Hindawi
Discrete Dynamics in Nature and Society
Volume 2018, Article ID 7521689, 10 pages
https://doi.org/10.1155/2018/7521689

Research Article

Goodwill and System Dynamics Modeling for Film Investment Decision by Interactive Efforts

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Received 8 May 2018; Accepted 26 August 2018; Published 13 September 2018

Academic Editor: Lu Zhen

Academic research pertaining to the marketing of film industry has identified advertising, film-making, and star power as the important factors influencing a movie's market performance. Prior research, however, has not investigated the joint influences of these factors. The current study has extended previous research by analyzing the investment decision of studios or investors. In order to analyze the optimal film investment decision in advertising, film-making, and stars power, this paper develops a goodwill model and system dynamic (SD) model, which allow us to disentangle the effects of advertising, film-making, and star power on film market performance. The results show that the film producer should increasingly lay emphasis on investing in advertising to absorb moviegoers' attention. Then the film producer should focus on investing in film-making when film quality has a great impact on the movie's reputation and audience's viewing decision. Furthermore, the film producer should pay more attention to the higher cost-performance stars who have more reasonable remuneration, better acting skills, and bigger box-office guarantee. Moreover, the numerical analysis reveals that rational audience contribute more than fans to a movie's box-office and bankable stars contribute more than high-profile stars to a movie's returns. Through SD simulation analysis, the film series yields higher profits than new theme movies although the cost of investment is the same.

1. Introduction

In the film industry, the investors are expected to make the best decisions involved in lots of funds in the shortest possible time [1]. According to Schwartz [2], "Industry estimates reveal that 60 percent or more of movies produced each year are box-office flops, those that do resonate with viewers can generate a pretty penny for investors". There are some cases where promising movies show poor box-office performance, and inconspicuous movies show unexpectedly good results [3]. "Make no mistake" shows that investing in films is a risky business [4–8]. If investment decisions fail, the costs of these mistakes for consumers are only the ticket price and an opportunity cost, but the costs for investors or producers are highly expensive [9]. Success (or mere survivability) largely depends on quickly aligning the organizational resources, like genre, director, super stars, advertising, technical effects, release time, etc. [1, 10]. The main factors affecting the financial success of a movie are of great use in making investment decisions. The film industry uses different hallmarks of quality in an attempt to control the level of uncertainty. We will categorize the factors contributing to film investment observed in the documents into three main effects: the advertising effect, film-making effect, and the star power effect.

The advertising effect refers to the fact that studios promote their own movies to increase the number of moviegoers and the box-office revenues through advertising channels, such as the release conference, the titbits, the trailers, and show tours. Nowadays, there are multiple channels, both online and offline, for advertising delivery. Typical examples are Weibo (microblog), WeChat, variety show, and outdoor billboard [11]. Frequent new product introductions and rapid turnover lead movie studios to advertise heavily. Movie advertising is an effective measure to influence consumers' quality perception [12]. It has been confirmed by previous scholars that advertising plays a crucial role in a movie's success. [13–15]. During the movie's prerelease period, advertising would inform viewers of the movie's characteristics and signal potential studio profit ability to investors. What is

more, effective movie advertising can not only lead to success (or failure) of a single movie at the box-office, but also result in an increase (or decrease) of the releasing studio's market value. [16]. Therefore, advertising effect is the first important factor contributing to film investment.

The film-making effect refers to factors including an initial story or idea through screenwriting, casting, shooting, sound recording and reproduction, editing, and screening the finished product before a movie showing. A quantitative approach using a combination of screenwriting domain knowledge, natural-language processing techniques, and modern statistical learning methods will help studios evaluate scripts and improve a movie's gross return on investment [17, 18]. Compared with advertising and star power, the film-making gives more direct impact on a movie's word-of-mouth in the eyes of the audience. For example, the top three movies—Star Wars, E.T. the Extra-Terrestrial, and Titanic—had no stars, but it is the movie itself—not the star—that makes the success [19]. The word-of-mouth, known as the passing of information from person to person, is a method used by consumers to express their experiences and feelings about a brand, product, or service without intending to take part in marketing and promotion [20]. Since movie is a kind of good experience, potential consumers may have difficulty in evaluating film-making quality and usually search for former consumer opinions. In this paper, the word-of-mouth refers to the moviegoer's reviews and movie ratings on the level of film-making [21–23]. Industry experts agree that word-of-mouth is a critical factor underlying a movie's staying power, which remains a powerful source for movie consumers and leads to its ultimate financial success [14, 24]. Duan et al. also found that both a movie's box-office revenue and word-of-mouth valence significantly influence word-of-mouth volume. Word-of-mouth volume in turn leads to higher box-office performance [25, 26]. Additionally, we often observe that some movies produced within much smaller budgets have achieved great success by utilizing viral marketing through word-of-mouth (e.g., The Hangover, Wolf Warriors II). Consequently, film-making effect is the second vital factor involved with film investment. The experience of a producer is a considerable factor, which is as powerful as director and actor [27].

The star (e.g., award winning actor and director) power effect on film success has yielded somewhat mixed results. Some papers have reported a positive relationship between the presence of a star and box-office revenues [28, 29]. However, another scholars found no relationship, even negative effects, between stars and theatrical revenues [30–34]. Even in the study of star power, the director and actor have different degrees of importance to a movie success. Most studies have indicated that director power is not very significant and at times is much weaker than an actor power [3, 35]. However, in China, a director plays a bigger role than actor regarding the box-office [36]. Meanwhile, the high-profile stars are able to command high fees, which itself contributed to the high budgets of their films, often disproportionately so [32]. That is to say, high-profile stars are not always equal to method actors. Last but not least, the star (actor and director) power effect is the third crucial factor in regard to film investment.

There is very little literature which focus on above factors' impact on financial performance of the film from the perspective of investment decisions. Both the film's reputation and box-office success are not solely influenced by individual movie attributes such as advertising, production, director, actor, distributor, release season, and screen number, which also depended on the causal relationship among all attributes related to movies [3]. Our paper departs from the recent literature and focuses on joint influences of these interactive factors, not just one single factor. Interestingly, this paper considers the investment decision of studios or investors and develops a goodwill model and system dynamic (SD) model, which allow us to disentangle the comprehensive effects of advertising, film-making, and star power.

The rest of the paper is organized as follows. In Section 2, we will present an expanded Nerlove-Arrow model, demand function, and profit functions by using differential game. In Section 3, based on the expanded Nerlove-Arrow model, we will derive the game equilibrium solution of film investors and introduce four star selection strategies. Then, according to the four star selection scenarios, we will discuss the cost-benefit of film investment by taking spectator heterogeneity and film heterogeneity into account separately. In Section 4, we will develop a SD model of film goodwill to reflect the dynamic impact of advertising, film-making, and star power on moviegoers and box-office; then we will simulate box-office trend in the film's release cycle. Concluding remarks and managerial implications are discussed in the last section.

2. Model Development and Notations

A movie is considered in this paper. The film producers make investment decisions in order to attract the majority of moviegoers who focus on the advertising, film-making, and star power in a movie. We introduce the notations in this paper as shown in Table 1.

We assume that the change of film goodwill follows the Nerlove-Arrow framework [37, 38]; i.e.,

$$\dot{G}(t) = \alpha A(t) + \beta M(t) + \eta S(t) - \delta G(t) \tag{1}$$

We suppose that advertising and star power have direct effects on the number of moviegoers. The film-making effort indirectly influences moviegoers through word-of-mouth, that is, film's goodwill. The number of moviegoers satisfies the following equation:

$$N(t) = \sigma S + \gamma A + \varepsilon G \tag{2}$$

Similar to the previous literature such as Feng and Liu [38], the advertising cost, film-making cost, and star remuneration functions are quadratic with marketing efforts, respectively; namely, $C(A) = (\mu_A/2)A^2(t)$, $C(M) = (\mu_M/2)M^2(t)$ and $C(S) = (\mu_S/2)S^2(t)$.

Furthermore, we assume that the film's investment funds are not constrained and have a common positive discount rate λ. For the convenience of calculation, we suppose that the distribution cost of the film is zero. The film producers

Table 1: Variables and definitions used in the model.

t	Time t, $t \geq 0$
$G(t)$	The accumulated film's goodwill at time t.
$A(t)$	The film's advertising effort at time t.
$M(t)$	The film-making effort at time t.
$S(t)$	The star power at time t.
$N(t)$	The number of moviegoers along time t.
$C(A)$	The film's advertising cost.
$C(M)$	The film-making cost.
$C(S)$	The star remuneration.
μ_A, μ_M, μ_S	Constants
p	The film ticket price.
J	The objective profit functions of the film.
$\alpha>0$	Positive coefficient measuring the impact of film's advertising.
$\beta>0$	Positive coefficient measuring the impact of film-making.
$\eta>0$	Positive coefficient measuring the impact of star power.
$\delta>0$	The decay rate of the film goodwill.
$\sigma>0$	Positive constant representing the effect of star power on the number of moviegoers.
$\gamma>0$	Positive constant representing the effect of film's advertising on the number of moviegoers.
$\varepsilon>0$	Positive constant representing the effect of film's goodwill on the number of moviegoers.
$\lambda>0$	The discount rate.

and investors strive to maximize their profit. Then, the film's objective function is

$$J = \int_0^\infty e^{-\lambda t} \left[p \times N(t) - \frac{\mu_A}{2} A^2(t) - \frac{\mu_M}{2} M^2(t) - \frac{\mu_S}{2} S^2(t) \right] dt \tag{3}$$

3. Equilibrium Solutions and Numerical Analysis

3.1. Equilibrium Solutions

Proposition 1. *Film investors' equilibrium strategies are given as follows.*

(1) The film advertising effort is

$$A^* = \frac{\varepsilon \alpha p}{(\delta + \lambda)\mu_A} + \frac{\gamma p}{\mu_A} \tag{4}$$

(2) The film-making effort is

$$M^* = \frac{\varepsilon \beta p}{(\delta + \lambda)\mu_M} \tag{5}$$

(3) The film star power effort is

$$S^* = \frac{\varepsilon \eta p}{(\delta + \lambda)\mu_S} + \frac{\sigma p}{\mu_S} \tag{6}$$

(4) The film investor's profit under the equilibrium condition is

$$\begin{aligned} V^*(G) = {} & \frac{\varepsilon p}{\delta + \lambda} G + \frac{\varepsilon p}{\delta + \lambda} \left[\frac{\alpha p}{\mu_A} + \frac{\alpha^2 \varepsilon p}{(\delta + \lambda)\mu_A} \right. \\ & \left. + \frac{\beta^2 \varepsilon p}{(\delta + \lambda)\mu_M} + \frac{\eta p}{\mu_S} + \frac{\eta^2 \varepsilon p}{(\delta + \lambda)\mu_S} \right] - \frac{\mu_S}{2} \left[\frac{\sigma p}{\mu_S} \right. \\ & \left. + \frac{\eta \varepsilon p}{(\delta + \lambda)\mu_S} \right]^2 + p \left[\frac{\gamma p}{\mu_A} + \frac{\alpha \varepsilon p}{(\delta + \lambda)\mu_A} + \frac{\sigma p}{\mu_S} \right. \\ & \left. + \frac{\varepsilon \eta p}{(\delta + \lambda)\mu_S} \right] - \frac{\mu_A}{2} \left[\frac{\gamma p}{\mu_A} + \frac{\alpha \varepsilon p}{(\delta + \lambda)\mu_A} \right]^2 \\ & - \frac{\beta^2 \varepsilon^2 p^2}{2(\delta + \lambda)^2 \mu_M} \end{aligned} \tag{7}$$

Proof. See the Appendix. □

Proposition 1 illustrates the following insights. (i) The film producer increasingly lays emphasis on investing in film advertising, such as releasing conference, titbits, trailers, and show tours, so as to absorb moviegoers' attention. Due to Proposition 1, there are three positive correlations as follows. One is the relationship between investment in film advertising and advertising contribution to film goodwill. The other is the relationship between investment in film advertising and advertising contribution to the number of moviegoers. The last one is the relationship between investment in film advertising and film goodwill's contribution to the number of moviegoers. (ii) The investment in film-making has positive correlation with both film-making contribution to film

Table 2: Movie star selection strategies.

	Box-office guarantee	No box-office guarantee
High movie remuneration	Strategy 1 (H, G)	Strategy 2 (H, NG)
Low movie remuneration	Strategy 3 (L, G)	Strategy 4 (L, NG)

Table 3: Parameters assignment of rational audiences.

	α	β	η	σ	γ	ε
Strategy 1 (H, G)	0.1	0.5	0.4	0.5	0.1	0.4
Strategy 2 (H, NG)	0.1	0.5	0.1	0.1	0.1	0.4
Strategy 3 (L, G)	0.1	0.5	0.4	0.5	0.1	0.4
Strategy 4 (L, NG)	0.1	0.5	0.1	0.1	0.1	0.4

Table 4: Parameters assignment of fans.

	α	β	η	σ	γ	ε
Strategy 1 (H, G)	0.1	0.2	0.7	0.7	0.1	0.2
Strategy 2 (H, NG)	0.1	0.2	0.7	0.1	0.1	0.2
Strategy 3 (L, G)	0.1	0.2	0.7	0.7	0.1	0.2
Strategy 4 (L, NG)	0.1	0.2	0.1	0.1	0.1	0.2

goodwill and its impact on audience's viewing decision. The more attention that film producer pays to investing in film-making, the more importance moviegoers attach to the film's quality. On the contrary, the film producer will reduce film-making investment if the audience pursue actor or director in a movie. So there are lots of shoddy movies which focus on the star popularity but ignore film-making quality. (iii) The investment in star has positive correlation with both star contribution to film goodwill and its impact on audience's viewing decision. When the star popularity hugely influences film goodwill and potential audiences, the film investors would like to invite well-known directors or famous actors whose cost performance is higher to participate in a movie.

3.2. Numerical Analysis and Strategic Comparative Analysis

3.2.1. Star Selection and Spectator Heterogeneity

(1) Star Selection. The star selection, as a critical component of the film investment, has a huge influence on the outcome of box-office, which has been largely ignored in past academic research [39]. The selection of movie stars by film investor can be divided into four strategies (in Table 2) according to the remuneration and box-office guarantee. The higher the remuneration that movie stars earn, the larger the μ_S, and vice versa. The value of α and γ is large if movie stars can bring high box-office, and vice versa.

(2) Spectator Heterogeneity. Anecdotal evidence suggests that the presence of superstars is not always a guarantee of success and, hence, a deeper study is required to analyze the potential audience of a movie [7]. Therefore, this paper considers the film audience to be heterogeneous. We only consider spectator heterogeneity: rational audiences and fans. The former's proportion is ω and the latter's share is 1-ω.

It is also assumed that the film ticket price is constant, p=1. Let $\mu_A = \mu_M = 1$, λ=δ=0.05. We assume that advertising has weak influence on film goodwill and moviegoers, so the range of α and γ is small.

(1) Rational audiences. They lay more attention on film-making and film goodwill. Therefore, β and ε have higher values, see Table 3.

(2) Fans. They lay emphasis on famous actor or director. Therefore, η *has* a higher value, but β and ε have lower values; see Table 4.

(3) Investment Analysis of Spectator Heterogeneity. On the basis of equilibrium solutions and numerical values, we draw bar charts shown in Figure 1. The film's investment strategy varies as the rational audience and fans have different viewing requirements for the film. Studios give high investment in film-making in the face of rational audiences. But the investment in star is high in order to cater to the fans. Firstly, the studios' investment in film advertising is the same whether for the rational audiences or fans. Secondly, because the film-making level has a great impact on word-of-mouth, studios increase investment in film-making to ingratiate rational audiences but economize the film-making costs in the face of fans. Thirdly, among these 4 strategies of star selection, the film investment in strategy 3 is the highest and significantly higher than the sum of investments in advertising and film-making. Meanwhile, the film investment in strategy 3 is several times higher than the cost of actors in other strategies. The investment in star of strategy 1 is the second and strategy 2 gives lowest investment in star when facing with the rational audiences. But, for fans, strategy 4 has the second investment to star, and strategy 2 gives lowest investment in star. No matter rational audiences or fans, the star selection in strategy 3 is the most cost-effective while the star cost-effectiveness of strategy 2 is minimum.

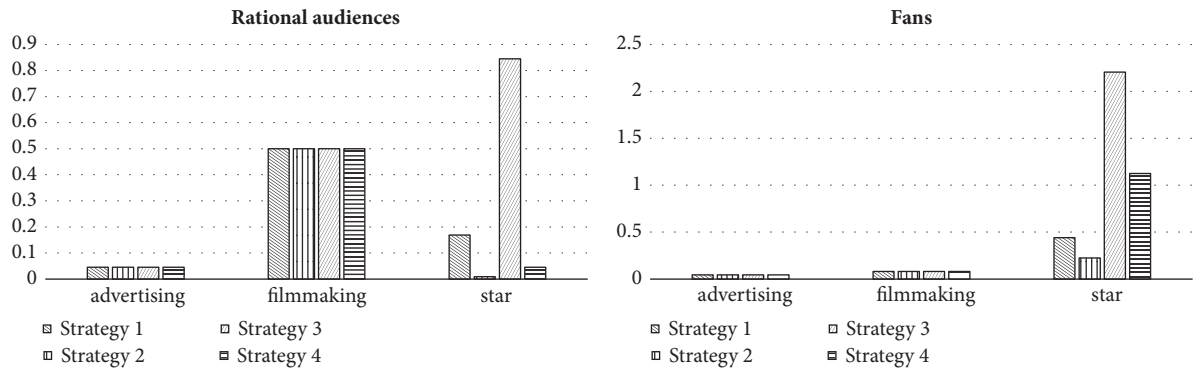

Figure 1: Investment analysis of spectator heterogeneity.

In fact, above analysis is precisely the case of investment made by film producers. For example, when selecting actors and actresses, film producers comprehensively take the combination of male and female protagonists into account. In Hong Kong movies, for instance, "award winning actors from Hong Kong usually work together with Chinese mainland second-tier actresses" or "Chinese mainland first-tire actresses usually work together with second and third-tier actors from Hong Kong and Taiwan". While considering the number of fans, they would arrange some well-known second- and third-tier stars with reasonable remuneration.

3.2.2. Film Heterogeneity and Numerical Analysis. This paper divides the film genre into new theme film and film series (e.g., Star Trek, Pirates of the Caribbean, or Fast & Furious). Compared with new theme films, films series refer to continuous, multiset, serial movies. The numerical analysis of film investment performance is as follows.

(1) New Theme Film. (1) Cost analysis. The movie cost under different star selection strategies is shown in Figure 2 (the vertical axis is dimensionless). The investment cost under different strategies increases with the proportion of rational audience ($\boldsymbol{\omega}$ is the proportion of rational audience, $\omega \in [0, 1]$). The cost increment of strategy 3 is the highest, and that of strategy 4 is the lowest. On the one hand, the cost of strategies 3 and 4 is higher than that of strategies 1 and 2 when fans are the main spectator group. On the other hand, when rational audience accounts for a large proportion, the total cost of strategy 1 is higher than that of strategy 4, but the cost of strategy 2 and strategy 4 tends to approach each other. Overall, the investment cost of strategy 3 is the highest and that of strategy 2 is the lowest. No matter what kind of movies, the investment cost of rational audience is higher than that of fans.

(2) The number of moviegoers and the box-office analysis. Figure 3 (the vertical axis is dimensionless) shows that high-paid stars contribute less to the number of moviegoers than the low-paid ones. The reason is that over-high cost limits film producers' investment in high-profile stars. Although the high popularity of stars makes a huge contribution to the number of moviegoers, the over-high remuneration lowers stars' cost performance. At the same time, the higher cost

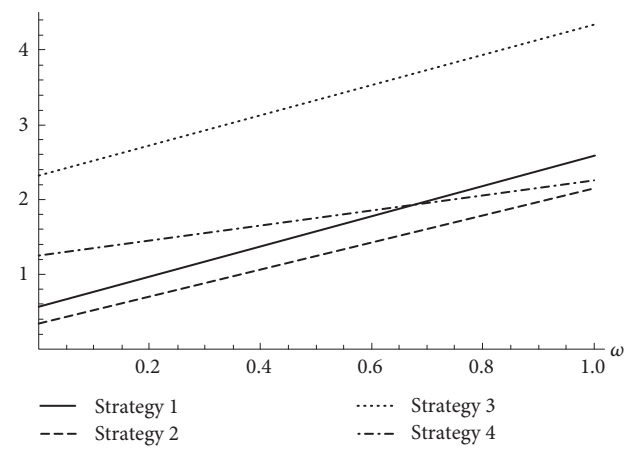

Figure 2: Total movie cost under different star selection strategies.

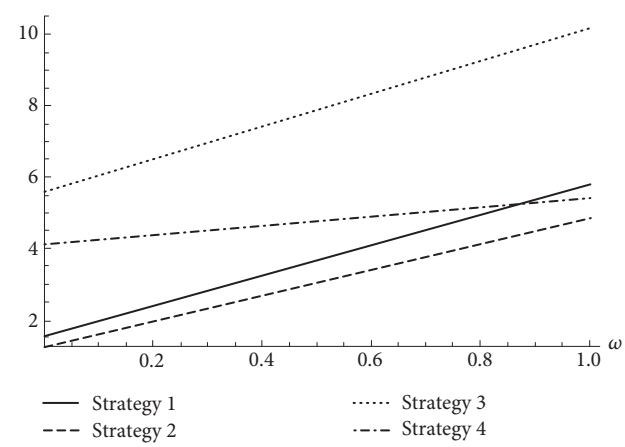

Figure 3: Moviegoers of new theme film under different star selection strategies.

performance makes producers increase the star investment and also increase the number of moviegoers. Bankable stars truly guarantee the box-office and the influence of such stars on the number of moviegoers is great. As the proportion of rational audience increases, this influence is more significant. It can be interpreted that rational audience always pay more attention to actors' acting skills and film-making quality. And

box-office guarantee means getting the audience's approval in the aspects of directors, acting skills, script selection, etc. The audience loyalty to bankable stars is higher, and then the number of moviegoers is more.

In Figure 3, the biggest number of moviegoers is in strategy 3 which has the participation of the low-paid but bankable stars, so-called low-profile stars with real strength. These stars own good acting skills, loyal audience, relatively reasonable remuneration, and high cost performance. Therefore, strategy 3 has a relatively strong influence on both fans and the rational audience and earns more expected profits than other strategies. The smallest number of moviegoers is in strategy 2 which has the participation of the high-paid but with no box-office guaranteed actors. Despite such stars having high popularity, their acting skills have been questioned and criticized by moviegoers. Generally, the movie they are involved in has no guarantee at the box-office, and its online word-of-mouth is also poor.

It is generally recognized that fans are an important criterion for film producers to choose actors. But Figure 5 shows that rational audiences are the main guarantee of box-office rather than fans. Due to that film producers' investment in rational audiences is higher than that in fans; the market performance of rational audiences is better than that of fans. The number of moviegoers is directly proportional to the ratio of rational audience and is inversely proportional to the ratio of fans. So, it is easy to understand the poor box-office performance of movies starring high-paid "little fresh meat" who have a huge number of fans but no box-office guarantee. For actors who have no box-office guarantee, as the number of fans decreases, moviegoers in strategy 2 with high-paid actors will outnumber strategy 4 with low-paid actors, which is mainly because of the impact of star popularity on the movie's reputation.

Meanwhile, with the development of network, film producers pay more and more attention to moviegoers' opinions. For example, during the preparation of many movies, as a result of fans' doubts and dissatisfaction with the star lineup, the incident of changing actors occurs frequently. This also shows film producers' expectations for moviegoers and box-office, and their consideration about stars' impact on film reputation when making investment decisions. At the same time, with the changes of online word-of-mouth after the movie is released, the reputation of stars changes accordingly. Some stars may surge in popularity because of their excellent acting skills, which further enhances the reputation of the movie; some actors are questioned because of poor acting skills, resulting in damage to the movie reputation and box-office slump.

(3) Revenue analysis. The final revenue of a movie is affected by box-office and investment costs. This paper focuses on film investment decision-making, and the ultimate goal is to maximize the movie's revenue. We assume that the revenues of all strategies are positive and the vertical axis is dimensionless. Figure 4 shows that the higher the rational audience ratio, the higher the movie revenue. Because when the film investor expects a movie to be positive and supposes that the rational audience is influenced by the word-of-mouth, with the increase of moviegoers, the accumulation

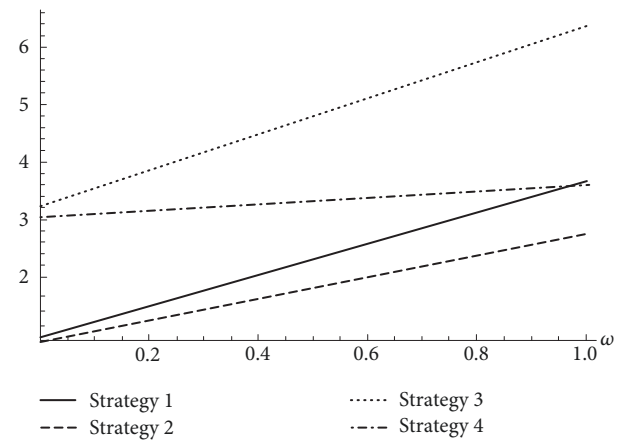

Figure 4: Revenue of new theme film under different strategies.

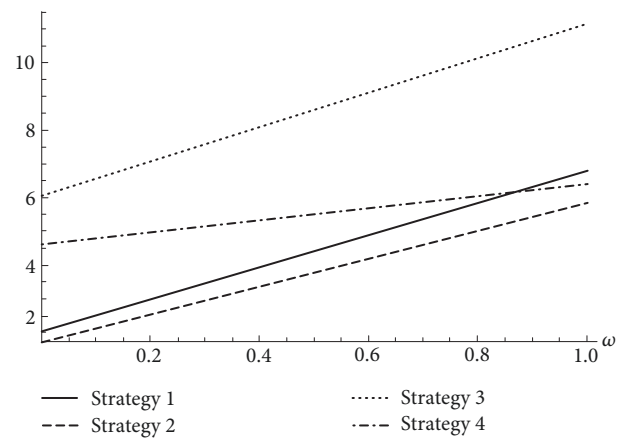

Figure 5: Moviegoers of film series under different star selection strategies.

of online word-of-mouth will increase the possibility of audience's going to cinema, thus increasing the film revenue. It is easy to understand that, corresponding to the number of moviegoers, revenues of movies played by bankable stars are higher than that with no box-office guaranteed stars. In addition, under cost's influence, revenues of movies played by low-paid actors are higher than that of high-paid actors.

(2) Film Series. Film series have a high reputation in the early stage of film release due to the accumulation of early series. High film reputation does not change the investment strategy, so the investment cost of film series is consistent with that of a new theme movie. As shown in Figures 5 and 6 (the vertical axis is dimensionless), influenced by accumulated popularity, the number of film series' moviegoers and its revenues are higher than that of a new theme movie. That is why film producers prefer giving investment in sequel movies rather than new theme movies when there is a good response to the serial movies. Therefore, there are always movies based on TV dramas, variety shows, and popular online novels. Besides, it is also easy to understand that the same story (e.g., Journey to the West) is reshot over and over again. All the above are

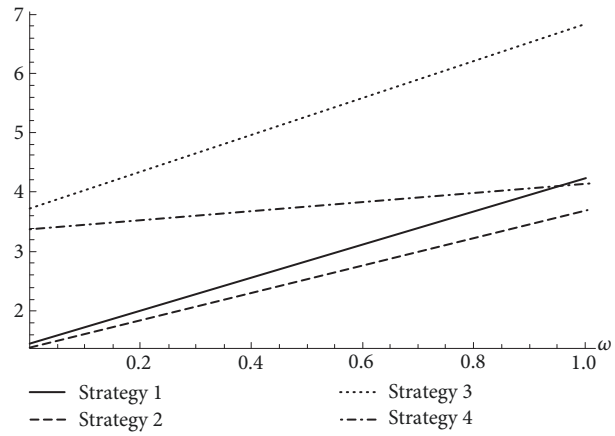

Figure 6: Revenue of film series under different star selection strategies.

the cases in which film producers take advantage of the high reputation accumulated before.

Similarly, the audience keeping high loyalty to some actor or director (being a fan of the star or director), on the one hand, is the recognition of the director's directing skills or actor's acting skills; and on the other hand, the director or actor's reputation that accumulated over a long period of time gives them a box-office guarantee in the mind of spectator. Therefore, the relationship between actors, directors, and movies should be mutual promotion: when an actor's popularity and acting skills or director's directing ability have high-performance in online word-of-mouth and box-office, then the movie will further enhance and consolidate the actor's or the director's popularity.

4. System Dynamics Analysis of Film Goodwill and Box-Office

4.1. The System Dynamics Model. System dynamics is a well-established methodology to model and understand the behavior of complex systems, and it has been extensively used for modeling the dynamic behavior of complex nonlinear systems [40, 41]. Based on the above film's goodwill model, the SD model of film goodwill reflects the dynamic impact of advertising, film-making, and star power on film performance. The advertising and star power factors have direct effects on the box-office, and the film-making effort indirectly influences the box-office through film goodwill. Then the box-office in turn affects the three factors. Figure 7 shows the stock and flow diagram for the system dynamics model of film goodwill by SD software-Vensim, version 7.1.

4.2. The System Dynamics Analysis. According to Chen and Yin [42], movies have relatively short life cycles, and the average exposure time of a movie is approximately one month. Based on SD model in Section 4.1 and equilibrium solutions in Section 3, we will analyze four star selection strategies of new theme film by SD simulation. Then we get the box-office trend of rational audiences and fans during the release period, as shown in Figures 8 and 9 (the vertical axis of box-office is dimensionless). In Figures 3 and 8, for rational moviegoers, strategy 3 has a higher investment in stars who are reasonably paid with box-office guarantee, and the film-making is excellent. Compared with other movies, strategy 3 can have a good performance at the early stage of release time and the potential development is great. As a result, it has considerable returns on investment. Movies (Strategies 1, 2, and 4) are ordinary in performance. Except for movies (Strategy 1) played by high-paid, bankable stars whose performance is slightly better, the box-office of other movies (Strategies 2 and 4) is close. In Figures 2 and 9, for fans, even though their idols act in the movies, they do not pay much for the low-quality film-making. Particularly in strategies 1 and 2, due to bad word-of-mouth caused by low investment in film-making, movies with high popularity stars cannot achieve good performance if just relying on fans effect. For movies with high investment in film-making, obviously, bankable stars are far more attractive to audience than that with no box-office guarantee. But, generally, the performance of movies with high investment in film-making is better than that with low investment in film-making.

In summary, in order to maximize the profit from Proposition 1, film producers choose different types of stars according to different needs of moviegoers, and thus make different investment decisions. However, returns of film investment follow the principle that high investment gets high returns. Among film investment strategies, strategy 3 has the highest investment, most moviegoers, and highest returns, while strategy 2 has the lowest investment, least moviegoers, and least returns.

Compared with new theme film, what film series reflect in the SD simulation is nothing but the fact that initial value of simulated box-office is higher. Other performances of film series in the release period are consistent with new theme film. So the SD analysis of film series is omitted in this paper. Because of the accumulated high reputation, the box-office of film series is always better than that of new theme film.

5. Concluding Remarks and Managerial Implications

This paper considers the joint effects of advertising, film-making, and star power on film reputation, the number of moviegoers, and box-office. We consider the investment decision of a movie made by studios or investors and develop a goodwill model and system dynamic model which allow us to disentangle advertising, film-making, and star power effects. The results are proved as follows.

Firstly, the film producers' investment in advertising, film-making, and star power are positively correlated with their contribution to film reputation and the number of moviegoers, but negatively correlated with the cost coefficient of three factors. The film producer will increasingly lay emphasis on investing in advertising, such as the release conference, titbits, trailers, and show tours, to absorb moviegoers' attention. The film producer focuses on investing in film-making when film quality has a great impact on the movie's reputation and the audience's viewing decision. For investment in stars, the film producer pays more attention to higher

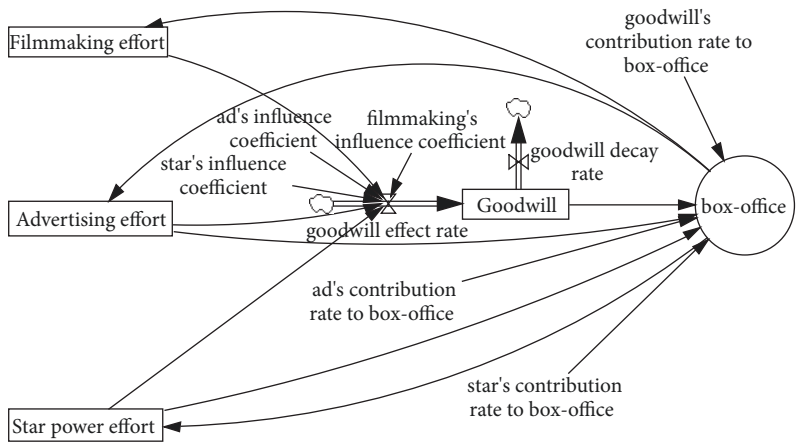

Figure 7: Stock and flow diagram for film goodwill.

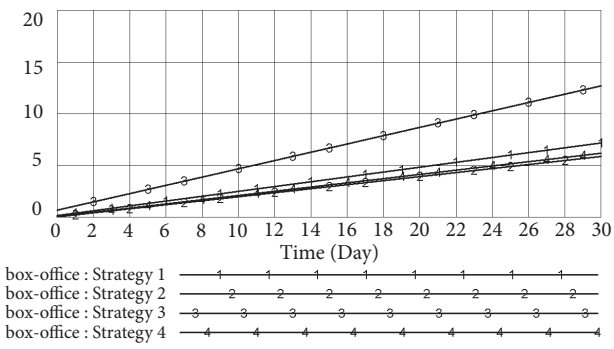

Figure 8: Box-office trend of rational audience against film release time.

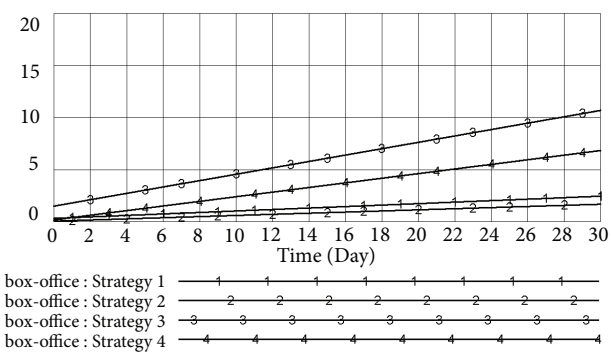

Figure 9: Box-office trend of fans against film release time.

cost-performance stars who have reasonable remuneration, good acting skills, and big box-office guarantee.

Secondly, the film producer makes different decisions to meet different audiences' viewing requirements. For rational audience, more attention is paid to film-making investment; but for fans, more attention is paid to investment in stars. Whether it is a new theme film or film series, the film investment cost for rational audience is higher than that for fans. Correspondingly, rational audience also contributes more box-office returns.

Thirdly, by the principle that high investment yields high returns, movies played by stars with reasonable remuneration and good acting skills have the highest investment cost. Correspondingly, these movies have the largest number of moviegoers and box-office returns. When movies played by stars with over-high remuneration and poor acting skills have the lowest investment, correspondingly, those movies get the least moviegoers and box-office returns. When rational audiences outnumber fans, despite the high remuneration, both moviegoers and box-office of movies acted by bankable stars are more than that acted by stars with no box-office guarantees.

Fourthly, the box-office will increase gradually over film release time. For the movies acted by bankable stars who are not well-known with low remuneration, they have excellent film-making quality and show the best performance. Therefore, they are most worthy of investment. For those movies acted by well-known stars but with no box-office guarantees, they show the worst performance and are least worthy of investment. Accordingly, such poor quality movies may yield disappointing box-office and reputation.

Finally, compared with new theme film, film series enable a better performance (e.g., number of moviegoers, box-office, revenues) because of high reputation. This is the fundamental reason why the film producers love serial movie.

The research findings about the film investment decision are based on the goal of maximizing film producers' profits. In reality, there are many random factors except for advertising, film-making, and star power affecting audience's viewing decision. However, this paper can provide instructions for making investment decisions in film industry from a managerial perspective. Compared with fans, the rational audience contributes more to a movie's box-office. Compared with popularity, bankable stars contribute more to a movie's returns. And compared with new theme film, film series yields higher profits.

Appendix

We solve the optimal control question and obtain feedback equilibrium solutions using backwards induction. We

suppose that the optimal profit function of a movie is $V(G)$. Then the Hamilton-Jacobi-Bellman (HJB) equation must be satisfied.

$$\lambda V(G) = \max\left[p(\sigma S + \gamma A + \varepsilon G) - \frac{\mu_A}{2}A^2 - \frac{\mu_M}{2}M^2 - \frac{\mu_S}{2}S^2 + V'(G)(\alpha A + \beta M + \eta S - \delta G)\right] \tag{A.1}$$

where $V'(G) = dV(G)/dG$. Maximization of the right-hand side of the HJB equation yields

$$A^*(V') = \frac{\gamma p}{\mu_A} + \frac{\alpha V'}{\mu_A} \tag{A.2}$$

$$M^*(V') = \frac{\beta V'}{\mu_M} \tag{A.3}$$

$$S^*(V') = \frac{\sigma p}{\mu_S} + \frac{\eta V'}{\mu_S} \tag{A.4}$$

It is easy to know Hessian Matrix of (A.1) is negative-definite. Equations (A.2)-(A.4) are the optimum solutions to maximize the profit in (A.1). Substituting (A.2)-(A.4) into (A.1), we obtain

$$\begin{aligned}\lambda V(G) &= p\left(\varepsilon G + \frac{\alpha V'}{\mu_A} + \frac{\gamma p}{\mu_A} + \frac{\eta V'}{\mu_S} + \frac{\sigma p}{\mu_S}\right) \\ &\quad + V'\left(\frac{\alpha^2 V'}{\mu_A} + \frac{\alpha p}{\mu_A} + \frac{\beta^2 V'}{\mu_M} + \frac{\eta^2 V'}{\mu_S} + \frac{\eta p}{\mu_S} - \delta G\right) \\ &\quad - \frac{\mu_A}{2}\left(\frac{\alpha V'}{\mu_A} + \frac{\gamma p}{\mu_A}\right)^2 - \frac{\beta^2 V'}{2\mu_M} \\ &\quad - \frac{\mu_S}{2}\left(\frac{\eta V'}{\mu_S} + \frac{\sigma p}{\mu_S}\right)^2\end{aligned} \tag{A.5}$$

We shall show that linear optimal value functions satisfy (A.5). Hence, we define

$$V(G) = e_1 G + e_2 \tag{A.6}$$

where e_1 and e_2 are constants.

By using the method of undetermined coefficients, we obtain

$$e_1 = \frac{\varepsilon p}{\delta + \lambda} \tag{A.7}$$

$$\begin{aligned}e_2 &= \frac{\varepsilon p}{\delta + \lambda}\left[\frac{\alpha p}{\mu_A} + \frac{\alpha^2 \varepsilon p}{(\delta + \lambda)\mu_A} + \frac{\beta^2 \varepsilon p}{(\delta + \lambda)\mu_M} + \frac{\eta p}{\mu_S} + \frac{\eta^2 \varepsilon p}{(\delta + \lambda)\mu_S}\right] + p\left[\frac{\gamma p}{\mu_A} + \frac{\alpha \varepsilon p}{(\delta + \lambda)\mu_A} + \frac{\sigma p}{\mu_S} + \frac{\varepsilon \eta p}{(\delta + \lambda)\mu_S}\right] \\ &\quad - \frac{\mu_A}{2}\left[\frac{\gamma p}{\mu_A} + \frac{\alpha \varepsilon p}{(\delta + \lambda)\mu_A}\right]^2 - \frac{\beta^2 \varepsilon^2 p^2}{2(\delta + \lambda)^2 \mu_M} - \frac{\mu_S}{2}\left[\frac{\sigma p}{\mu_S} + \frac{\eta \varepsilon p}{(\delta + \lambda)\mu_S}\right]^2\end{aligned} \tag{A.8}$$

Substituting (A.7)-(A.8) into (A.6), we get

$$V' = \frac{\varepsilon p}{\delta + \lambda} \tag{A.9}$$

Then substituting (A.9) into (A.2)-(A.4), we also obtain (4)-(6). Finally, substituting (4)-(6) into (A.1), and get (7).

This concludes the proof.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The authors gratefully acknowledge support from National Natural Science Foundation of China (Project No. 71571117) and Innovation Method Fund of China (Project No. 2016IM010400).

References

[1] D. Delen, R. Sharda, and P. Kumar, "Movie forecast Guru: A Web-based DSS for Hollywood managers," *Decision Support Systems*, vol. 43, no. 4, pp. 1151–1170, 2007.

[2] S. K. Schwartz, Investing in the big screen can be a profitable story, https://www.cnbc.com/id/39342145, 2010.

[3] K. J. Lee and W. Chang, "Bayesian belief network for box-office performance: A case study on Korean movies," *Expert Systems with Applications*, vol. 36, no. 1, pp. 280–291, 2009.

[4] A. De Vany and W. D. Walls, "Bose-einstein dynamics and adaptive contracting in the motion picture industry," *Economic Journal*, vol. 106, no. 439, pp. 1493–1514, 1996.

[5] A. De Vany and W. D. Walls, "Does Hollywood Make Too Many R-Rated Movies? Risk, Stochastic Dominance, and the Illusion of Expectation," *Journal of Business*, vol. 75, no. 3, pp. 425–451, 2002.

[6] A. De Vany and W. D. Walls, "Motion picture profit, the stable Paretian hypothesis, and the curse of the superstar," *Journal of Economic Dynamics & Control*, vol. 28, no. 6, pp. 1035–1057, 2004.

[7] E. Montañés, A. Suárez-Vázquez, and J. R. Quevedo, "Ordinal classification/regression for analyzing the influence of superstars on spectators in cinema marketing," *Expert Systems with Applications*, vol. 41, no. 18, pp. 8101–8111, 2014.

[8] W. D. Walls, "Chapter 8–bestsellers and blockbusters: movies, music, and books," in *Handbook of the Economics of Art & Culture*, vol. 2, pp. 185–213, 2014.

[9] J. Eliashberg, A. Elberse, and M. A. A. M. Leenders, "The motion picture industry: Critical issues in practice, current research, and new research directions," *Marketing Science*, vol. 25, no. 6, pp. 638–661, 2006.

[10] L. Zhang, J. Luo, and S. Yang, "Forecasting box office revenue of movies with BP neural network," *Expert Systems with Applications*, vol. 36, no. 3, pp. 6580–6587, 2009.

[11] J. Xiao, X. Li, S. Chen, X. Zhao, and M. Xu, "An inside look into the complexity of box-office revenue prediction in china," *International Journal of Distributed Sensor Networks*, vol. 13, no. 1, pp. 1–14, 2017.

[12] T. Hennig-Thurau, M. B. Houston, and G. Walsh, "Determinants of motion picture box office and profitability: an interrelationship approach," *Review of Managerial Science*, vol. 1, no. 1, pp. 65–92, 2007.

[13] F. S. Zufryden, "Linking advertising to box office performance of new film releases - A marketing planning model," *Journal of Advertising Research*, vol. 36, no. 4, pp. 29–41, 1996.

[14] A. Elberse and J. Eliashberg, "Demand and supply dynamics for sequentially released products in international markets: The case of motion pictures," *Marketing Science*, vol. 22, no. 3, pp. 329–354, 2003.

[15] A. Elberse and B. Anand, "The effectiveness of pre-release advertising for motion pictures: an empirical investigation using a simulated market," *Information Economics & Policy*, vol. 19, no. 3-4, pp. 319–343, 2007.

[16] A. M. Joshi and D. M. Hanssens, "Movie advertising and the stock market valuation of studios: a case of great expectations?" *Science*, vol. 28, no. 2, pp. 239–250, 2009.

[17] W. D. Walls, "Modeling Movie Success When 'Nobody Knows Anything': Conditional Stable-Distribution Analysis Of Film Returns," *Journal of Cultural Economics*, vol. 29, no. 3, pp. 177–190, 2005.

[18] J. Eliashberg, S. K. Hui, and Z. J. Zhang, "From story line to box office: A new approach for green-lighting movie scripts," *Management Science*, vol. 53, no. 6, pp. 881–893, 2007.

[19] A. Elberse, "The power of stars: Do star actors drive the success of movies?" *Journal of Marketing*, vol. 71, no. 4, pp. 102–120, 2007.

[20] C. Hung, "Word of mouth quality classification based on contextual sentiment lexicons," *Information Processing & Management*, vol. 53, no. 4, pp. 751–763, 2017.

[21] S. Basuroy, S. Chatterjee, and S. Abraham Ravid, "How Critical are Critical Reviews? The Box Office Effects of Film Critics, Star Power, and Budgets," *Journal of Marketing*, vol. 67, no. 4, pp. 103–117, 2003.

[22] C. C. Moul, "Measuring word of mouth's impact on theatrical movie admissions," *Journal of Economics & Management Strategy*, vol. 16, no. 4, pp. 859–892, 2007.

[23] P. Winoto and T. Y. Tang, "The role of user mood in movie recommendations," *Expert Systems with Applications*, vol. 37, no. 8, pp. 6086–6092, 2010.

[24] Y. Liu, "Word of mouth for movies: its dynamics and impact on box office revenue," *Journal of Marketing*, vol. 70, no. 3, pp. 74–89, 2006.

[25] W. D. Walls, "Increasing returns to information: Evidence from the Hong Kong movie market," *Applied Economics Letters*, vol. 4, no. 5, pp. 287–290, 1997.

[26] W. Duan, B. Gu, and A. B. Whinston, "The dynamics of online word-of-mouth and product sales - an empirical investigation of the movie industry," *Journal of Retailing*, vol. 84, no. 2, pp. 233–242, 2008.

[27] M. Bagella and L. Becchetti, "The determinants of motion picture box office performance: Evidence from movies produced in Italy," *Journal of Cultural Economics*, vol. 23, no. 4, pp. 237–256, 1999.

[28] B. R. Litman and L. S. Kohl, "Predicting financial success of motion pictures: the '80s experience," *Journal of Media Economics*, vol. 2, no. 2, pp. 35–50, 1989.

[29] S. Albert, "Movie stars and the distribution of financially successful films in the motion picture industry," *Journal of Cultural Economics*, vol. 22, no. 4, pp. 249–270, 1998.

[30] B. R. Litman, "Predicting success of theatrical movies: an empirical study," *The Journal of Popular Culture*, vol. 16, no. 4, pp. 159–175, 1983.

[31] S. P. Smith and V. K. Smith, "Successful movies: a preliminary empirical analysis," *Applied Economics*, vol. 18, no. 5, pp. 501–507, 1986.

[32] J. Sedgwick and M. Pokorny, "Movie stars and the distribution of financially successful films in the motion picture industry," *Journal of Cultural Economics*, vol. 23, no. 4, pp. 319–323, 1999.

[33] A. De Vany and W. D. Walls, "Uncertainty in the movie industry: does star power reduce the terror of the box office?" *Journal of Cultural Economics*, vol. 23, no. 4, pp. 285–318, 1999.

[34] W. D. Walls, "Screen wars, star wars, and sequels," *Empirical Economics*, vol. 37, no. 2, pp. 447–461, 2009.

[35] R. A. Nelson and R. Glotfelty, "Movie stars and box office revenues: an empirical analysis," *Journal of Cultural Economics*, vol. 36, no. 2, pp. 141–166, 2012.

[36] J. Zhou, Y. Yuan, and P. Tu, "Analysis of the collaboration network of Chinese film directors and actors," *Complex Systems and Complexity Science*, vol. 13, no. 3, pp. 69–75, 2016.

[37] M. Nerlove and K. J. Arrow, "Optimal advertising policy under dynamic conditions," *Economica*, vol. 29, no. 114, pp. 129–142, 1962.

[38] J. Feng and B. Liu, "Dynamic impact of online word-of-mouth and advertising on supply chain performance," *International Journal of Environmental Research and Public Health*, vol. 15, no. 1, p. 69, 2018.

[39] A. Liu, T. Mazumdar, and B. Li, "Counterfactual decomposition of movie star effects with star selection," *Science*, vol. 61, no. 7, pp. 1704–1721, 2015.

[40] J. Forrester, "Industrial dynamics: A major breakthrough for decision makers," *Harvard Business Review*, vol. 36, no. 4, pp. 37–66, 1958.

[41] R. R. P. Langroodi and M. Amiri, "A system dynamics modeling approach for a multi-level, multi-product, multi-region supply chain under demand uncertainty," *Expert Systems with Applications*, vol. 51, pp. 231–244, 2016.

[42] K. Chen and J. Yin, "Information competition in product launch: evidence from the movie industry," *Electronic Commerce Research Applications*, vol. 26, pp. 81–88, 2017.