.40
 P( 2, 2) =         0.00      0.10      0.90

 PL( 3)   =         1.00     -0.34     -0.51     -0.15

 PEV      =       447.00   -173.65   -207.45    -53.90
```

```
.RUN ESTOP

Enter probability offense has a prior estoppel case P(o): .5
Enter probability defense has a prior estoppel case P(d): .1
Enter name of case information file: CASE2.DAT
Enter name of preparation cost info file: PREP3.DAT
Enter name of file to contain report: REP3.DAT

Total fixed litigation costs     =      110.000

Enter name of plotting device: PLOT
Shall I plot the preparation cost function? Y
Enter name for plot file:
Enter a title for the plot: Example #2, Function #3
I will now plot the Total Cost function...
Enter name for plot file:
Enter a title for the plot: Example #2, P(o)=.5, P(d)=.1
CPU time 1.68   Elapsed time 1:30.58

EXIT

.TYPE REP3.DAT
 Probability of offensive estoppel =  0.500
 Probability of defensive estoppel =  0.100
 Number of cases                   =     10

     Awards      Fixed Costs

      100.000       11.000
      200.000       11.000
      225.000       11.000
      300.000       11.000
      350.000       11.000
      375.000       11.000
      425.000       11.000
      500.000       11.000
      750.000       11.000
      900.000       11.000

 Total fixed litigation costs     =      110.000

 Prep Cost=         0.00  11083.33 -55000.00  91666.67

 P( 0, 0) =         1.00

 PL( 1)   =         1.00      -1.00

 P( 1, 0) =         1.00      -1.00
 P( 1, 1) =         0.00       1.00

 PL( 2)   =         1.00      -0.60      -0.40

 P( 2, 0) =         1.00      -1.50       0.50
```

P(2, 1) =	0.00	1.40	-1.40			
P(2, 2) =	0.00	0.10	0.90			
PL(3) =	1.00	-0.34	-0.51	-0.15		
P(3, 0) =	1.00	-1.75	0.88	-0.13		
P(3, 1) =	0.00	1.58	-2.41	0.83		
P(3, 2) =	0.00	0.15	1.28	-1.43		
P(3, 3) =	0.00	0.02	0.25	0.73		
PL(4) =	1.00	-0.18	-0.47	-0.29	-0.05	
P(4, 0) =	1.00	-1.88	1.09	-0.23	0.02	
P(4, 1) =	0.00	1.67	-3.04	1.64	-0.26	
P(4, 2) =	0.00	0.18	1.49	-2.63	0.96	
P(4, 3) =	0.00	0.03	0.37	0.85	-1.25	
P(4, 4) =	0.00	0.01	0.08	0.38	0.53	
PL(5) =	1.00	-0.10	-0.41	-0.36	-0.14	-0.01
P(5, 0) =	1.00	-1.94	1.21	-0.30	0.03	0.00
P(5, 1) =	0.00	1.71	-3.45	2.29	-0.60	0.05
P(5, 2) =	0.00	0.19	1.66	-3.61	2.15	-0.38
P(5, 3) =	0.00	0.03	0.43	0.94	-2.37	0.95
P(5, 4) =	0.00	0.01	0.11	0.49	0.36	-0.97
P(5, 5) =	0.00	0.00	0.03	0.19	0.43	0.35
PL(6) =	1.00	-0.05	-0.34	-0.36	-0.21	-0.04
	0.01					
P(6, 0) =	1.00	-1.97	1.27	-0.34	0.04	0.00
	0.00					
P(6, 1) =	0.00	1.73	-3.75	2.83	-0.95	0.14
	-0.01					
P(6, 2) =	0.00	0.19	1.80	-4.47	3.40	-1.04
	0.11					
P(6, 3) =	0.00	0.04	0.48	1.07	-3.48	2.37
	-0.47					
P(6, 4) =	0.00	0.01	0.13	0.58	0.25	-1.83
	0.85					
P(6, 5) =	0.00	0.00	0.04	0.23	0.45	-0.04
	-0.69					
P(6, 6) =	0.00	0.00	0.01	0.09	0.29	0.40
	0.21					
PL(7) =	1.00	-0.03	-0.30	-0.34	-0.26	-0.09
	0.01	0.01				

P(7, 0) =	1.00	-1.98	1.30	-0.36	0.05	0.00
	0.00	0.00				
P(7, 1) =	0.00	1.74	-3.98	3.31	-1.31	0.26
	-0.03	0.00				
P(7, 2) =	0.00	0.20	1.94	-5.29	4.74	-1.92
	0.37	-0.03				
P(7, 3) =	0.00	0.04	0.52	1.23	-4.70	4.20
	-1.47	0.18				
P(7, 4) =	0.00	0.01	0.15	0.67	0.21	-2.84
	2.31	-0.51				
P(7, 5) =	0.00	0.00	0.05	0.27	0.51	-0.31
	-1.23	0.71				
P(7, 6) =	0.00	0.00	0.02	0.11	0.31	0.28
	-0.26	-0.46				
P(7, 7) =	0.00	0.00	0.01	0.05	0.18	0.34
	0.31	0.11				
PL(8) =	1.00	-0.01	-0.27	-0.32	-0.27	-0.15
	-0.01	0.02	0.00			
P(8, 0) =	1.00	-1.99	1.32	-0.37	0.05	0.00
	0.00	0.00	0.00			
P(8, 1) =	0.00	1.74	-4.18	3.76	-1.68	0.41
	-0.06	0.00	0.00			
P(8, 2) =	0.00	0.20	2.08	-6.11	6.19	-3.05
	0.80	-0.11	0.01			
P(8, 3) =	0.00	0.04	0.55	1.43	-6.07	6.51
	-3.10	0.69	-0.06			
P(8, 4) =	0.00	0.01	0.16	0.76	0.24	-4.14
	4.53	-1.82	0.25			
P(8, 5) =	0.00	0.00	0.05	0.31	0.60	-0.55
	-1.95	2.06	-0.52			
P(8, 6) =	0.00	0.00	0.02	0.13	0.36	0.26
	-0.61	-0.70	0.55			
P(8, 7) =	0.00	0.00	0.01	0.06	0.19	0.30
	0.06	-0.33	-0.28			
P(8, 8) =	0.00	0.00	0.00	0.03	0.12	0.27
	0.32	0.20	0.05			
PL(9) =	1.00	-0.01	-0.25	-0.30	-0.26	-0.18
	-0.04	0.03	0.01	0.00		
P(9, 0) =	1.00	-2.00	1.33	-0.38	0.05	0.00
	0.00	0.00	0.00	0.00		
P(9, 1) =	0.00	1.75	-4.37	4.21	-2.08	0.59
	-0.10	0.01	0.00	0.00		
P(9, 2) =	0.00	0.20	2.21	-6.95	7.79	-4.46
	1.45	-0.27	0.03	0.00		
P(9, 3) =	0.00	0.04	0.58	1.66	-7.63	9.42
	-5.54	1.73	-0.28	0.02		
P(9, 4) =	0.00	0.01	0.16	0.86	0.31	-5.81
	7.77	-4.30	1.10	-0.11		

P(9, 5) =	0.00	0.00	0.05	0.34	0.72	-0.79
	-3.02	4.40	-2.03	0.32		
P(9, 6) =	0.00	0.00	0.02	0.14	0.42	0.29
	-1.00	-1.06	1.69	-0.49		
P(9, 7) =	0.00	0.00	0.01	0.06	0.22	0.33
	-0.05	-0.65	-0.32	0.41		
P(9, 8) =	0.00	0.00	0.00	0.03	0.12	0.23
	0.19	-0.11	-0.31	-0.16		
P(9, 9) =	0.00	0.00	0.00	0.02	0.08	0.20
	0.30	0.26	0.12	0.02		
PL(10) =	1.00	0.00	-0.24	-0.29	-0.25	-0.20
	-0.08	0.03	0.03	0.00	0.00	
PEV	4235.00	-430.43	-1276.14	-1176.99	-805.83	-444.08
	-101.22	63.86	42.17	4.22	-0.56	

```
.RUN ESTOP

Enter probability offense has a prior estoppel case P(o): .1
Enter probability defense has a prior estoppel case P(d): .5
Enter name of case information file: CASE2.DAT
Enter name of preparation cost info file: PREP3.DAT
Enter name of file to contain report: REP4.DAT

Total fixed litigation costs     =      110.000

Enter name of plotting device: PLOT
Shall I plot the preparation cost function? N
I will now plot the Total Cost function...
Enter name for plot file:
Enter a title for the plot: Example #2, P(o)=.1, P(d)=.5
CPU time 1.23   Elapsed time 55.62

EXIT

.TYPE REP4.DAT
 Probability of offensive estoppel =  0.100
 Probability of defensive estoppel =  0.500
 Number of cases                   =     10

     Awards      Fixed Costs

      100.000      11.000
      200.000      11.000
      225.000      11.000
      300.000      11.000
      350.000      11.000
      375.000      11.000
      425.000      11.000
      500.000      11.000
      750.000      11.000
      900.000      11.000

 Total fixed litigation costs     =      110.000

 Prep Cost=        0.00  11083.33 -55000.00  91666.67

 P( 0, 0) =        1.00

 PL( 1)   =        1.00     -1.00

 P( 1, 0) =        1.00     -1.00
 P( 1, 1) =        0.00      1.00

 PL( 2)   =        1.00     -1.40      0.40

 P( 2, 0) =        1.00     -1.90      0.90
 P( 2, 1) =        0.00      1.40     -1.40
```

P(2, 2) =	0.00	0.50	0.50			
PL(3) =	1.00	-1.81	0.97	-0.15		
P(3, 0) =	1.00	-2.71	2.44	-0.73		
P(3, 1) =	0.00	1.58	-3.01	1.43		
P(3, 2) =	0.00	0.76	0.07	-0.83		
P(3, 3) =	0.00	0.38	0.50	0.13		
PL(4) =	1.00	-2.21	1.65	-0.49	0.05	
P(4, 0) =	1.00	-3.44	4.41	-2.51	0.53	
P(4, 1) =	0.00	1.67	-4.56	4.13	-1.25	
P(4, 2) =	0.00	0.89	-0.63	-1.21	0.96	
P(4, 3) =	0.00	0.56	0.29	-0.58	-0.26	
P(4, 4) =	0.00	0.33	0.48	0.17	0.02	
PL(5) =	1.00	-2.55	2.35	-0.96	0.17	-0.01
P(5, 0) =	1.00	-4.10	6.67	-5.40	2.18	-0.35
P(5, 1) =	0.00	1.72	-5.99	7.80	-4.50	0.97
P(5, 2) =	0.00	0.96	-1.38	-1.03	2.41	-0.95
P(5, 3) =	0.00	0.66	-0.13	-1.14	0.23	0.38
P(5, 4) =	0.00	0.46	0.35	-0.42	-0.33	-0.05
P(5, 5) =	0.00	0.31	0.47	0.19	0.03	0.00
PL(6) =	1.00	-2.83	2.99	-1.47	0.31	0.00
	-0.01					
P(6, 0) =	1.00	-4.69	9.09	-9.34	5.37	-1.63
	0.21					
P(6, 1) =	0.00	1.74	-7.30	12.17	-10.12	4.19
	-0.69					
P(6, 2) =	0.00	1.00	-2.10	-0.37	3.91	-3.29
	0.85					
P(6, 3) =	0.00	0.71	-0.60	-1.39	1.29	0.46
	-0.47					
P(6, 4) =	0.00	0.54	0.07	-0.96	-0.13	0.37
	0.11					
P(6, 5) =	0.00	0.40	0.37	-0.31	-0.35	-0.10
	-0.01					
P(6, 6) =	0.00	0.30	0.47	0.20	0.03	0.00
	0.00					
PL(7) =	1.00	-3.04	3.52	-1.89	0.36	0.10
	-0.05	0.01				
P(7, 0) =	1.00	-5.22	11.58	-14.17	10.33	-4.49
	1.07	-0.11				
P(7, 1) =	0.00	1.76	-8.51	17.06	-18.18	10.86
	-3.45	0.46				

P(7, 2) =	0.00	1.02	-2.77	0.64	5.24	-7.15
	3.71	-0.71				
P(7, 3) =	0.00	0.75	-1.06	-1.37	2.69	-0.23
	-1.29	0.51				
P(7, 4) =	0.00	0.58	-0.25	-1.33	0.55	0.84
	-0.21	-0.18				
P(7, 5) =	0.00	0.46	0.17	-0.80	-0.33	0.29
	0.18	0.03				
P(7, 6) =	0.00	0.35	0.37	-0.23	-0.35	-0.13
	-0.02	0.00				
P(7, 7) =	0.00	0.29	0.47	0.20	0.03	0.00
	0.00	0.00				
PL(8) =	1.00	-3.19	3.89	-2.12	0.19	0.40
	-0.21	0.04	0.00			
P(8, 0) =	1.00	-5.70	14.07	-19.71	17.11	-9.43
	3.22	-0.62	0.05			
P(8, 1) =	0.00	1.77	-9.62	22.32	-28.66	22.01
	-10.11	2.57	-0.28			
P(8, 2) =	0.00	1.04	-3.39	1.90	6.33	-12.57
	9.83	-3.69	0.55			
P(8, 3) =	0.00	0.77	-1.50	-1.15	4.29	-1.91
	-2.07	2.09	-0.52			
P(8, 4) =	0.00	0.61	-0.58	-1.54	1.59	1.00
	-1.15	-0.19	0.25			
P(8, 5) =	0.00	0.50	-0.06	-1.19	0.08	0.87
	0.09	-0.22	-0.06			
P(8, 6) =	0.00	0.40	0.24	-0.66	-0.44	0.18
	0.21	0.06	0.01			
P(8, 7) =	0.00	0.31	0.37	-0.16	-0.33	-0.15
	-0.03	0.00	0.00			
P(8, 8) =	0.00	0.29	0.47	0.21	0.03	0.00
	0.00	0.00	0.00			
PL(9) =	1.00	-3.28	4.09	-2.06	-0.35	1.06
	-0.60	0.15	-0.02	0.00		
P(9, 0) =	1.00	-6.13	16.53	-25.77	25.60	-16.79
	7.28	-2.01	0.32	-0.02		
P(9, 1) =	0.00	1.78	-10.66	27.85	-41.45	38.44
	-22.76	8.40	-1.77	0.16		
P(9, 2) =	0.00	1.05	-3.95	3.31	7.19	-19.69
	20.59	-11.42	3.34	-0.41		
P(9, 3) =	0.00	0.79	-1.91	-0.79	6.01	-4.72
	-2.34	5.20	-2.72	0.49		
P(9, 4) =	0.00	0.64	-0.89	-1.63	2.89	0.67
	-2.70	0.53	0.80	-0.32		
P(9, 5) =	0.00	0.52	-0.29	-1.49	0.78	1.43
	-0.56	-0.62	0.13	0.11		

P(9, 6) =	0.00	0.43	0.07	-1.04	-0.24	0.76
	0.32	-0.16	-0.12	-0.02		
P(9, 7) =	0.00	0.35	0.27	-0.53	-0.50	0.08
	0.22	0.09	0.02	0.00		
P(9, 8) =	0.00	0.28	0.37	-0.11	-0.32	-0.17
	-0.04	-0.01	0.00	0.00		
P(9, 9) =	0.00	0.29	0.46	0.21	0.04	0.00
	0.00	0.00	0.00	0.00		
PL(10) =	1.00	-3.33	4.12	-1.68	-1.36	2.23
	-1.31	0.38	-0.05	0.00	0.00	
PEV =	4235.00	-11747.98	12952.81	-5982.03	-1055.98	3041.23
	-1763.12	485.83	-54.93	-1.38	0.56	