OPERATIONS RESEARCH PROBLEMS
IN THE
MOTION PICTURE INDUSTRY

by

Vittorio Alessandro Baldini
"LAUREA" in Nuclear Engineering, Università di Bologna
(1968)

SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

January, 1975

Signature of Author ______________________________
Department of Nuclear Engineering, January 18, 1975

Certified by ______________________________
Thesis Supervisor

Accepted by ______________________________
Chairman, Departmental Committee
on Graduate Students

OPERATIONS RESEARCH PROBLEMS IN THE MOTION PICTURE INDUSTRY

by

VITTORIO ALESSANDRO BALDINI

Submitted to the Department of Nuclear Engineering on January 18, 1975, in partial fulfillment of the requirements for the degree of Master of Science.

ABSTRACT

This work is the first attempt, up to the author's knowledge, to apply the methods of O.R. to the problems of the motion picture industry. The preproduction and the production stages of the life of a movie have been analyzed: the early decisions about which movie, at which cost and for which audience to produce; the philosophy by which to split the financial risk; the rules to follow in order to reach the best deal among a group of production-risk-bearers; an explanatory analysis of the graph representing the gross of a picture against the time regressed onto the factors of success of the picture self; the prediction of the gross of a picture; the design of an optimal shooting schedule. A list of mathematical models have been also presented formulating the problem of how to reach the best deal among risk-bearers; of how to reach an agreement over the parameters of a probabilistic distribution of the gross of a picture; of the success of a movie; of the word-of-mouth effect; of the probabilistic distribution of the time required to shoot a scene; and of the one of designing an optimal shooting schedule. Throughout the work several hints and suggestions about many other aspects of the motion picture industry have also been offered as well as a few detailed analysis of some of them. Finally also a certain number of directions for future work have been proposed, concerning all aspects of the life of a movie, included the distribution stage.

Thesis Supervisor: John D. C. Little
Title: Professor of Operations Research and Management Science

Acknowledgments

Many people have contributed with suggestions and help of various efficaciousness to the building of this work. Professor Edward W. Davis, who helped me solve many practical problems, Professor Richard C. Larson, who gave me a good start, Professor Glenn W. Graves of UCLA, who shared with me his experience in the field, Professor Thomas L. Magnanti, who gave me very useful suggestions concerning some of the models and Professor John D. C. Little, who granted the final "imprimatur" to the thesis.

A grateful acknowledgment also to my friends Gabriel Bitran, Pitu Mirchandani, John Schmitz and John Hauser for their many fruitful and generous exchange of opinions.

Many thanks to Mr. Stanley Ackermann of the Directors Guild of America for his early encouragement, to Mr. David Golden, Mr. Hal Schaffel and Mr. Dick Stenta for their generous supply of data and information, to Mr. Milton Shefter of the Consolidated Film Industries and to Mr. George Justin of the Paramount for their sharp view of the problems. A special thanks to Mr. Mitchell Block for his enthusiastic and constructive support.

Finally many thanks to Miss Annelore Cooper for the accurate typing of the first chapter and to Mrs. Louise Balzarini for the incredible speed with which she typed the main body of this thesis and for the challenging task she gave me to search for unexisting mistakes.

Table of Contents

List of Figures

Chapter 1
INTRODUCTION

1.1 The Motion Picture Industry

1.1.1 Its Landscape

Operations Research is marketable only when it contradicts the manager's intuition: the mathematical proof that the manager's intuition is right being merely of academic value. The whole research work done for this thesis is motivated by those two statements. Of course the word contradiction in this case is used in a very general way: it means simply that the results obtained by applying Operations Research (O.R.) techniques to a set of facts and data are different from the ones obtained by a manager who uses only his intuition. The difference of course has to be such that the manager acknowledges "a posteriori" that the O.R. results are "better" (in the sense of his preference) to his own ones. How much better, whether slightly or by a large amount, is also a very relevant question since the manager will accept the O.R. results only at a price. This price is the indemnity to be paid to him for that certain loss of insight, feeling, dependability and quickness of response, that the use of analytical techniques generally imply: at least while one is in the process of getting confident with them.

Now for those results to be quite better, two conditions must hold: one, that the manager be wrong, and two, that enough data are available - in a suitable form, of course - for the data-hungry techniques to be successfully applied. The history of this thesis is the history of these two conditions and of the consequent communication gap experienced by a model-oriented mind in dealing with some goal-oriented ones. For the first individual the abstraction of a model out of a real problem and its transformation into a set of numbers is a step forward from the start, while for the second it's just a step in a direction away from the final result. A similar communication gap arises when arguing about unpredictable events: the theory-oriented mind transforms everything into probabilities (all values between zero and one, extremes excluded) and feels then perfectly comfortable in talking about expected values. (Although, of course, he wouldn't bet a single cent on the outcome of those events even in a fair lottery, since he generally misses any entrepreneurial courage). A practice-oriented mind, on the contrary, sees stochastic events as something about which no definite statement can be made (a probability which is not one is zero and vice versa,but who knows?): Therefore nothing at all can be said about them and the only way to do business is both to adopt solutions with built in "fat" and to be psychologically ready to lose.

As for our two previous conditions, the manager will be wrong only if the available information is somewhat misleading, either for some undecipherable complexity or for the existence of tricky underlying invisible facts. Sufficient data on the contrary requires plenty of time, money, patience and "savoir faire".

When I decided to apply the O.R. type of modeling to the Motion Picture Industry, I thought it was going to be just like an oversized homework: <u>given</u> the data and the problem find out the analytical path which leads to the hidden solution.

Well it wasn't quite that: in a way it seems that there are no data, there is no problem and there is no solution!

i) Data do not exist because the managers of the Motion Picture Industry are generally trained to face the problems while they arise (they are very unpredictable, I said) and either do solve them or fail to, but have certainly no time to abstract models out of them. Problems come and go and everytime look very different: therefore a model wouldn't mean very much to them. To store records of such problems, whether solved or not, is a waste of time and space: nothing more will be learned out of their records which hasn't been learned while dealing with them. But besides that, the next problem will have another face. Files of records though do exist, such as, weekly revenues' records or cast and staff performance's records, but their value is too important to the companies who own them, to be released to the public. Therefore the data collection can be made only through some specialized magazines, or via personal interviews.

ii) A real problem in the motion picture business doesn't exist:

"It's a difficult business, everybody knows that, but if you have a certain feeling you can manage to live with it. And besides that, how can you tell what the hell the public will like to see, two years from now. Artists are unsubstitutable and you can't constrain them. After all what counts is that you serve well your property by making a good picture. And even the weather can't be predicted with months of advance."

Nevertheless many companies are still willingly in the business and at the same time few real hits are produced every year.

iii) Finally a hidden solution to the problem doesn't exist since the problem would be considered as fully solved only if someone could make a hit out of every movie. Well, if there is any O.R. expert who would be able to do that with virtually no information available and no customer willing to pay the bill for the expertise and the data collection job, please stand up. This is where I am after almost a year of involvement with the apparently absurd idea to sell O.R. expertise to the Motion Picture Industry.

1.1.2 Some Remarks About It

The main difficulty encountered throughout this research, besides the ones previously exposed, is the need to prove to some top manager of the Motion Picture Industry that Management Science can be successfully applied to many of its operations and do solidly better than the traditional way. This obviously requires full access to valuable sets of data, a certain amount of time to elaborate them and to try on them several models, as well as a certain amount of financial backing while this work is being done. In lack of all that the task is clearly impossible.

A further obstacle is posed by the peculiar attitude that most of the people show in the presence of unpredictable phenomena. According to this attitude, which is a characteristic of the gamblers mentality, to lose or to win is a matter of luck. The latter is intended as an attribute of each individual which depends upon several factors such as time, mood, related context etcetera. Because of this attitude, which I happen to notice in some of the people of the Motion Picture Industry I had the chance to talk to, a financial loss, although unwanted, is though philosophically accepted "a priori" as something unavoidable: something which is in the "rerum natura". The importance of this attitude within this context, is that it affects their utility function for the return of a financial investment in a picture, by making the negative part of it flatter and closer to zero than it would otherwise be. The same attitude is also very likely to make an eventual demonstration of the Management Science's capability of reducing production costs and financial losses less valuable than it would otherwise be. In other words, the feeling seems to be that if the movie goes a lot of money will be made and the difference due to economic efficiency will be trivial. If it fails to go then there will be no noticeable advantage to having saved a few dollars.

"You can't control nor predict artistic creativity." Many interviewed reacted in this way to my proposals of applying Management Science to the movie productions. The statement reflects a common attitude of many people towards art - related businesses and it's worth analyzing what lies behind it.

a) First of all many people mix up artistic value with commercial success: the former is some message of universal value contained by the art piece which is generally first acknowledged by the contemporary or posthumous criticism. This is made by well educated and specialized people whose task is to point out to the public what and how the piece of art has to be seen. The whole process may take a long time and has generally little to do with the commercial success of the just created piece of art. It is definitively an unpredictable phenomenon since it depends also upon the historical course of the society, which in turn depends upon the combination of a great number of factors. Several times it may take quite a few years before the society gets there where the piece of art can be appreciated. And again it may never get there at all.

Commercial success on the contrary is both synchronism with and proper exploitation of the current taste of the public. This same taste appears in several manifestations of the society and because of that can be detected as a fully developed or as a growing trend from parallel fields. Other entertainment business, magazines and newspapers, political events and public polls may serve the purpose if properly interpretated. This interpretation of course, requires deep insight of the human psychology, an analytic mind, broad culture and to be living in a more specialized environment. For some of those factors motion picture's people find it hard sometimes to predict the success of a movie. Moreover every person is peculiarly sensitive to some human phenomena while being totally deaf to some others. Therefore only a totally uncorrelated sample of human beings exhaustively representative of the movie market could be able to predict what picture will be successful for which market (i.e., for which age bracket, social and income class, cultural back - ground, ethnic group, etcetera). The capability possessed by someone to predict or create a successful picture could be better explained in terms of the previous considerations, than by simply labeling it as magic spell, as some interviewed happen to do with me.

b) The second misunderstanding has to do with the be-havior of many so-called artistically talented people. For some reason an "artist" is generally seen as a "different and rather undisciplined person". While this may be true of the creators of real artistic values for their being somehow off-beat with the surrounding society, it shouldn't be true at all of the creators of successful pieces, who on the con-trary should be quite resonant with it.

This misunderstanding, together with the reverential awe that noncreative people have for the creative ones, is re-sponsible for the passive acceptance that many producers show for the rather non-professional behaviour of many directors. That many of the latters show very little concern for the cost and the time required to shoot a picture shouldn't cause any surprise: it is such instead the fact that this is accepted only for fear that to constrain an artist may result in a loss of creativity. The contrary is generally true, since an extravagant behaviour hides often a poverty of ideas, while the capability of creating among all the necessary practical constraints is one of the qualities which distinguish a good director from a bad one.

Moreover too many artists are considered as gifted only because they once had the luck of creating a very successful work. In the movie world this is particularly true since a single picture can yield a real fortune to all the people involved with it. As a consequence this will spread the voice that the director (here the main defendant against this accusation) has the "magic touch," especially if the successful movie happens to be his first one. This in turn will induce many producers to offer him a series of expensive contracts, based merely on the hope that he'll repeat the same success. Needless to say quite a few producers went bankrupt because of that.

The previous considerations are perfectly synthesized by the words of the successful screenwriter William Goldman;[1]

"There are only a couple of directors in all the history of the world who have had three films that have brought in $15-millions. One of them is an Englishman called David Lean and the other is not Mike Nichols or Arthur Penn or Cecil B. DeMille or Alfred Hitchcock or Billy Wilder or Elia Kazan or

George Stevens. It is George Roy Hill.
Because he is not publicity happy, he is not well known outside the business..." but "He is extraordinarily gifted director."

So much just to point out that if the statistics show that only a very small percentage (6%) of the movies produced earn money, the cause is not the unpredictability of the public's taste but rather the lack of preparation of the entrepreneurs. In fact except a small number of true professionals found at all levels of importance throughout the whole industry and few well managed companies,[1] the motion picture entrepreneurial world collects many real gamblers, who, missing all information about the market and its tough competitiveness, dive into expensive capital ventures in search of fortune. This trend though began to change in the late '60's and early '70's with the motion picture world slowly transforming into a real business, where a series of average earning pictures produced each year is far more valuable, than some rare and random hits obtained at the expenses of huge capital losses. The "new deal" may therefore be synthetized by the two facts:

1) quality control throughout each stage.
2) neglect the big winners and go for the percentage shots.

1.1.3 Its Economics

To give a quantitative idea of the economical landscape of the Motion Picture Industry, a sequence of excerpts selected from one of the most comprehensive books on the matter: "The Movie Business" by Blum & Squire[1] will serve the purpose:

"a theatrical world market for feature pictures of some $2 billion dollars annually still exists."

"...53 cents out of every dollar earned by American motion pictures comes from abroad ... namely, the United Kingdom, Italy and France"

But "... production and distribution of pictures for the theatrical market by the American majors, taken as a single unit for the past 20 years, has been a loser." In fact:

"... Annual Worldwide Box Office	$ 2 Billion
Film Rental Share - 30%	600 Million
Distribution Fees Deducted - 30%	180 Million
Amount Available for Distribution Costs (Prints and Advertising,etc.) and to Cover Negative Costs	$420-Million
Distribution Costs - 30% (of Film Rental)	180-Million
To Cover Negative Costs	240-Million

Some of the box office and film rental gross is done by foreign companies, indicating a smaller amount available for the American Companies. Thus, total returns available to cover production expenditures of about $250 million must be a highly optimistic figure; probably $200 million is closer to the amount produced by the market.

During most of the 1960's, seven major American motion picture companies assumed production risks each year exceeding $50 million each and all other U.S. companies and risk-takers probably totalled another $50 million, a total of about $400 million. Thus, the expense of making the product exceed the market return by something like two to one, and something had to give."

Also:

"In any year, the $600 million in film rentals postulated above would be generated by about 200 pictures, or an average of $3 million apiece. Some years, one could pick two which would gross $50 million apiece, one-sixth of the total. Profit shares might amount to 20% of that gross, a participation to the lucky recipients of $20 million, about 10% of the total reasonable production pool of funds. Probably total deductions from the cash pool, consisting of distribution proceeds which are not re-risked in other productions, are considerably more than 10%."

Finally:

"The rule of thumb is that in order to see any profits, a picture has to realize for the studio roughly 2.6 times its negative cost."

And:

"...70% of the domestic gross is in the first thousand dates."

1.2 The Making of a Movie

1.2.1 Feature vs TV Pictures

When talking about feature motion pictures a first distinction has to be made between the ones produced for theatrical release and the ones produced directly for the TV Broadcasts. From the point of view of the application of the O.R. techniques to them, the former differ from the latter mainly in the following respects:

i) Costs figures of an order of magnitude higher

ii) Much higher quality requirements

iii) Much longer planning and production delays

iv) It is possible to reabsorb production delays

v) The whole script (set of jobs to be performed, in the O.R. jargon) is known in advance (the script of the TV series are known only within 3-4 weeks of advance)

vi) No direct feedback of the market response into the product (this effect on the contrary is commonly used in the TV series)

vii) A consequence of points iii) and vi) is that the degree of uncertainty in the market response is much higher and so are the associated financial risks.

viii) Market prime times vary with a year-long cycle (for TV market it's weekly based)

This work deals only with the movies produced for theatrical release because the data collected so far refer to them and because the level of expenditures involved with them is high enough to justify an attempt to reduce it by the use of some O.R. modeling techniques. On the other hand the differences between the two types of products are strong enough that an attempt to extend this work to the TV series will probably require changes as substantial as the use of different models.

1.2.2 Stages, Responsibilities and Decisions

The making of a feature motion picture is a multi-million dollar event requiring as much as two years and involving hundreds of people as well as several different companies each specialized in some particular operation of the whole process. A complete description of the latter is beyond the scope of this work but can be found in the literature specialized on the subject [1], [3]. For the purpose of this work though the whole process can be partitioned in the folloqing three main stages (this partition on the other hand follows closely the real world organization of the process):

1) Preproduction stage
2) Production stage
3) Distribution stage

The objective of the first stage is to put together a "package deal" made out of an option on a story, on a director and on some good actors and to search for the financial means which would allow the whole thing to be produced. Every possible way of raising the capital (via personal funds, or as capital supplied by friends, foundations, companies, etc.) is possible at this stage and any gross generalization would be meaningless. Nevertheless in the most common case where a large share of the capital is obtained through a bank loan, is the Distributor who bears up to 90% of the risk of the production cost. The Producer therefore, besides putting the deal together, is held responsible for the production to run smoothly and to be kept within the limits of the anticipated budget. But is the distribution company that takes the risk of the financial investment in front of the money lenders. It is also during this stage that the story is converted into the final screenplay by the encharged Writer. The decisional problem faced by the producer is to convert the story into an "optimum package deal" at minimum cost, while the one of the Production-Distribution Company is to allocate each year a variable amount of financial resources into a set of pictures able to "best" meet the forecastable public taste a couple of years later.

During the second stage the screenplay is converted into the original copy of the film. Aim of this stage is to supply the Director with all the means he needs to create a good work, while still remaining within the anticipated time and cost constraints. Director of the operations is the Unit Production Manager (U.P.M.) His decisions can be overridden both by the Producer and in many instances also by the Director. The decisional problem faced by the U.P.M. is to set the "best" (the meaning of this will be specified later on) shooting schedule.

In the third stage the Distributor, having assessed the value of the picture in his hands, aims at exploiting it optimally. He is responsible to the Producer in recovering the largest share of the potential gross of the picture in the shortest time. His responsibility towards the Producer though is not binding in a contractual sense, but rather in a company-customer sort of relationship. On the other hand his share of interests in the movie's income will insure that he'll do his best.[1]

The decisional problems the Distributor has to solve are:

1. Assess the value of the picture he has on hand, and in order to get the most out of the first run:
2. Decide the optimal number of prints
3. Decide the times, means and total expenditure for the advertisement campaign
4. Set the minimum terms of the eventual bid for the picture
5. Evaluate the returning offers
6. Decide the best opening procedure

As soon as a few weeks of the first run have gone by the response of the public becomes known and the management of the remaining part of the first run becomes less affected by errors in forecasting. Therefore the next decisions such as:

7. Whether to open or not on a foreign market and
8. How to manage the so-called tail-end selling, are a lot easier to make.

---

(1) It will be seen later on that by law distribution and exhibition cannot be performed by the same company. This puts Distributors and Exhibitors on opposite sides and gives birth to all sort of problems in the recovery of the potential gross of the picture. Complaints of lousy distribution are common among producers and other interest holders, particularly whenever the distributor's interest in the picture is not very high.

According to the level of management involved in each of the three stages of the process, it is interesting to note, as a final comment, that each of these can be associated to one of the three sets O.R. partitions all the decisions:

1) First Stage - Strategic Decisions

2) Second Stage - Operational Decisions

3) Third Stage - Tactical Decisions

1.3 The O.R. Type of Problems

1.3.1 First Problem: Which Movie, at Which Cost, for Which Audience

Six facts:

1. Heteroschedasticity of success. That is to say the variance of the random variable (e.g. number of tickets sold) associated to the success of a movie increases with the amount of success itself.

2. High set-up cost. The cost of an average movie is $3 million, if you decide to produce it.

3. This cost is more or less independent upon its success.

4. Once completed, very little can be done to increase the sales of a lousy picture. Any movie should be better thought of as an amplifier of the money invested in its advertisement: the same figure invested in a better movie will always yield a higher return.

5. The salvage value of a lousy movie is generally small with respect to its cost. The value of a non completed movie is zero.

6. It is generally impossible to assess the value of a movie before it is completed and edited. To screen the footage of film already exposed will not mean much to anyone who is not the director. Indirect means, such as the professional reputation of the people who have been connected with it up to that point, must be used.

Because of these it is of primary concern to apply some proven, thorough and robust success forecasting and decision making methodology throughout the first stage of the making of a movie for the business to reduce money losses. In fact the following excerpts from reference 1 supply a rough idea of how some people in the business feel about the current state of the art:

"A book selling 100,000 copies or even less, for example, becomes a bestseller. A picture, however, must play to at least 20 million persons just to be considered average." (p.xv)

"...no combination of actor, actress, writer, director or producer, regardless of past records, hits or awards, can assure success." (p.58)

"Pictures are not bankable risks. No same banker can make loans for the production of a picture where the sole source of payment is revenue from that picture." (p.59)

"For 20 years the bankers has had to assume that each new picture financed would not return <u>any</u> of its production cost." (p.60)

"As to reducing cost, it must be mentioned that there seems considerable doubt that there is any correlation between the cost and return of feature pictures professionally made. If your budget is $1,500,000, stand off and look at the philosophy behind it; maybe a different concept will make it for $500,000. Sure some items won't be there, but are they really important in the marketplace?" (p.61-62)

"If we assume that over half of development money never results in a picture, then obviously we must do as much as we can to avoid this expense and more aggressively seek "packages". (p.107)

In summary the problems O.R. can try to solve during the first stage of the making of a movie are:

1. To create some analytical model able to yield the probabilistic distribution of the success of a movie, given its basic elements (story, screenplay, director, cast, etc.), the associated level of expenditure and the type of audience to which the movie is aimed.

2. To design a method for updating the above mentioned probabilistic distribution by each new decision or action undertaken concerning the planned picture. This would allow to feed its expected success back into the decision making process to indicate which action is optimal at each step.

3. For each decisional step to compute the drop out action. That is to say use some parameter of the updated probabilistic distribution of success (e.g. the expected income) to compute that action below which the expected income is so low that we would be better off by dropping the whole project. It is

obvious that to find out at an early step that all reasonable actions are below the drop out one would help to save a lot of money.

4. To define a loss structure for the whole project.

5. To obtain the utility function of the decision makers in the business and fit it with an appropriate analytical curve.

6. Many decisions are made by a number of executives gathering together and assessing the value of the work done for the project up till that point. A quantitative method which would allow a fast and efficient exchange of the information among the executives, is recommended.

1.3.2 Second Problem: Where and How to Save During Production

The following table shows an itemized budget of an average production:

Item	Cost as % of the total
Story	5
Production & Direction	5
Sets & Other Physical Properties	35
Stars & Cast	20
Studio Overhead	20
Income Taxes	5
Net Profit After Taxes	10

Items 3, 4 and 5 count for 75% of total cost and are the ones where some savings can be achieved by applying the O.R. type of analysis to them. How large these savings can be is shown by:

i) Eliminate one day of production on location = \$15,000 - \$25,000

ii) Eliminate one setting = \$10,000 - \$12,000

iii) Eliminate some of the extras used = \$150/person x day

The last two types of savings though are not likely to be obtained through the use of optimization techniques, since it is up to the Producer to eventually impose them to the Director. On the contrary the first one can be obtained at the expense of no major changes in the philosophy of the production. In fact at the present time it is the U.P.M. who is in charge of organizing and managing the production. His main concern is therefore to set a shooting schedule which is the shortest possible, but at the same time which retains enough flexibility to be compatible with all the constraints. These are both deterministic (i.e. scenes which require to be shot at a fixed date, night scenes which for contractual reasons are preferably shot on the night preceding the weekend, etc...) and stochastic (scenes whose shooting is affected by the weather, or by some other type of unpredictable events, etc.).

To meet all those requirements a fat solution is generally adopted: the daily shooting load is kept light enough to allow the recovery of any reasonable amount of time lost for whichever cause. Moreover, whenever possible, a by-standing set is kept ready to shoot alternative scenes in case the scheduled ones cannot be shot. This philosophy is obviously very expensive because of the erratic variability of the daily working time and the consequent low utilization factor of the available physical and human resources.

In terms of O.R. this can be modeled as a problem of stochastic scheduling (or in some other way which will be presented later on) and can be approached both in a deterministic way, by using expected values of the involved random variables, or directly through a stochastic approach. The latter of course involves a much higher complexity of the models used. In both cases though some saving can be achieved by regularizing the daily working time, by decreasing the total amount of time the shooting set stays idle and by diminishing the impact the unpredictable events may have on the flow of the production. Movies require that certain categories of actors are hired with continuity. Therefore a second important concern of the U.P.M. is to design a shooting schedule which minimizes the number of actors who have to stay idle while still being payed. An O.R. approach would be to handle this as a sort of sequencing problem.

These are the only two ways O.R. can attempt to reduce the production cost. Other means such as questioning the producer's or the director's or anyone else's decisions about the philosophy of the production, should not be taken into consideration, since they imply decisions which may affect the quality of the final result.

1.3.3 Third Problem: How to Squeeze the Most Out of a Picture

The following graph shows the qualitative behaviour of the curve representing the cumulative domestic gross of an average picture against the total number of bookings.

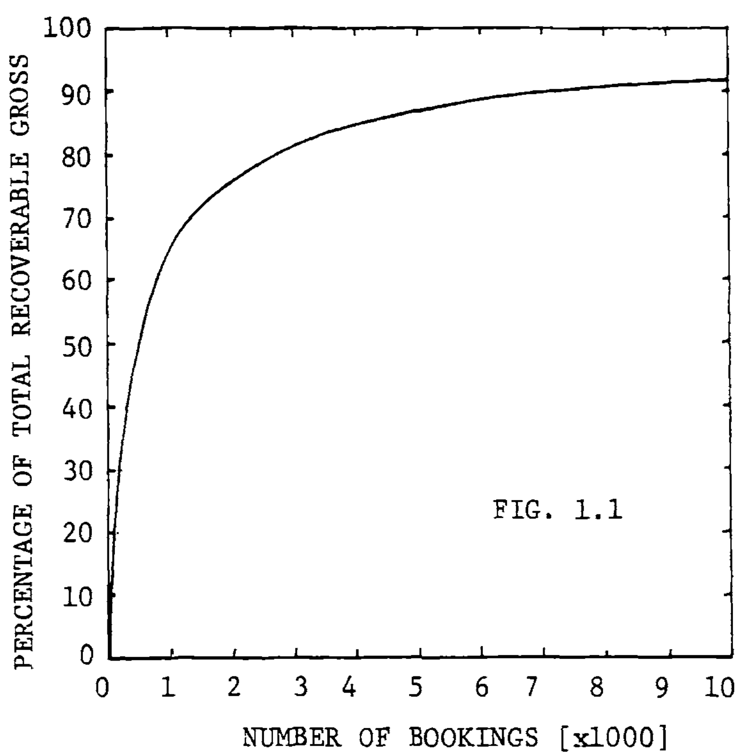


FIG. 1.1

(Source: 1973 Almanac of the Motion Picture Industry. Data are for the years 1969-1972 by the Department of Commerce.)

The following facts can be argued from the graph:

i) The marginal reward expressed in monetary terms of getting further bookings becomes very small after the first thousand ones. At that point some 70% of the total recoverable gross has already been collected. The marginal reward becomes even smaller if expressed in real terms: that is to say if we apply the present value factor to every point of the curve.

ii) The effectiveness of an advertisement campaign diminishes the more we go towards the flat part of the curve. This is so because at that point is missing the multiplicative factor of the word-of-mouth effect. This implies that the rate of recovery of the gross beyond say 70% of the total becomes extremely sensitive to the type of publicity made to the picture. The publicity in fact should be geared more accurately to the particular kind of picture it's dealing with and should be aimed in a differentiated manner at both first time and one more time spectators.

iii) Beyond the knee of the curve the amount of capital which can still be recovered is not much. This of course rules out any kind of expensive publicity, thus making the problem even more difficult.

iv) The previous arguments suggest that the recovery of the gross be divided in two different periods: up to say

70% and beyond that. Within each period the recovery techniques should be different as well as the types of publicity. This of course would imply that separate companies, having different structures, should operate in the two periods. For instance the existing distribution companies in the first period, something else in the second one.

A simple solution along this line is represented by the management of "The Godfather," a fast (and high) recovering picture, which after only two years of exhibition has already been sold to the television networks.

In the future one can think of the theatrical exhibition as a means of igniting the word-of-mouth effect and of recovering the first fraction of the gross, and of the video cassettes as a less expensive and more adjustable to the market's demand medium, which would accomplish the recovery of the remaining gross, while benefitting of the publicity previously created by the theatrical release. These facts are well known to some people in the business, as it can be read in the following excerpts from reference 1:

"After the percentage towns are sold - maybe as many as 5,000 bookings on a top film - it doesn't pay us to go after the rest." (p.187)

"This development in the area of what the trade calls "tail-end selling," leads us logically into what I believe will be the next major development in distribution." (ib.)

But also the recovery techniques employed during the first period needs an improvement, if it is true that:

> "Full-blown campaigns are given to only a few high-budget pictures. So a lot of attractions come to theatres as totally unknown quantities. House managers have neither the data nor the enthusiasm to exploit them to their patrons." (ib., p.190)

I personally have seen quite a few excellent movies enter the U.S. market after a successful show in Italy and stumble in a few days because of a totally inadequate advertisement campaign. Films as "The Anonymous Venetian" (1971) and "The Matter Affair" (1973) can serve as a well fitted example of this phenomenon.

Considering the previous arguments and the decisional problems (listed in 1.2.2) the Distributor has to face, what O.R. can do at this stage in the life of a picture is:

1. To find out the optimal switching point from one recovery technique to another one. At the present time for instance this would mean to compute after how many bookings it would be no longer worth to keep the picture on the theatrical market, since it would pay more to sell it to some television network. It would be quite easy also to compute the break even selling price at each day of the life of a picture, given a prediction of its "tail" for the case in which no more money would be invested in its promotion, and the expected rate of return of the investment opportunities available to the distributor.

2. To quantify, model and simulate the attitude of the potential spectators towards the movie. That is to say to find a way to measure and predict the multiplicative factor due to the word-of-mouth effect and the willingness of the spectator to see the movie more than once.

Basically this task could be broken down in three separate independent works:

i) A model of the first run to allow a fast prediction of the success of a picture. The model should incorporate the word-of-mouth effect which I believe is the predominant one among the causes of the success of a new release.

ii) An analysis of the subsequent runs given the information acquired throughout the first run. This work is more a matter of management's efficiency than of prediction.

iii) An analysis of the "tail-end selling" based upon spectators behaviour, cheap advertisement media and all the technically available solutions besides the theatrical release.

3. To model the prints-priorities problem in order to minimize the distribution cost. This problem derives its name by the fact that the prints (fifty could be a representative figure for their number) travel around from one exhibitor to another one. The path they follow is generally neither the shortest nor the cheapest one. By conveniently readjusting the

priorities between exhibitors it may be possible to realize some savings.

1.4 Explanatory Notice About This Work

This work is problem-oriented rather than solution-oriented. This work is also incomplete and the problems are treated with uneven depth. The reasons for this being so are several.

i) The set of data I have is generally neither suffucient nor complete. Moreover I do not have enough confidence in it to claim that a solution of a problem based upon it would be really meaningful.

ii) In the recent times O.R. Science has had more success in the creation of elegant theoretical tools than in their implementation, this latter result depending strongly upon the managerial experience of the O.R. experts. Because of this, there are a lot of good models which are available for potential applications.

iii) I do not know of any previous extensive publication focused on the management and on the modeling of the motion picture industry's processes. This requires that more time be spent on scouting, framing and modeling the existing problems than on solving them. I do believe, in fact, that more than half the success of an O.R. job depends upon finding the appropriate formulation of the problem.

For the previous reasons my aim has been to frame the whole work in independent sections and to show what kind of solutions O.R. could offer to the movie business. This approach will allow me later on to focus on some issue and carry its development as far as to try a practical implementation of the models based upon that issue, without having to reconsider the remaining sections. A more complete or a more homogeneously developed work would have been either too superficial or too extensive for a S.M. degree. One more reason supporting this approach is that since the late sixties a whole lot of new independent operators have entered the business. This material therefore, and any further extensions as well as any implementations of it may enable present and future operators to sharpen their decisions, reduce their losses and increase their profits.

"As to increasing the return, for over five years I have advocated an attempt at scientific evaluation of the factors which make a picture successful. If a guide could be developed which would reduce the failures and increase the successes by even a small percentage, it would go far to make a viable, healthy industry. And by reducing the risk, it would make the producer's job of financing his picture much easier.

Both reducing cost and improving the batting average are, at the moment, subjective and chancy. Spreading the risk, and hence perhaps making your venture more acceptable to risk-takers, is not." (Ref.1,p.62).

Chapter 2

FINANCIAL INVESTMENT DECISIONS BEFORE PRODUCTION

2.1 The Problem

To produce a feature motion picture requires to succeed in two challenging tasks: to find out all the money lenders who might be interested in supplying the capital needed to do the job, and, even more challenging one, to persuade them that the picture is going to be a good investment. Clearly the first task doesn't belong to this thesis and therefore I will make no attempt to deal with it. The second instead requires to supply a dependable estimate of the financial risk involved and of the return on the investment. The best way to do so is to build a series of analytical models formulating the many problems encountered throughout the life of the investment and to use them to supply the probability distribution of the return on the investment self. This in turn requires to break down the process of the investment into independent events and to associate to them the random variables which best represent them. In fact it will be much easier to predict the value of these random variables, by measuring the parameters the predictive models will suggest that they be associated to the present state of knowledge, than to predict the whole events by pure intuition. For instance the probability distribution of the box office gross on the number of spectators which will see the movie, will be a valuable tool in making many important decisions. This done, it will be required to investigate and to define some normative philosophy by means of which to split the financial risk involved among the largest number of independent risk-takers.

2.1.1 The Details

> "In looking around for businesses, most large multi-level companies look for leisure-time activities because-clearly-they are the businesses of the future." (Ref. 1, p. 98).

This is certainly true, but only if the motion picture industry will be able to supply some dependable quantitative analysis of the value of the investment opportunities offered. For instance both a major studio, which is committed to doing 20 to 25 films a year, and an independent producer requires to use predictive models to make the request for capital more attractive. Models are needed to forecast the composition and the taste of the public at some later time because of the lag intervening between the time the decision to finance a script or to go into production is made, and the time the picture is released. The forecast has to be particularly sharp since:

> "In addition, there has been a polarization in taste. More people are going to <u>certain</u> movies than ever before, but less people are going to movies generally - so the audience is shrinking." (Ib., p. 99)

Models are also needed, as I said, to forecast the gross of a picture (given that the picture is optimally distributed) and to predict the impact that all the decisions made throughout the preproduction stage will have on the gross itself. This will avoid wasting money on uncompleted ventures or mismatching the levels of commitment concerning the items (writer, director, actors, budget, etc.) which go into a single picture.

The Fracture between Distribution and Exhibition

One main difficulty though which makes the forecast of the market more uncertain than for other parallel industries in U.S., is that the ultimate customer of the industry, the public, is not himself the direct buyer of the product, but it is rather the exhibitor who buys it for him, with a taste some times different from the one of the public. In fact:

"Prior to 1948, it was an industry standard for most studios to own major interests in theatre chains, thereby controlling productions, distribution and exhibition. The Justice Department deemed this triple involvement to be anti-competitive, and began litigation against the companies. The majors- but not other companies involved - agreed to the entry of a "consent decree", in which they consented to divorce themselves of theatre ownership, in accordance with the Justice Department's anti-trust position. Thereafter, the landmark Supreme Court decision in 1948 (U.S. v. Paramount, et. al.) compelled all companies to divest themselves of theatre ownership, while retaining production and distribution. The result of the 1948 decision has been the emergence of many new theatre chains and small production entities, which now comfortably compete with the majors." (Ib., p.99)

Therefore the safest thing to do is to produce a movie which would possibly appeal to everybody. This is actually the most desired of the goals of the producers. Unfortunately such a movie is not easy to create and generally requires very large capitals, in this making the venture even more frightening. This is probably the reason for which in the last few years this type of movie has been tried with various results only by the large studios who can afford to dive into such large projects. The independent producers instead are left with the task of creating pictures aimed at specific audiences which have to and do cost less since they draw out of a smaller pool of market. One phenomenon though which should be carefully considered in aiming at the big "sensurroundous" adventurous pictures is that several of these pictures at the same time, will have to share the market. This is to say that if a spectator decides to see one of them, he won't probably go to see any other of them for a certain period of time. And if the time those movies are around, is limited to the Christmas vacations and following weeks, he just won't see them anymore. Some serious behavioural study needs therefore to be done to investigate the drainage effect that such kind of pictures have on the desire for adventures of many spectators.

Independent Production

From all this, one may tend to think that independent production will dominate the future for its higher flexibility and adaptability. The following list may supply some further ground for judgement:

Advantages:

1. Less expensive, more flexible and adaptable.
2. Money lenders do not generally interfere with production.
3. Time constraints are more relaxed.
4. More room for creativity.
5. Better control over the artistic values (i.e.: Too many cooks spoil the broth).
6. Unions tend to be more flexible toward it.

Disadvantages:

1. The distribution is difficult and not even sure. (You have to go through someone else's distribution company since a minimum of ten pictures a year have to be distributed by a company to operate successfully).
2. Insurances take time to pay.
3. Completion is not guaranteed.
4. Money lenders supply no help.
5. You have no strength on the market.

Nevertheless some recent attempt has been made to change the distribution rules by Tom Laughling with a re-release of "Billy Jack" first and then with "The trial of Billy Jack". This involves contracting with the exhibitors directly, investing in advertisements sums larger than ever and printing some 2000 copies of the film. This allows the producer to recoup the capital invested in the shortest possible time, drawing out of the public created by the advertisement campaign. The short time involved avoids the risk that the word-of-mouth effect be negative and cool the expectation of the public before the movie can reach it. This attempt though is still too recent to be able to draw definitive conclusions about the results.

Two Opposite Views

In reading the existing literature as well as in listening to the people in the business , I reported the impression there exist two opposite views about the industry as a potential field for financial investments. One, which could be defined as the intuitive approach, thinks of the business as of something different from any other existing one and relies upon human experience and sensitivity. The other one, definable as the scientific approach, attempts to reduce the unpredictable and the intangible aspects of the business by operating according to some methodology. A few excerpts from Reference 1 will put the distinction in better evidence:

"It is sad but true that movies have always been an imitative - not an innovative - industry. Miscalculation abounds." (p. 91)

"The industry still goes to the bank on names of people." (Ib.)

"But movies are the super, number-one guessing game." (Ib.)

An example of the first approach may be seen in the venture of the American Broadcasting Company (ABC), which entered the field in 1966, just to quit in 1972 after 36 releases, 44 stillborn projects each at an average cost of $130,000 and a loss estimated at upwards of $35,000,000. The breakdown of table 2.1 lists revenue and cost figures for the 36 releases. "Domestic Rentals" are monies remitted by exhibitors to the distributor on all U.S.-Canadian theatrical engagements. "Foreign Rentals" represent the distributor's share of boxoffice grosses in all other territories. "Distribution Fee" is the amount retained by the distributor to cover his operational overhead. "Prints & Advertising" refers not only to the cost of print manufacture, ad-pub campaign preparation and local advertising expenditures throughout the country, but also to miscellaneous distribution expenses charged directly to a given picture. "Negative Cost" is the total

37 ABC RELEASES WITH BANK INTEREST, OTHER COSTS

Film	Domestic Rentals	Foreign Rentals	Total Rentals	Distrubtion Fee	Prints & Advertising	Negative Cost	Bank-Loan Interest	Partici-pations	Total Costs	Profit - (Loss)
Bolshoi Ballet	$ 170,000	—	$ 170,000	$ 40,000	$ 125,000	$ 275,000	$ 40,000	0	480,000	($ 310,000)
Good Times	600,000	$ 200,000	800,000	190,000	380,000	1,115,000	165,000	0	1,850,000	(1,050,000)
Smashing Time	290,000	—	290,000	70,000	205,000	630,000	95,000	0	1,000,000	(710,000)
Cop-Out	205,000	50,000	255,000	60,000	220,000	665,000	105,000	0	1,050,000	(795,000)
Rover	70,000	225,000	295,000	85,000	285,000	1,325,000	195,000	0	1,890,000	(1,595,000)
Minute to Pray	885,000	—	885,000	175,000	485,000	280,000	35,000	75,000	1,050,000	(165,000)
For Love of Ivy	5,570,000	1,700,000	7,270,000	1,720,000	2,050,000	2,590,000	165,000	355,000	6,880,000	(390,000)
Charly	7,250,000	1,250,000	8,500,000	1,915,000	2,225,000	1,470,000	175,000	1,325,000	7,110,000	1,390,000
High Commissioner	455,000	150,000	605,000	150,000	415,000	1,055,000	170,000	0	1,790,000	(1,185,000)
Shalako	1,310,000	—	1,310,000	260,000	745,000	1,455,000	125,000	0	2,585,000	(1,275,000)
Diamond for Breakfast	0	—	0	0	20,000	1,250,000	175,000	0	1,445,000	(1,445,000)
Candy	7,300,000	—	7,300,000	1,460,000	1,900,000	2,720,000	235,000	1,010,000	7,325,000	(25,000)
Killing Sister George	3,450,000	1,875,000	5,325,000	1,425,000	1,820,000	2,555,000	275,000	0	6,075,000	(750,000)
Birthday Party	50,000	350,000	400,000	120,000	275,000	640,000	90,000	0	1,125,000	(725,000)
Hell in the Pacific	1,330,000	1,900,000	3,230,000	1,050,000	1,375,000	4,150,000	585,000	185,000	7,345,000	(4,115,000)
Midas Run	300,000	200,000	500,000	140,000	675,000	1,110,000	90,000	0	2,015,000	(1,515,000)
Ring of Bright Water	1,000,000	1,400,000	2,400,000	670,000	1,250,000	915,000	105,000	75,000	3,015,000	(615,000)
What Happened Alice?	2,025,000	1,200,000	3,225,000	905,000	1,300,000	1,725,000	155,000	0	4,085,000	(860,000)
Take the Money and Run	2,590,000	450,000	3,040,000	680,000	1,275,000	1,530,000	165,000	0	3,650,000	(610,000)
They Shoot Horses	5,910,000	3,080,000	8,990,000	2,485,000	2,150,000	4,880,000	775,000	0	10,270,000	(1,280,000)
Jenny	2,010,000	815,000	2,825,000	745,000	1,400,000	1,550,000	300,000	0	3,995,000	(1,170,000)
Mastermind	0	0	0	0	50,000	2,500,000	350,000	0	2,900,000	(2,900,000)
Too Late the Hero	615,000	975,000	1,590,000	455,000	850,000	6,250,000	800,000	0	8,355,000	(6,765,000)
Suppose They Gave War	630,000	450,000	1,080,000	280,000	750,000	3,600,000	600,000	0	5,240,000	(4,160,000)
Lovers Other Strangers	7,000,000	700,000	7,700,000	1,960,000	2,100,000	2,550,000	300,000	0	6,910,000	790,000
How Do I Love Thee?	150,000	125,000	275,000	75,000	325,000	1,975,000	325,000	0	2,700,000	(2,425,000)
Song of Norway	4,400,000	3,500,000	7,900,000	2,150,000	2,300,000	3,625,000	750,000	150,000	8,975,000	(1,075,000)
300 Year Weekend	0	0	0	0	75,000	260,000	75,000	0	410,000	(410,000)
Last Valley	380,000	900,000	1,280,000	365,000	850,000	6,250,000	1,000,000	0	8,465,000	(7,185,000)
Zachariah	505,000	120,000	625,000	160,000	550,000	1,200,000	150,000	0	2,060,000	(1,435,000)
Grissom Gang	340,000	250,000	590,000	160,000	625,000	3,000,000	475,000	0	4,260,000	(3,670,000)
Touch	485,000	650,000	1,135,000	315,000	550,000	1,200,000	150,000	0	2,215,000	(1,080,000)
Kotch	3,600,000	1,400,000	5,000,000	1,320,000	1,600,000	1,500,000	250,000	0	4,670,000	330,000
Straw Dogs	4,500,000	3,500,000	8,000,000	2,175,000	1,900,000	2,200,000	300,000	0	6,575,000	1,425,000
Cabaret*	8,000,000	3,500,000	11,500,000	2,763,000	1,800,000	2,285,000	350,000	1,750,000	9,048,000	2,452,000
Junior Bonner	1,900,000	900,000	2,800,000	745,000	1,250,000	3,200,000	425,000	0	5,620,000	(2,820,000)
Totals	$75,275,000	$31,815,000	$107,090,000	$27,278,000	$36,250,000	$75,460,000	$10,250,000	$4,925,000	$154,433,000	($47,343,000)**

(Source: "Variety", May 30,73,p.5)

Table 2.1

budget outlay for production, inclusive of ABC's 10% overhead charge. "Bank Loan Interest" are the costs assumed to finance the production. Finally "Participations" are all deferred payments due principals from gross or net income. Column 3,9 and 10 are respectively the sum of columns 1 and 2, 4 through 8 and 3 minus 9. To this final loss figure should be subtracted an estimated $25-millions net for video income and another $5-7-millions for "outright sales". On the other hand, losses incurred on unproduced but developed projects and unrecouped overhead cost is estimated at $20-millions, which brings the total loss at $35-millions.

Excerpts (again from Reference 1) which are in line with the methodological approach are inserted:

"... for over five years I have advocated an attempt at scientific evaluation of the factors which make a picture successful." (p. 62)

"We consider all cities that have a population in excess of about 100,000 as potential locations for a multi-theatre operation." (p. 220)

"We also attempt to evaluate the population centers by various economic and demographic considerations, including average age, income, education, and occupation of residents." (p.221)

"Then we begin to track on a basis of comparison with other pictures that have played those territories at approximately the same time of year and in the same theatres, and under the same terms - and that is how, by using an historical track, we can come up with what we think the picture ultimately will do." (p.106)

2.1.2 Splitting the Financial Risk

To leave a picture uncompleted is bad enough. To do so when all the budgeted capital has been spent, is the worst thing which could happen to a producer. This may happen, as was mentioned in the introduction, for over-budgeting or for the loss of some main character by death or else. Again nowadays the best way to handle a bummer is to bury it, since the more you keep it around the more you lose on it. These two just mentioned events are the most feared ones by the people of the motion picture industry, but there are many others in the life of a movie which involve financial losses of variable amounts. Several measures are currently taken to cope with the risk involved in the production of a picture. Among them the following are the most relevant ones:

1. To separate budgeted cost from completion cost.
2. To cover the completion risk at different levels: up to 15% and over 15%.
3. To take an insurance against accidental occurrences covering the Director and the main characters.
4. To split the risk onto players and others by partially compensating them with a share of the profits. Also by deferring some of their cash compensation up till after completion of the picture.

5. To put a limit on the investment: major companies, for instance, like to take on only prints and advertising costs.
6. To invest more than needed on equipment and personnel in order to avoid technical failures (keep a stand-by generator) and to increase the quality of the personnel's performance (stunt men for instance).
7. To take an insurance against bad weather conditions.
8. To separate potential values: that is to say to sell separately T.V. from theatrical release, U.S. from foreign market and eventually splitting it even further region by region.
9. To buy some present service offering in exchange different shares of the profit according to whether the picture is going to be a strong or a weak performer.

All these and any other way of dealing with risk in any human activity, can be reduced to a single conceptual framework of trading risk for compensation. For this purpose look at the business of producing a movie as at a generalized lottery endowed with a continum of outcomes from the most negative to the most positive ones. Here we assume, of course, that the cost of purchasing the right to participate to the lottery (in this case the production cost and any other associated cost) is subtracted out of every possible outcome. All we are left to do, facing such a lottery, is either to play or to refuse or better to trade some present sure wealth or some future uncertain one for some of the negative outcomes in order to make the lottery more appealing. That's what risk sharing is all about. Raiffa has shown that

"... we can represent any partition of a lottery that gives a p_1 chance at amount x_1 and a p_2 chance at amount x_2 in terms of an initial side payment b between the players plus a proportional sharing of the lottery." (6, p.194)

Again for the more general case of many parties involved in a lottery with a more complex structure of possible discrete and continuous outcomes, any partition could be represented as a beforehand redistribution of wealth among players and a proportional sharing of the whole lottery. Unfortunately to compute for each player his amount of side payment and his share of the lottery may prove to be analytically too involved. Therefore, letting $\tilde{x}$ be the random variable associated with the outcomes of the lottery, b and s respectively the amount of side payment and the share that I offer as the owner of the lottery to any interested party, let's distinguish among the following 4 different basic trading frameworks:

A) Insurance: I'll give you b for sure today for your picking up some negative values of $\tilde{x}$ tomorrow.

B) Producer-Director (or Actors) agreement: I'll give you s of $\tilde{x}$ tomorrow for a certain worth of performance you give me today.

C) Deferred payment: I'll give you b tomorrow for a certain worth of performance today, if $\tilde{x}$ won't have certain values.

D) Producer-Distributor agreement: I'll give you s_1 of $\tilde{x}$ tomorrow for some worth of performance today if $\tilde{x} \leq x_0$, I'll give you instead s_2 if $\tilde{x} > x_0$.

Case A covers what's currently being done in 1,2,3,5,6,7, while 4 is represented by both B and C . Finally D takes care of 8 and 9. Notice that all cases could be reduced to a simple unconditional lottery that the producer would be facing, once the new value of all the outcomes subject to the agreements would be recomputed. Notice also that the most important thing to do when facing such a lottery is to thoroughly analyze all its outcomes (especially the negative ones), find out all the independent events which may cause them to occur, and eventually have the responsibility of each of them borne by an independent risk-taker. This may require an accurate fault-tree type of analysis akin to the ones performed in safety engineering.

In the next section I will show a way of using O.R. concepts to analyze and formulate a problem covered by situation B.

2.1.3 Producer-Director Problem

Top directors and top actors are expensive: no same producer would borrow all the money needed to hire them just for the sake of investing it into their compensation. Moreover it is known that a movie which goes pours in a lot of money: a share of the profits of a boxoffice success is therefore a valuable asset. A posteriori, of course! Because of these reasons and whenever possible, most of the people above the line (Producer, Director, Stars, etc....), are compensated with a combination of salary, benefits, deferred compensation and profits or gross participation. How much of each of them is a matter of their bargaining ability (or of their agents), of their risk aversion and of the movie's forecasted box office behaviour. The three factors just mentioned are, separately taken, characteristic problems of O.R. and a lot has been written about them in general. Nothing instead has been done to apply the general results to the problems of the motion picture industry.

Risk attitude and how to measure and model it is nothing new, but what may be peculiar to the movie business is the fact that quite a few people in it have a gambler's type of behaviour, or in other words they have a risk prone attitude. Forecasting techniques are numerous and many of them may be applied to this business with a certain degree of success, but what is peculiar to it is both the strong dominance of the human factor in the quality and success of a movie, and the absolute impossibility of simulating the public response to the picture before its production (and the consequent capital expenditure) is completed. Finally, up to my knowledge, nothing has been done to model and measure the bargaining ability of a deal maker.

In this section I will present a simplified model of the deal made by two parties only: the Producer and the Director. The study of this model will offer interesting suggestions about how to formulate the same problem in the case of many more parties involved and with more realistic assumptions. I will refer to it as the P-D Problem.

The real situation this simple model represents is the one in which a Producer borrows a certain amount of capital in order to produce a movie and wants to hire a certain Director to do the job. He offers to the latter a mixed compensation of a certain amount of cash and of some share of the profits that the movie which is to be produced will make.

<u>Assumptions</u>:

1) No other parties will participate to the profits.

2) Profits are intended as the revenues "off-the-top". That is to say after the exhibitors retain their share of the box office gross, what is left are the rental revenues. The latters are used first to repay the distribution expenses (distributor's fee, prints, advertisement,etc...), then to repay the loan (principal plus interests) and then eventually to pay for the producer's fee. Whatever is left are the profits.

3) The two parties reach an agreement on which is the distribution of the probability of the rental revenues (or of the box office gross since the formers are intended here as a constant fraction of the latter).

4) I neglect all time effects on money's value. In other words there is neither inflation nor interests to be paid or earned on a capital. This implies that the only difference between the cash now and the share of the profits later is the uncertainty about the level the profits will reach.

5) The quality of the picture, included Director's performance, is independent of the type of deal agreed upon.

6) The type of deal offered by the Producer doesn't affect his "a priori" chance of contacting whichever Director he wants to.

The Model

Random variable: $\tilde{x}$ = rental revenues

Decision variables:
- y = Director's salary
- s = Director's profits participation

Parameters:
- y_0 = Production cost (included, if the case, the Producer's fee)
- a = Distribution cost (included the Distributor's fee)
- Thus: $c = a+y_0+y$ = Total cost of releasing the picture on the market
- K^D = Director's market value

Functions:
- $f(x)$ = Probability Density Function of $\tilde{x}$
- $u^D(\$)$, $u^P(\$)$ = Director's and Producer's Utility functions respectively (Normalized to 0 so that $u(0)=0$)

For both the Director and the Producer (from now on referred to as D and P) to enter the deal, the latter has to satisfy the two following conditions:

(2.1 D) $u^D(y) + u^D\{\ell^D\} \geq u^D(K^D)$

(2.1 P) $u^P(-y_0-y) + u^P\{\ell^P\} \geq 0$

Or equivalently:

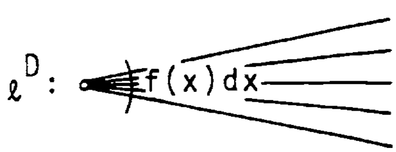
(2.2 D) $CME(\ell^D) \geq K^D - y$

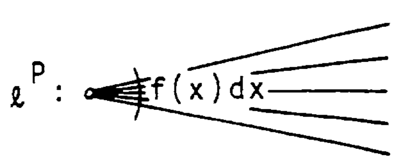
(2.2 P) $CME(\ell^P) \geq y_0 + y$

Where $CME(\ell)$ = Certainty Monetary Equivalent of the "lottery" ℓ to the Decision Maker facing the lottery.

K^D is here intended as the minimum salary D would be happy to work for in the case he wouldn't participate to the profits.

While the "lotteries" faced by D and P are respectively:





Lottery	State of nature	Cash inflow	Utility of it
ℓ^D	$x \geq c$	$s(x-c)$	$u^D[s(x-c)]$
	$0 \leq x \leq c$	0	0
ℓ^P	$x \geq c$	$(1-s)(x-c)+y_0+y$	$u^P[(1-s)(x-c)+y_0+y]$
	$a \leq x \leq c$	$x-a$	$u^P(x-a)$
	$0 \leq x \leq a$	0	0

Fig. 2.2

and

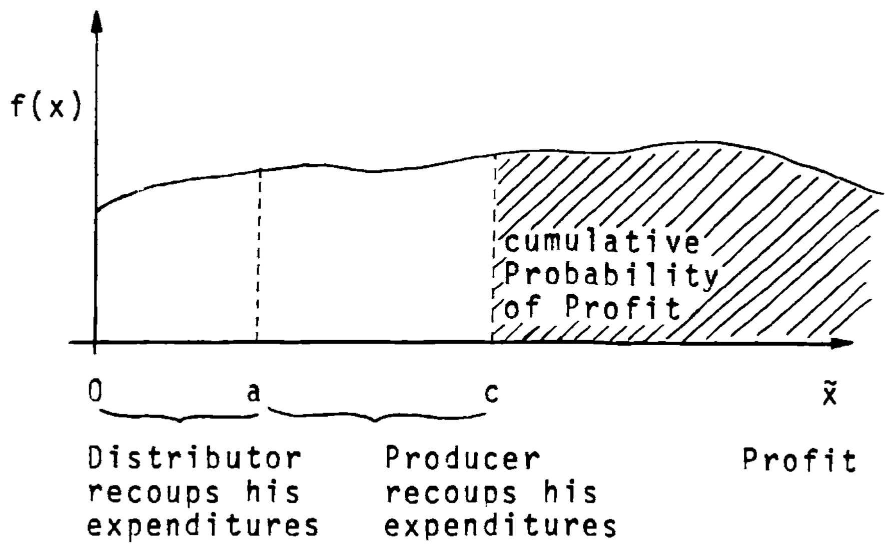


Fig. 2.3

(2.3 D) $$u^D\{\ell^D\} = E_{\tilde{x}}[u^D(g^D(x))] = \int_c^\infty u^D[s(x-c)]f(x)dx$$

and

(2.3 P) $$u^P\{\ell^D\} = E_{\tilde{x}}[u^P(g^P(x))] = \int_a^c u^P(x-a)f(x)dx +$$

$$+ \int_c^\infty u^P[(1-s)(x-c)+y_0+y]f(x)dx$$

where $g^D(x)$, $g^P(x)$ represent the terms under which D and P respectively benefit from the rental revenues.

Upon integration of equations (2.3) and substitution of them into (2.1), two equations in s and y are obtained which express the conditions upon which the deal is feasible. Let these be:

(2.4 D) $D(s,y) \geq D_0$ where D_0 and P_0 are two

(2.4 P) $P(s,y) \geq P_0$ constants

The hatched area of Fig. 2.4 represents the region of the feasible deals.

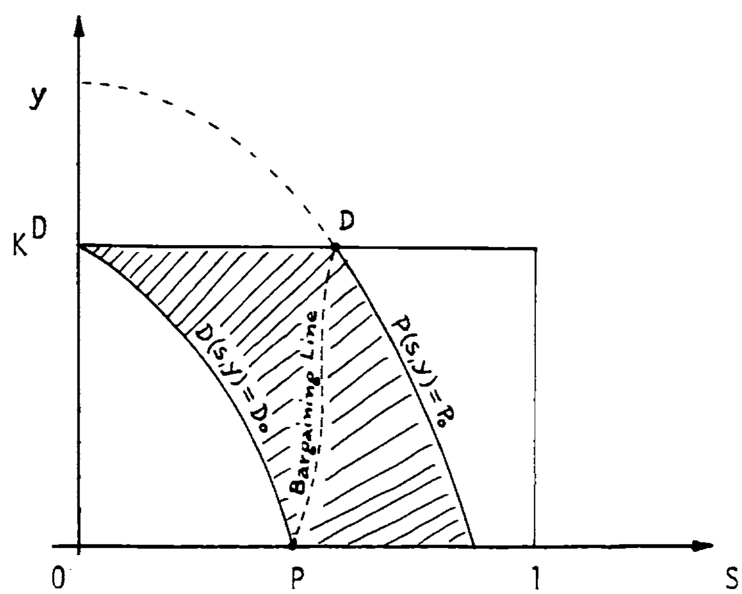


Fig. 2.4

Notice, for instance, that the points lying on the curve $D(s,y) =$ const. represent deals whose terms have equivalent value to D. In other words, any two deals whose terms

(s_1,y_1) and (s_2,y_2) satisfy $D(s_1,y_1) = D(s_2,y_2)$ should leave D indifferent in chosing between them. The analogous holds for P . Suppose now that the points labeled D and P represent the best terms D and P could respectively achieve in the deal. Then the bargaining between the two will take place along the line connecting these points. I will refer to it as the Bargaining Line or simply as BL. Notice that this line represents the set of admissible points, all other points being dominated by some point of the line. Notice finally that also the region included between $y = K^D$ and the extension of the P curve represents theoretically feasible deals, but that no sane Producer would ever offer terms like that.

The problem faced by the two bargainers is thus first to see whether the deal is feasible at all, that is to say to check that the set:

$$\Omega = \{(s,y):D(s,y) \geq D_0, P(s,y) \geq P_0, 0 \leq s \leq 1, y \geq 0\}$$

is not empty. The second problem is the one of reaching an agreement on some point of the BL. This problem can be formulated as:

$$(2.5) \qquad \operatorname{Max}_{\lambda}[\lambda P(s,y) + (1-\lambda)D(s,y)]$$

$$\text{s.t.} \quad (s,y) \in \Omega$$

$$0 \leq \lambda \leq 1$$

The objective is here to maximize a linear combination of P(s,y) and D(s,y), from here on referred to as the two criteria of optimization. The simplest way of weighting the two criteria is to use the bargaining ability of the two contendents (or of their agents, of course) as weights. Let therefore the bargaining strength of P and D be measured respectively by λ^P and λ^D. It is obvious then, that in the above formulation:

$$\lambda = \frac{\lambda^P}{\lambda^P + \lambda^D} \quad \text{and } 1 - \lambda = \frac{\lambda^D}{\lambda^P + \lambda^D}$$

Notice for instance that if P is a real smart and tough cookie then $\lambda^P >> \lambda^D$ and the previous problem becomes: Max P(s,y) s.t. $(s,y) \in \Omega$, whose optimal solution yields the point P.

<u>The admissible set</u>

It is generally convenient, whenever it is not analytically too involved, to visualize the set of admissible points (also definable as the points representing the Pareto-optimal deals), by eliminating one of the two decision variables between the two equations D = D(s,y) and P = P(s,y). This will yield, for instance, the parametric equation:

$$\phi(D,P,y) = 0 \quad (2.6)$$

where P and D are now the new variables and y is the parameter. Within the two constraints $P \geq P_0$ and $D \geq D_0$, if y is allowed to vary between 0 and some upper bound, say $\overline{y}$, the equation above describes all the points of the feasible set Ω . Eventually for some value $y = y^*$ the same equation will yield all or part of the set of admissible points or equivalently the whole BL or some segment of it (eventually reducible to a single point) expressed as a function of the variables P and D (See Fig. 2.5).

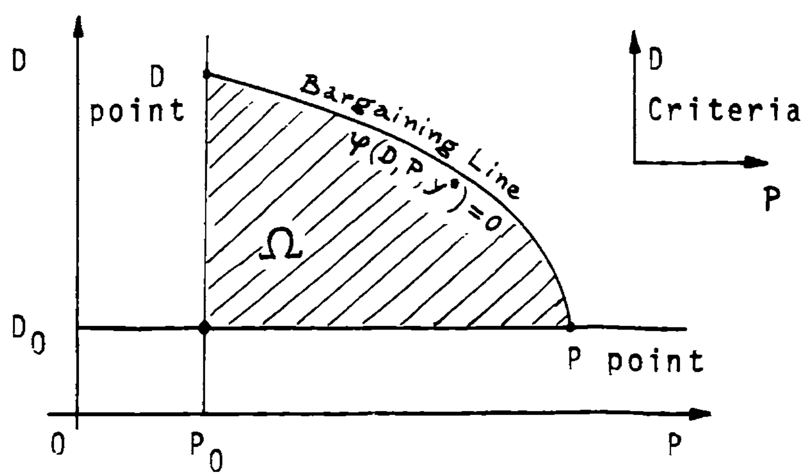


Fig. 2.5

The point (P_0,D_0), which is also the vertex of the right cone whose extreme rays are the two criteria P and D, represents the minimum terms attainable by both contendents. The cone itself is made out of all possible directions of optimization which can be obtained as a linear combination of the two criteria. The set Ω therefore represents all the feasible deals and the portion of its boundary contained in the above mentioned cone is the BL. It is clear from this picture why all the points of the interior of Ω are dominated by the ones of its upper-right boundary: for any interior point there is at least one point of the boundary in which one of the two contenders can get better terms without reducing the global value of the terms obtained by the other one. Notice that the extremes of the BL are the same P and D points represented in Fig. 2.4. The advantage of the use of this representation of the set of feasible deals (obviously whenever the equation $\phi(D,P,y) = 0$ can be easily obtained and solved) is that both it separates all the points which are potential candidates for the optimal deal from all other ones and it allows an easy analysis of the sensitivity of the optimal deal to the bargaining strength of the contendents. (For more information about the topic see Ref. 7).

More than 2 contendents

In reality there will be at least 5 or 6 people involved in the deal. In fact, Distributor, Producer, Director and some Stars will participate to the gross or to the profits with different formulas. The first obvious generalization of the model is therefore to allow an indefinite number of persons to be involved in the deal and formulate it as:

$$\text{Max} \sum_i \lambda^i I^i$$

$$\text{s.t. } I^i(s_i, y_i) \geq I_0^i \qquad \text{all } i$$

(2.7)

$$\sum_i s_i = 1$$

$$\sum_i y_i = 0$$

$$s_i \geq 0 \qquad \text{all } i$$

$$y_i \quad \text{unrestricted}$$

Where:

λ^i = bargaining strength of i^{th} individual

I^i = terms or criterion " " "

I_0^i = minimum terms " " "

s_i = share of the profits" " "

y_i = cash received (if positive) or disbursed (if negative) by the i^{th} individual

Here the objective should be $\sum_i \frac{\lambda^i}{\lambda} I^i$ with $\lambda = \sum_i \lambda^i$, but being the latter constant it can be omitted.

Further generalization

The last generalization is to allow the deal to be bargained not only in terms of cash and profits participation, but also in terms of any other item such as benefits, deferred compensation, etcetera, whose utility can be quantified by the individuals involved in the deal.

Let:

x_{ki} = share of item k granted to individual i in the deal. Then the problem can be formulated as:

$$\text{Max} \quad \sum_i \lambda^i I^i$$

$$\text{s.t.} \quad I^i(x_{1i}, x_{2i}, \ldots, x_{ni}) \geq I_0^i \qquad \text{all } i$$

(2.8)

$$\sum_i x_{ki} = \begin{cases} 1 & \text{if item k is a resource external to the group of individuals} \\ 0 & \text{if item k is a resource internal to the group of individuals} \end{cases}$$

$x_{ki} \geq 0$ if item k is an external resource

x_{ki} unrestricted if item k is an internal resource

($x_{ki} > 0$, $x_{ki} < 0$ according to whether individual i respectively receives or gives the share of item k)

Example I: EMV'ers and Diffuse Knowledge

Let's assume:

(2.9) $$u^D(\$) = u^P(\$) = \$$$

(This implies that D and P will evaluate the terms of the deal merely on the basis of its expected monetary value) and:

(2.10) $$f(x) = \begin{cases} \frac{1}{b} & 0 \leq x \leq b \\ 0 & \text{else} \end{cases} \quad \text{with } b \geq c \text{ for simplicity}$$

where: b = maximum value that P and D agree the rental revenues will ever attain.

This implies that D and P have no idea whatsoever about the amount of money the movie will make, but have a feeling for the extension of the range in which that amount will fall. By substituting (2.9) and (2.10) into (2.3) and into (2.1) we get:

(2.11 D) $$D(s,y) = y + \frac{(b-c)^2}{2b} s$$

(2.11 P) $$P(s,y) = -(y_0+y) + \frac{(c-a)^2}{2b} + \frac{(b-c)^2}{2b}(1-s) + \frac{b-c}{b}(y_0+y)$$

and the conditions:

(2.12) $$\begin{cases} D(s,y) \geq K^D \\ P(s,y) \geq 0 \end{cases}$$

Considering that $c=a+y_0+y$, these conditions yield:

(2.13 D) $$D(s,y) = As - Bys + C\,y^2 s + y \geq K^D$$

$$P(s,y) = -As + Bys - C\,y^2 s - y \geq -E$$

where: $$A = \frac{b}{2} - (a+y_0) + \frac{(a+y_0)^2}{2b}$$

$$B = 1 - \frac{a+y_0}{b}$$

$$C = \frac{1}{2b}$$

$$E = \frac{b}{2} + \frac{a^2}{2b} - (a+y_0)$$

The peculiarity of the assumptions made makes the case somewhat uninteresting since from equations (2.13) we obtain:

$$D + P = 0$$

which together with the constraints:

$$D \geq K^D$$

$$P \geq -E$$

represent the set of feasible points. The region of feasible deals thus degenerates into a segment of the straight line: $D+P=0$, and it is coincident with the BL.

<u>A numerical example</u>

Let's pick the following values:

$a = 1$

$b = 20$ (all expressed in \$-millions)

$y_0 = 2$

$K^D = 1$

then: $A = 289/40$

$B = 34/40$

$C = 1/40$

$E = 281/40$

These values substituted into equations (2.13) yield the two following self-explanatory figures:

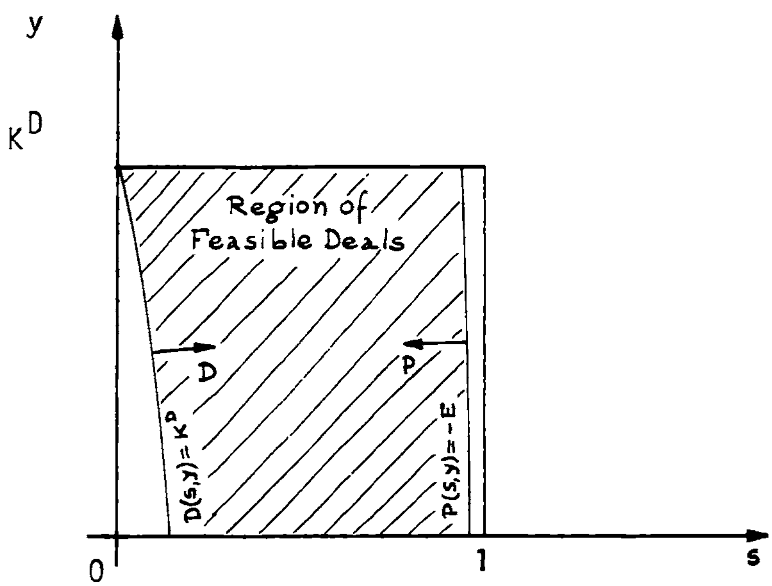


Fig. 2.6

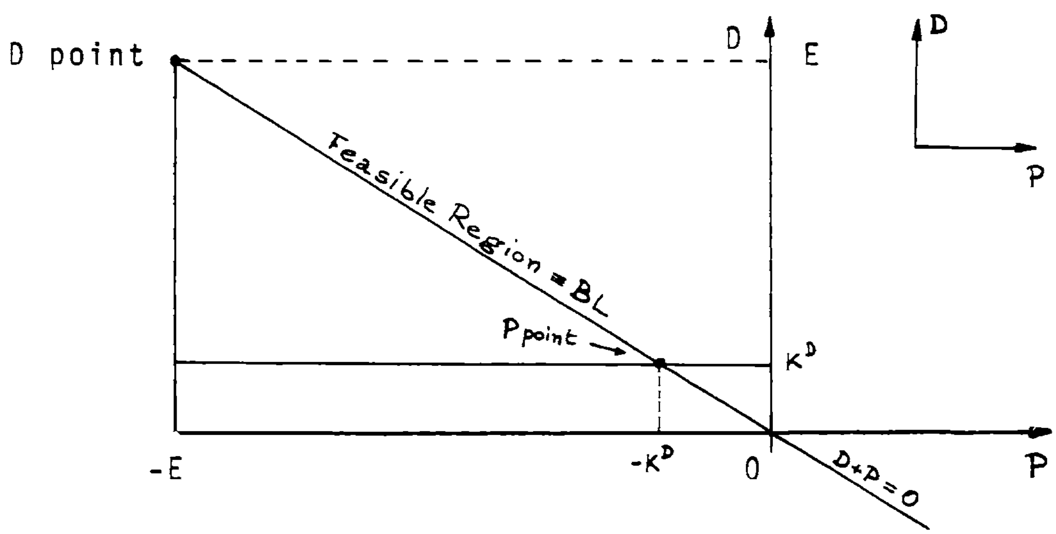


Fig. 2.7

Notice

It is important to notice that the assumption 3 that P and D reach an agreement on both the shape of the probability distribution of the rental revenues and on the value of its parameters is not a casual one. In fact leaving aside the issue concerning the shape of it, which is much more involved, it is worth to comment upon the value of the parameters of the distribution.

Let's assume the distribution be uniform between 0 and some b, and let b^P, b^D be the values suggested by P and D respectively, then it is very likely that $b^P \geq b^D$. In fact in suggesting a high b^P, P brings up the value of the share of profits he is offering to D and may be able therefore to close the deal with a smaller amount of front cash y . Alternatively he may be able to offer a smaller share of the profits without increasing the cash offer. Conversely D has all the good reasons to bring b^D at the lowest possible level to get either a higher s or a higher y, his global expected utility remaining constant. The value of the parameter they will eventually agree upon, will depend upon both the bargaining strength of the two and the sample information eventually obtained by analogy with previous similar pictures. How to combine the two contrasting informations is a matter of the

Bayesian Decision Theory. Without entering into a detailed development of the topic, I would like to hint a way to approach it.

Call $h = \frac{1}{\sigma_{\tilde{x}}^2} = \frac{12}{b^2}$ the amount or the precision of the prior knowledge possessed by a bargainer, then P and D will have respectively h'^P and h'^D. Say that by some analogic sampling they obtain b^s and h^s and let a measure of the bargaining strengths of P and D by λ^P and λ^D, then the value they will eventually agree upon will be:

$$(2.14) \quad b = \frac{\lambda^D \dfrac{b'^D h'^D + b^s h^s}{h'^D + h^s} + \lambda^P \dfrac{b'^P h'^P + b^s h^s}{h'^P + h^s}}{\lambda^P + \lambda^D}$$

As an example suppose:

$b^s = 15$, $b'^D = 10$, $b'^P = 30$; $\lambda^P = .7$, $\lambda^D = .3$

then:

$b''^D = 11.54$, $b''^P = 18$ and $b = 16.06$

This work will be needed in the two following situations:

1) To forecast at which value the agreement will be reached before sitting at the negotiations table and therefore to

prepare the best strategy for them.

2) To predict the entity of the error between the value thus agreed upon and the true state of nature.

Exponential Utility and Normally Distributed Knowledge

Let: $f(x) = N(x|\mu,\sigma^2)$

and:

$$u^D(\$) = A^D\left(1-e^{-\frac{\$}{r^D}}\right)$$

$$u^P(\$) = A^P\left(1-e^{-\frac{\$}{r^P}}\right)$$

with: $A^D = \dfrac{e^{\frac{M^D}{r^D}}}{e^{\frac{M^D}{r^D}} - 1}$ = a normalizing factor so that:

$$u^D(\$) = \begin{cases} 0 & \text{if } \$ = 0 \\ 1 & \text{if } \$ = M^D \end{cases}$$

and the similar for P, and with r^D, r^P a measure of D's and P's respective risk aversion,

then for the deal to be appealing to both P and D, in equations (2.2) it must be:

$$CME(\ell^D) = -r^D \ln\left[1 - A^D\, G(c|\mu,\sigma^2) + A^D\, G(c|\mu',\sigma^2)\, e^{-\left[\frac{s}{r^D}(\mu-c) - \frac{(s\sigma)^2}{2r^{D2}}\right]}\right]$$

(2.15D)

where: $$G(c|\mu,\sigma^2) = \int_c^{+\infty} \frac{1}{\sqrt{2\pi}\,\sigma}\, e^{-\frac{(x-\mu)^2}{2\sigma^2}}\, dx$$

and: $\mu' = \mu - \frac{s}{r^D}\sigma^2$

while:

$$CME(\ell^P) = -r^P \ln\Big\{1 - A^P\Big[G(a|\mu,\sigma^2) - G(c|\mu,\sigma^2) - e^{-(\frac{\mu-a}{r^P} - \frac{\sigma^2}{2r^2})}\big[G(a|\mu'',\sigma^2) - G(c|\mu'',\sigma^2$$

$$+ G(c|\mu,\sigma^2) - e^{-\left[\frac{(1-s)(\mu-c)+(c-a)}{r^P} - \frac{(1-s)\sigma^2}{2r^{P2}}\right]}\, G(c|\mu''',\sigma^2)\Big]\Big\}$$

with: $\mu'' = \mu - \frac{\sigma^2}{r^P}$

$\mu''' = \mu - \frac{(1-s)\sigma^2}{r^P}$

and obvious meaning of the remaining symbols.

Conclusions

The solution of the P-D Problem for more realistic assumptions than the ones adopted requires the numerical solution of equations like (2.15) and may be therefore computationally very complex. A difficulty in finding the optimal deal may arise from the fact that if all the bargainers have the same type of risk attitude (risk aversion for instance) then the solution of problem (2.8) may require the minimization or maximization of a convex function subject to convex constraints. This is a problem not yet fully understood and it therefore needs more theoretical work before being able to successfully applying it to cases like the one arising in the motion picture industry's context. Though it is certainly worthwhile to try it on examples of increasing complexity in order to gain insight and understanding and at the same time to develop all the techniques needed to assess the value of all the parameters involved.

2.2 Available Data

"We must know how our various pictures are doing around the world before we can develop those cost control patterns which can be applied not only to a specific picture at a given time, but to the entire annual output as it affects - or is affected by - the success or failure of that single picture.

Such knowledge comes to us first through NGC which gives us a weekly report of domestic film rentals during the previous week. Similarly, each local distributor in a foreign country reports distribution income either to our local representative in the territory or directly to London or New York. The major territories are reported on a weekly basis and the smaller territories bi-weekly or monthly. Major territories include Japan, the United Kingdom, France, Italy and West Germany. Reports come in as quickly as the local distributor can send them on. Thus we have a fair estimate every week of how our pictures are doing all over the world - an important body of information with which we begin "tracking" our successes and failures.

As tracking begins, we can read early warning signs. If the picture opens poorly, we are in difficulty because it is a rare picture that opens badly and then builds. This building has become even less possible in recent years, simply because more people are going to theatres as a result of word-of-mouth publicity. If word-of-mouth on a picture is not good when it opens, it is unlikely that it will improve." (1,p.105)

2.2.1 Some graphs and their statistical reduction

In Figures 2.8 through 2.15 the weekly and the cumulative grosses are plotted against the time. The weekly gross (dots) and the cumulative gross (crosses) refer respectively to the left and to the right hand side vertical axis. The data have been obtained from "Variety" magazine for a set of 1973,1974 pictures. These graphs supply some ground for a few observations. First of all the data come

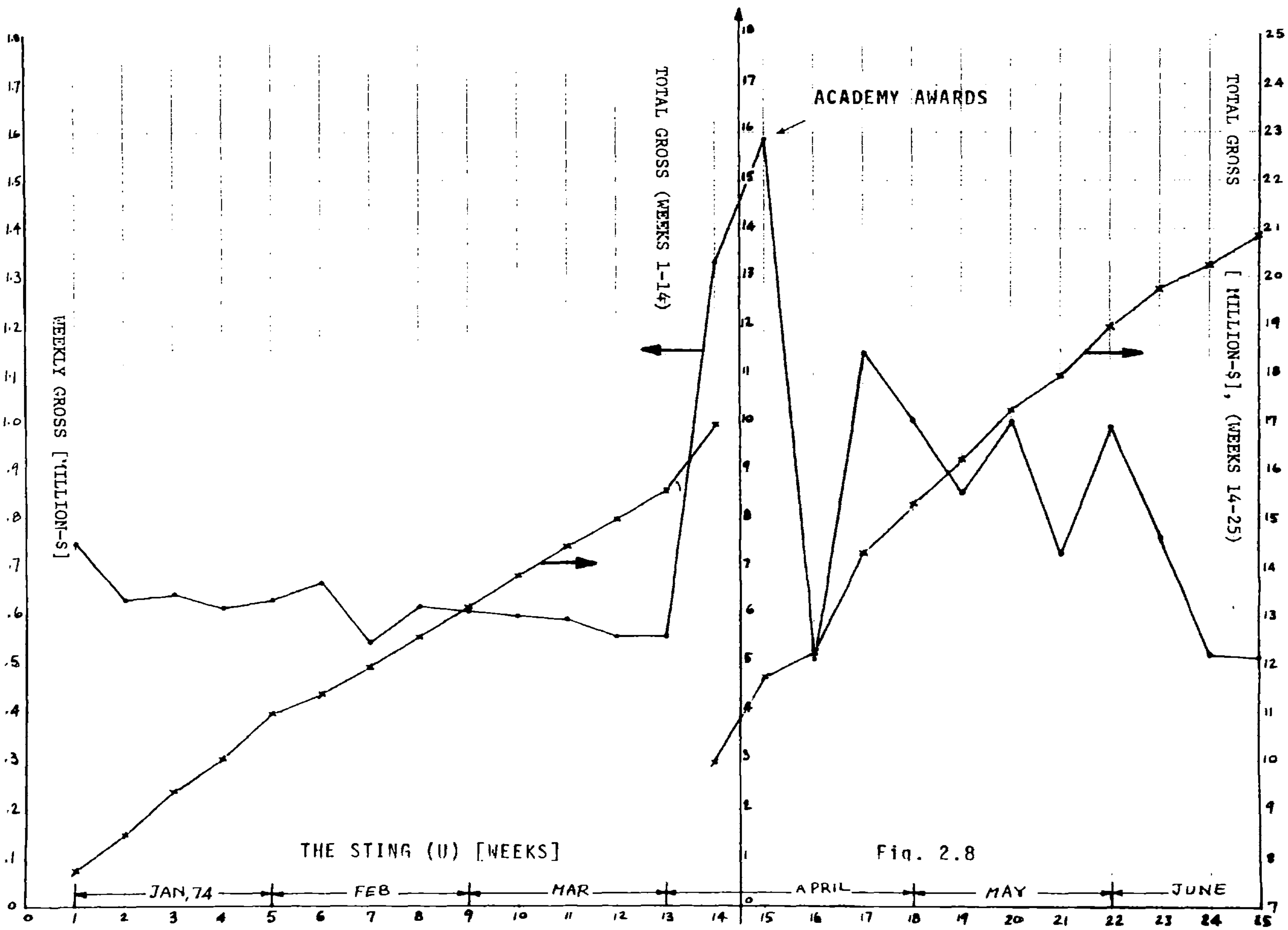
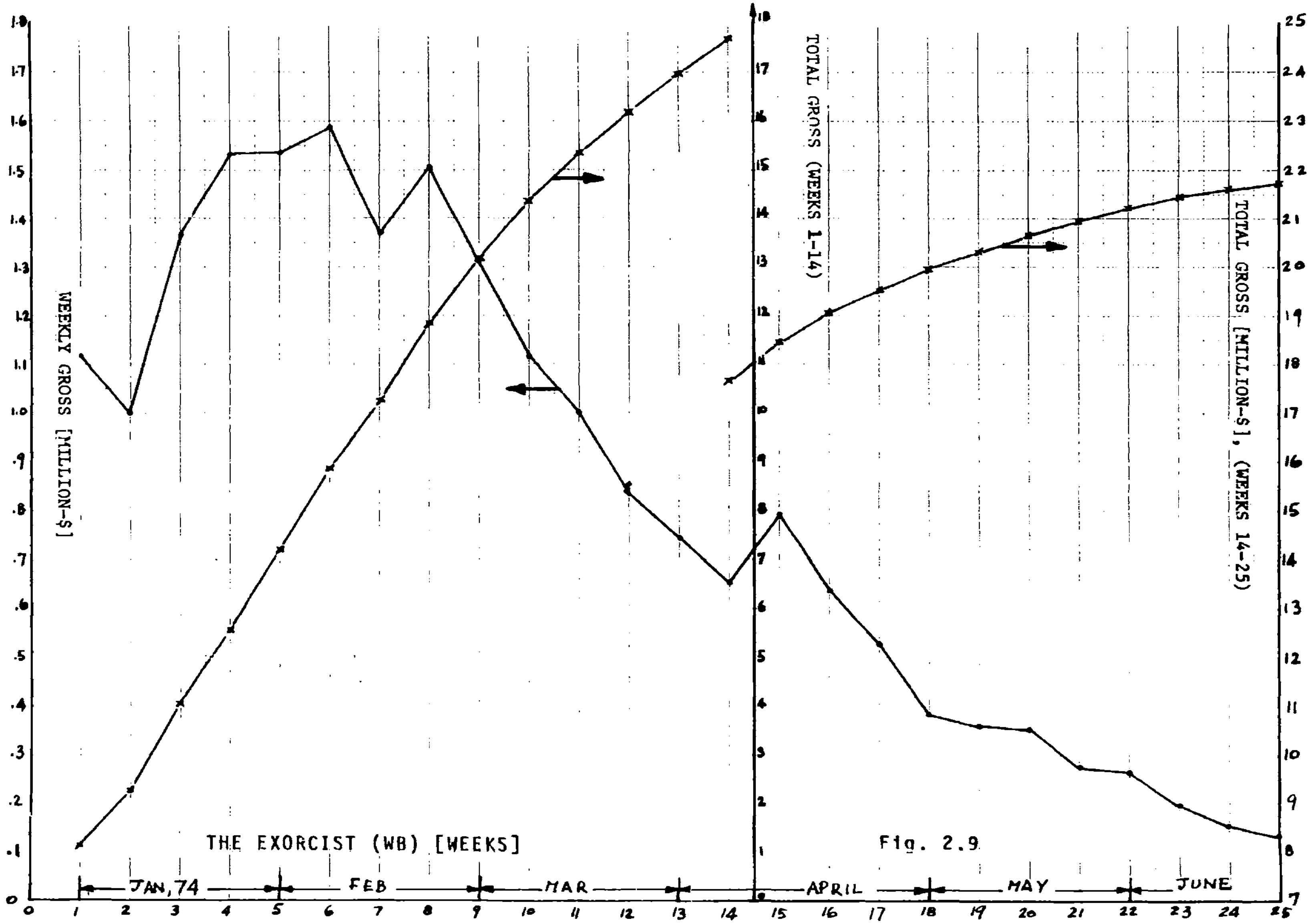
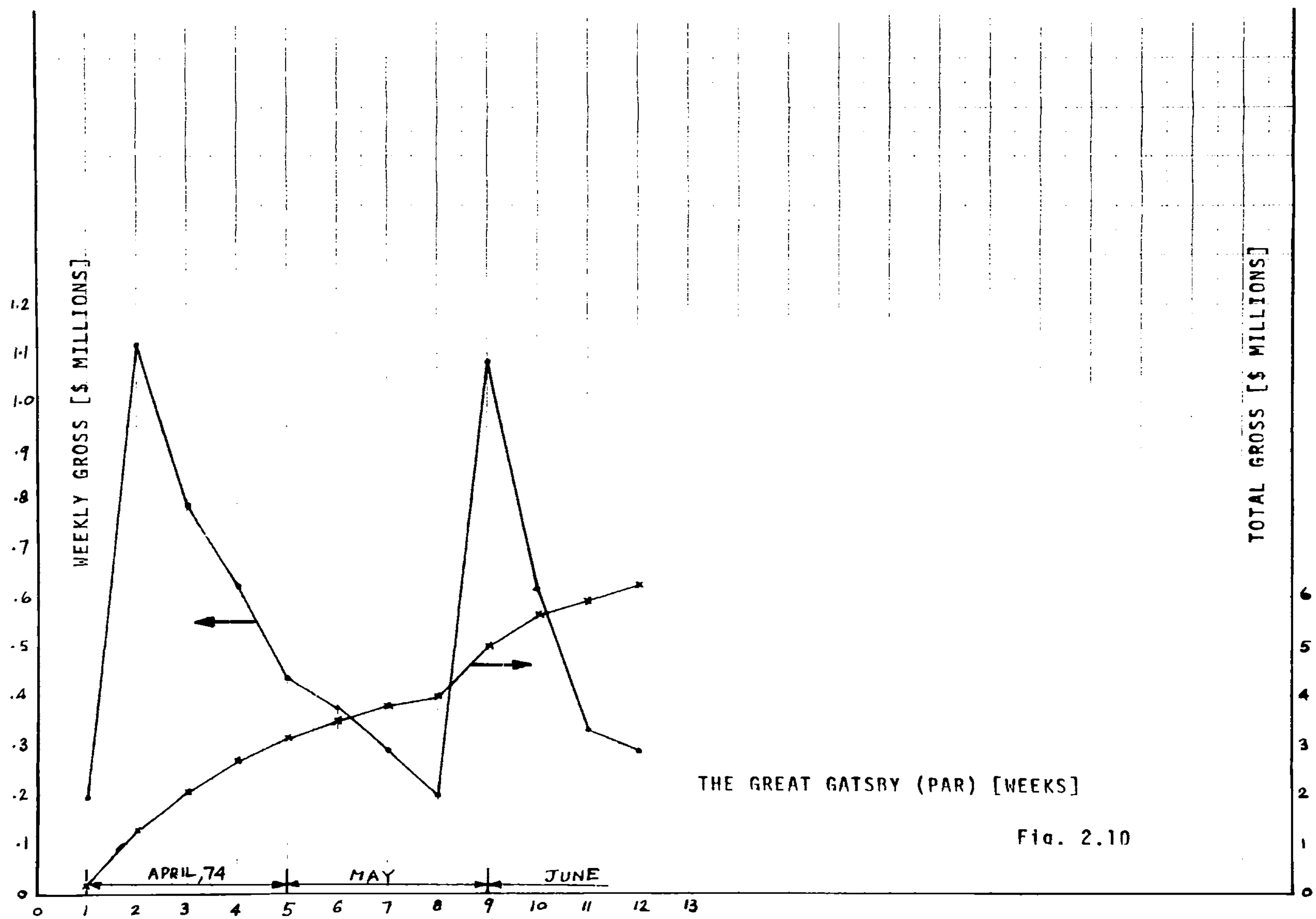

ACADEMY AWARDS
WEEKLY GROSS [MILLION-$]
TOTAL GROSS (WEEKS 1-14)
TOTAL GROSS [MILLION-$], (WEEKS 14-25)
THE STING (U) [WEEKS]
JAN, 74
FEB
MAR
APRIL
MAY
JUNE

Fig. 2.8


WEEKLY GROSS [MILLION-$]
TOTAL GROSS (WEEKS 1-14)
TOTAL GROSS [MILLION-$], (WEEKS 14-25)
THE EXORCIST (WB) [WEEKS]
Fig. 2.9
JAN,74
FEB
MAR
APRIL
MAY
JUNE



THE GREAT GATSBY (PAR) [WEEKS]

Fig. 2.10

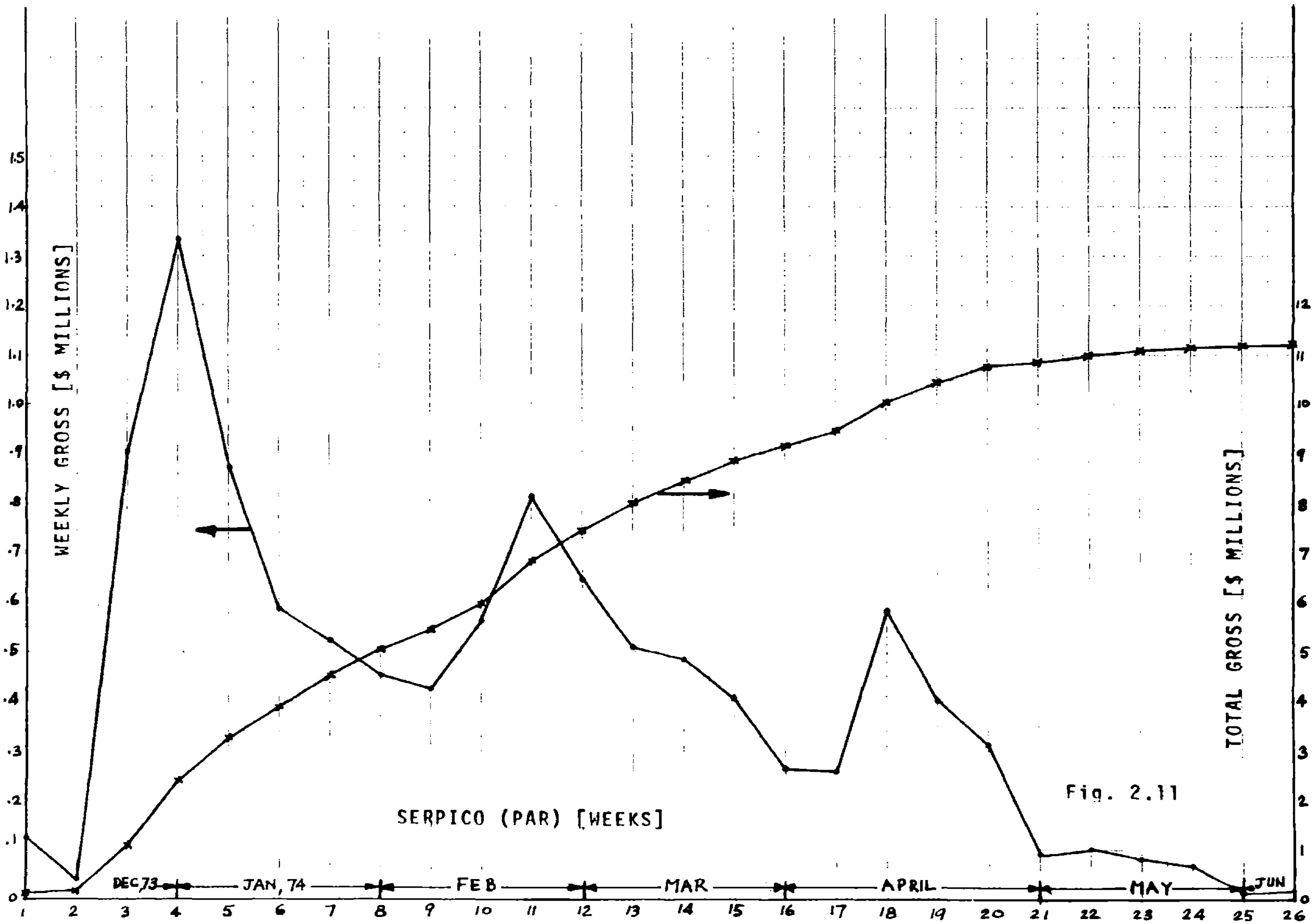

WEEKLY GROSS [$ MILLIONS]
TOTAL GROSS [$ MILLIONS]
SERPICO (PAR) [WEEKS]
DEC 73
JAN, 74
FEB
MAR
APRIL
MAY
JUN
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5
0 1 2 3 4 5 6 7 8 9 10 11 12

Fig. 2.11

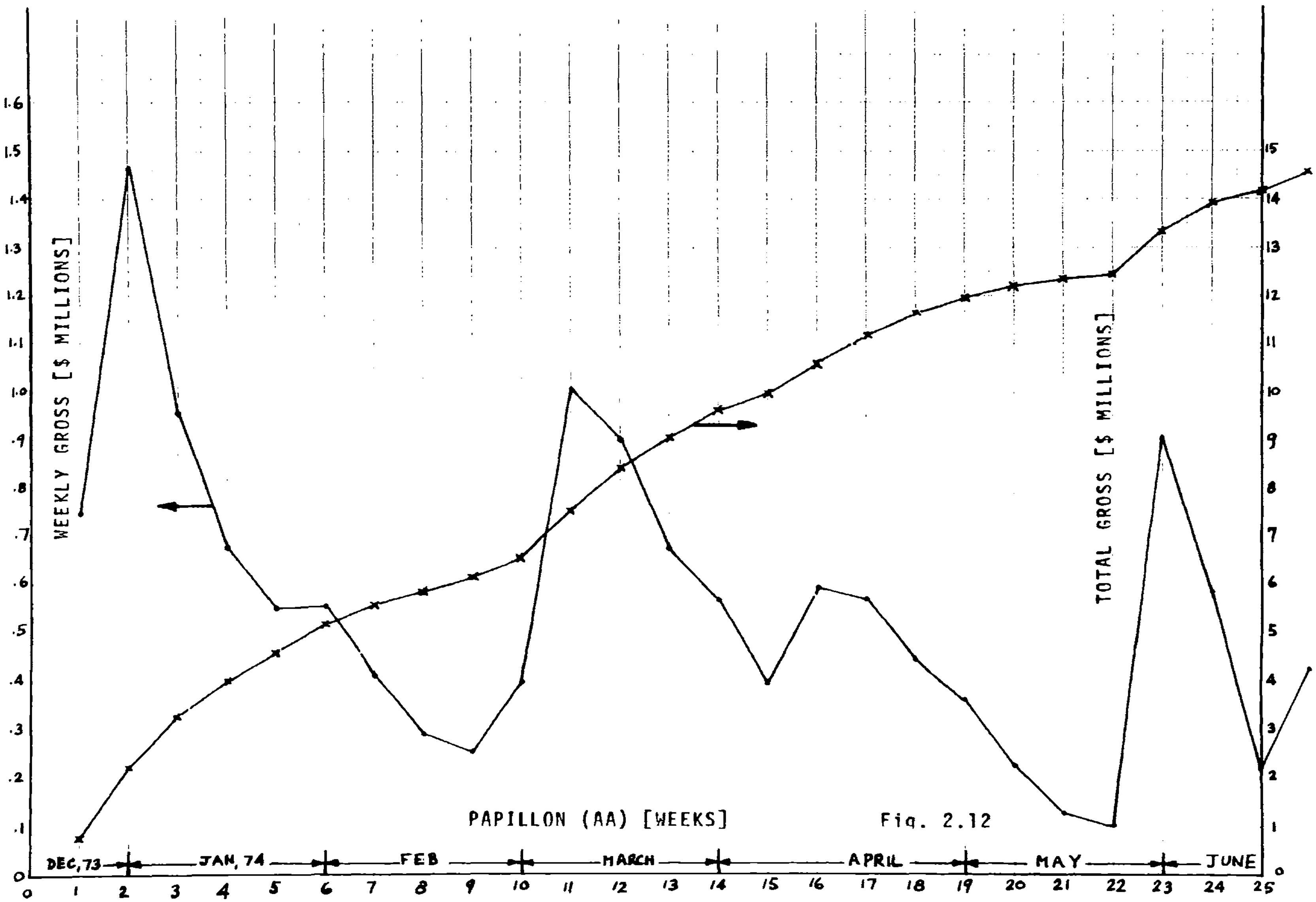

WEEKLY GROSS [$ MILLIONS]
TOTAL GROSS [$ MILLIONS]
PAPILLON (AA) [WEEKS]
DEC, 73
JAN, 74
FEB
MARCH
APRIL
MAY
JUNE

Fig. 2.12

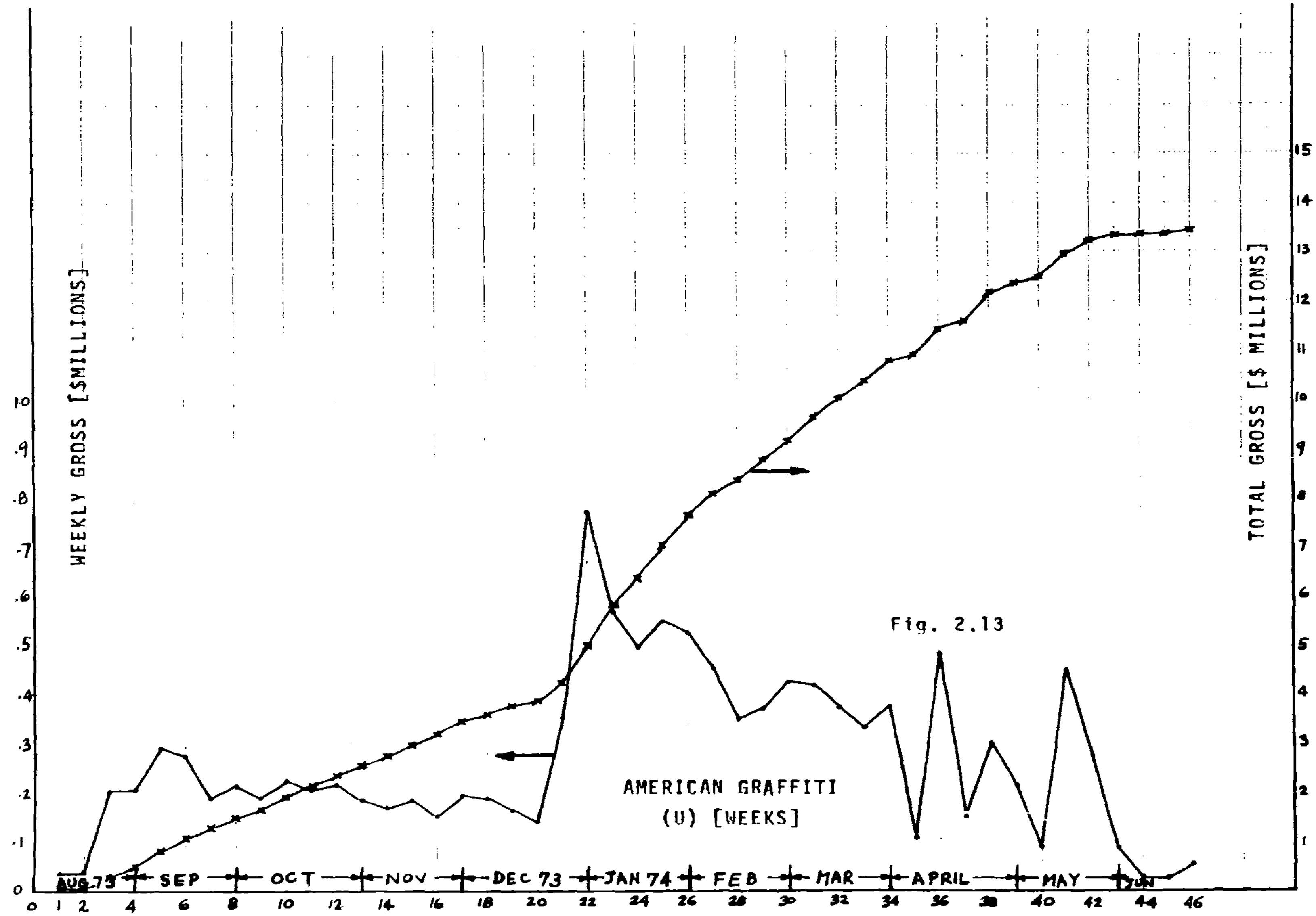
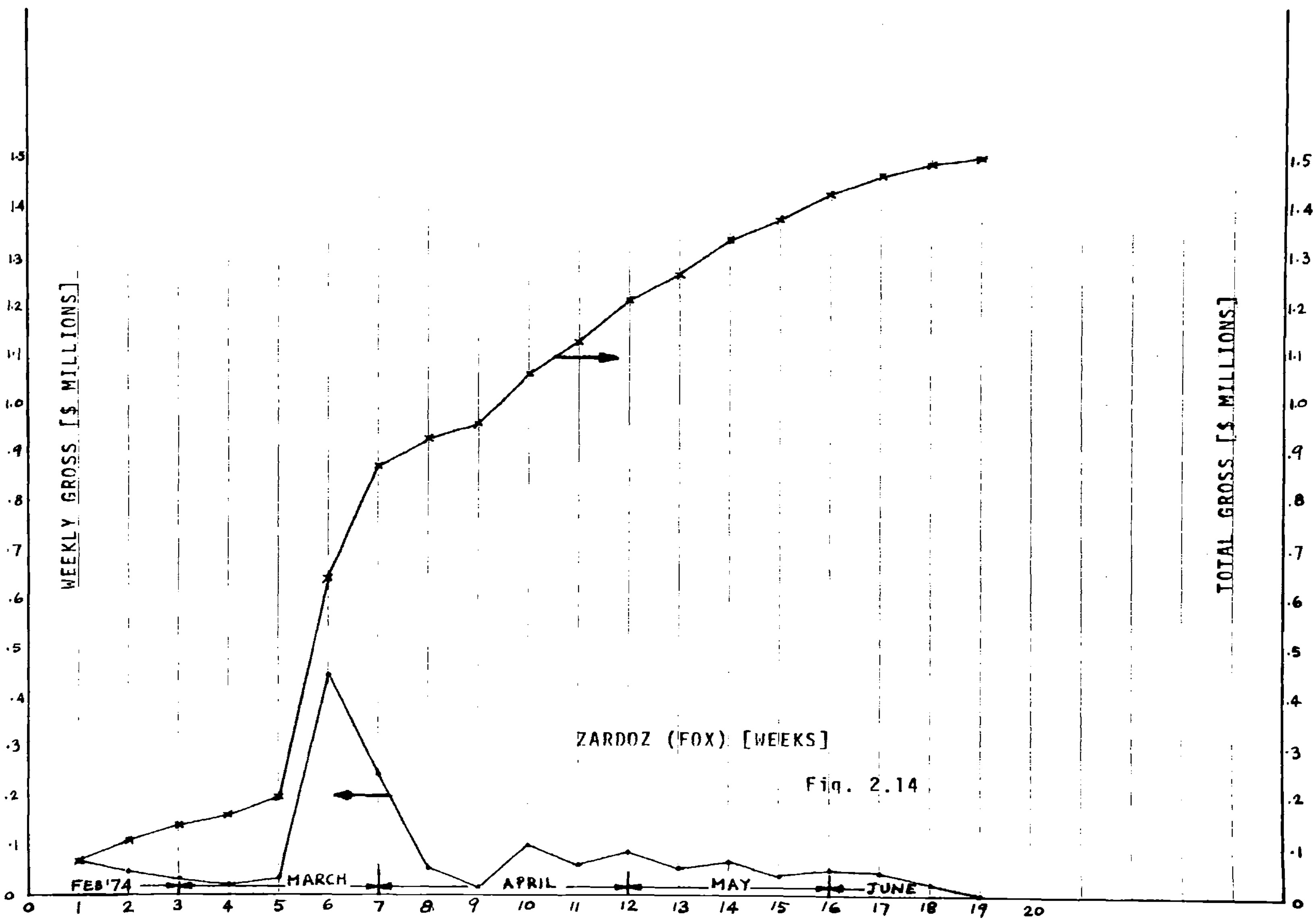

WEEKLY GROSS [$MILLIONS]
TOTAL GROSS [$ MILLIONS]
AMERICAN GRAFFITI
(U) [WEEKS]
AUG 73
SEP
OCT
NOV
DEC 73
JAN 74
FEB
MAR
APRIL
MAY
JUN
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0 1 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46

Fig. 2.13



ZARDOZ (FOX) [WEEKS]

Fig. 2.14

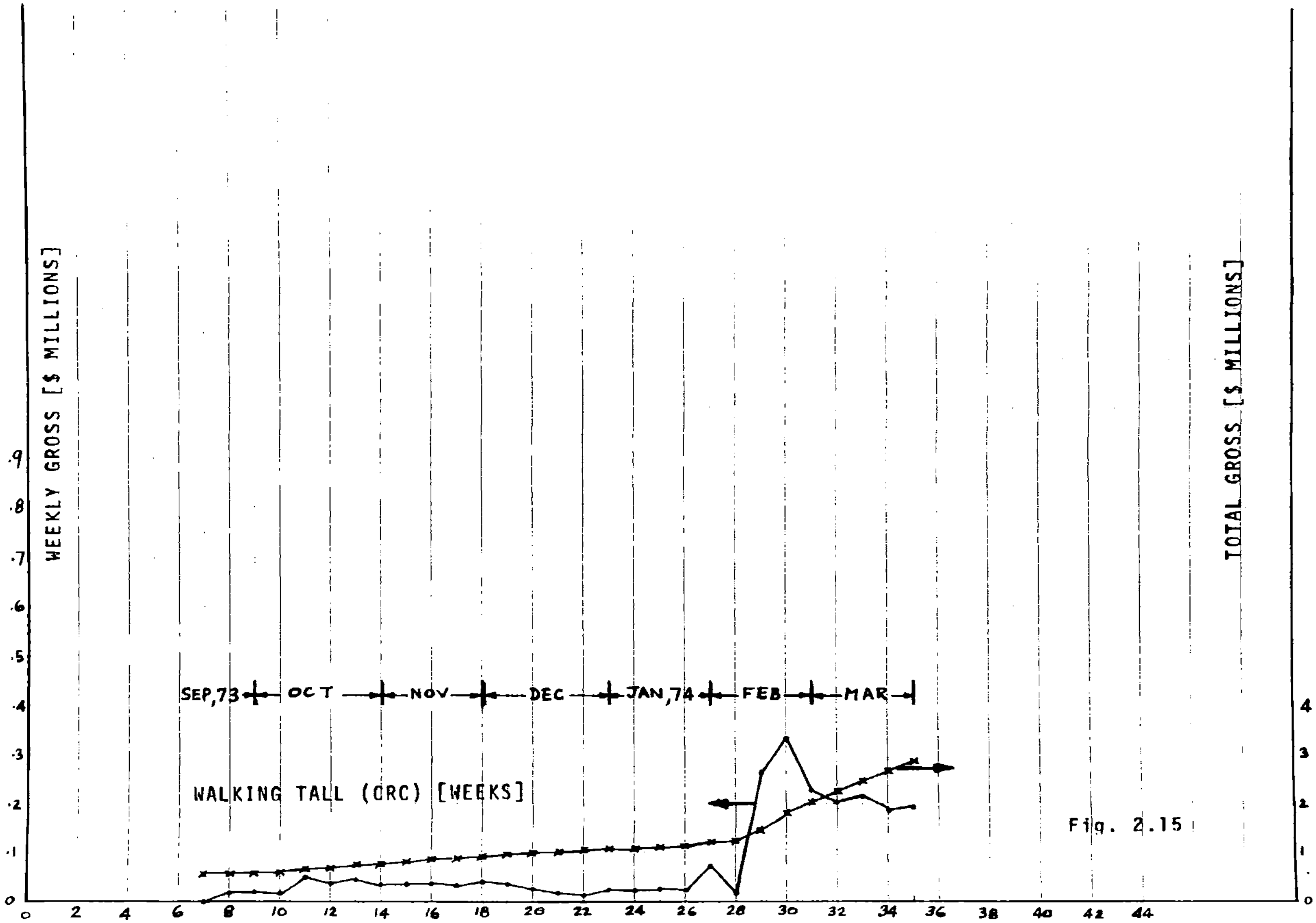

WEEKLY GROSS [$ MILLIONS]
TOTAL GROSS [$ MILLIONS]
WALKING TALL (CRC) [WEEKS]
SEP,73
OCT
NOV
DEC
JAN,74
FEB
MAR
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
4
3
2
1
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44

Fig. 2.15

in a way which is not fitted for an accurate analysis since several disturbance effects are presents which are responsible for the existing peaks. After a single or multiple opening in the big cities, as soon as the word about the picture spreads throughout the public, more seating capacity is added by opening new theatres and by bringing the picture to new towns. This shoots the gross up even when the picture may already be losing. The same is true if some advertising campaign is being made. Then the date also plays a role since:

"For the motion picture business, the peak periods are no-school periods, summer months, and the holidays." (1,p.220)

It is therefore of primary concern to eliminate the effect of:

1. Newly added seating capacity, together with the price of the tickets sold. Actually the number of tickets sold weekly would also be useful for a comparison with the graph of the gross.
2. Advertising campaign by amount spent and media used, with the appropriate coefficient of effectiveness.
3. The time of the year.
4. Awards won by the picture or any other world event which may be held responsible of having an associative impact upon the public.

This could be done by dividing the gross by some appropriate coefficient (for instance, total seating capacity times the average price of the tickets) or by disaggregating the data and following the gross of few representative theaters. The purpose of this statistical reduction of the data is to obtain a smoother curve: if possible with a single maximum.

2.2.2 A representation of the gross

The overall performance of a picture is a function of its first run and of how well the word about it, built during the first few months, is managed in order to get the most out of the successive runs. Actually the initial fraction alone of the first run should incorporate all the information needed to evaluate the global performance of the picture. In fact:

"Once a typical picture has played for from four to eight weeks, the dimensions of the problem or the prospects are clear." (1,p.105)

Therefore the whole graph of the weekly gross should be separated in two parts: A) the first couple of months and B) the rest of it. It seems logical to think that part B is strictly a function of part A, of the word-of-mouth effect (referred to as WOM in the following sections) and of how well the distributor and the exhibitors are able to exploit these two facts. For the purpose of this section imagine that distribution and exhibition will be done optimally for each picture so that for a comparison between pictures it will be sufficient to take their respective part A's into consideration. I then assume that both the value of the picture (here assumed to be the expectation for it built into the market by the preceding advertising campaign) and the potential of the picture with respect to the WOM effect can be fully detected looking only at part A. Conversely I assume that for the purpose of predicting the total gross of a picture it will be sufficient to predict the part A of its weekly gross. In other words part A becomes its classification tag, so that any distribution strategy designed to exploit the worth of a picture should start from this piece of information.

As far as representing part A I suggest to use the parameters obtained from the curves \$=\$(t) [see Fig.2.16], which I list below.

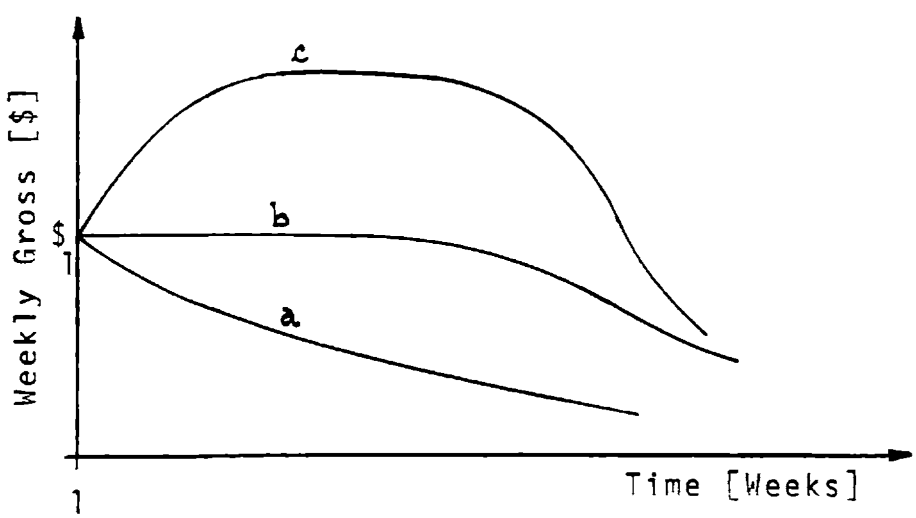


Fig. 2.16

The curves $\$=\$(t)$ shown in Fig.2.16 have approximately the hypothetical shape which I believe would be obtained from the part A of the weekly gross of any picture once corrected of all the disturbance effects previously mentioned.

<u>The representative parameters</u>

1. $y_1 = \$_1$ If this is large, either one of the following facts can be true about the movie:

   i) It has hit a pool of interest of the public.

   ii) It has received a strong and effective advertising campaign. (See "The Sting", "The Exorcist," "Serpico" and "The Great Gatsby")

2. $y_2 = \left.\frac{d\$}{dt}\right|_{t=1}$ Instead of the initial derivative it would probably be more meaningful to use the average derivative of the first couple of weeks.

   The following situations can occur:

   i) y_2 negative (curve a): the movie is not so good ("The Great Gatsby", "Papillon", "Zardoz")

   ii) y_1 large, $y_2 \gtrsim 0$ (curve b): the movie is good, it has hit a large pool of interest (i.e.: picture for everybody), but the WOM is slow. It needs some more advertising to catch up ("The Sting")

iii) y_1 small, $y_2 \approx 0$: movie not bad but of limited or marginal interest ("American Graffiti", "Walking Tall") (For instance, a movie which interests only the male population looses much more than half the public).

iv) y_2 positive (curve c): there is a fast and strong WOM effect going on. The latter is a phenomenon related to the emotions and "The Exorcist" was appealing mostly to the emotional people.

3. $y_3 = \frac{d^2\$}{dt^2}$ (curve c), average for a few weeks after the beginning: if y_3 is negative, then the pool of interest is not very large. The movie will exhause the available public in a short time. ("The Exorcist")

4. $y_4 = \frac{d\$}{dt}$, for the descending part of the curve:

i) $y_4 = 0$ or slightly negative (curve b): it is worth to invest some more money in advertising it to exploit it further ("The Sting")

ii) y_4 very negative (curve c): the movie has shown all its potential.

5. y_5 = number of weeks before the curve begins to drop.

This list is intended to suggest a methodology to extract from the graph of the weekly gross of a picture some information about its performance. Many more graphs should be analyzed to decide which set of parameters best represents the behaviour of the picture. Nevertheless I want to point out that the representation of the value of a movie in terms of these parameters it's useful in order to build a predictive model for its total gross and can help the distributors both in giving a quantitative appraisal to the picture and in evaluating the returning bids of the exhibitors. In fact:

"On very important pictures...the distributor establishes minimum terms acceptable on a competitive bid. The pictures are then awarded, not by an auction bid, but to the "best bid by the numbers". The distributor is, however, entitled to evaluate the variances in the potential grosses of the theatres involved, and decide - if he wishes - that an ostensibly low bid will result in greater returns than a better-looking "numbers" bid. For example, a 400-seat house may offer $10,000 as a guarantee on the film, and certain favorable terms. A theatre with 1,200 seats, on the other hand, may offer no front money, but might produce greater revenue at the same percentage terms because of its capacity." (1, p.202)

"The distributor may or may not include his minimum requirements. He may, for example, offer a picture for three-week minimum booking and minimum terms. The terms - the actual cost of film rental - will be spelled out in the distributor's letter in this way: "First week: 60% of the gross receipts; Second week: 50-60%; Third week: 40-60%." (Ib.,p.216)

"The bid will also ask the clearance required by the exhibitor; i.e., the kind of exclusivity he wants in his area." (Ib.,Ib.)

"Prior to screening we (the exhibitors) are usually advised of the company's appraisal of the value of the picture." (Ib.,p.201)

"In bidding, one bids both playing time and terms" (Ib.,p.216)

2.3 Suggestions about predicting the success of a movie

A few quotations in order to enter in "medias res":

"Film rights for a novel might cost $100,000. Then, to develop a screenplay from it would cost an additional $35,000 to $100,000, without any sure guarantee of its quality. While starting with an original screenplay might involve as much as $200,000 for the rights, it may be evaluated as a screenplay without the risk of time and money that is inherent in the adaptation of a novel. The screenplay, after all, is the blueprint of a film." (1,p.11)

"A producer who has a fairly good action script, for example, can make the film for $2-million with one actor, and $2.5-million with a "top" actor. That extra cost is something he must begin to think about in terms of actual return. Is it worth the extra $500,000? Will the film do $2-million more in business as a result of over-investment in this actor?" (Ib.,p.91)

2.3.1 A framework for the evaluation of the projects

This section was initially intended to be longer, more sophisticated and more detailed. Luckily, while advancing in the research and in the understanding of the topic, I came to realize that the problem of predicting the success of a picture is worth a dedicated research of its own. Lots of measures are currently undertaken by the people involved with this issue in order to minimize the losses, but many failures are still recorded. Therefore any definitive statement on my side would have been only an act of presumption. The problem is extremely stochastic in nature for the predominance in the production process of the human over the mechanical element. Quality control therefore can only be achieved by reviewing the work done very often and by re-doing from scrap whatever doesn't pass some judgemental test imposed by the decision makers.

The aim of the next sections therefore will be to suggest a list of models by which to break down the problem into a set of distinguishable and separately manageable facts and to formulate them. Any better attempt at solving this problem can only be done after that hopefully I will have had a thorough experience in the field and have collected a large data basis. I believe in fact that the best way of approaching any problem is to start from what is currently being done about it. For this reason I have collected and organized in a few logical schemes the process concerning the decision of investing some money into a piece of literary material, in order to transform it into a feasible production plan. Fig.'s 2.17 through 2.20 show respectively the flow-charts representing the whole process for both a studio and an independent producer, and the time scale for the sequence of events which make up the life of a movie. At each lozenge of the flow charts a decision has to be made about the next course of action. The set of possible actions is:

i) Drop the project

ii) Go ahead

iii) Start all over again

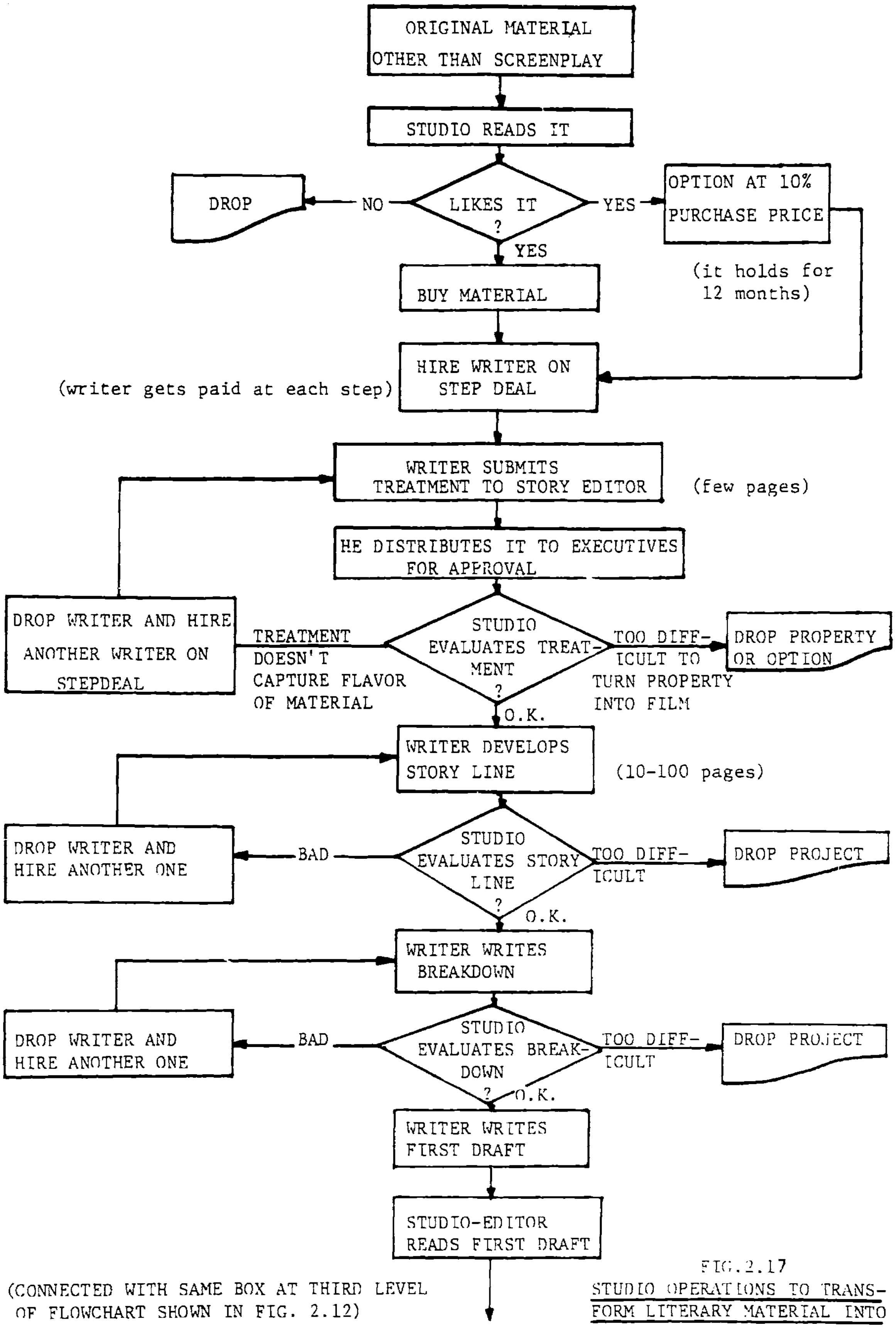


FIG.2.17
STUDIO OPERATIONS TO TRANSFORM LITERARY MATERIAL INTO SCRIPT

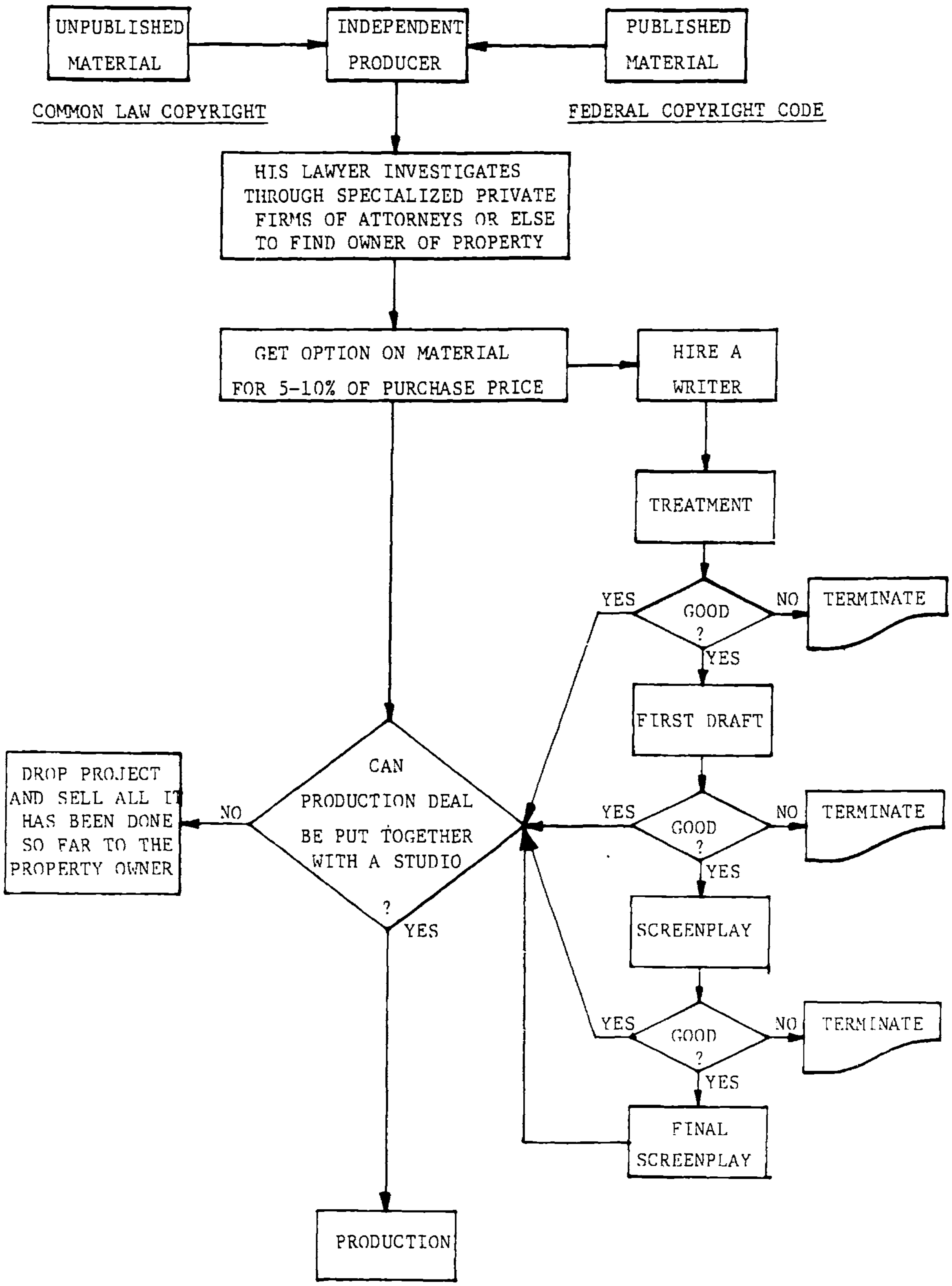
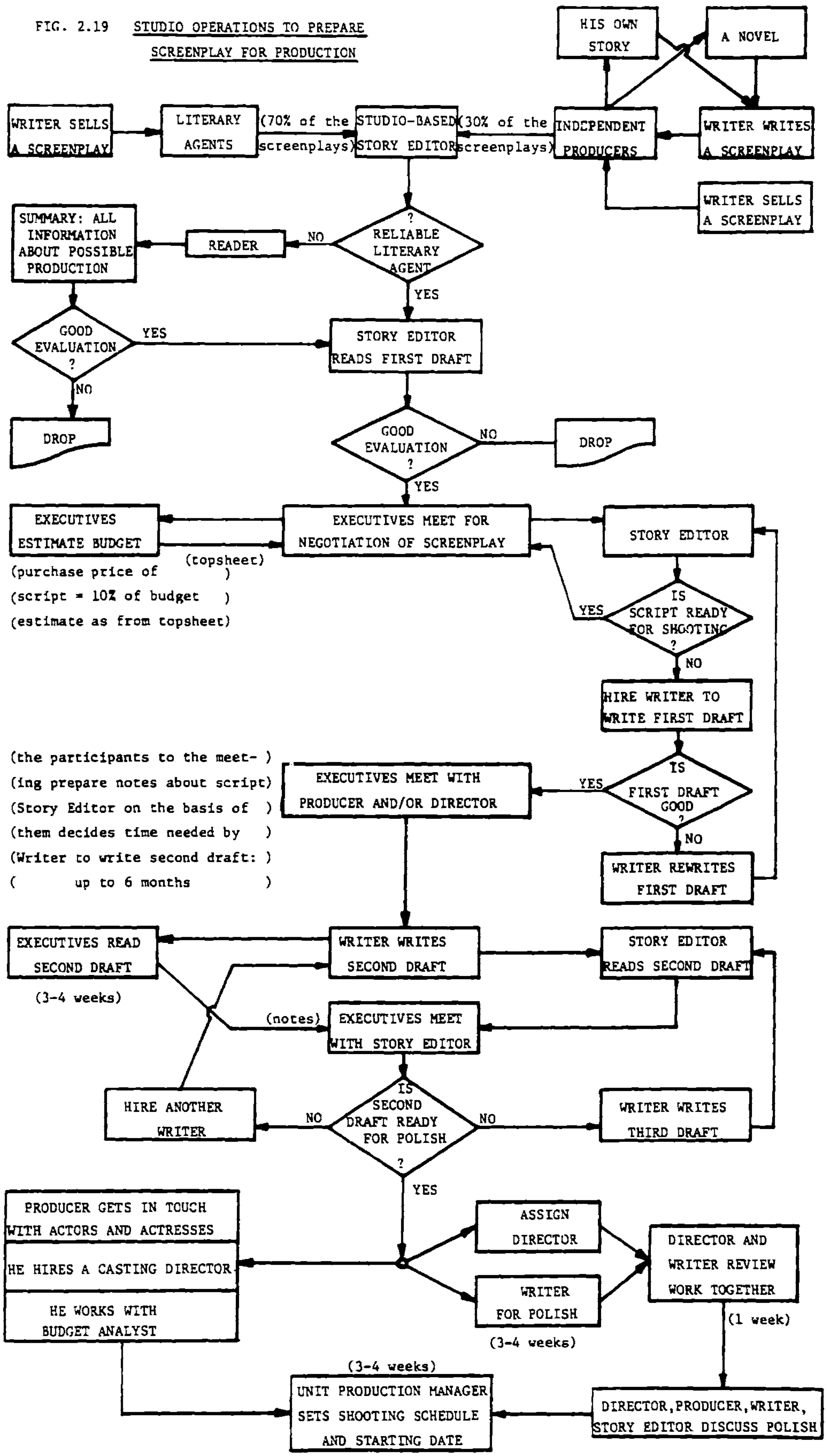


FIG. 2.18 TRANSFORMATION OF LITERARY MATERIAL INTO SCRIPT BY AN INDEPENDENT PRODUCER

FIG. 2.19 STUDIO OPERATIONS TO PREPARE SCREENPLAY FOR PRODUCTION



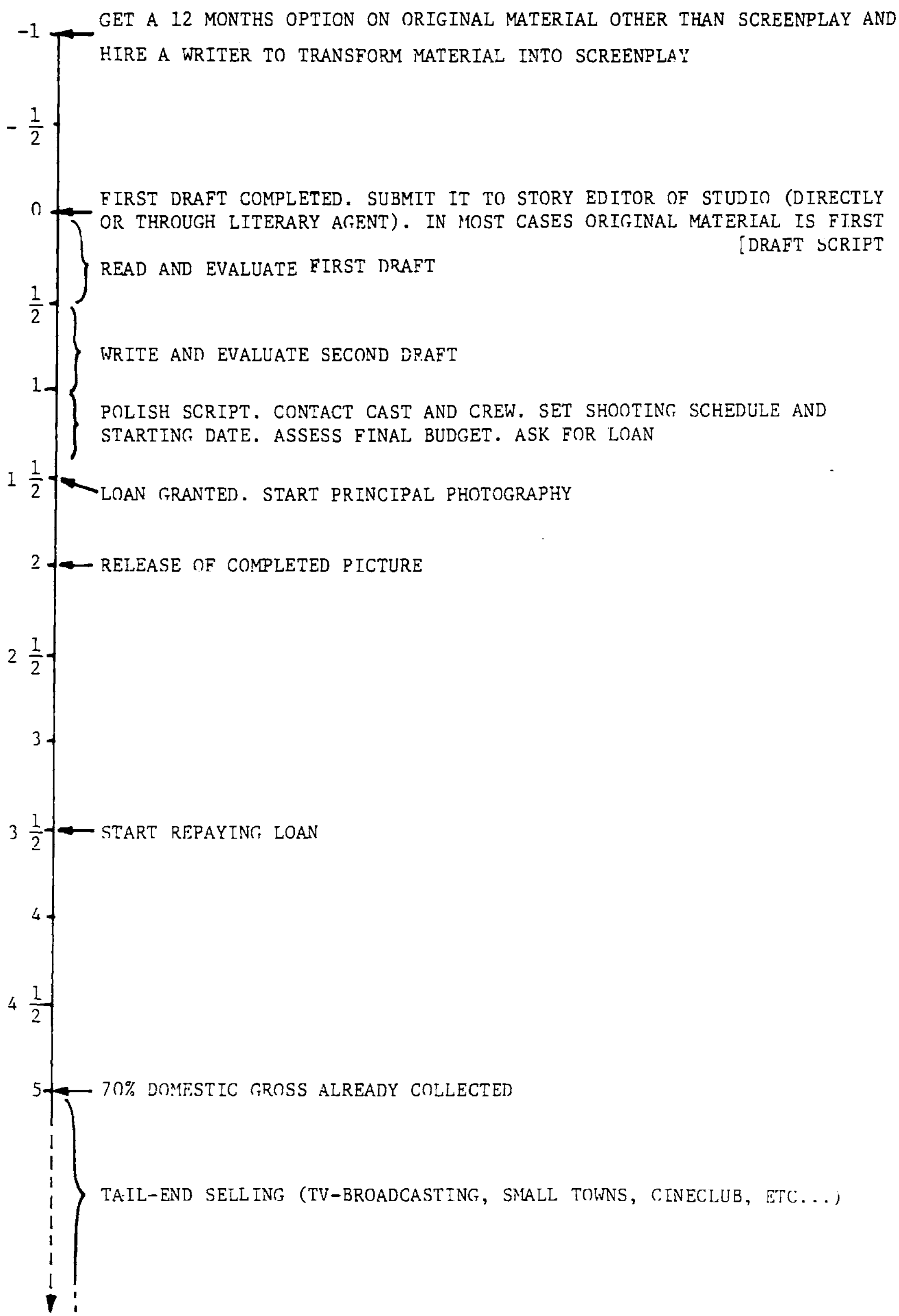


FIG. 2.20 CHRONOLOGICAL TABLE OF THE MAIN STEPS IN THE LIFE OF A MOVIE

These three actions correspond more or less to:

i) No commitment

ii) Medium commitment

iii) Heavy commitment

Maybe to partition the set of actions in a finer way, including an itemized level of commitment (i.e.: so much to improve independently say the story or the action content or the dialog or the definition of a character to fit a certain actor or else) and to use quantitative parameters in order to evaluate a project, will help sharpening the decisions made. Nevertheless to select a project out of a list of potential candidates, a global quantitative judgement has to be used. This judgement should be made very early in the life of the project, using unexpensive assessment techniques, in order to minimize the money **wasted** in aborted projects. A quantitative single-value judgement should take into consideration the utility for the monetary return of the project, together with an estimate of the discount factor to be applied to each dollar earned by the picture. In fact, total grosses being equal, a weekly gross shaped like the one of "The Exorcist" is preferred to the one of "The Sting", since the former shows a faster return of the capital.

A scheme which indicates how to analyze the risk and the potential of a project is shown in Fig. 2.21:

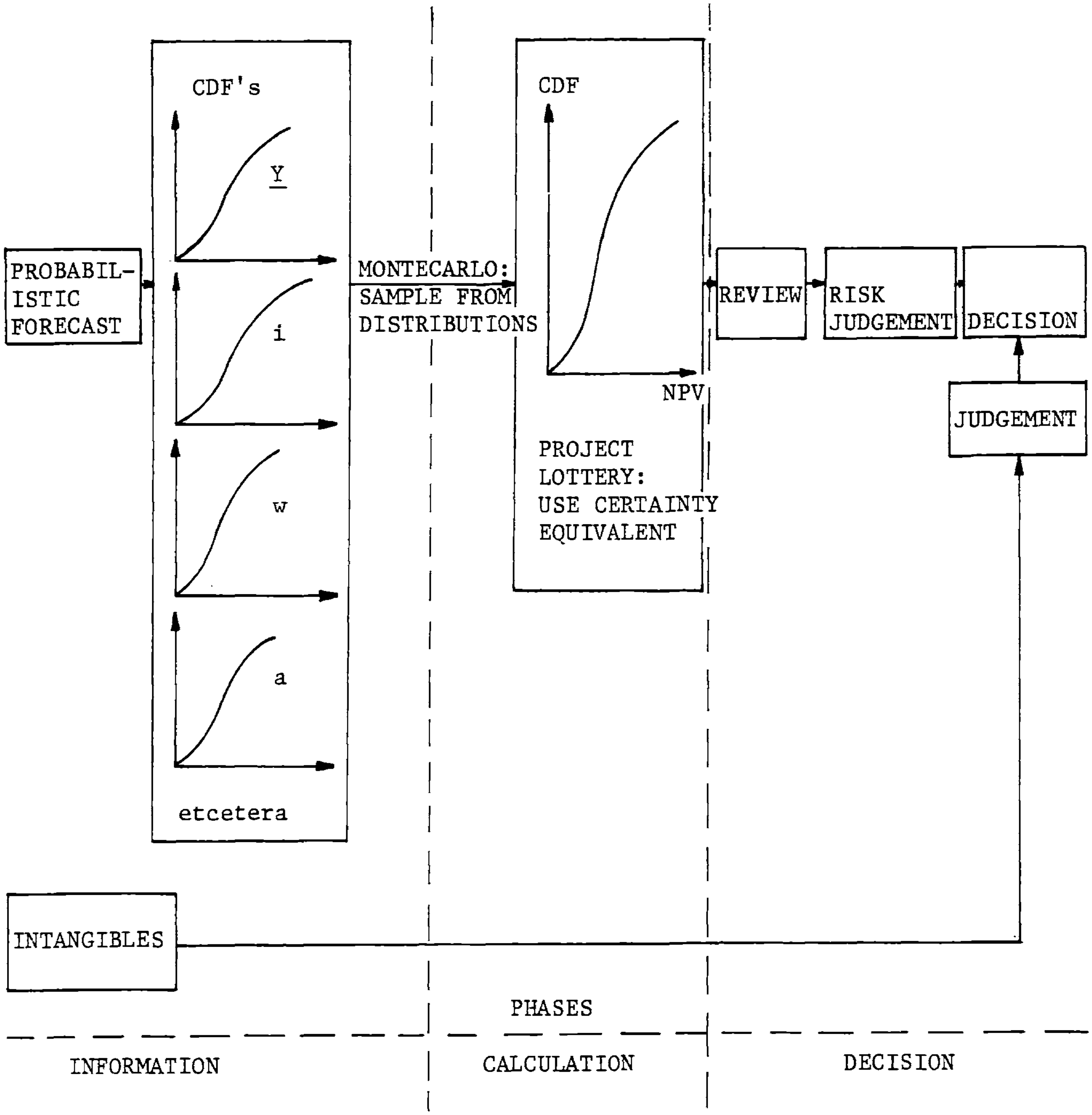


Fig. 2.21 (Source: Course 15.781)

where CDF = Cumulative Distribution Function

NPV = Net Present Value of the project

$\underline{Y}$ = vector of parameters which carry the information about the weekly gross

i = financial interest rate

w = word of mouth effect

a = effectiveness of the advertising

This scheme assumes the independence of the parameters whose CDF's are shown in the information phase of the project and for this reason has to be used with a certain amount of care.

As far as evaluating the parameters needed in the information phase, a suggestion is worth a further study. The people's reaction to the presentation of a movie could be tested by making up fake posters and reviews of several future projects and by showing them to a selected audience. By this way, I believe, it would be possible to test the effectiveness of the advertising philosophy as well as the appeal of the project to the public. This would in turn allow to estimate the number of potential supporters the picture would have at the time of its release on the market.

I insofar assumed that whichever was the picture produced, it would have always been possible to distribute the picture optimally. This implies and independence between production and distribution strategy which may not be true at all. In fact at least as far as the time of the year is concerned not every picture is worth being released on primary times as well as not every time of the year is a good release time for certain pictures. Therefore it seems logical to analyze a project keeping in mind its future distribution strategy, its opening time and its advertising campaign.

2.3.2 The factors of success

When questioned about what makes a picture successful, an executive ranked the following items:

1) The story (i.e. the skill of the writer)

2) The actors (people identify with them)

3) The supporting things (i.e.: the making of the movie)

M. F. Mayer [2] list the following elements of popularity (not in order of importance):

1) Sentimentality

2) Family Films

3) Musicals

4) Adventure

5) Violence

6) Sexuality

7) Humor

8) The Bizarre and the Unusual

9) The Horrow Film

10) Racial Themes

11) Neo-realistic Films

12) Anti-establishment Pictures

But when attempting at drawing a conclusion about what makes a successful film, he writes:

1) The story? Maybe, but it's no guarantee.

2) The cast? Only insofar as it secures a loan.

3) The director? Too erratic.

4) A large budget? No.

5) Juxtaposition of time and content. Yes, but how to obtain that? (N.d.A.)

And he therefore concludes:

> "The film must be well cast, capably directed, broadly advertised and publicized with a strong word-of-mouth reaction". (p.40)

Each moviegoer, of course, has his own opinion, somewhat different, about what makes a picture successful. It is a matter of how one breaks a movie into pieces and then analyzes it piece by piece. This is a philosophical issue of primary importance and should probably be best examined by some student of linguistics-related disciplines. Whichever may be the analysis and the division of a movie into elements, one needs a method of ranking each of them, if a meaningful factor analysis has to be performed.

One method which is currently used in several applications of Decision Analysis is to rank each hypothetical factor by giving it a score between 1 and 5. It is a simple method, easy to grab and to question people with.

It is generally acknowledged that no advertising campaign nor good reviews can do as much for the financial success of a picture as a strong positive WOM effect can do.

But, as I previously pointed out, this is an emotions-based phenomenon. It is therefore more effectively induced by the creation of a single man, than by the one of a group of executives gathering together, whose task may eventually be only the one of acknowledging the existence of such a driving force in a work. If a single person must be, than in order of intervention, the key-persons in the creation of a successful movie are the Writer (W), the Producer (P), the Director (D), the Stars (S) and the Composer (C) (or anyway the person encharged with the sound); this last one being an unexpectedly underrated person.

In order to evaluate the dependence upon them of the WOM effect one needs:

1) A breakdown of the main elements, which make up the professional value of W,P,D,S and C, which may be held responsible for the creation of a strong WOM effect.
2) A subjective evaluation of W,P,D,S and C by elements obtained by questioning the people in the business.
3) An objective evaluation, again by elements, obtained from the records of their past performance. For this purpose a very valuable tool would be a library of statistics concerning the performance of W,P,D,S,C. For the Directors, for instance, it should include statistics such as:

$\frac{\sum_i C_i}{\sum_i G_i}$, $\frac{N(G_0)}{N_{TOT}}$, N_{TOT}, Number of films in a year, Variance of the Gross of the movies directed, etc. .. Where:

C_i = Production cost of i^{th} movie directed by a given Director

G_i = Total Gross of i^{th} movie directed by a given Director

$N(G_0)$ = Number of films directed by a given Director which grossed more than G_0

N_{TOT} = Total number of movies directed.

With the pretension of being neither exhaustive nor definitive, a meaningful breakdown (as of point 1) can be the following:

Writer:

1. Invention in the story line (of course a true invention, not to be mistaken with the gimmicks or the gadgets he may throw into an actionless script in order to add some color to it).
2. Dialogue
3. Characterization of the personages
4. Development of the story

Producer:

1. Appropriateness of his choice of the story with respect to its fitting to the future public's taste.

2. Ability in matching Director and Cast to each other and to the story.
3. Organizational capabilities
4. Ability in finding the financial support

Director:

1. Creativity or Imagination
2. Resourcefulness
3. Psychological insight into the actors mood
4. Feeling for the desires of the public
5. Leadership

Actors:

1. Charisma
2. Sense of measure
3. Professional behaviour
4. Adaptability and flexibility

Composer:

1. Melodic invention (or imagination and richness in the choice of the pieces)
2. Fitting of the music to the scenes (by harmony or by contrast)
3. Arrangement and Orchestration (choice of the sounds, of the instruments, etc.)

The WOM effect, as any chain reaction, builds up faster if the number of spectators who see the picture at the very beginning is larger. This number can be increased by:

1) Investing more money in the advertising campaign.
2) Releasing the picture on primary time and in the big cities first.
3) Using a best-seller book as original material.
4) Getting good critical reviews.

The validity of the last point though, is not acknowledged by everyone as:

"Happily, the reviews are totally unimportant on a film. No one except maybe the critic's mother is going to go to a film or stay away from a film because he says it's good or it's bad". (1,p.9)

Other factors which may eventually improve the success of a picture are:

1. A good editing work
2. To have two or even three main male characters instead of only one.
3. A High budget

2.3.3 A list of models

I) In section 2.3.1 we saw that at each lozenge (stage) of Figures 2.10 through 2.12 an assessment has to be made about the potential of a project and a decision has to be taken concerning both the level of financial commitment for the next stage and the items for which this commitment has to be taken. The potential of the picture can be measured by a single-value parameter (for instance its expected total gross) or by a multivalue-parameter (for instance the Y's suggested in section 2.2.2). For the two cases the assessment will be made respectively by using the expressions:

(2.16) $$u = u(\$,i)$$

and $$u = u(\underline{Y},W,\underline{C},i)$$

where: u = utility function of the decision makers

\$ = total gross, i = discount factor

$\underline{Y} = (y_1,y_2,...,y_5)$, W=WOM, $\underline{C}=(c_1,c_2,...)$=coefficients of the disturbance effects mentioned in sec. 2.2.1.

In the simplest of the cases \$ and $\underline{Y}$ can be estimated respectively through a single and a multiple linear regression onto the factors of success listed in section 2.3.2. (i.e. the elements making up the professional value of the people who will work at the project, after that subjective and objective knowledge about them have been combined together. In the more general case, since some interference between elements (a certain actor with a certain director, for instance) is very likely to exist, a quadratic regression is more appropriate. Therefore, letting $\underline{X} = (x_1, x_2, \ldots, x_n)$ be the column vector of the elements, then the equation to use will be respectively:

$$\$ = \underline{A}^T \underline{X} + \underline{X}^T \underline{\underline{B}}\ \underline{X} \tag{2.17}$$

and

$$\underline{Y} = \underline{\underline{\Gamma}}^T \underline{X} + \underline{X}^T\ \underline{\underline{\Delta}}\ \underline{X} \tag{2.18}$$

where $\underset{(n\times 1)}{\underline{A}}$, $\underset{(n\times n)}{\underline{\underline{B}}}$ and $\underset{(5\times n)}{\underline{\underline{\Gamma}}}$, $\underset{(n\times n)}{\underline{\underline{\Delta}}}$ will have to be computed through quadratic regressions onto the elements $\underline{X}$ from the observations $\underline{\$}$ and $\underline{\underline{Y}}$ obtained from previous movies.

At the end of each stage j the decision makers set a lower bound u_j^* to their utility for the potential of the project, so that if $u_j < u_j^*$, the project is dropped. In order to increase the generality of the approach, if u_j is a random variable and its distribution can be obtained in some way, than the decision makers will drop the project whenever:

$$P\{u_j \geq u_j^*\} \leq P_j^*$$

P_j^* being a lower bound to the above probability.

Notice that to avoid dropping a project at an advanced stage of development, the lower bound should be very high at the beginning and should decrease with the advancement of the project. On the other hand at the early stages the knowledge about the potential of the picture is very uncertain, which would ask for looser bounds at these stages. This seeming conflict will have to be resolved case by case.

The problem with this approach is that it is analytically very cumbersome and that the number of observations, respectively $\underline{\$}$ and $\underline{\underline{Y}}$, may not be sufficient for any meaningful regression to be performed. Moreover it leaves unanswered the question about how to estimate the WOM effect.

II) In this section an attempt is made of handling the WOM effect onto the weekly gross by means of a time correlation. The model is therefore:

$$(2.19) \qquad \$_t = \begin{cases} \beta \$_{t-1} + \underline{\zeta}\, \underline{\omega}_t + \tilde{\varepsilon}_t & p \\ \gamma \$_{t-1} + \tilde{\eta}_t & 1-p \end{cases}$$

where p = probability that the movie will show a positive WOM effect

β, γ, $\underline{\zeta}$ = parameters to be estimated

$\underline{\omega}_t$ = vector of controllable variables (mainly the advertising)

$\$_t$ = gross of week t

$\tilde{\varepsilon}_t$, $\tilde{\eta}_t$ = error terms

Resolving (2.19) leads to:

$$\$_t = [p\beta+(1-p)\gamma]\ \$_{t-1}+p\ \underline{\zeta}\ \underline{\omega}_t + \tilde{\delta}_t \tag{2.20}$$

where $\tilde{\delta}_t = p\ \tilde{\varepsilon}_t + (1-p)\tilde{\eta}_t$

This model requires and independent estimation of the probability of success p and of the correlation parameters. In other words the philosophy behind it is to find:

1) The probability that the movie will be a hit.

2) Given that the movie is a hit, estimate the level of gross it will eventually reach.

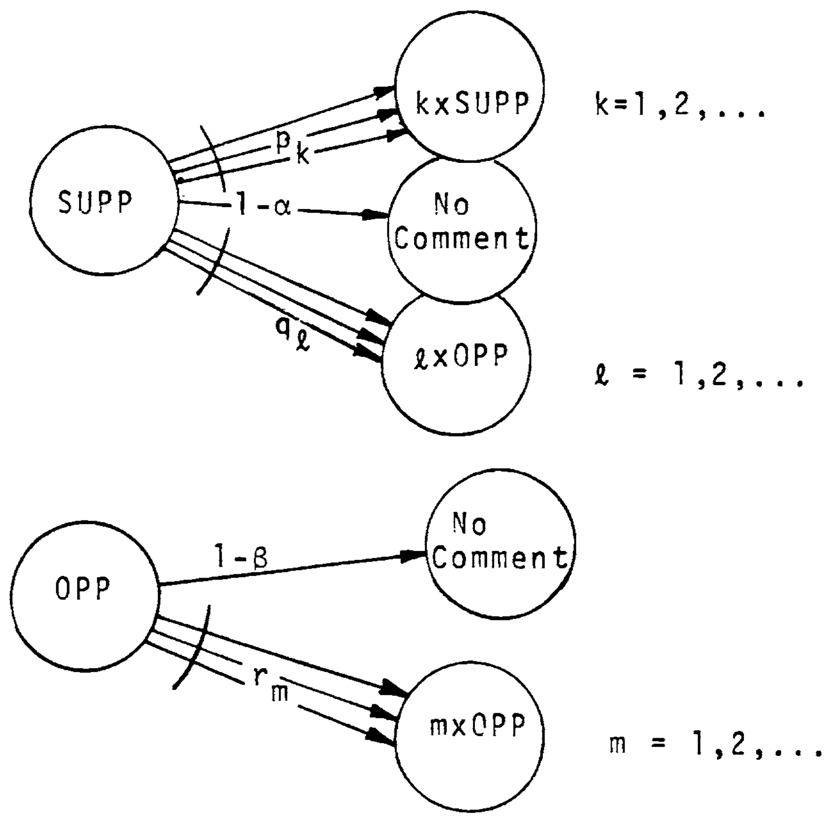
III) This model attempts to formulate the WOM effect exactly for what it is: a branching process.

Definitions:

<u>Supporter</u> = a person who will go to see the movie after having been made aware of its existence by any means: advertising, critics, the conversation with someone who has already seen the movie, etc.

Opposer = someone who won't go to see the movie after having been made aware of its existence by the same means as above.

Then the flowgraph is:



Where: $\alpha = \sum_k p_k + \sum_\ell q_\ell$, $\beta = \sum_m r_m$

No Comment = state in which the system will fall if both the SUPP or the OPP won't communicate their impressions about the movie to anybody or if they won't find anyone to talk to who is not already a SUPP or an OPP or who won't have already seen the movie himself.

It is necessary here to assume that if a SUPP talks to an OPP or viceversa none of the two will change his mind.

A complication arises from the fact that both SUPP and OPP will generate new SUPP's and OPP's at random times after their birth. For this reason one could assume for instance:

$$P\ \{\text{SUPP generates a SUPP in time } t,\ t+dt\} = \lambda e^{-\lambda t}\,dt$$
$$P\ \{\text{SUPP generates a OPP in time } t,\ t+dt\} = \mu e^{-\mu t}\,dt$$
$$P\ \{\text{OPP generates a OPP in time } t,\ t+dt\} = \nu e^{-\nu t}\,dt$$

With this assumption:

$$p_k = P\{\text{SUPP generates } k \text{ SUPP's between 0 and } t\} = \frac{(\lambda t)^k e^{-\lambda t}}{k!}$$

and the similar for the other types of births.

Notice that at time t after its release, the total gross earned, or which is bound to be earned later on by the picture, is equal to the existing number of SUPP's times the average price of the tickets sold.

The development of the model as it is may be very involved, thus some simplificative hypothesis will have to be made. One such simplification is to split the problem in two phases and formulate it assuming first:

1) Infinite boundaries (i.e.: an infinite number of people which can be turned into a SUPP or an OPP) and then study the probability of extinction of the process self.
2) Finite boundaries, with α and β growing after a certain time up to quenching the whole process.

Chapter 3

POTENTIAL SAVINGS DURING THE PRODUCTION

3.1 The Production Problem

Many of the large losses in the motion picture industry of the last few years were largely from heavy cost over-runs. To avoid this, the present and future producers will have to review the general philosophy according to which movies were previously made and try to strongly reduce the production cost. In fact:

"If the difference between being in the red and the black on an annual divisional accounting can turn on a swing of as little as $100,000 a picture, management must ask itself - what factors in handling each film can we control so as to effect the divisional statement in this manner?" (1, p. 106)

In the introduction I mentioned that the production cost is commonly split into: above the line and below the line cost. The former refers to the creative functions, (i.e.: Writer, Producer, Director, Stars, Art Director, Cameraman and Unit Production Manager) and cannot therefore be reduced if not by shrewdly bargaining with their respective agents. This topic has been quickly overviewed in the previous chapter and therefore won't be covered here. The 'below the line' cost instead, which generally makes up to 60% of the total production cost, can be reduced by holding the total production time to the lowest possible level, by hiring each person of the cast for the shortest length of time and by designing a shooting schedule flexible enough to accommodate a fair number of unpredictable accidents which may occur during the production. In fact:

"One of the major challenges in estimate budgeting is judging the time schedule, not only for the whole production but for each of the various aspects of production. Each area needs a certain amount of preparation time to get ready for shooting. And some individuals within a given area will work more days than others in that area. This applies to talent as well as production crews. A certain cast member may not report until the twelfth day of production, while another may be on call throughout shooting. Extras are brought in and taken out as needed. If the film involves some shooting on location, there may be one or two scouting trips required for such people as the director and the unit manager plus others who may need to seek out and study the area. Being as accurate as possible in estimating all of the various contingencies of the time-table can be very crucial to the validity of the budget." (Ib., p.86)

"But nothing saves money on a film compared to cutting days off the schedule. Every other change becomes relatively minor." (Ib., p.167)

But since:

"There is no attempt to pad a budget in anticipation of requests to cut it later. There is not even an allowance for possible complications arising from bad weather or illness. It is assumed when the budget is made up that conditions will be ideal and everything will happen according to plan. Even construction is budgeted on ideal conditions. It is not assumed that there will be night crew constructing, which could involve permit men who may not be quite so efficient as number one men. Nor is it considered that the crew might be working on a stage with a red light that will go on periodically to signal the crew to cease noisy activities while a company next door is shooting. Even in location shooting, it is assumed that everything will proceed smoothly and there will be no unanticipated expenses, such as building or re-paving roads or getting stuck in the mud and having to bring in heavy equipment for a rescue operation." (Ib., p.85)

Then:

"Another area of costs protection lies in a constant review of spending on the picture while it is in production. We exert pressure to budget realistically in advance to keep cast costs down, to reduce location moves, and eliminate "protection" personnel and equipment." (Ib.,p.107)

Moreover to the producer it is of particular importance to be able to stay within the limits of the original production, because:

"Today, many companies have what they call a "penalty factor". They might say, "All right, you can spend up to $2.3-million. If you go over budget by $200,000, you have to pick up $100,000 of that deficit." (Ib.,p.175)

But eventually:

"The success of a budget is not measured only in dollars spent or saved, but more importantly in how well it served the property by providing a plan which could produce a good product." (Ib.,p.86)

This chapter, therefore, under a set of simplificative assumptions, deals with an attempt at formulating the problem of designing a shooting schedule which comply with all the previous requirements.

3.1.1 Designing the shooting schedule

The Unit Production Manager (in the following pages referred to as U.P.M.) is hired by the Producer with the task of preparing the production plan. He is given the script which contains the story broken down by scenes. Each scene indicates which characters appear in it, the lines of dialogue and the action to be represented. In many cases it may indicate also for how long the camera is supposed to roll, the camera movements, the sound and any other suggestion the writer may desire to give to the Director. The U.P.M. decides what is needed for each scene, then groups together all those scenes which can be shot within a single set. Finally he transfers all information concerning each set into the continuity breakdown sheets: one set per sheet. He then estimates the time required by the Director to film each set, by using his working speed (in pages of script a day) as a piece of information. If instead the Director is new or hasn't yet been assigned to the project, he will attempt at estimating his speed, by whichever information he will be able to gather. The length of time allowed for each scene has to include the time for the instruction of the crew and the cast, for the rehearsal, for the lighting and for the eventual number of retakes. The last ones are characteristics of the Director's shooting style.

"Upon completion of all the continuity breakdown sheets, this information is then transferred to the breakdown board, a large headboard where all the cast and various requirements are listed. And to the right on individual colored strips, all the sets are listed along with the breakdown page, sequence, day or night, number of pages, set numbers, actors who work in that particular set, along with extras, bit players, and other requirements listed on the continuity breakdown. Then, the strips are juggled in a manner which is most convenient for shooting, as well as to hold the actor's shooting time to an absolute minimum. By way of example, an actor might work in the beginning of the picture and not again until the very end. It should also be considered that excessive overtime is costly and anything over 12 hours a day amounts to double time. It is also important to the director that as much continuity as possible be retained in the final result. Upon completion of the breakdown board, a meeting is then set up with the director and/or producer so that he is aware of what he must accomplish each day. After the director has approved the breakdown board, the information we have now gathered is incorporated into a shooting schedule." (1,p.147)

For the Producer though as well as for the U.P.M., the

"... biggest problem might be a complication regarding some of his cast, who are available only on certain dates. Their schedules can determine when shooting must start and/or end. But generally, there is adequate lead time on features. For television, however, with the quantity that must be turned out in barely a week of shooting, there is usually little lead time. The television schedule of necessity is fast-paced." (Ib.,p.111)

3.1.2 In what sense an optimal schedule

The goal is to design a minimum cost schedule. Unfortunately not all the costs which will arise throughout the production are known in advance: therefore the objective of whichever formulation one chooses to adopt won't possibly include all the cost elements. The balance at this point is between simulation versus optimization. That is to say one can use a very sophisticated objective and investigate with it the dependence of the total cost from each cost element . Otherwise one can use simple measures of performance as objectives, find the optimal schedules with respect to each of them within a set of rigid constraints, and then conduct some sensitivity analysis to gain insight into the model. The second approach is generally easier to follow at an early stage in the analysis of a real world problem, and is therefore the one I choose to adopt.

Flexibility is the main goal the U.P.M. aims at in designing the shooting schedule of a picture. By this way he is able to cope with whichever random event will occur during the production. To put flexibility in mathematical terms is virtually impossible, since each movie requires an analysis on its own. The U.P.M. does that by designing a schedule loose enough to accommodate a fair amount of delay each day. He also takes care of such random events as bad weather by keeping aside an alternative interior set ready to use. He therefore sets for each day an alternative number of interior scenes to be shot instead of the exterior ones. As the production goes on he then relies heavily on the daily control and readjustment of the schedule to keep up with the production plan.

The next measure of performance is the compactness of the schedule. A certain amount of money can be saved by holding the number of working days of each actor to a strict minimum. This is a deterministic problem which can be exactly solved by a mathematical programming formulation using binary variables. A requirement of the Actor's Union concerning the continuity of their employment introduces a complication, which will be seen in a later section, but also this latter one can be exactly formulated. The last measure of performance one can think of is some function of the idle time of the set. Total or average idle time (the latter is equivalent to the former if the total number of days of production is fixed) are possible such functions. The variance of the idle time with respect to its mean value could be another one: somewhat more complex to formulate, but generally more appropriate. Also the relative idle time is sometimes used in similar problems drawn from other industrial contexts. That is to say, the objective to minimize is:

$$f(I) = \frac{I}{T+I}$$

where T = Total Shooting time, I = Idle time and consequently: T+I = Total production time. This last problem is currently solved by fractional programming techniques.

3.1.3 Suggestions for the breakdown board

A breakdown board has to have the following properties:

1. Portability (has to be light enough to be transported manually on location)
2. Low cost (this though depends upon its performance)
3. Practicality (easy to use by anyone)
4. Reusability (the U.P.M. has to be able to use it over and over again)
5. High information content (has to allocate a large number of data: up to say 500 sets, times 50-100 bits of information per set)
6. Visibility of Display (if possible has to display all the information at one time)
7. Manipulability (must allow the U.P.M. to interchange storage positions of sets easily and quickly)
8. Evidence of display (if the goal is to achieve the shortest and the most compact schedule, the data, such as expected shooting length of a scene and characters playing in each scene, should be easy to see at first sight. It should also carry some information concerning the confidence in the estimate of the expected shooting length)

The breakdown board used nowadays performs very well with respect to all properties but the 7^{th} and 8^{th}. The cardboard strips containing all the information concerning one set are not easy to shift around, nor do they display by any simple means any data concerning expected shooting length and confidence in the estimate. An electronic system could perform very well with respect to these two properties, but it would be very expensive and too heavy to transport. The issue though is worth some investigation.

3.2 Mathematical formulations of the optimal schedule

3.2.1 The general framework of the problem

Problem: Design the shooting schedule of a movie.

Objective: Find that shooting schedule which minimizes the cost of producing the movie by:

i) Minimizing the number of days required to shoot all the scenes* (i.e. trim down the time the set stays idle)

ii) Make a compact use of the resources of the set.

(This means to hire each actor and rent each piece of necessary equipment for the shortest period of time possible.)

---

* Note: To avoid confusion between the working set and the sets which group all the scenes whose data are contained in the same cardboard strip, I will use the word "scene" to label the amount of information making up a single strip.

Constraints: i) Do not overcome regular working time. (overtime work is expensive)

ii) Shoot all the scenes

iii) Hire actors with "continuity".

Notice:

In the Codified Basic Agreement of 1967 of the Producer Screen Actors Guild, the last requirement reads as follows:

1) "Employment of the day player shall be for consecutive days from the beginning of the engagement....." [Schedule A, Section 6A] (DEF.: "A day player is a player employed by the day other than an extra, stunt man, professional singer, or airplane pilot." [Ib., Sec.1])

2) ".... Continuous Employment - Weekly Basis - Weekly Salary-One Week Minimum Employment...." [Schedule B, Sec.3]

"The player's week in each instance shall commence on the day of the week on which such player is first placed on salary. In case of any suspension or interruption of such player's employment at anytime for seven consecutive days or more, for any reason whatsoever, such player's week shall thereafter commence on the day of the week when he is again placed on salary" [Ib., Sec. 10]

Notice that a daily salary is exactly defined only for daily players. For weekly players though a daily salary can be defined as an useful measure of the daily cost of those actors to the Producer. This figure is then used to compute the cost to the Producer of the continuity requirement. For multiple picture players (employed for two or more pictures per year), contract players (employed for a period of time without any specification of role, picture or series) and for deal players (employed for one or more specific pictures and with a picture-based salary computed as a combination of cash and share of profits), the continuity rule doesn't apply strictly. It is obvious though that whenever to work on sparse days would represent an inconvenience to them, the continuity requirement can be imposed to help setting a more compact schedule as far as their appearances is concerned. For this purpose a daily salary will have to be defined also for these players. The continuity requirement can be imposed also to expensive pieces of rented equipment which have a high installation cost or need a long time to be installed. By this means the schedule will set the scenes containing those pieces of equipment on a series of days the more consecutive possible.

Notice also that for the purpose of designing the shooting schedule the daily salary doesn't need to be the real one, but can be used as an adjustable parameter to vary the compactness of the schedule of a certain actor or item. Finally, the requirement that the daily players be hired for consecutive days from the beginning of their engagement, is more constraining than the continuity requirement applicable to the weekly players. Nevertheless in the mathematical model introduced later on to represent and solve the problem just mentioned, I will make no distinction among different categories of actors.

Three reasons motivate me to do so:

a) The salary of the daily players is rather low with respect to other categories of actors or to the rental of some pieces of equipment.

b) Daily players have generally a low frequency of appearance.

c) Should this not be the case, at any time whatsoever the Producer has the option to convert a daily engagement into a weekly one.

For these reasons in designing the shooting schedule the daily players are either not taken into consideration at all, and eventual adjustment will be made a posteriori on the schedule generated by the model, or will simply be handled as weekly players.

Other Constraints

In a more complete representation of the real problem, any formulation will have to include also other constraints, for any model to generate a schedule closer to a ready-to-shoot one. Such constraints stand for further requirements imposed by the Unions contract and by a more detailed analysis of the real problem. They fall basically in 4 categories:

1) Fixed dates scenes. These constraints will have to impose that certain scenes be scheduled at certain given dates. This may be required by some actors, by some items

or by some particular location, to be included in the picture, being available only at certain dates. Or again by some natural or human event, to be photographed, existing only at a certain date.

2) Night scenes. The Unions require a minimum amount of rest between two consecutive working periods. Therefore if the crew is placed on call in the middle of the week (say Tuesday) for a night work and if the two adjacent working periods are both day ones, they will have to be scheduled for Monday and Thursday respectively. This in turn will shrink the working week down to only 4 working periods with the consequent loss of one full day of work. To overcome this problem the night work is normally scheduled for the night preceding the week-end so that enough rest time will intervene between the last one and the next working period. Obviously whenever a night work will be scheduled for Friday night, some more night work may be scheduled for Thursday, and so on backward wise until exhaustion of all the night scenes, without loss of any working period. Because of this, night scenes will have to be scheduled before the day scenes.

3) Location scenes. There is presently a strong trend towards shooting on locations as opposed to studio shooting, in order to improve the quality of the picture. Unfortunately

location work is heavily affected by weather conditions. To avoid the loss of time caused by bad weather, an interior setting is generally kept ready aside and an alternative group of interior scenes is scheduled for each day. A complete formulation of the problem will have to divide the scenes into at least 3 classes: day location, night location and interior ones and use the latter ones as an alternative work for the previous ones. This on the other hand is what is already being done at the present time.

4) <u>Coupling coefficients</u>. It is possible to think that many scenes share all or part of the same setting: this implies that if scene i_2 is scheduled after scene i_1 some time may be trimmed from the preparation of the setting for scene i_2. This is partially accounted for at the present time, by grouping scenes into strings of scenes which are then labelled as a single set. Another way of taking advantage of this fact would be to define coupling coefficients $C_{i_1 i_2}$ between scenes such that if scene i_2 is scheduled immediately after i_1, their lengths (expected time it will take to shoot them) will be respectively d_{i_1} and $c_{i_1 i_2} \cdot d_{i_2} < d_{i_2}$. The above mentioned facts will not be considered in the following treatment of the topic, if not in a marginal way,

since their inclusion in any model would involve an increase of its mathematical complexity, without adding much to the understanding of the proposed approaches.

3.2.2 A possible simplification

Given the script or equivalently the matrix of the actor's appearance $||a_{ik}||$, with

$$a_{ik} = \begin{cases} 1 & \text{if actor k appears in scene i} \\ 0 & \text{otherwise} \end{cases}$$

the first thing to check is whether the whole matrix can be reduced to a block diagonal one by columns and rows exchanges only. Where this the case, each group of scenes belonging to a block submatrix could be scheduled on its own, as if obtained from one of a series of shorter independent scripts. This result would reduce the size of the problem of designing the schedule by splitting it into a set of smaller problems. Basically the situation is the one depicted in Fig. 3.1, where the hatched areas contain the only non-zero coefficients.

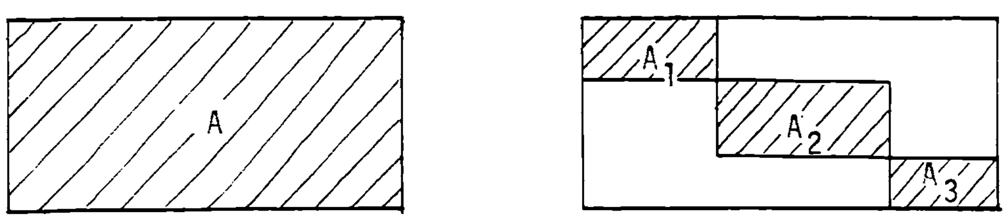


Fig. 3.1

To check if the reduction is possible, put a circle around any element you want to start with, then circle every other element lying on the same row or column. Go then to any of the already circled elements and repeat the same procedure. If you can't terminate before having circled all non-zero elements, then there are no independent blocks. If some non-zero non-circled elements are left, then these have no rows or columns in common with any of the previous ones and can therefore be moved by simple rows and columns exchanges to form and independent block.

3.2.3 Some probabilistic approach

Left aside all unpredictable events such as weather, accidents, failure or else, the probabilistic quantity I will take into consideration is the duration of any single scene in order to find its probabilistic distribution. With this the distribution of the length of the working load for any given day can be computed by knowing the scenes which make up the schedule for that day and by assuming independence between scenes. Let $\tilde{\ell}_i$ be the length of the i-th scene, then this can be expressed as:

$$\tilde{\ell}_i = c_{ji}\tilde{\ell}_{0i} + \sum_{k=1}^{\tilde{r}_i} (\tilde{\ell}_{1i})_k \tag{3.1}$$

where: c_{ji} is the coefficient which couples scene i to the scene j which is scheduled immediately before scene i

$\tilde{\ell}_{0i}$ is the set-up time duration of scene i (instruction, rehearsals, lighting, etc.)

$\tilde{r}_i$ is the number of takes of scene i

$\tilde{\ell}_{1i}$ is the duration of a single take of scene i (that is to say the time between two consecutive takes).

As a general rule the scenes full of dialogue have a high value of $\tilde{r}_i$, while scenes full of action have a high $\tilde{\ell}_{0i}$. If we can assume that both $\tilde{\ell}_{0i}$ and $\tilde{\ell}_{1i}$, are normally distributed, questioning the U.P.M. about their expected values and variances should produce useful data. In fact, while reading the screenplay, the U.P.M. attributes implicitly a mean duration to each scene and has a feeling for the variance of its total shooting time: thus he allows more time for a scene if he feels that either of the two might be large. In the same way, his knowledge of the director's professional characteristics gives him a feeling for $\tilde{r}_i$. Thus all that is needed in this respect is a way of translating those feelings into simple numerical figures. The variables $\tilde{r}_i$, though, may also be considered as due to an almost Bernoulli random variable, although P, the probability that the r^{th} take is good, may not be constant, since p(r), the probability that a scene is taken r times, may go down for large values of r (i.e. 10-15) quicker than a geometric distribution does for a P which fits low values of r. This will eventually have to be checked with the data obtained from past records of the number of times each scene has been shot. That is to say, see whether by plotting r against the frequency f(r) a curve is obtained which looks like a geometric distribution. If this is the case each director should have his own average value for P given the kind of movie he is supposed to shoot.

An alternative hypothesis is to assume that the probability of a scene being taken k times is constant for $k=1,2,\ldots,r_i$ and zero for any other value. That is to say:

$$P\{k \text{ takes of scene } i\} = \begin{cases} \frac{1}{r_i} & 1 \le k \le r_i \\ 0 & \text{else} \end{cases}$$

where r_i is a characteristic of the Director and the type of scene i belongs to.

Let's assume $\tilde{\ell}_{0i}$ and $\tilde{\ell}_{1i}$ independent and normally distributed with parameters μ_{0i}, σ^2_{0i} and μ_{1i}, σ^2_{1i} respectively. Let's also assume $\tilde{r}_i$ Bernoulli with probability P_i and independent from $\tilde{\ell}_{0i}$ and $\tilde{\ell}_{1i}$, then the transform of the PDF

(Probability Density Function) of the duration of scene i is:

$$(3.2)\quad f^T_{\ell_i}(s) = e^{-sc_{ji}\mu_{0i}+s^2\frac{c_{ji}^2\sigma_{0i}^2}{2}} \frac{P_i\, e^{-s\mu_{1i}+s^2\frac{\sigma_{1i}^2}{2}}}{1-(1-P_i)e^{-s\mu_{1i}+s^2\frac{\sigma_{1i}^2}{2}}}$$

which doesn't appear invertible, but may be useful for computing expected value and variance. One note is that it may be more realistic to represent the coupling coefficient c_{ji} as a change of location of the distribution of $\tilde{\ell}_{0i}$ rather than as a change of scale. In other words, it is at the moment unclear whether the situation looks like the one of Fig. 3.2:

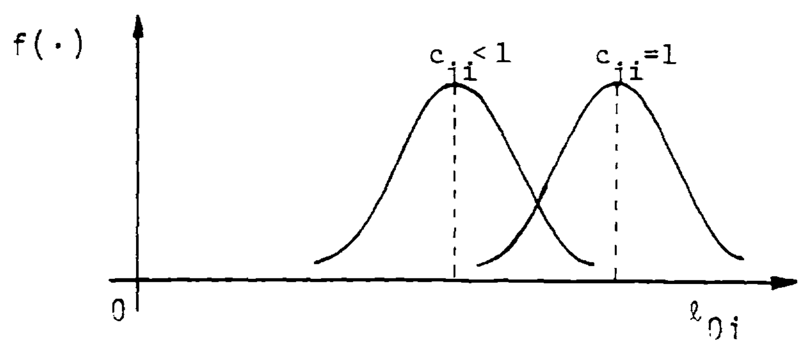


Fig. 3.2

or rather like Fig. 3.3:

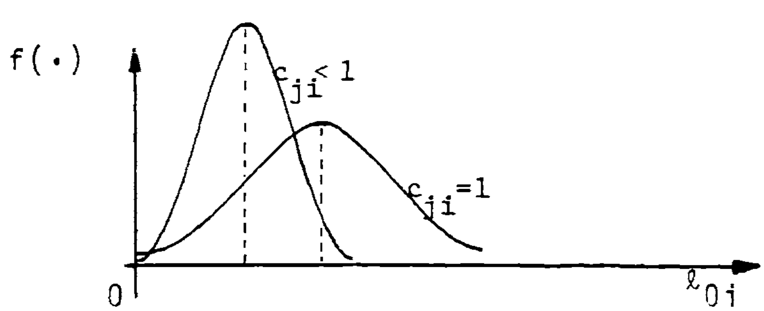


Fig. 3.3

Expected duration of the day's schedule and of the entire production.

Given the succession of the scenes in a day, that is to say given the value of the coupling coefficients, their duration may be assumed as independent, thus the distribution of the duration d of a single day's schedule may be obtained from the transform:

$$(3.3) \qquad \left[f_d^T(s) \right]_{m_{j\pi}} = \prod_{k=1}^{m_{j\pi}} \left[f_{\ell_k}^T(s) \right]$$

where: $i_1, i_2, \ldots, i_{m_{j\pi}}$ are the identification numbers of the $m_{j\pi}$ scenes scheduled for day j according to the permutation π . At this point, what is left to do is to find for every day a permutation of scenes which generates an optimal schedule with respect to some measure of performance.

Here are some ideas:

a) Some plot should be done to get a rough idea of the shape of $f_d(d_0)$ for different scene permutations and different values of all the parameters. If by chance it happens that the distribution appears more or less Gaussian or at least it is approximately symmetric, then the situation is the one of Fig. 3.4:

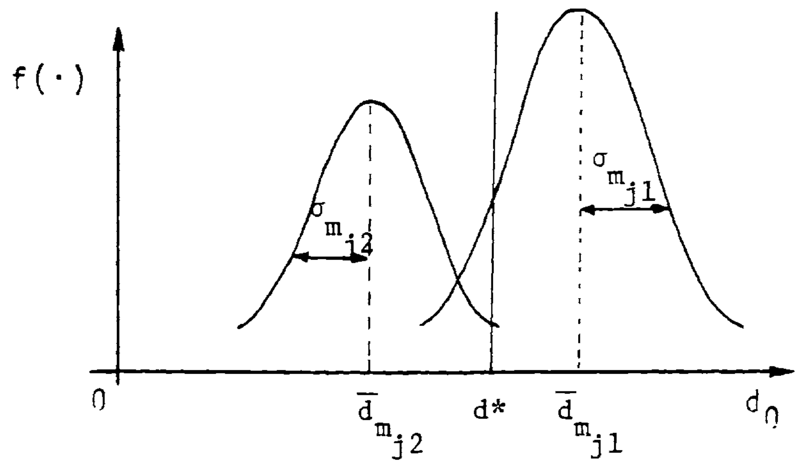


Fig. 3.4

For each permutation π of m scenes in the schedule of the day j we can compute from the

$\left[f_d^T(s) \right]_{j,\pi,m}$ both the expected duration $\bar{d}_{m_{j\pi}}$ and the variance. Then by fixing a value d^* of the expected duration of the schedule which appears satisfactory, we can search for a permutation which gives the minimum value:

$$\min (\bar{d}_{m_{j\pi}} - d^*)^2 \text{ among all } \pi\text{'s}$$

Of course, to reduce the computational burden the goal of optimality may be sacrificed by accepting any permutation for which: $(\bar{d}_{m_{j\pi}} - d^*)^2 \leq \delta^2$. It is obvious, for instance, that for a symmetric distribution of the single day schedule, if we fix $d^* = 8$ hours, we will accept every day an average probability of being late or of having to work overtime of 50%. Similarly, if we fix: $d^* = 8-\sigma_{m_{j\pi}}$ hours, (specifying a safety margin equal to one standard deviation) we accept an average probability of being late around 16%. The validity of this result though, depends upon how well our situation satisfies the requirements of the Central Limit Theorem. The latter requires that the number of production days is large ($D>10$), that the distributions of the duration of the daily schedules are not too different from each other and that each distribution is fairly symmetric.

Thus, by increasing d^* I make the schedule "tighter" and I increase the probability of being late with the production. In other terms, d^* is the control parameter of the delay.

If σ^2, the neighborhood around d^* within which I consider a daily schedule as good, is small, and if for instance I pick $d^* = 8$ hours and if, to be conservative, I also suppose not to work overtime, then at day D, that is at the expected end of the production, the distributions of the delay accumulated will be $N(D,D\sigma^2)$, where σ^2 is the average value of the variances of the duration of the daily schedules and where the anticipations are considered as negative delays.

This distribution, within the assumption that the cost of a movie is proportional to the time spent to shoot it, represents also the probability of overbudgeting.

b. Another way of selecting the permutations of scenes which give the optimal schedule could be the following: suppose the distribution of the duration of the day's schedule looks still familiar enough that you can define its shape by computing the first two or three moments, then we can compute with a certain approximation the cumulative probability that the day's schedule will be through before the end of the regular working time (say 8 hours). Call this probability $P_{m_{j\pi}}$ and the time between the end of the schedule and of the end of the working day $x_{m_{j\pi}}$. The random variable x represents a wasted idle time of the set. Fix x^* as an idle time you are willing to accept, then $P_{m_{j\pi}}$ (shaded area of Fig. 3.5 is the cumulative probability that the day's schedule will leave an

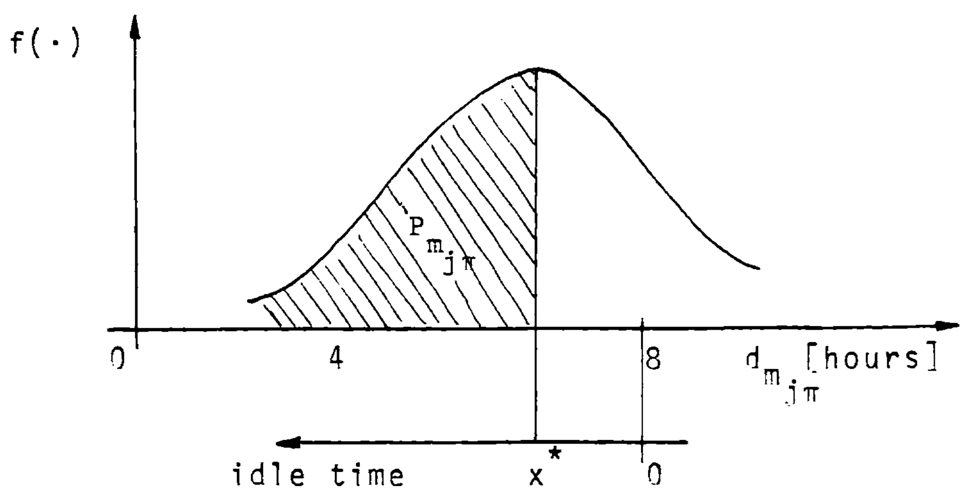


Fig. 3.5

idle-time equal to x^*, i.e.: $P_{m_{j\pi}} = P\{x_{m_{j\pi}} \geq x^*\}$. Then, if we are satisfied with a value P^* of that probability, then what is wanted is:

$$\min \sum_{j=1}^{D} [(P^{*}-P_{m_{j_\pi}})^{2} \mid x^{*}]$$ where D is the number of production-days

The value of these probabilistic formulation doesn't lie in the fact that one can use them to generate the optimal schedule: the analytical complexity in fact, is too high for the problem to be solved in this way. These approaches can be very useful instead to check the "tightness" of an optimal schedule generated by a deterministic approach to the problem. That is to say, given two optimal schedules, both solutions of some simpler deterministic problems, one compares their likelihood to give birth to unrecoverable delays by testing them with the above mentioned methods.

3.2.4 The Cutting Stock Problem

Once the expected length ℓ_i of each scene has been computed from an equation likewise 3.2 or otherwise has been empirically estimated, then the total idle time can be minimized by formulating the problem as a "Cutting Stock Problem".

For this purpose let I be the total number of scenes and let I_k be the number of scenes having expected length ℓ_k, $k=1,2,\ldots, K$, $1 \leq K \leq I$ so that $\sum_{k=1}^{K} I_k \ell_k = I$

then let the column vector p_j be the j-th scheduling pattern, that is to say: $p_j = (n_{1j}, n_{2j}, \ldots, n_{Kj})^T$ where n_{kj} indicates the number of times a scene of length ℓ_k is used in any day if the scheduling pattern p_j is adopted for that day. Let also x_j be the total number of times that the scheduling pattern p_j is used in the whole schedule.

Then since all the scene have to be scheduled it must be:

$$(3.4) \qquad \sum_{j=1}^{J} n_{kj} x_j \geq I_k \qquad k = 1, 2, \ldots, K$$

for $\quad x_j \geq 0$ and integer

If we minimize the total length of the schedule (i.e. the total number of production-days), we implicitly minimize also the total idle time. Therefore an appropriate objective is:

$$\min Z = \sum_{j=1}^{J} x_j \quad \text{subject to the inequality (3.4)}$$

(remember that each time we use a scheduling pattern we commit an entire day). Unfortunately for any practical problem, J, although finite, is too large for the problem to be solved as formulated. Let therefore π_k be the dual price associated to the k-th constraint, then if:

$$\bar{c}_j = 1 - \sum_{k=1}^{K} \pi_{kj} n_{kj} \geq 0$$

for any feasible solution $\underline{X} = (x_1, x_2, \ldots, x_J)$, then the latter would also be optimal.

Therefore for any feasible solution $\underline{X}$, we can search for the min $\bar{c}_j$ for all j's, in order to check whether the latter is non-negative, or equivalently, we can look for:

$$\text{Max } z = \sum_{k=1}^{K} \pi_k n_{kj}$$

$$\text{(3.5)} \qquad \text{s.t.} \quad \sum_{k=1}^{K} \ell_k n_{kj} \leq w \qquad j = 1,2,\ldots,J$$

$$n_{kj} \geq 0 \text{ and integer}$$

w = total length of the working day (say 8 hours)
The shooting patterns imposed by the optimal solution do not need to be used to schedule any specific day, therefore given the optimal $\underline{X}$ we can interchange the days until we reach the optimal compactness. Or in other words we maximize the compactness of the schedule within the optimal solution of the previous problem.

This formulation has two main drawbacks:

1. If a certain scene has to be scheduled on a certain day for any of the reasons mentioned in sec. 3.2.1, then we could attempt to solve the previous problem for the remaining I-1 scenes with that particular day having now a length shorter

than w . This would be the case of a Cutting Stock Problem with rolls of different length. Unfortunately this generalization doesn't work for this case since there is no way to impose that the optimal solution of this new problem include that particular shorter day.

2. Given the heavily stochastic nature of the process, ℓ_i may be very far from the real length of scene i . The optimal solution of problem 3.4 and 3.5 can thus result a very poor solution a posteriori. But on the other hand the U.P.M. doesn't know any better.

3.2.5 Compactness: first formulation

In this section I propose a general formulation of the problem of designing the optimal shooting schedule of a movie, imposing the compactness as an explicit objective and the total idle time as an adjustable less important one. In general terms this is a case of vector optimization since we use **two independent objectives.**

The following identification indexes will be used:

i for the scenes

k for the actors

j for the days

with:

$0 \leq i \leq I \qquad (I = 150\text{-}500)$

$0 \leq k \leq K \qquad (K = 10\text{-}20)$

$0 \leq j \leq J \qquad (J = 30\text{-}50)$

Notice that J is not known a priori but can be estimated by a conservative figure.

The data are the following ones:

$$a_{ik} = \begin{cases} 1 & \text{if actor } k \text{ \underline{appears} in scene } i \\ 0 & \text{otherwise} \end{cases}$$

ℓ_i = expected number of hours it will take to shoot scene i

S_k = daily salary of actor k (salary here has the meaning specified in sec. 3.2.1. Also k doesn't need to be necessarily an actor, but rather any expensive piece of equipment as well as any item indispensable to the scene)

w_j = length of the j-th working day (I will assume $w_j = w = 8$ hours for all j)

$f_i = \frac{\ell_i}{w}$ = expected length of scene i measured as a fraction of the regular working day

Finally W = a weight to be assigned by the Production Manager to the second term of the objective function which represents the minimization criterion aimed at reducing the total length of the schedule.

I expect that in most cases it will be possible to fix: $W = 0$ since reducing the spreading of the actors reduces implicitly also the total length of the schedule. It may be possible though that a schedule few days longer than another one will be more compact than the latter one. On the other hand we saw in section 3.1 that the largest savings are obtained by cutting days off the shooting schedule. For this reason it may be necessary to explicitly include the total length of the schedule as an objective to be minimized, and play with W as a parameter, in order to obtain the minimum-cost schedule.

The decision variables are:

$$x_{ij} = \begin{cases} 1 & \text{if scene } i \text{ is \underline{scheduled} for day } j \\ 0 & \text{otherwise} \end{cases}$$

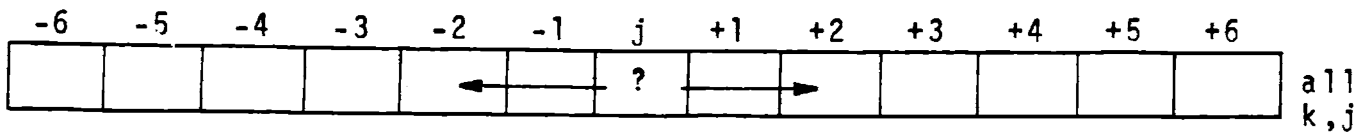
$$z_{kj} = \begin{cases} 1 & \text{if actor } k \text{ has to be \underline{paid} in day } j \\ 0 & \text{otherwise} \end{cases}$$

Notice that:

$z_{kj} = 1$ if and only if either one of the following situations occur:

a) $\sum_{i=1}^{I} a_{ik} x_{ij} \geq 1$ (i.e. actor k is scheduled to work on day j) or

b) actor k is not scheduled to play on day j, but he is scheduled to play on some day before j as well as on some day after j while the number of days intervening between these two days is less than 7. In other words consider:



$$\ldots\ldots.z_{kj-1},z_{kj},z_{kj+1}\ldots\ldots.$$

defining: $A(n) = \sum_{\ell=j-1}^{n} z_{k\ell}$, $B(n)= \sum_{m=j+1}^{n+7} z_{km}$ where $n=j-1,j-2,\ldots,j-6$

we have that if:

i) $z_{kj} = 1$, then there are no problems: it stays so

ii) $z_{kj} = 0$ and $A=0$ or $B=0$ or both, again there are no problems: it stays so

iii) $z_{kj} = 0$ but $A(n)\geq 1$ <u>and</u> $B(n)\geq 1$, then z_{kj} has to be $=1$

This could be formulated by imposing the conditional constraint that:

$$(3.6) \qquad z_{kj} = 1 \text{ if } \sum_{\ell=j-1}^{j-6} \quad \sum_{m=j+1}^{\ell+7} z_{k\ell} \cdot z_{km} \geq 1 \quad \text{all } k,j$$

which for K = 10 actors, J = 40 days (this number would be only a conservative estimate of course), would yield 400 quadratic constraints.

But a quadratic constraint in binary variables is still something very hard to handle, therefore the following larger but linear formulation is certainly to be preferred:

$$\text{Min} \sum_{k=1}^{K} S_k \sum_{j=1}^{J} z_{kj}$$

(A1) s.t. $z_{kj} \geq \sum_{i=1}^{I} f_i a_{ij} x_{ij}$ all k,j (pay all actors whenever they are scheduled to play)

(B1) $\sum_{i=1}^{I} f_i x_{ij} \leq 1$ all j (don't overcome regular working time)

(C1) $\sum_{j=1}^{J} x_{ij} \geq 1$ all i (schedule all the scenes)

(3.7)

(D1) $z_{kj} \geq z_{k\ell} + z_{km} - 1$ all k,j and $\ell = j-1, j-2, \ldots, j-6$;

$m = j+1, j+2, \ldots, \ell+7$

(21 constraints for each k,j)

(employment continuity constraint)

$$z_{kj} = 0,1;\; x_{ij} = 0,1$$

For $K = 10$ actors, $J = 40$ days and $I = 200$, the total number of constraints would be: 400+40+200+8,400=9,040 while the variables are: 400 of the z_{kj}'s and 8,000 of the x_{ij}'s.

Notice that:

a) Whenever the total length becomes an objective to be explicitly minimized, then the term: $W \cdot f(I)$ should be added to the objective above, where $f(I)$ is related to the total amount of slack time remaining available after constraints (B1) have been satisfied.

b) The exact formulation of constraints (C1) would require a strict equality, to be sure that no scene is scheduled twice. On the other hand the objective drives to zero all the x_{ij}'s which are not bound from below by constraints (C1). Therefore if some scene gets scheduled twice, this happens only when no extra cost is implied to the objective (i.e. when in both days where that scene is scheduled enough idle time is available to allocate it and when all the actors appearing in it have to be paid anyway). This circumstance would obviously not cause any problem to a real schedule.

c) Whenever $K \gtrsim I$ (although quite unusual) it may be convenient to express the set of constraints (A1) by the alternative tridimensional formulation:

(3.8) $$z_{kj} \geq a_{ik}x_{ij} \quad \text{all } k,j,i$$

this would greatly increase the number of constraints but would eliminate the requirement that the z_{kj}'s be restricted to binary values.

3.2.6 Compactness: second formulation

Given any shooting schedule, define for each actor k a row vector $P_k=[P_k(1),P_k(2),P_k(L_k)]$ for $k=1,2,\ldots,K$ where:

$P_k(1)$ = first day in the given shooting schedule in which actor k is scheduled

$P_k(2)$ = second day in the given shooting schedule in which actor k is scheduled

. .
. .
. .
. .
. .
. .

$P_k(L_k)$ = last day in the given shooting schedule ... .

the meaning of the $P_k(q)$'s $(q=1,2,\ldots,L_k)$ is represented in Fig. 3.6.

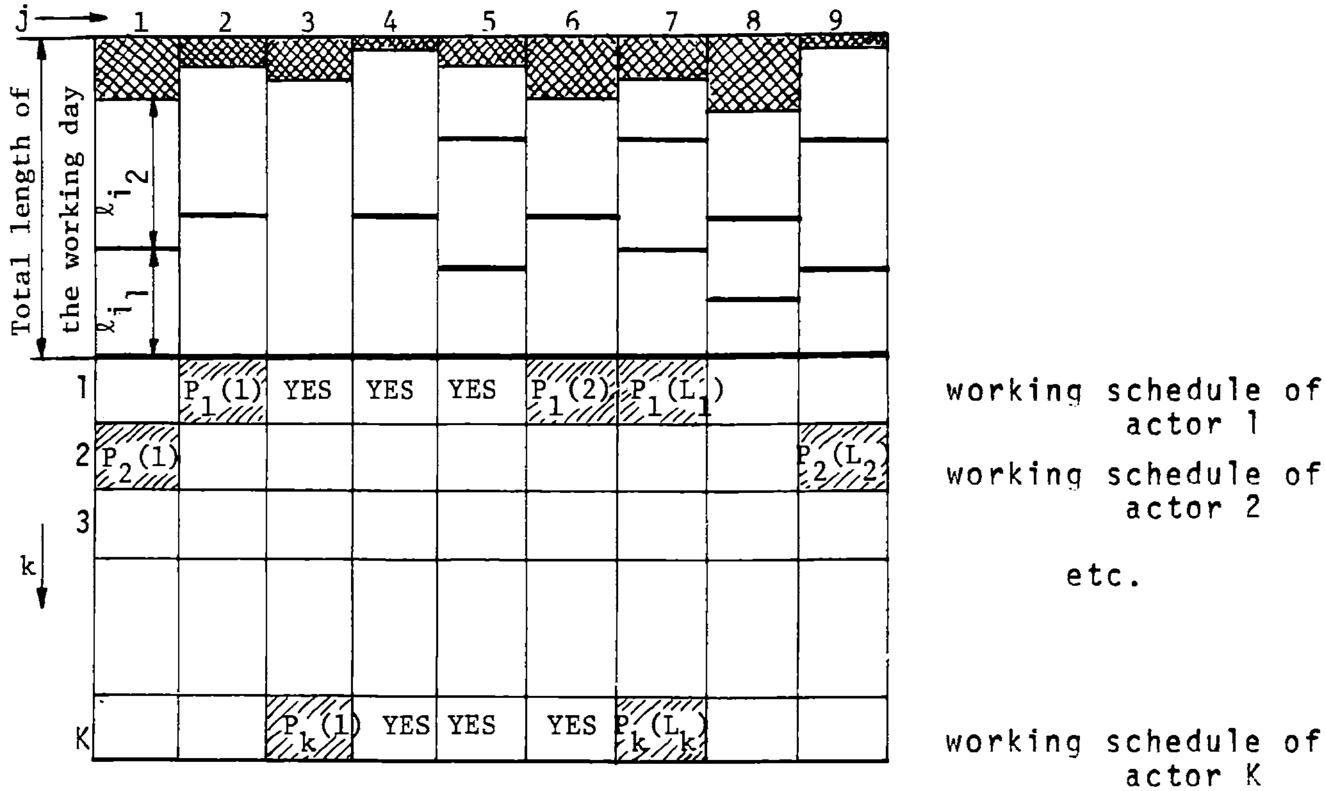


Fig. 3.6

In the upper half of the fiqure the cross hatched are represent the idle time left at the end of each day j, while ℓ_{i_1} and ℓ_{i_2} are respectively the lengths of scene i_1 and i_2 here represented as vertical rectangles of unit width and height proportional to their length. In the lower half each hatched area shows in which day each actor is scheduled, while YES indicates that he has to be paid, even if he is idle.

In the previous formulations we defined the decision variables:

$$Z_{kj} = \begin{cases} 1 & \text{if actor } k \text{ has to be } \underline{\text{paid}} \text{ in day } j \\ 0 & \text{otherwise} \end{cases}$$

then: $Z_{kj} = 1$ for $j = P_k(1), P_k(2), \ldots, P_k(L_k)$

(i.e. if actor k is <u>scheduled</u> for day j)

But $Z_{kj} = 1$ also if $P_k(q+1)-P_k(q) \leq 7$ (for the continuity requirement mentioned in sec. 3.2.1)

that is to say:

$$Z_{kj} = 1 \quad \text{for } j=P_k(q)+1, P_k(q)+2, \ldots, P_k(q+1)-1 \quad \text{and } q=1,2,\ldots, L_k-1$$

on the other hand:

$$Z_{kj} = 0 \quad \text{if } P_k(q+1)-P_k(q) \geq 8$$

that is to say:

$$Z_{kj} = 0 \quad \text{for } j,q \text{ same as above}$$

therefore let's introduce the integer valued variables defined by:

$$\left.\begin{aligned} s_{kq} &= 7 - [P_k(q+1)-P_k(q)] \\ t_{kq} &= [P_k(q+1)-P_k(q)]-8 \end{aligned}\right\} \quad q=1,2,\ldots,L_k;\ k=1,2,\ldots, K$$

and the 0,1 variable η_{kq}, then the continuity constraint can be formulated as:

(3.9)

(A2) $(1-\eta_{kq})s_{kq} \leq 0$

(B2) $\eta_{kq} \cdot t_{kq} \leq 0$ $\quad q=1,2,\ldots,$

(C2) $Z_{kj} \geq \eta_{kq}$ for $j=P_k(q)+1, P_k(q)+2, \ldots, P_k(q+1)-1$ $\quad k=1,2,\ldots,$

(D2) $\sum_{j=P_k(q)+1}^{P_k(q+1)-1} Z_{kj} \leq \eta_{kq}[P_k(q+1)-P_k(q)-1]$

$$\text{In fact if } s_{kq}>0 \Rightarrow \eta_{kq} = 1 \Rightarrow \left\{ \begin{array}{ll} Z_{kj} \geq 1 & j=\text{same} \\ \text{and} & \\ \sum_{j=P_k(q)+1}^{P_k(q+1)-1} & Z_{kj} \leq P_k(q+1)-P_k(q)-1 \end{array} \right\} \Rightarrow Z_{kj}=1 \quad j=\text{same}$$

which implies that each actor has to be paid at least once in each of those days but for a total number of times not exceeding the number of days intervening between $P_k(q)$ and $P_k(q+1)$.

$$\text{If instead } t_{kq}>0 \Rightarrow \eta_{kq} = 0 \Rightarrow \left\{ \begin{array}{ll} Z_{kj} \geq 0 & j=\text{same} \\ \text{and} & \\ \sum_{j=P_k(q)+1}^{P_k(q+1)-1} & Z_{kj} \leq 0 \end{array} \right\} \Rightarrow Z_{kj}=0 \quad j=\text{same}$$

Which implies actor k doesn't get paid while at idle.

The objective is therefore:

$$\min \sum_{k=1}^{K} S_k \sum_{j=P_k(1)}^{P_k(L_k)} Z_{kj}$$ over all feasible schedules, and here

lies the problem since the total number of feasible schedule is a gigantic one: **something like 10^{300} for an average movie!**

Notice that the use of this objective makes problem 3.9 simpler, since it makes the set of constraints D2 trivially satisfied.

An alternative way of formulating constraints A2 and B2 is:

(E2) $s_{kq} \leq M \cdot \eta_{kq}$

(F2) $t_{kq} \leq M(1-\eta_{kq})$

where M = conservative estimate for the total length of any good schedule in number of days. M represents an upper bound for both s_{kq} and t_{kq}

In fact by the fact that we are minimizing and by constraints C2 the program will always pick the smallest value of Z_{kj} and therefore also of η_{kq}, while by constraints E2 and F2,

if $\eta_{kq} = 0$ F2 is satisfied for any possible value of t_{kq} just as B2 will be and E2 and A2 will be identical. If $\eta_{kq}=1$ the same is true for s_{kq}.

3.2.7 A heuristic approach

The use of exact formulations for the problem of maximizing the compactness of the schedule has its main drawback in the complexity of the mathematics and in the limitation of the size of the problems one is able to solve by them. Besides that, an optimal solution, even if such with respect to the compactness, may not be it at all with respect to the total cost of the schedule. Therefore it is worth to analyze a simpler and much less fancy approach, which though has performed rather well for a problem of small size. It is a heuristic lacking of any proof of optimality and based only upon common sense rationals.

What we want is to set down the schedule in such a way as to minimize the number of readjustments to be made to it in order to improve its compactness, once all the scenes have been scheduled. Each readjustment in fact, causes other readjustments to be made in order to recompact the schedule and so on. The number of these readjustments grows with the number of actors displaced by the first readjustment. On the other hand since we generate our schedule by placing down the scenes sequentially, we want to order all the scenes before starting. The order has to be such, that at the beginning, when we have many more degrees of freedom, as far as where to place the scenes is concerned, we take care of those scenes which would require the most penalizing readjustments, if placed at the very end. On the other hand, toward the end, we are left with a limited number of choices as where to place the scenes and therefore we want to take care of those scenes which would not perturb at all the already achieved compactness. Thus take the following parameters into consideration:

$$S_k$$

$$n_k = \sum_{i=1}^{I} a_{ik} \quad ,$$

$$C_i = \sum_{k=1}^{K} S_k a_{ik} \quad ,$$

$$N_i = \sum_{k=1}^{K} a_{ik} \quad ,$$

$$\ell_i$$

First Objective: Order the <u>actors</u> which are the main problem.

1. It costs at least S_k for each day that a certain scene, containing actor k , is displaced from the original position. Therefore order first actor k who has the highest salary S_k.

2. If two actors have the same salary, it is very likely that displacing a scene containing the one who appears in the largest number of scenes, won't decrease the actual compactness. In fact any readjustment may displace that scene from its original position to a day where the same actor is already scheduled to play. Therefore order first the actor who appears the least. (i.e.: smallest n_k)

Second Objective: Order the scenes within the previously established hierarchy of actors.

3. If C_i is high, it is very likely that scene i contains a set of very expensive actors, besides the one we are considering. Therefore order first the scene with the highest C_i.

4. If N_i is high, then for the same value of C_i, it is very likely that scene i contains a bunch of inexpensive actors, besides the one we are considering. Thus order first the scenes with the lowest N_i.

5. Finally if ℓ_i is high, it won't be very easy to find a spot where to place scene i, without displacing many other scenes. Therefore order first the scenes with the highest ℓ_i.

In short the sequence is:

$\uparrow S_k$, $\downarrow n_k$; $\uparrow C_i$, $\downarrow N_i$, $\uparrow \ell_i$

(Instead of C_i we could also use $\xi_i = \frac{\sum_{k=1}^{K} \frac{S_k}{n_k} a_{ik}}{N_i}$ which is a weighted sum of the appearances of all the actors in scene i.

The ordering according to the five rationals is made out in the following way:

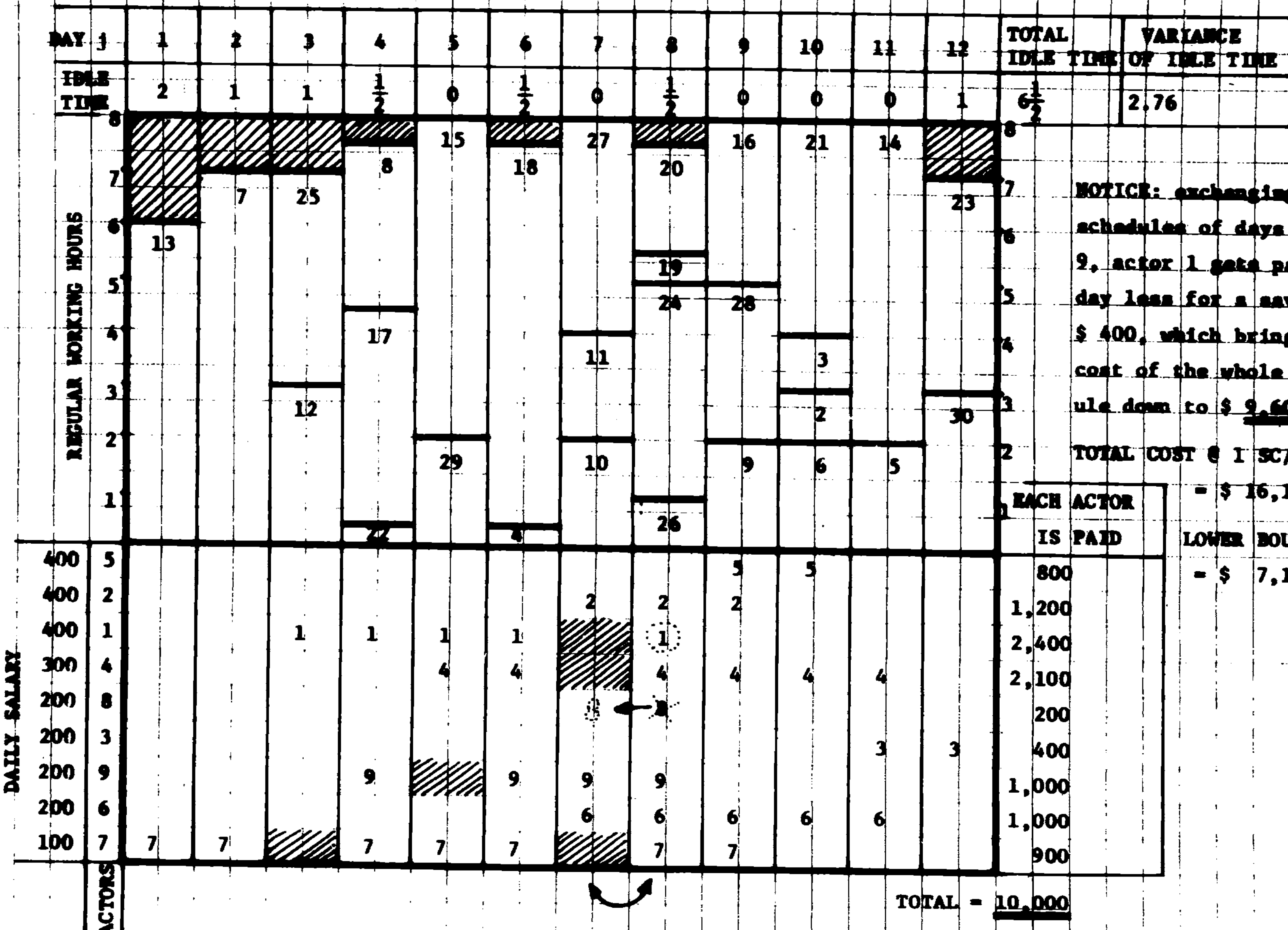
1. Select all the scenes which contain the k with the highest S_k and put them on top of the list of scenes.
2. If there is a tie for S_k, select the ones which contain the k with the lowest n_k.
3. Among the first group of scenes just selected, select the i's for which C_i is the highest.
4. If tie for C_i, select the ones with smallest N_i.
5. If tie for C_i and N_i, select the ones with largest ℓ_i.
6. Select among the remaining scenes the ones which contain k which scores second best with respect to 1 and 2, and so on.

Once all the scenes have been ordered, fill the smallest number of days with the ones belonging to the first group. Then readjust them in order to have the ones containing the second selected actor arranged on one side and the ones with the third selected one on the other side. Try also to obtain the best compactness with respect to all actors within this group of scenes. Pick then the second group of scenes from the list and arrange them on the schedule aiming at maximum compactness within this new group and the previous one. Do so only by carefully placing the ones belonging to the new group. Pick the third group and so on. Fig. 3.7 is a display of data from an hypothetical 30-scenes script. Fig.'s 3.8 and 3.9 compare two schedules obtained respectively by this procedure and by simple careful inspection.

i NUMBER OF THE SCENE	ℓ_i [hrs] EXPECTED DURATION OF SCENE i	N_i HOW MANY ACTORS PLAY IN i	C_i COST OF SCENE i @ ONE SC/DAY	DAILY SALARY [$], S_k: 400	400	200	300	400	200	100	200	200
			NUMBER OF ACTOR, k	1	2	3	4	5	6	7	8	9
			MATRIX OF THE a_{ik}'s									
1	1	1	400	1								
2	1	2	500				4		6			
3	1	1	400					5				
4	1/2	2	500				4					9
5	2	2	500			3	4					
6	2	1	200						6			
7	7	1	100							7		
8	3	3	700	1						7		9
9	2	2	500					5		7		
10	2	2	400						6			9
11	2	1	400		2							
12	3	1	400	1								
13	6	1	100							7		
14	6	2	500				4		6			
15	6	3	800	1			4			7		
16	3	3	1000		2			5	6			
17	3	2	600	1								9
18	7	3	800	1			4			7		
19	1/2	3	1000	1	2						8	
20	2	3	1100	1	2		4					
21	4	1	400					5				
22	1/2	1	400	1								
23	4	1	200			3						
24	4	3	900	1	2					7		
25	4	1	400	1								
26	1	3	800		2				6			9
27	4	1	400		2							
28	3	2	700				4	5				
29	2	3	800	1			4			7		
30	3	1	200			3						
TOTAL = $89\frac{1}{2}$ hrs; TIME = 12 days		TOTAL = 16,100 COST @ ONE SC/DAY		S_k/n_k: 33.34	57.14	66.67	33.34	80.00	33.34	12.50	200.0	40.00
# OF TIMES ACTOR k APPEARS, n_k				12	7	3	9	5	6	8	1	5
FOR A TOTAL NUMBER OF HOURS				36	$16\frac{1}{2}$	9	$29\frac{1}{2}$	13	15	37	$\frac{1}{2}$	$9\frac{1}{2}$
MINIMUM NUMBER OF DAYS EACH ACTOR SHOULD BE HIRED FOR:				5	3	2	4	2	2	5	1	2
AT A MINIMUM PAY OF:				2,000	1,200	400	1,200	800	400	500	200	400

THE MINIMUM COST OF THE MOVIE IS THEREFORE $ 7,100

Fig. 3.7 Set of Data from a Small Script



NOTICE: exchanging the schedules of days 8 and 9, actor 1 gets paid one day less for a saving of $ 400, which brings the cost of the whole schedule down to $ 9,600

TOTAL COST @ 1 SC/DAY = $ 16,100

LOWER BOUND = $ 7,100

FIG. 3.8 SCHEDULE OBTAINED BY USING THE HEURISTIC PROCEDURE

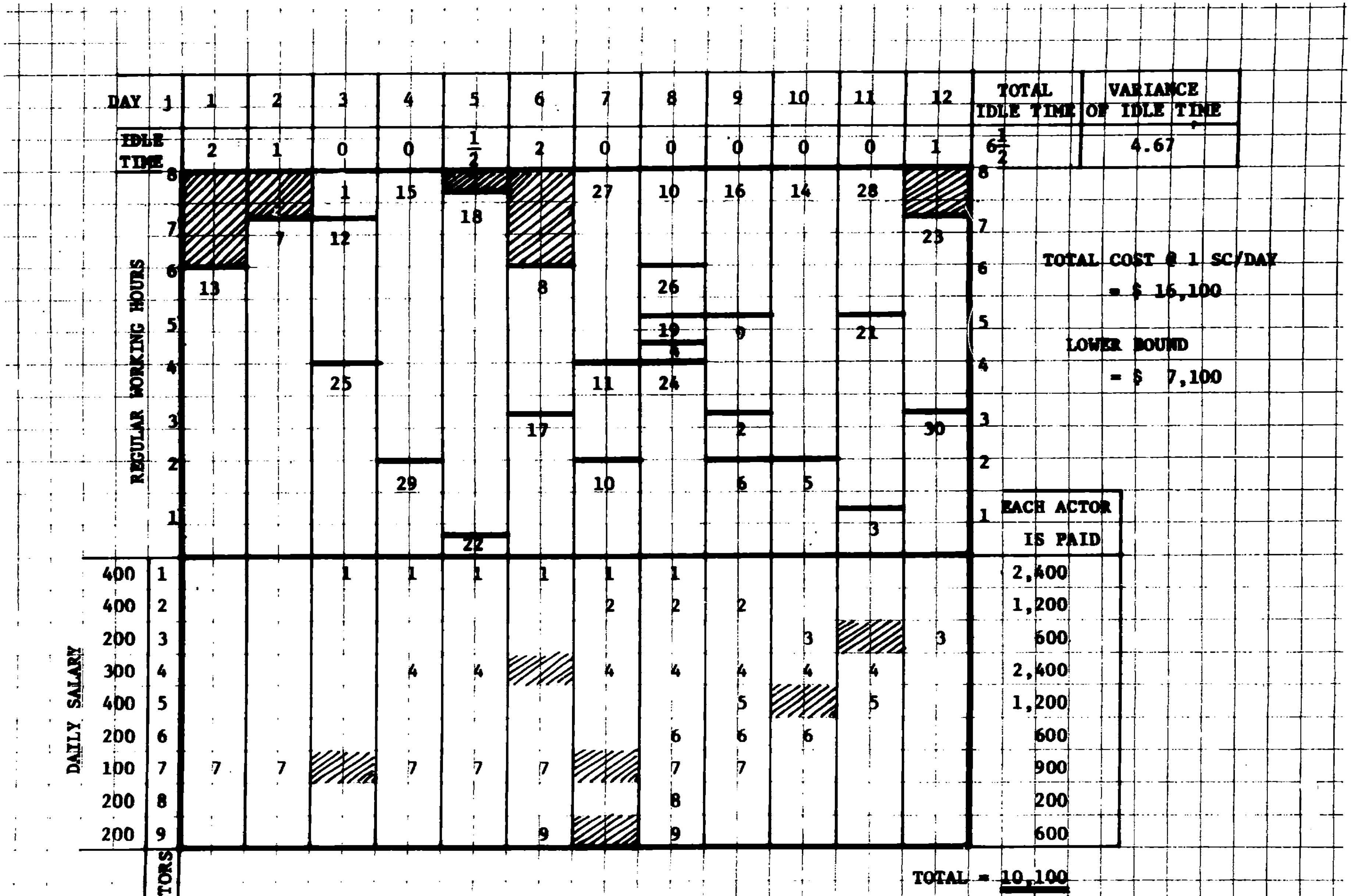


FIG. 3.9 SCHEDULE OBTAINED BY CAREFUL INSPECTION

Conclusions and recommendations for further work

By this work I have shown a series of approaches to the analytical solution of some problems of the motion picture industry. These have been selected among the ones faced by the decision makers of the business throughout the preproduction and the production stage. Lack of data and funds though have prevented me from extending the analysis up to a more detailed level, but any further extension of it should not need more than a straight forward extrapolation of the concepts presented insofar. The only question which may require some particular shrewdness to be solved is the one concerning the size of the models listed. These have generally a number of variables and constraints which is large with respect to the possibilities of the existing computers. This may therefore require some further investigation as far as their formulation is concerned, in order to obtain a reduction of their size.

The next step is necessarily the one of testing the models on small sample problems in order to gain confidence with the analytical tools before attempting a real world implementation of them.

Another topic which is bound to be considered, is the one concerning the problems met throughout the postproduction stage. In fact the analysis of problems such as the one of assessing the value of a picture on hand and of designing its optimal distribution policy, given its value, have a great potential for cost reduction and for increase of profits.

List of References

1. A. William Bluem, Jason E. Squire, The Movie Business, Hasting House, New York, (1972).
2. Michael F. Mayer, The Film Industries, Hasting House, New York, (1973).
3. Paul A. Baumgarten, Donald C. Farber, Producing, Financing and Distributing, Drama Book Specialists, New York, (1973).
4. Stanley J. Brooks, Brooks' Standard Rate Book, (Annually) Stanley J. Brooks & Ass., 1487 Glendon Ave., L.A., Cal.
5. Motion Picture Almanach, (Annually), Rockefeller Center, 1270 Sixth Ave., New York, N.Y.
6. Howard Raiffa, Decision Analysis, Addison-Wesley, MA.,(1970).
7. Gabriel R. Bitran, Admissible points and vector optimization: a unified approach, Ph.D., Thesis, A.P. Sloan School of Management, MIT, Feb. 1975.
8. Samuel Karlin, A first course in stochastic processes, Academic Press, New York, (1969)
9. Said Ashour, Sequencing Theory, Springer-Verlag, Berlin, (1972).
10. L. Gelders, P. R. Kleindorfer, Coordinating Aggregate and Detailed Scheduling Decisions in the One-Machine Job Shop, Operations Research, pp. 46-60, Jan.-Feb. 1972.

11. Richard W. Conway & Oth., Theory of scheduling, Addison-Wesley, Mass., (1967).

12. J. F. Pierce, W. B. Crowston, Tree-search algorithms for Quadratic Assignment problems, MIT., May 1969, 389-69.

13. Robert S. Garfinkel, George L. Nemhauser, Integer Programming, J. Wiley & Sons, New York, (1972).

14. Leon S. Lasdon, Optimization Theory for Large Systems, The Macmillan Co., London, (1970).

15. Elihu Katz, Paul F. Lazarsfeld, Personal Influence, The Free Press, New York, (1965).

16. Chin Long Chiang, Introduction to stochastic processes in biostatistics, J. Wiley & Sons, New York, (1968).

17. Andrew Sarris, The American Cinema, Dutton.

18. Directors Guild of America, Directory of Members, 1972-1973.

19. Producers Guild of America, "The Journal", 8201 Beverly Blvd., L.A., Cal.

20. Variety (Weekly), 154 West 46th St., New York

21. Box Office (Weekly), Associated Publications, 1270 Sixth Ave., Room 2403, New York.

22. Billboard (Weekly), 9000 Sunset Blvd., L.A., Cal.

23. Hollywood Reporter (Daily), 6715 Sunset Blvd., Hollywood, Cal.

24. The Last Days of Babylon?, Forbes, Nov. 1, 1969, pp.65-74.

25. Movie machines that cut production costs, Business Week, Sept. 15, 1973, pp. 204-208.

26. MCA's jubilee year: Oscars and profits, Financial World, June 12, 1974, p. 15.