Game Theoretic Analysis of Production Structures in the Japanese Animation Industry: Comparison of Conventional and Production Committee Systems

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Abstract. This paper presents a game theoretic analysis of production structures including several stakeholders in the Japanese animation market and its related goods markets. We construct a decision-making model of the industry including players of four kinds: an animation studio, a broadcasting company, a related products manufacturer, and consumers. Additionally, we model two production structures: the conventional system and the production committee system. By analyzing the equilibrium states of this model, we conclude theoretically that the animation studio raises the effort level with decreasing marginal costs of related products and/or with increasing network externality effect and increasing royalties the studio receives. For the total profit and the effort level, we found that the production committee system is better than the conventional system.

Keywords: Japanese animation industry, Game theory, Decision-making, Production committee system

1 Introduction

In Japan, the content industry market size, including that for Animation, is estimated at more than 100 billion dollars. Particularly, Japanese animation is so popular throughout the world that the role of the Japanese animation industry is expected to become increasingly important in the future[1]. Furthermore, although the animation industry is a service industry, it is closely related to tangible manufacturing products because related goods such as DVDs, character figures, and TV games are produced and provided in parallel.

According to a report released by the Digital Content Association of Japan[2], however, some problems exist in the content industry. Although the content industry in America, exemplified by that in Hollywood, earns profits worldwide, the Japanese content industry cannot make big gains abroad in spite of its popularity. Some reasons underlie the current situation. One problem is piracy, which is an important issue in the content industry[1][2]. Many researchers have conducted studies of piracy. Tanaka[3] studied the effect of file-sharing software on music CD sales in Japan. Smith et al.[4] pointed out that increased broadband internet penetration has led to a significant increase in DVD sales in the US.

Another problem is the “production structure” of the Japanese animation industry. This industry has many stakeholders: for example, animation companies to which animation creators belong, broadcasting companies, manufacturers of DVDs and other anime-related goods, advertising agencies, trading companies, consumers, and so on. The most important issue in this structure is that animation studios, most of which are small, cannot obtain sufficient profits to maintain the quality of their content because large companies such as broadcasting companies dominate negotiations. Animation studios will be disadvantaged if these circumstances continue. Concern persists about the decline of this industry in the future. Nevertheless, few studies have used a mathematical analysis approach to examine these problems related to the Japanese animation industry.

This study examines production structures of the Japanese animation industry, especially addressing two kinds of production structures: the conventional and the production committee systems. Based on a game theoretic approach, we formulate stakeholders' decision-making and production structures. Then, we analyze them theoretically and compare the two structures.

2 Modeling of Animation Production Structures in Japan

2.1 Formulating Each Player

We construct a game theoretic model of Japanese animation industry composed of players of four kinds: an animation studio, a broadcasting company, a related products manufacturer, and consumers.

Animation Studio. The animation studio receives a budget from the broadcasting company. Then the studio makes a decision about the effort level, which dictates the amount of its production expenditure. In addition, the studio receives as royalties some revenues from sales of the products that the related product manufacturer produces. The profit function is therefore defined as $\Pi_s = B - F(x) + \alpha \sum_{k=1}^{s} p_k q_k$, where B signifies the budget from the broadcasting company, p_k and q_k respectively denote the price and the sales quantity of product k, α is the rate of royalties which the studio receives, s is the number of types of anime-related goods that the manufacturer produces, x stands for the effort level of the studio, and $F(x)$ is the cost of producing the anime, which is the function of the effort level x. The studio decides the effort level x to maximize its profit.

Broadcasting Company. The broadcasting company pays some revenues from sponsors to the animation studio for its production. The company also receives a part of the sales of anime-related products as royalties. The profit is $\Pi_b =$

$A - B + \beta \sum_{k=1}^{s} p_k q_k + L$, where A signifies the budget from sponsors, β denotes the rate of royalties which the company receives, and L is defined as the license fee from a related products manufacturer. Herein, A, β, and L are exogenous variables. Then the company decides how much of budget B is paid to the studio.

Manufacturer. The related products manufacturer produces anime-related goods and pays a part of its sales to the studio and company as royalties. The profit is described as $\Pi_m = (1 - \alpha - \beta) \sum_{k=1}^{s} p_k q_k - \sum_{k=1}^{s} (c_k(q_k) + f_k) - L$, where $c_k(q_k)$ and f_k respectively stand for the variable cost and fixed cost of production for product k.

Consumers. The utility function of consumer i who purchases product k is $U_{i,k} = v_{i,k} + a_k(m) - p_k$. In that equation, $v_{i,k}$ denotes consumer i's own utility of product k. In addition, $a_k(m)$ signifies the increment of utility by increasing m. Here, m is defined as the number of consumers who have watched the anime. Consequently, $a_k(m)$ denotes the effect of indirect network externalities.

2.2 Production Structures

Conventional Production System. A conventional production system can be depicted as Figure 1. There are interdependent relationships among the players. Their decisions are fundamentally made with the sequence of a broadcasting company, an animation studio, and related products manufacturers. Therefore, the game structure in our model can be described simply as a sequential game with perfect information: first, the company chooses budget B; then the studio makes a decision about the effort level x; finally, the manufacturer decides the price p_k of product k.

Production Committee System. This type of system has been emerging recently in anime production in Japan. In the production committee system, stakeholders form a committee by agreeing to finance the project. Therein, a chain of decision process from animation production to selling related products is conducted collaboratively. Thereby, their decisions are made by working together. The structure is depicted in Figure 2. It can be represented by replacing each profit with the total profit that is the sum of each player's profit. The decision sequence is the same as the previous one.

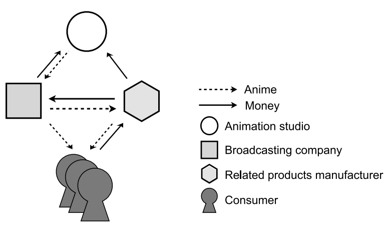

Fig. 1. Conventional production.

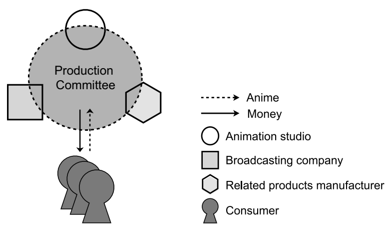

Fig. 2. Production committee system.

3 Theoretical Analysis

3.1 Condition setup

For simplicity, we assume that the related products manufacturer produces only one type of product. Accordingly, we can omit k from the formulas. The variable cost and indirect network externalities are defined as $c(q) = cq$ and $a(m) = a(m(x)) = rx$, respectively. Herein, c stands for the marginal cost. $a(m)$ is assumed as a linear function of m and m as a linear function of x; r is a constant and signifies the effect of indirect network externalities related to the anime. Moreover, we simplify the anime production cost as $F(x) = x^2 + d$, where d is the fixed cost to produce the anime. By such an arrangement, consumer i's utility function can be represented as $U_i = v_i + rx - p$. Then, we assume that the value of v_i is distributed with uniformity from 0 to 1 and that consumers purchase the product only if consumer i's utility U_i is positive. Consequently, the sales quality q is calculated as $q = \int_{U_i \geq 0} dv = \int_{p-a(m)}^{1} dv = rx - p + 1$, which signifies the demand function. Constraint $rx \leq p \leq rx + 1$ can be derived by the assumption of a uniform distribution of v_i in $[0, 1]$.

3.2 Deriving Equilibrium

Subgame perfect Nash equilibrium in the conventional production system can be derived using backward induction. First, we calculate the price p for which the manufacturer makes a decision to maximize the profit Π_m. The price p^* in equilibrium is calculated as $p^* = \operatorname*{argmax}_p \Pi_m$. Second, we derive the effort level x of the animation studio. The studio makes a decision in anticipation of the manufacturer's decision. Therefore x is calculated as $x^* = \operatorname*{argmax}_x \Pi_s$ s.t. $p = p^*$. If the studio's profit Π_s is a negative value, we assume that the studio produces no cartoon film and that each decision-maker's profits are zero. Finally, we calculate budget B. The broadcasting company makes a decision in anticipation of the decision of the animation studio. Here, B is calculated as $B^* = \operatorname*{argmax}_B \Pi_b$ s.t. $x = x^*$ and $p = p^*$.

In the production committee system the decisions can be made cooperatively. They make decisions to maximize the total profits of $\Pi_{total} = \Pi_s + \Pi_b + \Pi_m$. Subgame perfect Nash equilibrium is similarly derived as follows: first, p^* is calculated using $p^* = \operatorname*{argmax}_p \Pi_{total}$ and then x^* is determined by $x^* = \operatorname*{argmax}_x \Pi_{total}$ under the condition of $p = p^*$. Here, B^* cannot be determined because variable B disappears from the formula of Π_{total}.

3.3 Subgame Perfect Nash Equilibrium in The Two Structures

Equilibrium states are presented in Tables 1 – 3. Tables 1 and 2 present the theoretical equilibrium in case of the conventional production systems. The equilibrium values of p^* and x^* are classified according to the values of α, r, and c. The company decides budget B^* on the condition that the value of studio's profit Π_s is positive. Therefore B^* depends on x^* as well as some exogenous variables such as d, A, and L. Therein, l is defined as $l = 1 - \alpha - \beta$.

Table 3 presents the theoretical equilibrium for the production committee system. As in the previous case, the equilibrium values of x^* and p^* are classified according to the values of r and c.

4 Discussion

4.1 Implications from Theoretical Analysis

We discuss the structures of the animation industry. Figure 3 depicts the reaction function of the manufacturer (3-(a), 3-(b)) and the profit function of the studio (3-(c), 3-(d)) in the conventional production, which are derived as an theoretical output especially in case of $0 < \alpha r^2 < 2$. First, see 3-(a) and 3-(c) in Figure 3. As shown in 3-(c), the effort level, $x^* = \frac{ar}{4-ar^2}$, brings about the largest studio's profit and the manufacturer's best response p^* is determined by selecting the corresponding point from the reaction function in 3-(a). In this case, the studio's effort level x^* is positive, derived as an inner point. In addition, the value of $x^* = \frac{ar}{4-ar^2}$ at equilibrium means that the studio's effort level is increasing by a large α or r, implying that the increment of royalties to the studio or large effect of network externalities makes the studio's effort level enlarge. For example, to increase r, social networking services might be useful to promote communication among anime fans, thereby producing word-of-mouth effects[5][6].

Meantime, in case of $c \geq \frac{2l}{\sqrt{4-\alpha r^2}}$ (3-(b), 3-(d)), the effort level at equilibrium is $x^* = 0$. Therefore, as the manufacturer's marginal cost c increases, it decreases the studio's effort level. Therefore, for high-quality anime, it is necessary to reduce the marginal cost of the related products manufacturer. For instance, it can be considered that the manufacturer should provide an online distribution service instead of DVD packages because the marginal cost to copy digital data is almost zero.

The same effects are basically present in cases of the production committee system as well. Such indirect effects imply that the relationship among stakeholders is intricately interwined, demanding careful strategies to foster high-quality anime production.

4.2 Problems in Conventional Production Structure

Table 2 presents many cases in which the animation studio's profit Π_s is zero even if the production is conducted and makes other players profitable because the broadcasting company provides a very small budget to the studio, meaning the decision is best for the company at theoretical equilibrium. The situation indicates that the studio cannot obtain profits because the broadcasting company has a clear advantage over the animation studio in the production structure. The studio will suffer financially and creators associated with the studio will be

Table 1. Theoretical equilibrium in conventional production: x^* and p^*.

Condition of α and r	Condition of marginal cost	x^*	p^*
$0 < \alpha r^2 < 2$	$0 < c < \frac{2l}{\sqrt{4-\alpha r^2}}$	$\frac{\alpha r}{4-\alpha r^2}$	$\frac{1}{2}(\frac{\alpha r^2}{4-\alpha r^2} + \frac{c}{l} + 1)$
	$c \geq \frac{2l}{\sqrt{4-\alpha r^2}}$	0	1
$2 \leq \alpha r^2 \leq 3$	$0 < c < \frac{(\alpha r^2-2)l}{2}$	$\frac{\alpha r}{2}$	$\frac{\alpha r^2}{2}$
	$\frac{1}{2}(\alpha r^2 - 2)l \leq c < \frac{2(\alpha r^2-2)l}{4-\alpha r^2}$	$\frac{l+c}{rl}$	$\frac{l+c}{l}$
	$\frac{2(\alpha r^2-2)l}{4-\alpha r^2} \leq c < \frac{2l}{\sqrt{4-\alpha r^2}}$	$\frac{\alpha r}{4-\alpha r^2}$	$\frac{1}{2}(\frac{\alpha r^2}{4-\alpha r^2} + \frac{c}{l} + 1)$
	$c \geq \frac{2l}{\sqrt{4-\alpha r^2}}$	0	1
$\alpha r^2 > 3$	$0 < c < \frac{(\alpha r^2-2)l}{2}$	$\frac{\alpha r}{2}$	$\frac{\alpha r^2}{2}$
	$\frac{1}{2}(\alpha r^2 - 2)l \leq c < (\alpha r^2 - 1)l$	$\frac{l+c}{rl}$	$\frac{l+c}{l}$
	$c \geq (\alpha r^2 - 1)l$	0	1

Table 2. Equilibrium in conventional production: B^* and profits.

x^*	Condition	B^*	Π_b^*	Π_s^*	Π_g^*
$\frac{\alpha r}{2}$	$d < \frac{\alpha^2 r^2}{4}$	0	$A + \beta\frac{\alpha r^2}{2} + L$	$-d + \frac{\alpha^2 r^2}{4}$	$\frac{l\alpha r^2}{2} - c - f - L$
	$\frac{\alpha^2 r^2}{4} \leq d < A + L$ $+\beta\frac{\alpha r^2}{2} + \frac{\alpha^2 r^2}{4}$	$d - \frac{\alpha^2 r^2}{4}$	$A - d + L + \frac{\alpha+2\beta}{4}\alpha r^2$	0	$\frac{l\alpha r^2}{2} - c - f - L$
	$d \geq A + L$ $+\beta\frac{\alpha r^2}{2} + \frac{\alpha^2 r^2}{4}$	0	0	0	0
$\frac{l+c}{rl}$	$d < \alpha\frac{l+c}{l} - (\frac{l+c}{l})^2$	0	$A + \beta\frac{l+c}{l} + L$	$-d + \alpha\frac{l+c}{l} - (\frac{l+c}{l})^2$	$l - f - L$
	$\alpha\frac{l+c}{l} - (\frac{l+c}{l})^2 \leq d < A + L$ $+(\alpha+\beta)\frac{l+c}{l} - (\frac{l+c}{l})^2$	$d - \alpha\frac{l+c}{l}$ $+(\frac{l+c}{l})^2$	$A - d + L$ $+(\alpha+\beta)\frac{l+c}{l} - (\frac{l+c}{l})^2$	0	$l - f - L$
	$d \geq A + L + (\alpha+\beta)\frac{l+c}{l} - (\frac{l+c}{l})^2$	0	0	0	0
$\frac{\alpha r}{4-\alpha r^2}$	$d < \frac{\alpha}{4l}(l^2 - c^2) + \frac{\alpha^2 r^2}{4(4-\alpha r^2)}$	0	$A + \frac{\beta}{4l^2}\{(\frac{4l}{4-\alpha r^2}{}^2) - c^2\} + L$	$\frac{\alpha}{4l}(l^2 - c^2)$ $+\frac{\alpha^2 r^2}{4(4-\alpha r^2)} - d$	$\frac{1}{4}(\frac{\alpha r^2}{4-\alpha r^2} + \frac{c}{l} + 1)^2 - \frac{4c}{4-\alpha r^2} - f - L$
	$\frac{\alpha}{4l}(l^2 - c^2) + \frac{\alpha^2 r^2}{4(4-\alpha r^2)} \leq d <$ $\frac{\alpha}{4l}(l^2 - c^2) + \frac{\alpha^2 r^2}{4(4-\alpha r^2)} + A + L$ $+\frac{\beta}{4l^2}\{(\frac{4l}{4-\alpha r^2}{}^2) - c^2\}$	d $-\frac{\alpha}{4l}(l^2 - c^2)$ $-\frac{\alpha^2 r^2}{4(4-\alpha r^2)}$	$A - d + \frac{\alpha}{4l}(l^2 - c^2)$ $+\frac{\alpha^2 r^2}{4(4-\alpha r^2)}$ $+\frac{\beta}{4l^2}\{(\frac{4l}{4-\alpha r^2}{}^2) - c^2\} + L$	0	$\frac{1}{4}(\frac{\alpha r^2}{4-\alpha r^2} + \frac{c}{l} + 1)^2$ $-\frac{4c}{4-\alpha r^2} - f - L$
	$d \geq \frac{\alpha}{4l}(l^2 - c^2) + \frac{\alpha^2 r^2}{4(4-\alpha r^2)} +$ $A + L + \frac{\beta}{4l^2}\{(\frac{4l}{4-\alpha r^2}{}^2) - c^2\}$	0	0	0	0
0	$d < A + L$	d	$A - d + L$	0	$-f - L$
	$d \geq A + L$	0	0	0	0

Table 3. Equilibrium in production committee system.

Condition of r	Condition of c	x^*	p^*	Π_{total}^*
$0 < r^2 < 2$	$0 < c \leq 1$	$\frac{(1-c)r}{4-r^2}$	$\frac{-r^2 c + 2c + 2}{4-r^2}$	$A - f - d + \frac{(1-c)^2}{4-r^2}$
	$c > 1$	0	1	$A - f - d$
$2 \leq r^2 < 4$	$0 < c \leq \frac{1}{2}(r^2 - 2)$	$\frac{r}{2}$	$\frac{r^2}{2}$	$A - f - d + \frac{r^2}{4} - c$
	$\frac{1}{2}(r^2 - 2) < c \leq 1$	$\frac{(1-c)r}{4-r^2}$	$\frac{-r^2 c + 2c + 2}{4-r^2}$	$A - f - d + \frac{(1-c)^2}{4-r^2}$
	$c > 1$	0	1	$A - f - d$
$r^2 \geq 4$	$0 < c \leq \frac{r^2}{4}$	$\frac{r}{2}$	$\frac{r^2}{2}$	$A - f - d + \frac{r^2}{4} - c$
	$c > \frac{r^2}{4}$	0	1	$A - f - d$

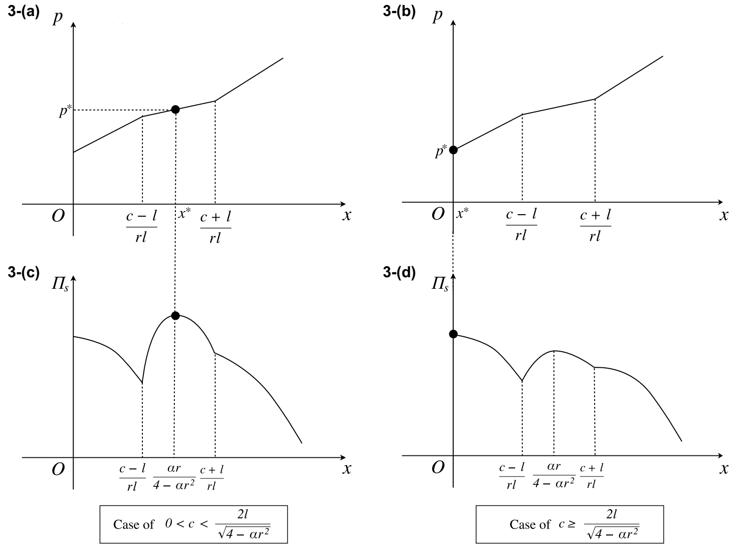

Fig. 3. Manufacturer's reaction and studio's profit functions in case of $0 < \alpha r^2 < 2$.

forced to work in harsh conditions at low pay. If such a situation were to continue, talented creators in the next generation would decrease and they would shun the industry. Eventually, the Japanese animation industry might lose competitiveness in international markets, as reported by the Digital Content Association of Japan[2].

4.3 Comparison of Two Production Structures

In terms of profits and the effort level, we can compare the two production structures. Because there are many theoretical equilibrium states by a combination of some parameters, it is difficult to compare the two structures analytically. We therefore compare them with numerical calculations as follows:

- r is set, varying in $[0.1,\ 3.0]$ with an increment of 0.1
- c is set, varying in $[0.1,\ 2.0]$ with an increment of 0.1
- α and β are set, respectively varying in $[0.01,\ 1.00]$ with an increment of 0.01 to satisfy the condition of $0 < \alpha + \beta < 1$

Accordingly, combinations of values of those parameters are 3,090,600. Figure 4 presents the comparison of the two production systems with numerical calculation. The circle graphs represent the ratio, counting the frequency of outputs of the numerical comparison with respect to the total profit and the effort level. Herein, the total profit stands for the sum of the studio's profit, the broadcasting company's profit and the manufacturer's profit. The result means that the total profit of the production committee system is greater than or equal to that

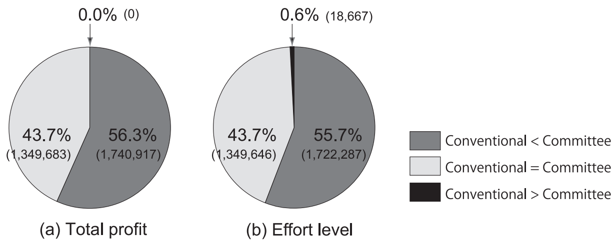

Fig. 4. Comparison between the conventional and the production committee systems.

of the conventional system in all parameter combinations. Regarding the effort level, the cases that the conventional system is greater are very few. Therefore, the production committee system can be regarded as a good structure in anime production.

5 Concluding Remarks

In Japan, the animation industry will become increasingly important in the future. However, it confronts severe problems in its production structure. To elucidate the mechanism, we constructed and analyzed a game theoretic model comprised of decision-makers of four kinds. Results show that the studio reduces the effort level with increasing marginal cost of related products. For example, an online distribution service might be a more valid method than DVD packages to increase the studio's effort level. In addition, the effort level of the studio becomes high with increasing royalties from the manufacturer and with the effect of externalities. Comparison between two production structures shows that the production committee system is better than the conventional one in terms of the total profit and the effort level. Approaches like those in our study are important to assess the future development of competitiveness in this industry.

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