Evolutionary Concept, Genetic Algorithm and Exhibition Contract in Movie Industry

Kean Siang Ch'ng

University Science Malaysia

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keansiang168@yahoo.com.hk

Abstract

The paper is about application of evolutionary concept, particularly the application of natural selection process, to the study of movie industry. The importance of the application is that it allows for the heterogeneity and interdependency of market agents in analyzing the economic choice decision. This complexity always presents an obstacle to the study of market behavior, especially when one has to take into account the constant reinforcing effects among the variables, which often renders the problem elusive. The paper intends to explain the economic process, taking into account this complexity through the use of evolutionary concept.

Keyword: Evolutionary selection, opportunity costs, learning and sharing rule.

1 Introduction

Economic problems usually do not follow the reductionist approach, rather, the analysis on economic choices sometimes requires us to look into the interconnectedness and heterogeneity of agents and the process these choices are made. In this situation, the diversity at the micro level, the interrelatedness, and the adaptive behavior become crucial to the analysis.

This paper intends to illustrate this complexity in the market, with application to movie industry. Our purpose is to relate the dynamics of economic forces to the Post Darwinian natural selection process. The dynamism rests on the interaction among the diverse agents in the market. Each time when a new film is introduced, it is tested with the existing environment; the incumbents and the movie goers' taste. Some films die out from the race, and others stay on. The incumbents are then tested with new innovations again. Given the limited number of screens to show the large number of new introductions, the process of introduction and replacement is rapid and the competition is stiff. Thus, the industry agents, the distributor and exhibitor, have to constantly alert of the trend of demand, the performance of the competitors, the type of word of mouth spread in the market and other information, in order to update their business strategies. This involves one to take into account the diverse information available, pick and assess all the information, in order to search for an optimal choice to suit the environment revealed during that time. Thus, this requires one to learn. The learning process is what we intend to explain in this paper. We apply an evolutionary approach to illustrate the natural selection process of business strategies; weaker strategies are replaced with fitter ones, given the information available at that time.

Although the reason of the market behavior, especially the supply decision is explained in the past literature, the process, particularly how the decision is made is not explored in detail. This maybe due to the limitation of the conventional empirical method to account for the complexity and the dynamics concerned. This paper is one of the first attempt to model the movie industry using evolutionary approach, therefore, a number of methodological issues may arise. The paper is to stir discussion on the methodological aspects, especially related to movie industry.

The paper is divided into five sections. Section two relates the evolutionary concept, particularly the process, selection, mutation and replication, to the movie industry. Section three illustrates the process of Genetic Algorithm as a tool to implement the process, and search for optimal strategy. Section four analyzes the results, and section five concludes.

2 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 coordinations which characterize the industry's growth. The creation of new innovations, the demise of the established ones, the constant shift in importance of surviving films are 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. In this subsection, we propose 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 aid 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 implications of the competition in evolutionary term 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 prerequisite 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 capability of players to respond instantaneously to the market demands also plays a role. As the 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, explain 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.

2.1 Selection in Movie Industry

In this sub-section, 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 an entity, which is the combination of genes or modules. 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. So in each environment or time of consideration, there are different genes, and each combination or schema gives different payoff. So, there is a pool of schemata from which the industry players can choose. Evolutionary process is a search process to locate a fit schema from the library of schemata.

We next define movie as an interactor in the market place. During the interaction and competition process, if an inefficient gene, and consequently an inefficient schema is selected, it renders the full potential of an *interactor* not fully utilized. For example, if a highly potential film is released in a non peak season, it will cause the potential of the movie not fully utilized. In this case, the release strategy is the gene, and this gene causes low payoff. Or in another case, if the release is synchronized with other high potential movie, which has high cannibalization effect, the film will die prematurely. Thus, again the release pattern and the characteristics of the movie are the genes, and their combination or schema causes the film to die faster. In an evolutionary dynamic implementation, it is interactor which interacts with other interactors. And the factors which decide living and dying of the interactor are the selection of genes and combination of these genes or schema in the ongoing evolutionary dynamic process.

In a competition model of evolution, the units of selection are the sections of schema that codes for "traits" that distinguishes one interactor from another interactors in the competition to survive. For example, from the first case above, the unit of selection is done on the gene (the release pattern).

Natural selection process will alter the gene and the schema. Through selection and replication; stronger gene and schema which can endure the competition and propel the movie will be remained and subsequently replicated. For example, if time is discrete, and there are many combinations of genes in a particular time. Each of this combination gives different payoff, and therefore, schema with higher payoff will be selected to pass its traits to other schema. The process will continue until the payoff of each schema is same.

2.2 Propagation of Genes

The survival of film depends on type of genes and schema selected by the agents. Therefore, industry players have to identify for schema which suits the environment in order to survive the competition. This involves many variables or genes and also large pool of combination of these variables or schema. This requires effort to look into the many effects of the genes from other movies on the film's performance, and make adjustment or selection from the pool of genes to be taken to suit the environment. Therefore, selection process is carried out to choose the most dominant or satisficing strategy even before the film is released.

After the schema is decided, which usually takes into account the potential revenue against "house nut", the cannibalization effect and marketability, the film is then run with other conpetitors. Thus, genes or schema selected are used to assess its suitability against environment revealed. For example, the gene (wide release pattern) is tested with the existing word of mouth of the movie. If the gene (wide release pattern) is proven to be able to generate large followings, the effort is then adopted by the agents, in evolutionary term, the gene is then propagated in the population. Thus, the spread of a particular type of schema throughout the society or in a macro level is due to the success of the gene to generate higher payoff than other genes.

3 Genetic Algorithm and Sharing Rule

We will perform simulation exercises to illustrate the evolutionary process mentioned above. We will focus on the sharing rule in the exhibition contract as an example for our case. We use Genetic Algorithm throughout the simulation exercises.

This section intends to find the most profitable schema among the population of schema using Genetic Algorithm. The population of schema is generated to reflect the different potential revenue of each stream. Each schema contributes to the derivation of fitness, and a pair of fitness are taken randomly from the population to perform crossover and selection. The fitter's gene is then passed to the weaker, and the weaker parent is replaced by the child.

We first generate a population of Box Office revenue each week for a movie. In reality, distributor and exhibitor will take into account the opportunity costs,e.g. the potential revenues of other movies in the portfolio, the cannibalization effect from competitors, the distribution of revenue and the house nut in deciding whether to continue or stop the play. The combination of all these variables are converted into binary bits to enable crossover and selection.

3.1 Distributor v.s Exhibitor

Tension between distributor and exhibitor occurs when there are increasing number of movies vying for the limited slots available in the exhibition market. This limits the run length and number of screen of a movie. It therefore, requires effective screen management to maximize profit.

The dilemma is obvious when we investigate the objectives of distributor and exhibitor. Distributor would want 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 is main concern to the distributor. Further argument is that, if the movie has sufficient time, the revenue stream in the subsequent runs will be higher than it is terminated early.

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 exhibitor, if the movie is not generating enough revenue to cover the cost (house nut) or the other movies in the portfolio can garner larger audience, the movie should be replaced. Thus, the screen management decision usually takes the effects of potential of other movies, seasonality, and the revenue stream of the movie into account.

To mediate the conflict, revenue sharing contract is drawn to compensate exhibitor for giving longer run time for the movie. If the collected Box Office is high during the run, distributor's portion in the revenue sharing contract is higher, or the revenue sharing distribution should be in favor of distributor when the Box Office is low. This takes into account the opportunity costs that a exhibitor incurs when deciding on the run length of the movie. Large portion accrued to exhibitor when the total Box Office is low, enables exhibitor to cover its cost, and at the same time discourage replacement.

In the first simulation in the following, we intend to investigate the characteristics of the changing contract given the demand revealed throughout the run and the opportunity cost of not showing other films. We intend to find how the changing contract can ensure longer run length and when exhibitor should consider replacement strategy.

We generate population of revenue stream each week for a movie. The decision to whether stop or continue a movie depends on the potential revenue from other movies in the portfolio and the exhibition contract between exhibitor and distributor. A movie will be replaced if the potential of other movie in the portfolio is larger. In this subsection, we assume that available strategies are varying degrees of ratios in contract. We intend to find most profitable sharing rule given the demand of the movie and the other movies in the portfolio.

3.2 Generation of population

We generate 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.

There are total of 70 bits in a binary string, which contributes to a schema; a combination of demand, potential demand and a distribution contract. The feature of the contract resides in the last 10 bits of the binary string.

We generate 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.

3.3 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:

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

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

3.4 Genetic search process

Crossover allows binary string to exchange information with each other and produce new "children" in the population. In our 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, we allow the new child produced to replace the one of the parents. The overall improvement is made possible by this exchange of information from the stronger individual to weaker individual.

The crossover is performed on the last 10 bits of a string; which contains the information about the sharing rule in the contract. Fitness is then calculated after the crossover for each string in the population. 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.

4 Results and discussion

4.1 Contract to encourage play

After the film is released, distributor faces a dilemma between increasing the revenue and shortening the run length; if the objective is to increase the revenue on a particular week through extracting higher revenue from the contract, exhibitor's share will be lower and thus distributor risks early termination of his film. On the other hand, if distributor allows higher share to the exhibitor, the share accrued to the distributor is lower and thus cannot cover the costs. To solve this dilemma, distributor would want to find a sharing contract which could help maximize the revenue and at the same time avoid premature termination.

Given the revenue revealed and the opportunity costs, and the constraint faced by the distributor, distribution contract should be able to ensure positive fitness or real revenue collected by exhibitor. We use the method Genetic Algorithm to search for the satisficing contract among the population of contracts each week. The contract revealed through the method should be able to maximize the revenue collected by the distributor and also avoid termination by the exhibitor. Figure 1 through figure 8 exhibit the change of fitness through crossover and replacement of gene among the populations for generation 10 to generation 200. The method reveals which contract, given the opportunity costs and the gross revenue collected, ensure positive fitness or real revenue to the exhibitor and therefore, how large the portion of the revenue should be collected by distributor. In the first week of the run, as shown in figure 1, gene of individual contract in the population is selected and replaced by the new individual produced from the crossover and mutation. Since one of the parents quality gene is passed over to the child, better new generation is produced progressively throughout the generations. This new generation should be able to ensure positive fitness but would not allow for too much real revenue to the exhibitor to avoid exhibitor from enjoying highest potential of the film.

Although if the gross collected exceeds one million per week, the exhibitor's portion is fixed to be in the region 10% and 30% and if less 70% to 80%. To avoid too much of the potential enjoyed by the exhibitor, distributor will seek for most optimal contract which ensure profitable run for the exhibitor and larger portion enjoyed by himself. Thus, Genetic Algorithm reveals the different contract in different revenue collected and opportunity costs throughout the film's run. In the figures, some individuals in the population are able to progress to higher fitness, and those not able are facing high opportunity costs, which renders the fitness to be stagnant. As in figure 3, the fitness in the population is not improved as in other figures, because the opportunity cost for each situation is high, and therefore, fitness cannot be improved after 200 generations.

The distribution contract allows 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

9 exhibits 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 distributor to fix a contract between 10% to 20% and ensure positive fitness or nett revenue collected for the exhibitor. Positive fitness allows the film to run for longer period and the ratio avoids exhibitor from enjoying too high the potential of the film. However, the declining revenue after week 7th increases the contract to 90%, which belong to the exhibitor. The change allows exhibitor to extract higher revenue from the gross, and induce him to continue the play.

Figure 10 illustrates a changing contract when the film exhibits a strong leg. Opportunity cost is higher than the revenue collected in the first week of the run. To avoid termination and ensure play, distributor allows exhibitor to enjoy 90% of the collected revenue. This continues to the third week of the run. The strong leg exhibits by the film allows distributor to lower the contract benefit to 20% in the forth week, and still the fitness is in the positive region. This continues to fifth and sixth week of the run. In week 7, distributor increases the benefit to 90%, to induce exhibitor to continue play the movie.

4.2 Contract to share risks

The variability of demand is the main concern of the risk sharing contract. In the paper by Hanssen (2002) and Filson et al (2004) argue that the unpredictability of demand *ex ante* rules out the theory of asymmetric information. Furthermore, the arrival of talkies or sound in 1930s renders the change of production structure in the studio; before sound, movies are identifiable through roster of stars employed on the studio's payroll and the demand is predictable. Its introduction increases the production costs and concerns of studio's downside risk.

This high unpredictability also worries the exhibitor if he rented the film for a flat fees. If the film is rented out a flat fee to the exhibitor, the downside risk is transferred from studio to exhibitor. In the event of high budget flop, it will wipe out the entire stream of revenue which the exhibitor collected. Thus, risk sharing contract requires distributor and studio to share portion of the risk with the exhibitor.

Before sound, input from exhibitors contributed to the success of a film, through the life music accompanied during the play. In the era, exhibitors became the large residual claimant of the revenue collected, and film was rented out with a flat fee. Flat rental fee prevented shirking from exhibitor. However, with the advent of sound, risk sharing contract became the norm. The attraction of a film is no longer depends on the life sound staged by the exhibitors; people go to see movie because of the film itself. This reduces the benefit for shirking. In the sound era, allowing exhibitor to share the revenue encourages him to continue the play, and compare with flat fee, it discourages pre mature termination. Thus, sharing contract eliminates benefits for the exhibitor to shirk, and compensates him through taking the risk of prolonging the life of a film.

The risk sharing element of an exhibition contract is illustrated in our simulation exercise in figure 9. When the movie is first released, the high demand it garnered in the first three weeks of the run compensates the high risk averse party, in this case is distributor. During this interval, "Best Week Clause" and "Holdover Clause" are triggered to compensate the high risk party. Lower risk averse party, the exhibitor, is compensated with lower portion of the total revenue collected, which are in the 20% region. 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, i.e. the risk borne by exhibitor increases, and therefore, it deserves a higher reward to showing the film. Similarly, to encourage run length, exhibitor should be rewarded with accordance with the risk they bear. In figure 10, 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 diminishes. The risk gradually increases after the 6th week of the run, and based on the risk sharing rule, it would given larger share of the revenue collected.

Thus, the revision of the dynamic distribution contract is based on the apportionment of the risk between the parties. With assumption that the opportunity cost is not constant, due to the new introduction of new products, our simulation result shows the concave sharing rule.

5 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 the economic behavior which are usually analyzed follow the reductionist approach. We argue in the paper that the complexities; interdependency of heterogenous 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 the nature, and it would create much methodological concerns. Its purpose is to stir discussion on the evolutionary concept, particularly its application to the study of movie industry.

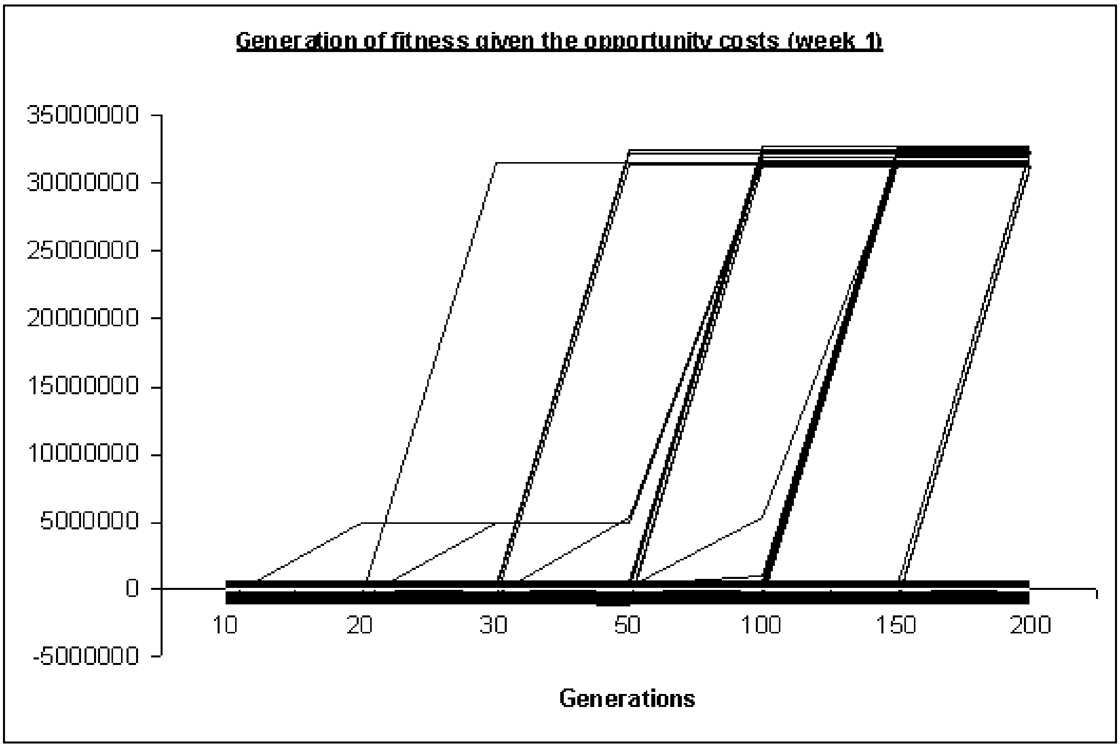

Figure 1: The change of fitness in generations given the potential revenues for other movies (week 1)

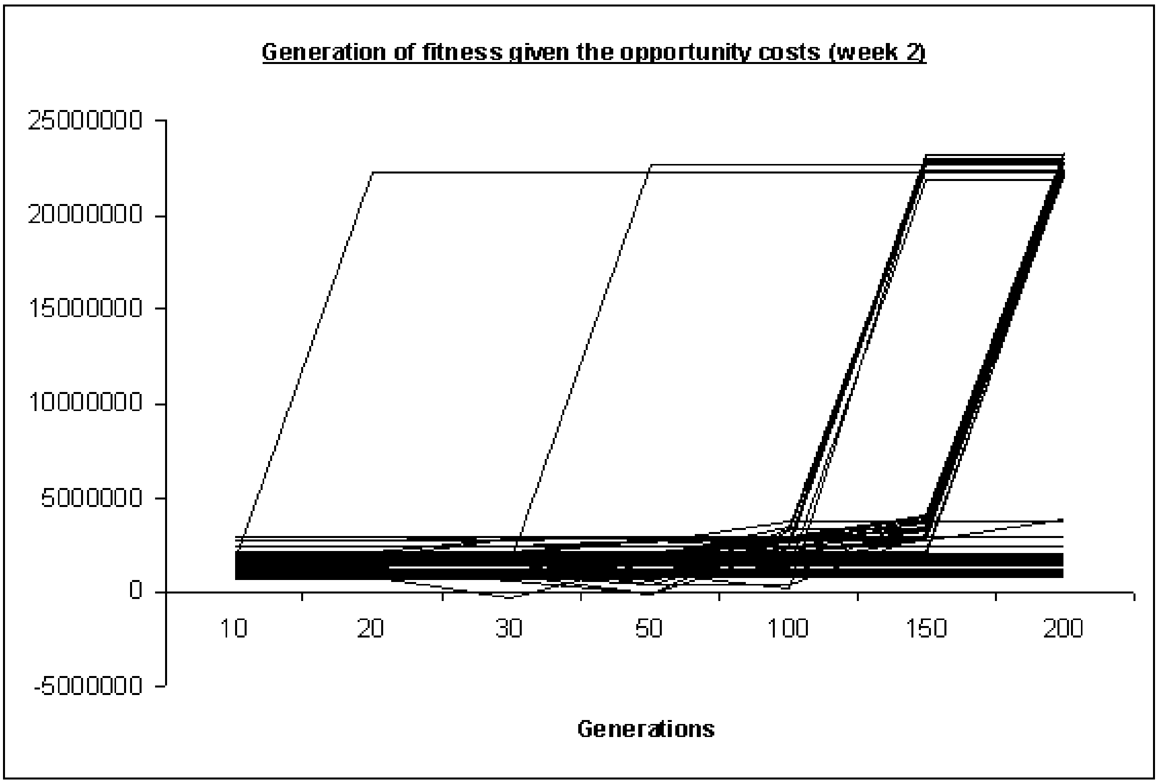

Figure 2: The change of fitness in generations given the potential revenues for other movies (week 2)

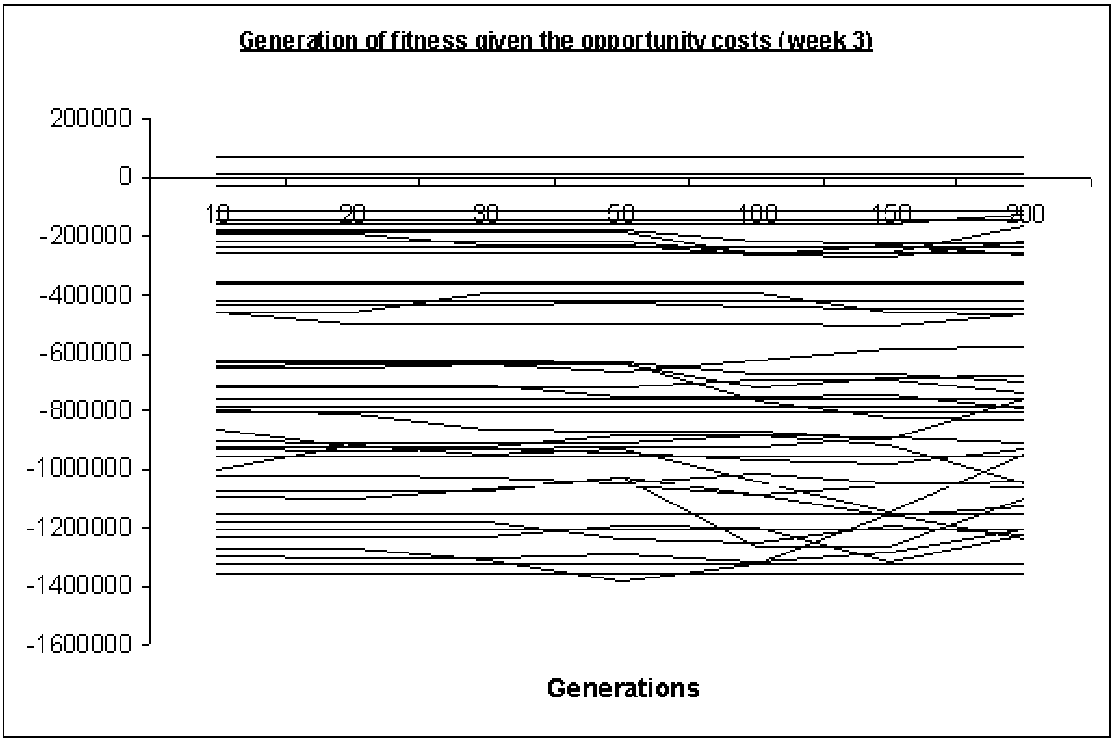

Figure 3: The change of fitness in generations given the potential revenues for other movies (week 3)

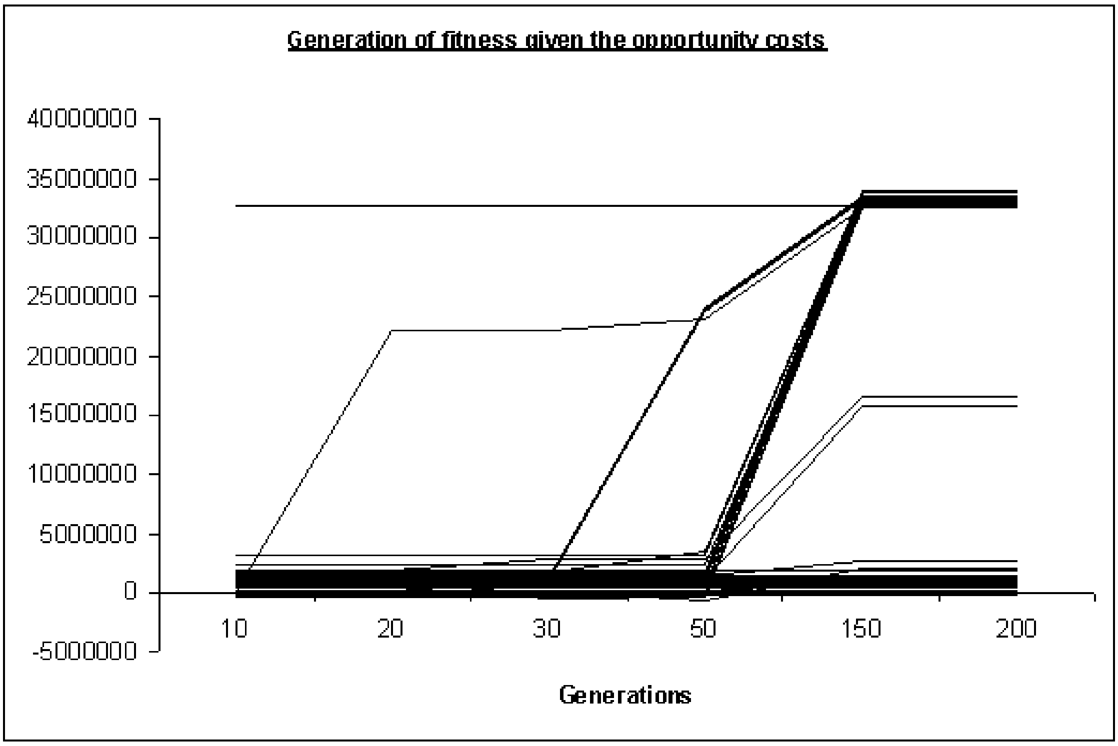

Figure 4: The change of fitness in generations given the potential revenues for other movies (week 4)

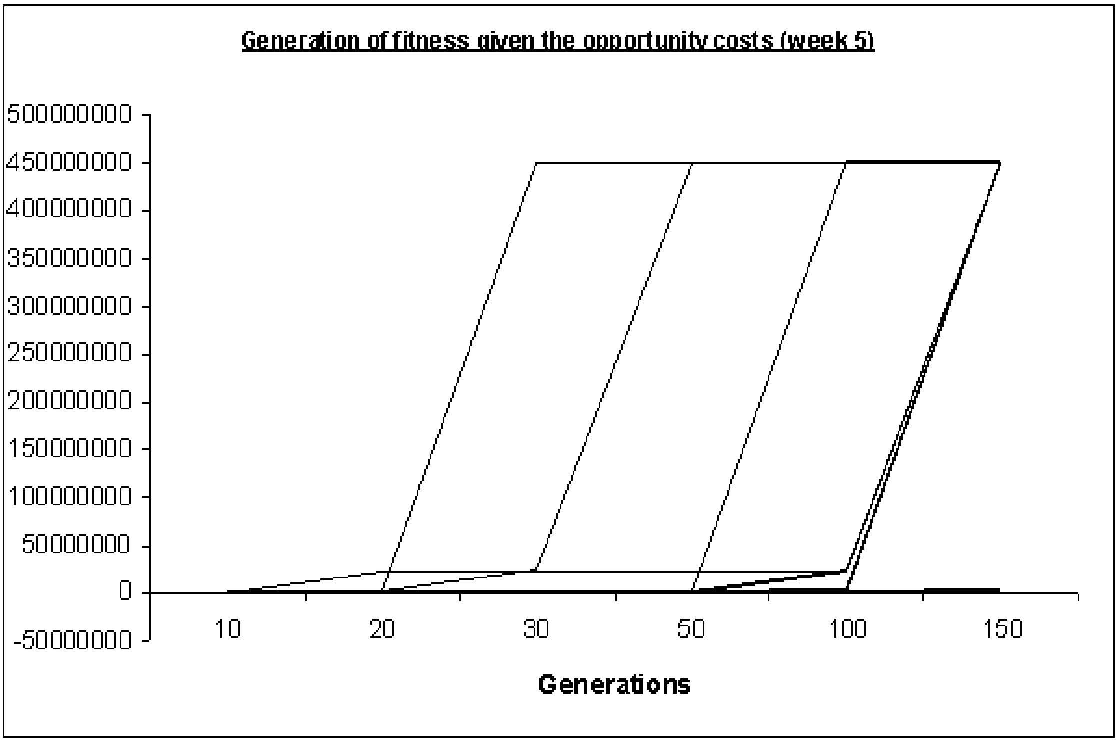

Figure 5: The change of fitness in generations given the potential revenues for other movies (week 5)

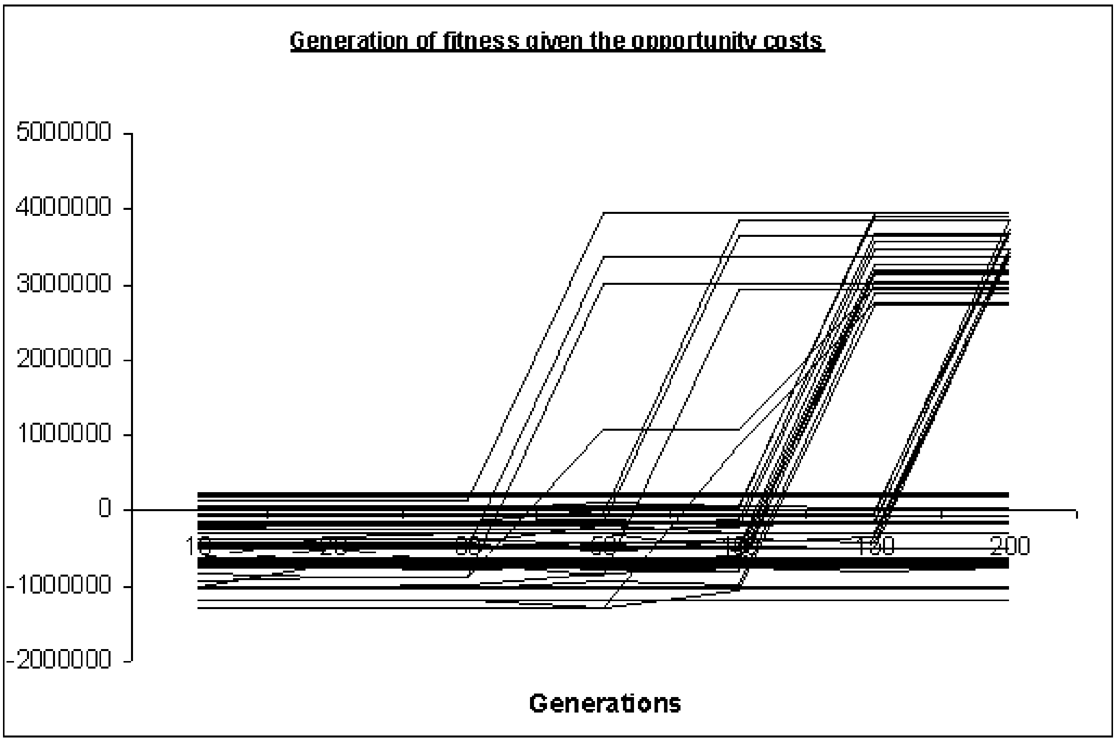

Figure 6: The change of fitness in generations given the potential revenues for other movies (week 6)

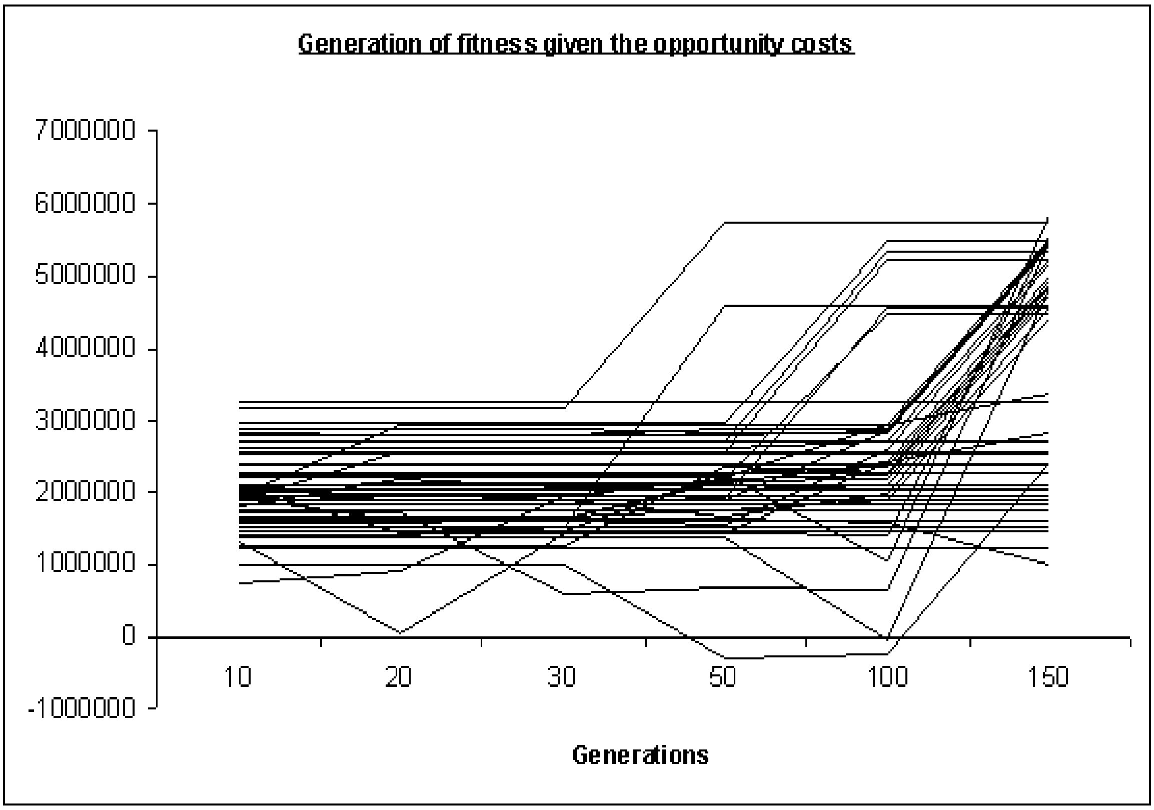

Figure 7: The change of fitness in generations given the potential revenues for other movies (week 7)

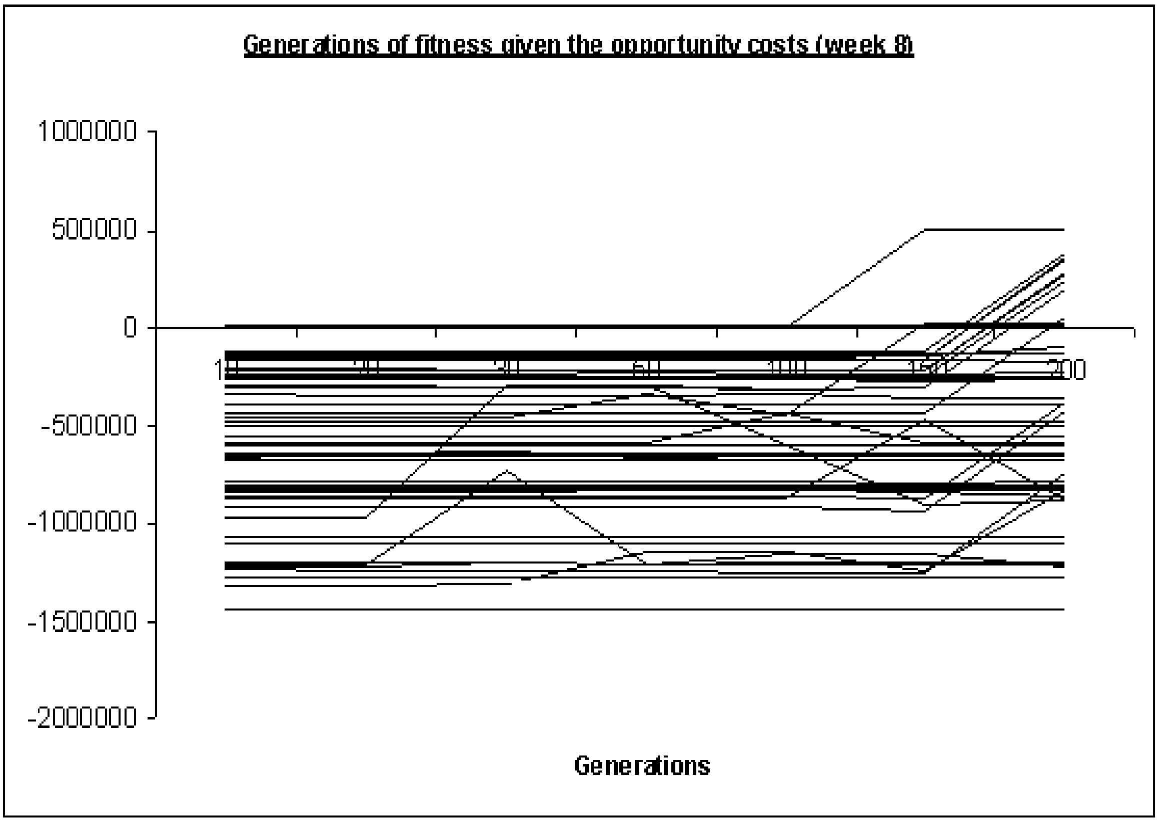

Figure 8: The change of fitness in generations given the potential revenues for other movies (week 8)

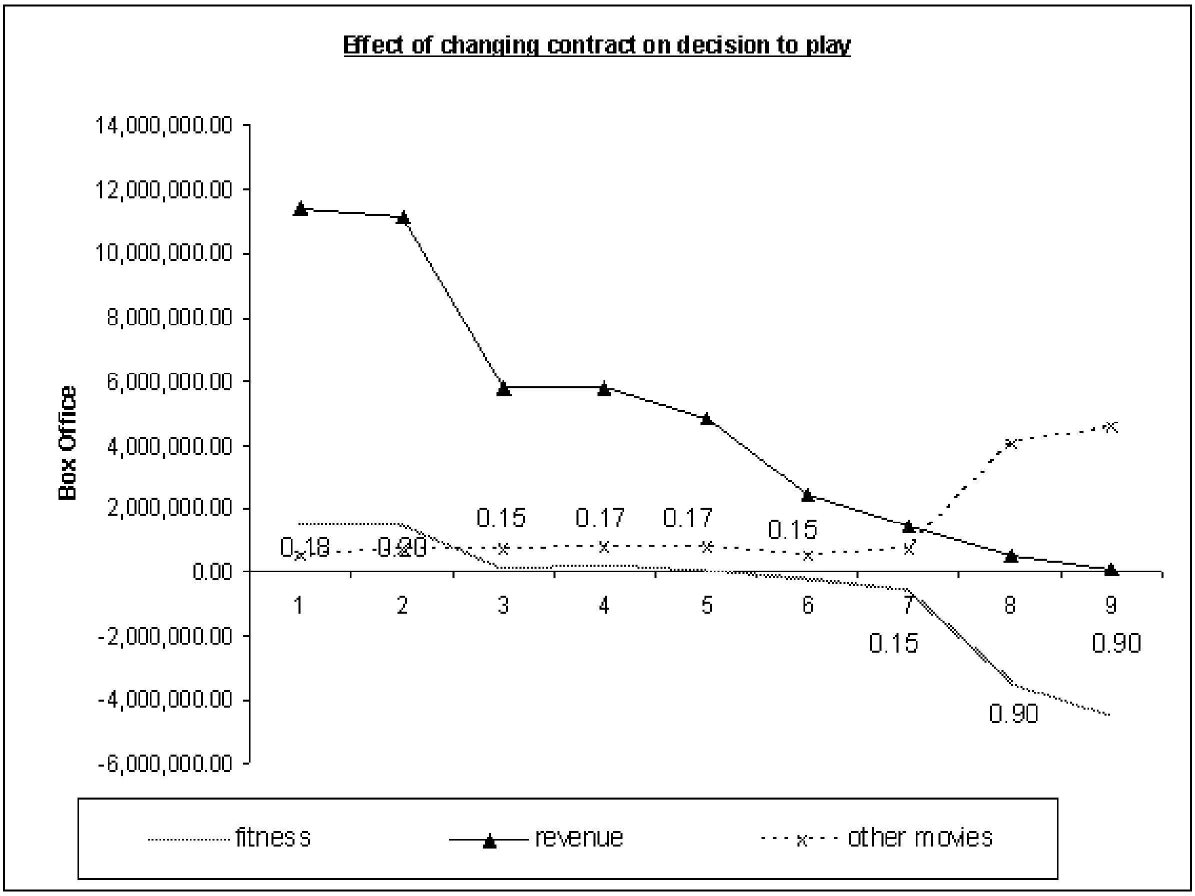

Figure 9: The effect of changing contract on extending the length of a film. The fitness function is written as $(BO_i \frac{x}{x+y}) - BO_{I-i}$, where $x = 0.1$ if $BO_i > 10m$, and if $BO_i < 10m$, $x = 0.3$ in first and second week, $x = 0.4$ in third week, $x = 0.5$ in fourth week, and $x = 0.6$ in fifth week. During the search process by GA, the constraints 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, and at the same time ensures positive fitness of this selected contract. Note that if the fitness falls to negative region, means that with the given contract, the revenue cannot cover the opportunity cost. It means the movie will be replaced.

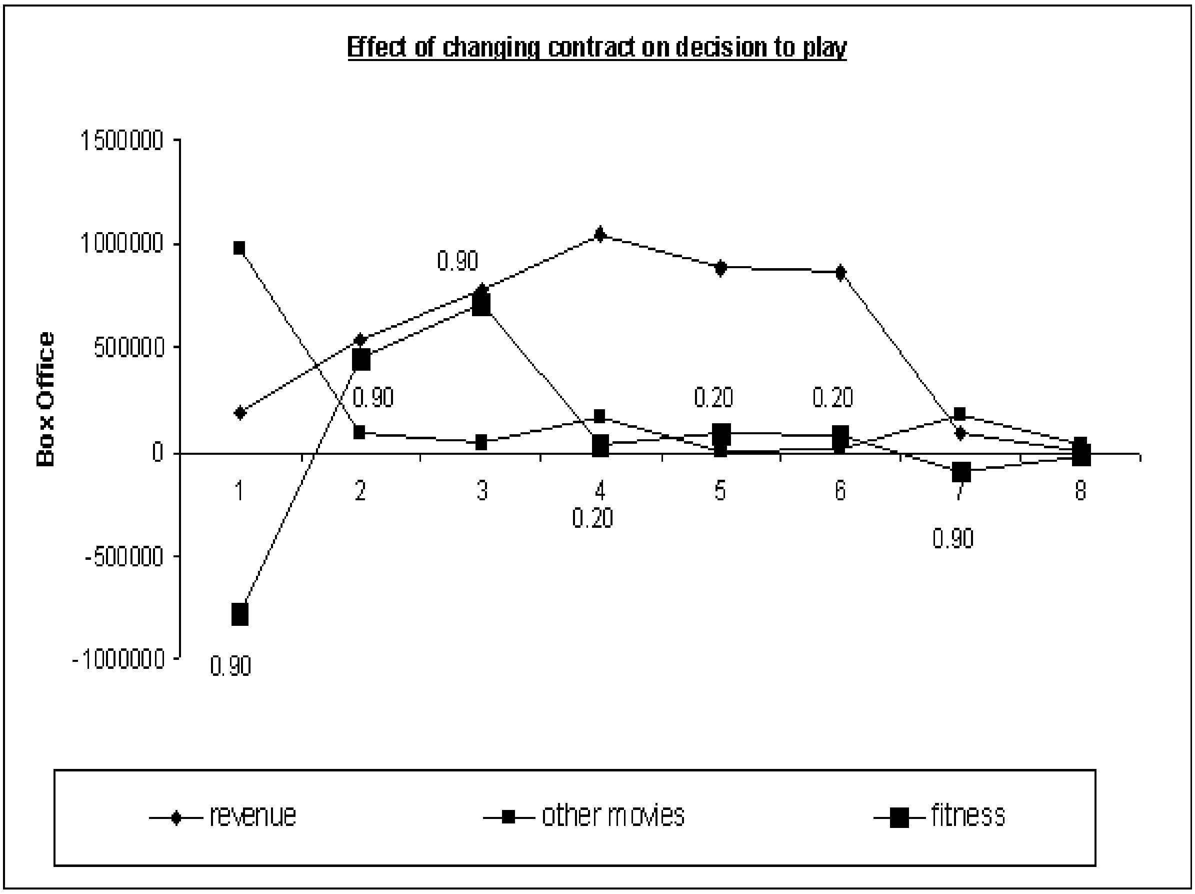

Figure 10: The effect of changing contract on extending the length of a film (when the movie exhibits strong strength

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