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*Full Length Research Paper*

# Evolutionary concept, genetic algorithm and exhibition contract in the movie industry

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**The conflict between exhibitor and distributor arises due to the limited number of slots available in the exhibition market, constant new introductions, business relationship and also the downside risk of a film's demand. The inter-connections and the conflicting nature of these factors renders the screen management decision difficult. The study models this complexity on nature, by relating the Post Darwinian natural selection process to the variables involved. It focuses on selection of the fittest exhibition contract among many potential contracts within a given environment. Genetic algorithm is used to perform the search process. The study found that, there are two roles that a contract should perform in order to be chosen besides being the profit maximizer; to encourage play and to share risk.**

**Key words:** Evolutionary selection, genetic algorithm, opportunity costs, learning and sharing rule.

## INTRODUCTION

Economic agents sometimes face a complex situation. Imagine the release decision of a product, vying for limited shelve space with other competing products. The owner has to select a product which maximizes the revenue and reduces the wastage of shelf space. However, when the downside risk of the product is not known, the decision making becomes difficult. There are two possibilities that could arise; if the product turns out to be promising, the opportunity cost is reduced. If the product turns out to be a flop, and since a given contract is binding, the shelf space is wasted and the opportunity to maximize collection is deferred. In the latter case, the opportunity cost is very high. This paper intends to illustrate this complexity in the market, with application to the exhibition contract in the movie industry. The study uses genetic algorithm (GA) to search for an optimal sharing rule which takes into account these complexities to solve the problems faced in theatrical markets.

To see the role of the contract in the industry, we first have to look into the tension which tends to arise between distributor and exhibitor. Tension between distributor and exhibitor occurs when there is an increasing number of movies' vying for the limited slots available in the exhibition market. Particularly, the distributor wants a sufficient time to play a movie, and since prior release demand is not known, premature termination of the run, before the movie can reveal its potential, that is the main concern to the distributor. Accordingly, the distributor will think that if the movie has sufficient time, the revenue stream in the subsequent runs will be higher.

This objective is in conflict with the exhibitor's, when the number of screen and other movies in the portfolio are taken into account. For the exhibitor, if the movie is not generating enough revenue to cover the cost or if the other movies in the portfolio can garner larger audience, the movie should be replaced.

To mitigate the conflict, a revenue sharing contract is drawn to compensate the exhibitor for giving longer run time for the movie. If the collected Box Office is high during the initial run, the distributor's portion in the revenue sharing contract is higher, or the revenue sharing distribution should be in favor of the distributor. This takes into account the opportunity costs that an exhibitor incurs when deciding on the run length of the movie. Larger portion accrues to the exhibitor when the total Box Office is low, this ensures the exhibitor is able to cover the cost, and at the same time discourage early replacement. Our purpose is to relate this dynamic of

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economic forces to the Post Darwinian natural selection process and to search for optimal contract.

Although, the reason for the market behavior, especially the evolution of exhibition contract is explained in the past literature (Chisholm, 1993; De Vany and Walls, 1996; Weinstein, 1998; De Vany, 2002; Filson et al., 2004), the process particularly how the decision is made is not explored in detail. This maybe due to the limitation of the conventional empirical method in accounting for the complexity and the dynamics concerned. This paper is the first attempt to model the movie industry using the evolutionary approach.

The study finds that the exhibition contract plays a very significant role in avoiding premature termination and risk sharing. In particular, the flexibility in rewarding high risk bearer in the initial run of a movie (that is, the distributor) ensures profitability and encourages innovation. This is to avoid overpayment of profit to the exhibitor. When the demand is diminishing, the portion of the profit sharing contract that belongs to the exhibitor increases while the share of the distributor decreases. This is to ensure positive profit levels and to avoid termination. Thus, in the initial run, the high risk bearer, that is, the distributor has a higher share of the gross collected than the exhibitor. While in the end of the run, the exhibitor bears a higher risk than the distributor, thus, the exhibitor is paid with higher share according to the contract.

## LITERATURE ON GENETIC ALGORITHM

The scheduling problem occurs in a large variety of forms and areas of concern, with huge economic and social consequences. The application of GA as a means to search for optimal strategy or space among the potential solutions is because of the size, the complexity of the search space and the stochastic element inherent in a particular circumstance.

For a problem of scheduling with N tasks and with M resources, the number of potential solutions is $\binom{N+M-1}{M-1}N!$ which grows as a super-exponential function of the number of tasks and resources. In addition, to the size of the search space, the dynamics of the tasks also renders the scheduling problem complex; the old scheduling has to be constantly changed and adapted to the new environment. In this case, schedules remain valid only for a limited amount of time, and the new environment revealed in the subsequent periods warrant a new scheduling algorithm to search for different schedules.

The success of GA in solving scheduling problems rests on its flexibility in finding global competitive optima in large and complex search spaces. Some of the early works on GA includes Golberg and Lingle (1985), who invented the order-based representation and the associated permutation operators to solve the traveling salesman problem. The method orders a task (cities) for a single resource (salesman). The information included in the study is that the historical demand of the cities, size and also the track record of the salesman. A similar method is applied in the ordering of tasks of chromosomes by Syswerda (1991) and a similar approach with multiple resources by Bagchi (1991). This order-based approach enables each resource to be given a task to avoid under-utilization and reduce waste.

However, other schedule optimization methods relate to the maximization or minimization of variables rather than the order-based resource allocation. The resource-constraint scheduling problem is analyzed by Gupta et al. (1993) who address an n-job single machine scheduling problem, with the objective of minimizing the flow time variances among the tasks. They categorize the problems into sets of ten problems and use genetic algorithm to search for optimal solution. Angus et al. (2005) describes a planning, scheduling and control system in airport support services companies to achieve effective and efficient operations in the supply chain. A standard genetic algorithm is used to minimize the operational cost and reduce the excessive resources used in aircraft ground support operations. In this scheduling problem, since the timetable is fixed; the flight schedule is fixed; the standard algorithm is used to maximize the utilization of vehicles used in the operations. The variables are completion time for each job, flow time for each job and ready time for each job. Other applications of genetic algorithm include job-shop scheduling by Nakano and Yamada (1991), project scheduling by Nordstorm and Tufekci (1994) and crew scheduling by Levine (1996). This string of research represents the standard genetic algorithm, which intends to optimize a variable or variables rather than the order-based algorithm.

The application of GA to search for solutions is also widespread in financial markets to search for optimal solutions, given the large number of macro-variables. For example, Chidambaran et al. (1999) in option pricing, GA as an optimization searching tool in technical trading applications by Neely et al. (1997), Jones (1999) and Dempster and Jones (2001) in foreign exchange market.

One of the common elements in genetic algorithm is the search of optima solution taking into account all the competitive forces. Some of the factors in the population might be positive, and some may produce negative results. In the paper by Chidambaran et al. (1999), the performance of trading strategy maybe factored by interest rate, which can be either going up or down. The combination of hike in interest rate and the growth potential of gross domestic product (GDP) of a country may render decision making difficult; as interest rate increases implies investment in equities are less profitable than other vehicles of investment.

The use of GA to model movie contracts, especially the exhibition contract, directly addresses the conflicting forces present in the industry. Since the demand of a movie is not known ex ante the decision making process is always contingent to the revealed demand. Therefore, the study needs to search for optima in each discrete time taking into account all the conflicting factors; the opportunity costs of not showing a movie (in this case we need to account for alternative movies which are played in other cinemas), the demand of the existing movie, the exhibition contract and others. Therefore, players (distributors) will have different strategies in each time frame. This is because it has to learn about the demand revealed to streamline the optimizing variable, in this case the exhibition contract.

## Evolutionary concept in movie industry

Movie industry provides a fertile framework for evolutionary thinking in view of the diversity of innovations and the constant interactions and co-ordinations. The creation of new innovations, the demise of the established ones, and the constant shift in importance of surviving films is ever present activities. The meaning of evolution we want to refer to is the developmental idea of the internal unfolding activities and the Post Darwinian evolution of adaptation of populations under the process of competitive selection. Here, the study proposes to connect the economic ideas, especially the constant change in the exhibition market, with the nature of evolutionary concepts. The intention is to show how the evolutionary change; selection, variation, fitness and adaptation can be useful to the study of industry's change.

The central point is that the evolution provides a non-equilibrium account of why the market changes. Evolutionary concepts explain the changing patterns of co-existence among the innovations; the patterns describe the relative importance of these innovations, and how the relative importance changes over time; some are eliminated and others survive in a certain time window. As such, the wide array of innovations in movie industry, and the highly competitive environment provide a perfect framework to apply the concept in the industry.

The implication of the competition in evolutionary terms is two-fold. It replaces the thinking of representative behavior or uniform agents, with one which has myriad of independent and different behaviors. This is the pre-requisite for the evolutionary process to take place. This diversity is caused by the differentiation strategy by the industry players. The ability to adapt to new environment by the players, for example, the various capabilities of players to respond instantaneously to the market demands also plays a role. As a result, it gives birth to the population of movies which are varied in terms of their characteristics, and with selective significance which makes the evolution process possible.

Secondly, in the evolutionary market institution, market competition does not converge to efficiency, in the sense of resources allocation, but rather in terms of adaptation to the new development revealed throughout the run. Therefore, what distinguishes the evolutionary market is its openness to new forms of activity and the ability to eliminate the obsolete ones when a film runs out of its marketability and shelf life.

In conventional equilibrium sense, the changes may converge to a rest point instead, in evolutionary concept, neither the changes of the types of movie nor the box office are attracted to a static reference point. Its arguments provide a significant explanation concerning the relative importance of the agents to the development or the evolving of the characteristics of the industry. For example, the introduction of talkies in the 1930s, the practice of vertical integration of distributors and the exhibitors, blind-booking, the contracting practices and the splitting of revenues between the two parties, all explain that there are two forms of change in the industry; transformational change in the nature of the individual elements in the population and variational change in the composition of the population.

Thus, it is clear that the evolutionary theory is naturally a growth theory; it is about the relative and absolute rates of expansion and contraction, and about how films use resources effectively to optimize revenues throughout the run.

## METHODOLOGY

### Selection in movie industry

Here, we illustrate how the selection process takes place in the movie industry, and how we can analyze the dynamics of the industry from the evolutionary perspective. We begin with an individual movie as a chromosome, which is the combination of genes. When movie interacts and competes in the market place, the success and failure depends on the ``gene" selected.

Gene refers to a particular characteristics or events which belong to a movie, for example, the amount spent on advertising, the share of the exhibition contract, the genre of the movie, the release strategy and so on which characterizes the efforts of agents to capture audience. Different environment requires different strategies and genes. Evolutionary process is a search process to locate a fit genes or a combination of genes to suit a particular situation.

During the run of a film, if an inefficient gene, and consequently an inefficient chromosome is selected, it renders the potential of a movie not fully utilized. For example, if a high-potential film is released in a non-peak season, the potential of the movie will not be fully utilized. In this case, the release strategy is the gene, and this gene causes low payoff. If the release is synchronized with other high-potential movies, which have high cannibalization effect, the film will die prematurely. Thus, again the release pattern and the characteristics of the movie are the genes, and this combination causes the film to die faster. In a competition model of evolution, the units of selection are the sections of chromosome that codes for ``traits" that distinguishes one movie from other movies in the competition to survive. For example, from the first case above, the unit of selection is done on the gene (the release pattern).

The evolutionary selection process is as follows: the survival of a film depends on the type of genes selected. Therefore, industry players have to identify the genes which suit the environment in order to survive the competition. This involves many variables or genes and also a large pool of combinations of these variables. The suitability and its durability in the competitive market is then evaluated with “house nut”, or its ability to generate word of mouth. If the gene is proven to be able to generate large followings, the effort is then adopted, in evolutionary term; the gene is then propagated in the population. Thus, the spread of a particular type of a gene is due to the success of the gene to generate higher payoff than other genes.

**Genetic algorithm (GA) and sharing rule**

The study will perform simulation exercises to illustrate the evolutionary process mentioned above. The study will focus on the sharing rule in the exhibition contract as an example for the case. The study uses GA throughout the simulation exercises.

The population of chromosome is generated to reflect the different potential revenue. Each chromosome represents a particular fitness measure, and a pair of chromosomes is taken from the population to perform crossover and selection. The fitter gene is then passed to the weaker, and the weaker parent is replaced by the child.

The study first randomly generates a population of Box Office revenue each week for a movie. In reality, distributor and exhibitor will take into account the opportunity costs, for example, the potential revenues of other movies in the portfolio, the distribution of revenue and the house nut in deciding whether to continue or stop the play. The combination of all these variables is converted into binary bits to enable crossover and selection. The study focuses on the varying degrees of ratio in the exhibition contract. We intend to find the most profitable sharing rule given the demand of the movie and the other movies in the portfolio.

**Generation of population**

The study generates a random population of revenue for a movie and potential revenue for other movies each week. The combination of these two categories reside 60 bits in a binary string; the first 30 bits reflects the film's demand and the second 30 bits belong to the potential revenue or the cost of not showing the other movie. The feature of the contract resides in the last 10 bits of the binary string.

The study generates 50 binary strings in each population in every week of a film's run, or 50 different combinations of the movie's demand and potential demand. Similarly, the feature of the contract is varied among the population given the demand of the movie.

**Fitness function**

A binary string's fitness is calculated based on the nett demand collected during the run, after deducting the opportunity cost; the potential demand by other films in the portfolio. Specifically, the fitness is written as:

$$Fitness = (BO_i \frac{x}{x+y}) - BO_{I-i}$$

where BO = Box Office of movie i and I is the total number of movies in the portfolio. The sharing contract consists of two parts; the portion accrued to exhibitor (x) and (y) to distributor.

The exhibition contract is flexible; the portion x and y are constantly changed depend on the revenue revealed throughout the run. This is because a flexible contract will ensure a longer run for the film; for if the contract is fixed, whenever the opportunity cost is above that of the film shown, exhibitor will replace the film even before the film can build its leg.

If the contract is flexible, whenever the opportunity cost, the potential revenue from other movies in the portfolio, exceeds the revenue earned by the film, especially in the later run of the film, the portion x is increased to compensate the exhibitor for showing the film. Therefore the life of the film will be stretched and prolonged.

Another reason for the flexible contract is that it reduces the benefits of shirking. If it is a flat rate, the exhibitor will not benefit from extending the week of run, allocating for extra time or number of screenplays, or extra reels for the film which is garnering large followings. The only benefit to the exhibitor in this case is to show many different movies at the same time.

However, if the contract is flexible, the revenue to the exhibitor is very much dependant on the total Box Office collected for the film, thus reducing the benefits of shirking.

In the simulation exercise, the study uses this fitness to calculate the fitness value. The study will first show the search process and the improvement of the overall fitness of the population. To illustrate the practice of the industry, we will then limit the ``x" portion to a certain percentage to reflect the risk level and how it is used to encourage run time.

**Genetic search process**

Crossover allows binary string to exchange information with each other and produce new ``children" in the population. In the population, selection is performed on two strings; fitter string will pass its information to a weaker string in order to improve the new generation. However, in order to search for better or to vary the choices of the individuals, the study allows the new child produced to replace one of the parents. The overall improvement is made possible by this exchange of information from the stronger individual to weaker individual.

The process; crossover and mutation, are performed on the last 10 bits of a string; which contains the information about the exhibition contract. Mutation is performed 0.002 of the time, and crossover is performed when traits from fitter individual replace the traits in the weaker individual. The number of bits is taken randomly from the string of the parent, and pass on to the child. The child will then replace the weaker parent. Fitness is then calculated after the crossover and mutation for each string in the population. The process of the search is performed employing the software, Mathematica.

During the search process, the portion x and y in the contract are changed to suit the bearable risk level and the objectives of distributor and exhibitor. If the initial Box Office is high, then the portion x (that is, exhibitor's share) should be low, and portion y (that is, distributor's share) should be high. This is because the costs borne by distributor (that is, the distribution rental and advertisement costs) are higher than what is incurred by exhibitor. And the fitness function should be in the positive region in order to avoid termination by exhibitor.

After several weeks of the run and when the movie starts to decay, the portion x should be increased. At this stage, the exhibitor bears a higher risk level than in the initial stage of the film's run; the opportunity cost of showing the film increases. Thus, in order to prolong run time, the portion x is increased, and the portion y is reduced.

The study will first illustrate the selection process by using the fitness function. The process searches for the highest payoff among the population. The fitter individual will pass its traits to the weaker individuals, and is allowed to improve on its fitness. To illustrate the industry's practice, the change of the contract is limited to 90/10 (best week clause), 30% for first week and second week, 40% for third week, 50% for fifth week and 60% thereafter. If the Box Office exceeded 10 million, GA will stop its search process at 10% (portion x), and will calculate the fitness. If it is lesser than 10 million, the ``x" portion is limited to 30%, and the fitness value then calculated.

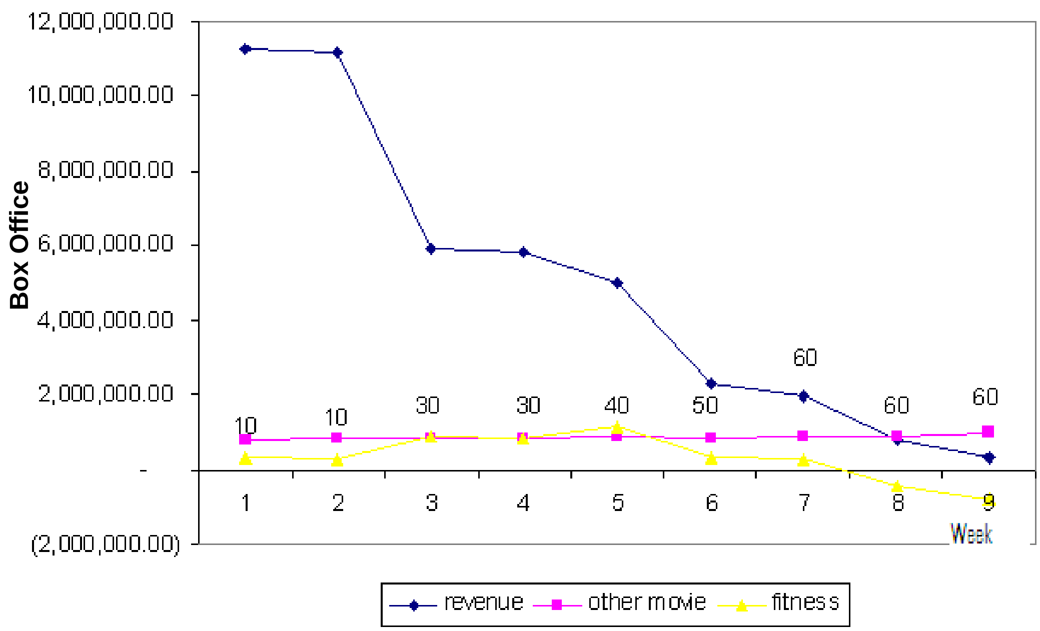


**Figure 1.** The effect of changing contract on extending the length of a film.

## RESULTS AND DISCUSSION

### Contract to encourage play

The exhibition contract allows the distributor to optimize the revenue and at the same time avoid premature termination. This is achieved through searching for positive fitness given the opportunity costs for each film. Figure 1 shows the changing contract and fitness each week of the run. The film attracts high revenue from week 1 to week 7, within which the opportunity cost or the cost of not showing the other film is lower than the revenue collected for the film. This allows the distributor to fix a contract between 10 to 20% and ensure positive fitness or net revenue collected for the exhibitor. Positive fitness allows the film to run for a longer period and at the same time the ratio also avoids the case where the exhibitor enjoys too high returns for the film. However, the exhibitor's share has to be increased to 90% after week 7th as the revenue is declining. The change allows the exhibitor to extract higher revenue from the gross, and induces him to continue the play.

Figure 2 illustrates a changing contract when the film exhibits a strong leg. Opportunity cost is high in the first week of the run. To avoid termination, the distributor will have to allow the exhibitor to enjoy 30% of the collected revenue. This continues to the second week of the run. In week three, 40% of the revenue is paid to the exhibitor. In week four, the Box Office exceeds 10 million, which triggers the best week clause. To avoid too much potential paid to the exhibitor, the contract is changed to 90/10 after house nut. After which, the normal rule applies until week seventh. In this week, the fitness dives to the negative region, and the film is replaced.

### Contract to share risks

The risk sharing element of an exhibition contract is illustrated in our simulation exercise in Figure 1. When the movie is released, the high demand it garnered in the first three weeks of the run should be used to compensate the high cost bearer, in this case the distributor. During this interval, ``Best week clause" and ``Holdover clause" are triggered to compensate the distributor. Lower risk bearer, the exhibitor, is compensated by lower portion of the total revenue collected. Based on the fitness or net revenue accrued to the exhibitor, it should be able to cover the opportunity cost or the reservation utility which are derived from the cost of not showing other movies in the portfolio.

However, the opportunity cost of the exhibitor rises in the subsequent runs of the film. This requires higher compensation to justify for the longer run life. After 7th week of the run, the opportunity cost of not showing other movies increases, that is, the risk borne by exhibitor increases, and therefore, it deserves a higher reward for showing the film. Similarly, to encourage run length, exhibitor should be rewarded in accordance with the risk they bear. In Figure 2, high opportunity cost in the first week of the run requires distributor to allow exhibitor to enjoy larger portion of the revenue. The risk drops after the film is revealed to be able to garner large followings, and therefore, the payment accrued to the exhibitor

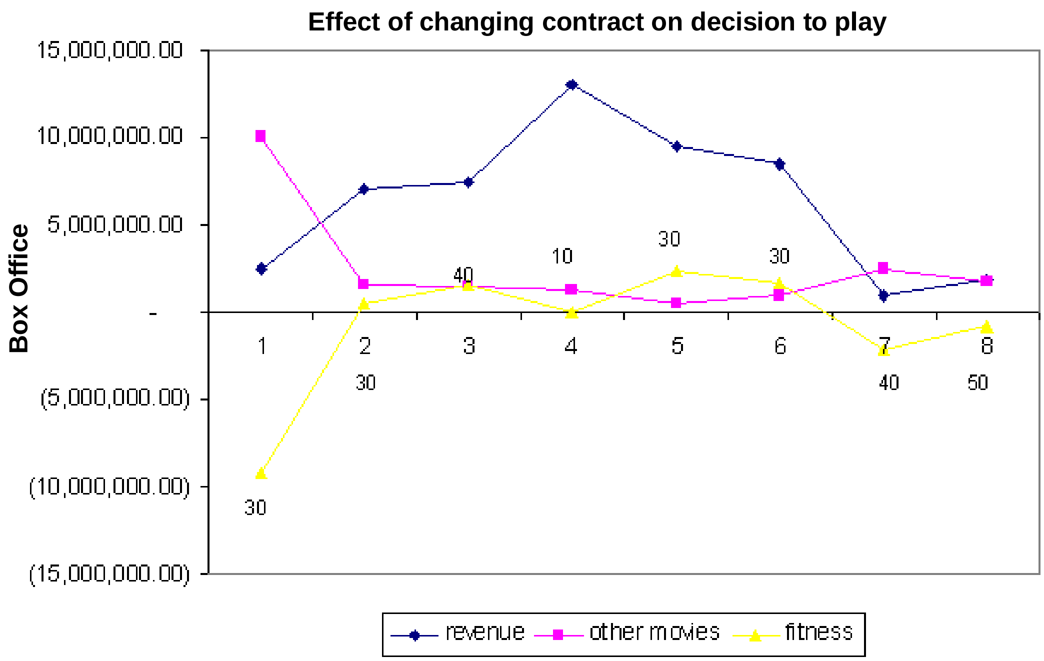


**Figure 2.** The effect of changing contract on extending the length of a film (when the movie exhibits strong strength.

diminishes. The risk gradually increases after the 6th week of the run, and based on the risk sharing rule, it would give the exhibitor a larger share of the revenue collected.

## CONCLUSION

The paper suggests an evolutionary approach to the study of movie industry. This application to model the complexity leads us to relook into the economic behavior which is usually analyzed following the reductionist approach. The study argues in the paper that the complexities; interdependency of heterogeneous market agents, constant interactions and learning, present a constantly reinforcing effect, which renders the decision making dynamic and non-converging. This environment, requires one to employ a different methodology to analyze the decision making process. The paper is the first to relate dynamics in movie industry to nature.

Due to limitation of data, particularly data on real sharing rule, cost of production, house nut and also advertising cost, we only take into account the opportunity cost to illustrate the conflict between players. Future research incorporating the variables could improve the results further.

The fitness function is written as:

$$\left(BO_i \frac{x}{x+y}\right) - BO_{I-i},$$

where I= 2 and when $x$= 0.1 if $BOi$> 10 $m$, and if $BOi$< 10 $m$, $x$= 0.3 in first and second week, $x$ = 0.4 in third week, $x$ = 0.5 in fourth week, and $x$ = 0.6 in fifth week.

During the search process by GA, the constraint of the percentage is set, and the less than optimal contract is replaced. For example, during the first two weeks of the run, GA will stop at $x$= 10%, and those with $x$< 10% or $x$> 10% will be replaced. The purpose of the process is to search for the most optimal contract, at the same time ensures positive fitness of this selected contract and has to ensure not too much of the revenue is paid to the exhibitor. Note that if the fitness falls to the negative region, it means that with the given contract, the revenue cannot cover the opportunity cost. It means the movie will be replaced.

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