Should public broadcasting companies be continued, scrambled, disbanded or privatized?

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Should public broadcasting companies be continued, scrambled, disbanded or privatized? *

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Abstract

In this paper, we construct a tractable mathematical model to examine the optimal structure of a public broadcasting company. We then compare four possible scenarios from a welfare perspective: a public broadcasting company continues operating, is scrambled, is disbanded or is privatized. In our setting, the situation where only some households choose scrambling is inferior to the situation where all households pay a license fee. However, if the need for the public broadcasting company is low, it should be disbanded. Under a uniform distribution, this reference point is that more than 50% of households agree to disband the public broadcasting company; however, this percentage is crucially dependent on the shape of the distribution. Our model also suggests that privatization of a public broadcasting company is superior to disbandment if the number of commercial broadcasting company is smaller than social optimum number.

Keywords: public broadcasting, noncommercial broadcasting, public goods, public choice

JEL classification: D6, H4, H41, L5, P16

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1 Introduction

Globally, there are many public broadcasting companies, for example, BBC in Britain, ARD and ZDF in Germany, FTV in France, YLR in Finland, EBS in Korea, and NHK in Japan. They operate broadcasting stations funded by a license fee paid by citizens living in their respective countries. [1] Such stations have created many interesting TV programs, and have played a special role in times of stress like natural disasters or terrible accidents. However, in recent years, the role of public broadcasting companies has been questioned following the entry of many cable operators, the diversification of customers' recreation activities and an expansion of Internet-based substitute services. This point is sometimes raised as a question in party policies; for example, the United Kingdom's prime minister mentioned the possibility of reconsidering the license fee system in the general election of 2019, and Minister of Internal Affairs and Communications in Japan has frequently made reference to the NHK license fee in recent years.

Generally, political arguments tend to be biased in one direction. In this paper, we then provide an objective viewpoint based on economic theory using a tractable mathematical model. We construct a one-shot static model where households, which have heterogeneous tastes with respect to watching TV, obtain utility from consumption and watching TV. There are two types of broadcasting companies: commercial and public. On the one hand, commercial broadcasting companies create TV programs using advertising-revenue funding from producers of consumption goods. On the other hand, public broadcasting company creates TV programs funded by license-fee revenue from households. Using this model, we compare three political options from a welfare perspective. The first option is that the public broadcasting company continues operating. Under this option, every household pays a license fee, and we refer to this as the "continued economy". The second option is that households are granted the option to choose scrambling. Some households will choose scrambling, while others will choose non-scrambling when enough households prefer watching TV programs created by a public broadcasting company; we refer to this economy as the "scrambled economy". However, every households choose scrambling when the majority of households place little value on public broadcasting, and we refer to this as the "disbanded economy". The third option is that the public broadcasting company is privatized. In this economy, the public broadcasting company transforms into a commercial broadcasting company, and we refer to this economy as a "privatized economy".

[1] There are various names for such license fees; for example, television license fee, broadcast receiving license fee, public broadcasting tax (Yle tax), reception fee, etc. In this paper, we use the term license fee to cover all such possibilities.

In this paper, we determine which economy eventuates, and which economy is most desirable. Our results depend crucially on a key variable: the need index for a public broadcasting company, which is determined by the following: hours of TV watching; a relative preference for a public broadcasting company; efficiency in terms of investment in a public broadcasting company; and license fee as a percentage of total household income. Our model provides six interesting results. First, the "continued economy" is superior to the "scrambled economy" and "disbanded economy" when the need index for the public broadcasting company is sufficiently high. Second, there is no case in which the "scrambled economy" is superior to the "continued economy" in our model. Third, the "disbanded economy" is superior to the "continued economy" when the need index for the public broadcasting company is low. Fourth, the "disbanded economy" is superior to the "continued economy" even if the public broadcasting company acts appropriately when the need index for the public broadcasting company is extremely low because of a decrease in hours of TV watching or a deterioration of a relative preference for a public broadcasting company. Fifth, the "disbanded economy" is superior to the "continued economy" when more than half of households approve disbanding the public broadcasting company under a uniform distribution; however, this percentage is crucially dependent on the shape of the preference distribution. Sixth, the "privatized economy" is superior to the "disbanded economy" if the number of commercial broadcasting companies is smaller than the socially optimal number.

This paper is related to previous studies, which we group into three categories. The first category is papers examining public goods. Most broadcasted TV programs can be watched by every household as long as they have a receiver: non-excludable. A large number of households can watch TV programs simultaneously at the same quality: non-rivalrous. Goods that are non-excludable and non-rivalrous are called public goods. Following Samuelson (1954), numerous papers have examined public goods. In recent years, some papers have considered heterogeneity of preferences for public goods; for example, Epple and Sieg (1999), Bayer, Ferreira and McMillan (2007), Bayer, Keohane and Timmins (2009), and Teulings, Ossokina and Groot (2018). [2] Our model considers heterogeneity of tastes for watching TV program which has properties of public goods. In Section 3.2, we examine the policy granting the option to choose scrambling. From a public goods perspective, we can interpret this policy as eliminating the non-excludability property of TV programs created by public broadcasting company.

[2] Many studies in other fields have considered heterogeneity. For example, in growth theory, Iwaisako and Ohki (2019) and Ohki (2019) examined the role of innovation under firm heterogeneity.

The second category is papers examining public choice or new political economy, which examines about the intersection between economics and political science, following Arrow (1951) and Black (1958). Our model shows the minimum percentage of approvers of scrambling (disbanding) policy required in order to increase social welfare. Our result can then provide a reference point for when governments should adopt a scrambling (disbanding) policy.

The third category is papers examining broadcasting; for example, Steiner (1952), Spence and Owen (1977), Beebe (1977), Nilssen and Sorgard (2000), Gal-Or and Dukes (2001), Cunningham and Alexander (2004), Anderson and Coate (2005), and Anderson, Foros and Kind (2018). They mainly examined the relationships between program diversity, market structure and viewer preferences. [3] As our model focuses on the necessity of public broadcasting company, we construct our model as simply as possible. Then we simplify these relationships discussed in the above-mentioned literature; however, we believe that considering such factors enhances our model and that this extension is important for future work.

Our paper proceeds as follows. In Section 2, we construct a basic model. In Section 3.1, we examine the welfare of the "continued economy". In Section 3.2, we examine the welfare of the "scrambled economy" and the "disbanded economy", and compare these to the "continued economy". In Section 3.3, we examine the welfare of the "privatized economy", and compare it with the "disbanded economy". In Section 4, we generalize the distribution of taste for watching TV, and discuss how the shape of the distribution affects our results.

2 Model

We construct a static model in which households, which have heterogeneous tastes for watching TV, obtain utility from consumption and watching TV. There are two types of broadcasting companies: commercial and public broadcasting. Using this model, we derive the equilibrium under three policy options. The first option is to make every household pay a license fee. The second is to allow households the option to select scrambling, and thus households that do not want to watch public broadcasting programs do not have to pay a license fee. The third option is to disband the public broadcasting company, and transform it into a commercial broadcasting company. We then compare these three options from a welfare perspective.

[3] In addition to these studies, a series of studies about pulse auction, such as Milgrom (2004), can also be categorized as papers examining broadcasting.

2.1 Households

The number of households is exogenously given, and normalized as unity. Household members obtain utility from consuming goods and from watching TV. They are heterogeneous in tastes for watching TV, $\theta \in [0, 1]$. In the basic model, we specify a uniform distribution as follows:[4]

$$g(\theta) = 1 \quad 0 \leq \theta \leq 1 \ , \tag{1}$$

Household members having θ maximize their utility as follows:

$$\max_{C, v_C(j), v_P} U(\theta) = \ln C + \theta \left[\int_0^n q_C(j) \left[v_C(j) \right]^{\frac{1}{2}} dj + \gamma q_P \left[v_P \right]^{\frac{1}{2}} \right]^2 , \tag{2}$$

where C is consumption, $q_C(j)$ and $v_C(j)$ are the quality and hours watched of TV programs created by commercial broadcasting company j respectively, n is the number of commercial broadcasting companies, q_P and v_P are the quality and hours watched of TV programs created by public broadcasting company, respectively, and γ is the relative preference for public broadcasting company. [5] Consumption goods are provided by one industry, the preferences for which are expressed in natural logarithms. TV programs are provided by n commercial broadcasting companies and one public broadcasting company, with CES preferences, following Dixit and Stiglitz (1977). [6]

Households face two constraints. The first is a budget constraint as follows:

$$CP \leq I - F_L, \tag{3}$$

where P is the price of consumption goods, I is income that is exogenously given and F_L is a license fee

[4]In Section 4 and appendix B, we consider other distributions: linear distribution and discrete distribution respectively.

[5]Public broadcasting companies seem to differ from commercial broadcasting companies in certain ways. On the one hand, public broadcasting companies can create unbiased news, educational, cultural and long-term documentary programs because they are not subject to audience ratings, and their budget is guaranteed by a license fee. On the other hand, their programs may be too formal and may not be exciting because they broadcast from a public perspective. In our model, TV viewers evaluate programs from public broadcasting companies higher (lower) than that of commercial broadcast companies when $\gamma > 1$ ($\gamma < 1$).

[6]For analytical simplicity, we normalize the elasticity of substitution among the broadcasting companies to equal two.

that is also exogenously given. [7] The second constraint is a time constraint as follows:

$$\int_{0}^{n} v_C(j)\, dj + v_P \leq V, \tag{4}$$

where V is hours watching TV, which is exogenously given. [8] Solving the static utility maximization problem of the household, we now derive the amount of consumption goods, hours watching commercial broadcasting company j and hours watching the public broadcasting company as follows:

$$\begin{aligned} C &= \frac{I-F_L}{P} \\ v_C(j) &= \frac{V[q_C(j)]^2}{\int_0^n [q_C(j)]^2 dj + [\gamma q_P]^2} , \\ v_P &= \frac{V[\gamma q_P]^2}{\int_0^n [q_C(j)]^2 dj + [\gamma q_P]^2} \end{aligned} \tag{5}$$

2.2 Commercial broadcasting companies

Commercial broadcasting companies create TV programs and obtain advertising revenue according to viewer ratings. [9] A high viewer rating is interpreted as resulting from the high quality of the TV program. Thus, the revenue of each commercial broadcasting company is expressed as a proportion of the aggregate advertising revenue of the whole industry depending on their relative quality:

$$x(j) = P_A \frac{q(j)}{Q}, \tag{6}$$

where $x(j)$ is the advertising revenue of commercial broadcasting company j, $Q \equiv \int_0^n q(j)\, dj$ is aggregate quality, and P_A is aggregate advertising revenue. Clients tend to pay high advertising rates when the effectiveness of advertising is high, and then we assume that aggregate advertising revenue, P_A, is an increasing function of aggregate quality, Q, as follows:

$$P_A = Q^{\beta}, \tag{7}$$

[7] In this paper, we do not consider the labor market, and income is determined exogenously. Thus, we cannot capture the effects of policy changes on labor demand, wage rate and income. Although this effect is important in general equilibrium models, for simplicity we ignore it.

[8] In this paper, we do not consider the substitution among watching TV, enjoying other leisure activities and working. Thus, we cannot capture the effect of policy changes on hours watching TV, which then affects hours enjoying other leisure activities or working. Although this effect is important in general equilibrium models, for simplicity, we also ignore it.

[9] In the real economy, advertising rates are determined by various factors: popularity of the program, broadcast length, bargaining power of commercial broadcasting company, business conditions of client, etc. Considering these factors would make our model more sophisticated; however, for simplicity, we focus only on viewer ratings.

where $\beta < 1$ is the elasticity of aggregate advertising revenue with respect to aggregate quality, which is exogenously given. We assume that each commercial broadcasting company can improve its quality of TV program by investing as follows:

$$q_C(j) = 2^{\frac{1}{2}} s_C(j) [i_C(j)]^{\frac{1}{2}}, \tag{8}$$

where s_C is the efficiency of investing, which is exogenously given, $i(j)$ is the amount of investment in commercial broadcasting company j. We normalize the unit cost of investment to unity, and express the profit of broadcasting company j as follows:

$$\pi(j) = x(j) - i(j) - f, \tag{9}$$

where f is a fixed cost. Each commercial broadcasting company maximizes this profit function subject to (6), (7) and (8). We restrict our analysis on the symmetric equilibrium by assuming that all commercial broadcasting companies behave in the same way. Thus, we obtain endogenous variables in the symmetry equilibrium as follows: [10]

$$\begin{aligned} q_C &= [n]^{\frac{-[1-\beta]}{2-\beta}} [s_C]^{\frac{2}{2-\beta}} \\ i_C &= \tfrac{1}{2}[n]^{\frac{-2[1-\beta]}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}} \\ \pi_C &= \tfrac{1}{2}[n]^{\frac{2[\beta-1]}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}} - f \\ Q &= [n]^{\frac{1}{2-\beta}} [s_C]^{\frac{2}{2-\beta}} \end{aligned}. \tag{10}$$

2.3 Consumption goods

We assume that the consumption goods are homogeneous. The price of the consumption goods, P, comprises advertising cost and other factors as follows: [11]

$$P = \alpha P_A + \bar{P}, \tag{11}$$

[10] Free entry is assumed in many papers. In this case, the profit of each company goes to zero, and $n = [2f]^{\frac{2-\beta}{2[\beta-1]}} s_C^{\frac{-2\beta}{2[\beta-1]}}$ is satisfied. However, in this paper, we assume that n is exogenous because entry of commercial broadcasting companies is restricted by the government in the real economy.

[11] In many papers, perfect competition is assumed among firms producing consumption goods. For example, we can set the profit function as $\pi_C = PC - F_V C - P_A$ where F_V is the variable production cost of the consumption goods. If the consumption goods are produced in perfect competition, this profit goes to zero. Substituting (5), we obtain $P = \frac{F_V[I-F_L]}{I-F_L-P_A}$. From this equation, we confirm that the price of the consumption goods is an increasing function of P_A and that it comprises other factors.

where $\bar{P}$ includes factors determining the price of the consumption goods excluding advertising cost, which is exogenously given, and α is a parameter measuring the extent to which advertising cost raises the price of the consumption goods.

2.4 Public broadcasting company

There is one public broadcasting company in the economy and it creates TV programs funded by a license fee from households. The quality of TV programs created by the public broadcasting company is expressed as follows:

$$q_P = s_P \left[i_P \right]^{\frac{1}{2}}, \tag{12}$$

where s_P is the efficiency of investing, which is exogenously given, and i_P is investment in the public broadcasting company. The public broadcasting company invests part of the license fee from households as follows:

$$i_P = \omega \zeta F_L, \tag{13}$$

where $\omega \leq 1$ is the ratio of investment to the revenue of television license fee, which is exogenously given, and $\zeta \leq 1$ is the rate of collection of the license fee. [12] Thus, the quality of the public broadcasting company is expressed as follows:

$$q_P = s_P \left[\omega \zeta F_L \right]^{\frac{1}{2}}, \tag{14}$$

3 Analysis

In this section, we compare some scenarios from a welfare perspective: public broadcasting company continues to operate, the television programs of the public broadcasting company are scrambled for an applicant, the public broadcasting company is dissolved completely, the public broadcasting company is

[12] According to the survey released by Ministry of Internal Affairs and Communications in Japan, the rate of collection is 93.4% for BBC, 95.9% for ARD and ZDF, 90.7% for FTV, 99.9% for KBS and 82.1% for NHK. Public broadcasting companies do not use the entire amount collected from license fees to improve the quality of TV programs. For example, the ratio of the collection cost to the license fee is 2.7% for BBC, 2.2% for ARD and ZDF, 1.0% for FTV, 10.0% for KBS and 10.8% for NHK.

privatized.

3.1 Continued economy

In this subsection, we examine the welfare when the public broadcasting company continues to operate, and every household pays a license fee. We call this economy the "continued economy". Although the rate of collection of the license fee is not 100% in the real economy as shown in footnote 12, license fees are, in principle, imposed on all households in many countries. Thus, we assume that every household pays a license fee, and we set the proportion of households paying a license fee in the "continued economy" as follows:

$$\zeta = \int_0^1 d\theta = 1, \tag{15}$$

Substituting (5), (10), (14) and (15) into (2), we obtain the equilibrium value of the utility of households having θ as follows:

$$U^C(\theta) = \ln \frac{I - F_L}{\bar{P} + \alpha [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}}} + \theta V \left[[n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{4}{2-\beta}} + [\gamma s_P]^2 \omega F_L \right]. \tag{16}$$

As we assume θ follows a uniform distribution expressed as (1) , we obtain the welfare under the "continued economy" as follows:

$$U^C = \int_0^1 U^C(\theta) g(\theta) d\theta. \tag{17}$$

Substituting (1) and (16) into this equation, we obtain:

$$U^C = \ln \frac{I - F_L}{\bar{P} + \alpha [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}}} + \frac{1}{2} V \left[[n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{4}{2-\beta}} + [\gamma s_P]^2 \omega F_L \right]. \tag{18}$$

3.2 Scrambled economy, disbanded economy

In this subsection, we derive the welfare when households are granted the option to choose scrambling or non-scrambling. In this case, each household can choose whether to watch the TV program created by the public broadcasting company and pay a license fee or not watch it and not pay a license fee. We call the former choice non-scrambling, and the latter choice scrambling. If a household having θ chooses scrambling, their utility is expressed as follows:

$$U^{SS}(\theta) = \ln \frac{I}{\bar{P} + \alpha [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}}} + \theta V [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{4}{2-\beta}}. \tag{19}$$

By choosing scrambling, on the one hand, their utility increases because they do not pay the license fee; however, on the other hand, they cannot watch TV programs created by the public broadcasting company, which decreases their utility.

If a household having θ chooses non-scrambling, their utility is expressed as follows:

$$U^{SN}(\theta) = \ln \frac{I - F_L}{\bar{P} + \alpha [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}}} + \theta V \left[[n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{4}{2-\beta}} + [\gamma s_P]^2 \omega \zeta F_L \right]. \tag{20}$$

Note that $U^{SN}(\theta)$ is inevitably smaller than $U^{C}(\theta)$ because a decrease in the proportion of households paying the license fee reduces the quality of the TV programs created by the public broadcasting company. When households can choose scrambling or non-scrambling, the proportion of households paying a license fee is expressed as follows:

$$\zeta = \int_{\theta^*}^{1} d\theta = 1 - \theta^*, \tag{21}$$

where θ^* is the critical value as to whether households choose scrambling, which is determined endogenously as:

$$\begin{aligned} &\ln [I - F_L] - \ln \left[\bar{P} + \alpha [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}} \right] + \theta^* V \left[[n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{4}{2-\beta}} + [\gamma s_P]^2 \omega [1 - \theta^*] F_L \right] \\ &= \ln I - \ln \left[\bar{P} + \alpha [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}} \right] + \theta^* V \left[[n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{4}{2-\beta}} \right] \end{aligned}. \tag{22}$$

The LHS (RHS) of this equation expresses the utility of households having θ^* when they choose non-scrambling (scrambling). If the LHS of equation (22) is smaller (greater) than the RHS, the marginal benefit of a household having θ^* from choosing scrambling is greater (smaller) than the marginal cost, and more households choose scrambling (non-scrambling), and θ^* increases (decreases). The interior equilibrium value of θ^* is then determined at the point where the LHS equals the RHS.

To check the stability visually, we rearrange (22) to obtain the following:

$$\theta^* [1 - \theta^*] = \frac{1}{X}, \tag{23}$$

where

$$X = V [\gamma s_P]^2 \omega F_L \ln \frac{I}{I - F_L}$$

is the need index for the public broadcasting company. This index is an increasing function of hours watching TV, V, the relative preference for the public broadcasting company, γ, the efficiency of investing in the public broadcast company, s_P, the investment rate of the public broadcasting company, ω, and the ratio of the license fee to the total income of the household, $\frac{I}{I-F_L}$.

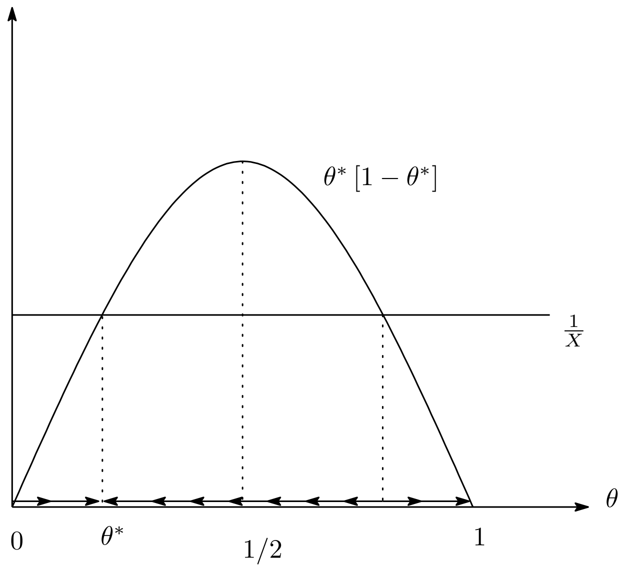

Figure 1: Determination of θ^* in the interior equilibrium

In Figure 1, we depict the determination of θ^* in the interior equilibrium. The inverted U-shaped curve expresses the LHS of equation (23), and the horizontal line expresses the RHS of equation (23). As discussed above, if the LHS of equation (23) is smaller (greater) than the RHS, θ^* increases (decreases). When the situation where every household is required to pay a license fee changes to the situation where households have the option to choose scrambling, the critical value goes to θ^* from zero. [13]

In this case, households with $0 \leq \theta \leq \theta^*$ choose scrambling, while households with $\theta^* < \theta \leq 1$ choose non-scrambling, and we call this economy the “scrambled economy”. In the “scrambled economy”, the

[13]As shown in Figure 1, the larger of the two intersections is unstable, and we confirm that θ^* is determined by the smaller of the two intersections.

equilibrium value of welfare is expressed as follows:

$$U^S = \int_0^{\theta^*} U^{SS}(\theta)\, g(\theta)\, d\theta + \int_{\theta^*}^{1} U^{SN}(\theta)\, g(\theta)\, d\theta \tag{24}$$

Substituting (1), (19) and (20) into this equation, we obtain:

$$U^S = \begin{array}{l} \theta^* \ln \frac{I}{I-p_P} + \ln[I - F_L] - \ln\left[\bar{P} + \alpha [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}}\right] \\ +\frac{1}{2} V \left[[n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{4}{2-\beta}} + [\gamma s_P]^2 \omega [1-\theta^*] F_L\right] - \frac{1}{2} [\theta^*]^2 V [\gamma s_P]^2 \omega [1-\theta^*] F_L \end{array}. \tag{25}$$

Now we compare U^S to U^C as follows:

$$U^S - U^C = -\frac{1}{2}\theta^* \left[\left[\theta^* - \frac{1}{2}\right]^2 + \frac{3}{4}\right] V [\gamma s_P]^2 \omega F_L < 0 \tag{26}$$

This equation shows that the welfare of "scrambled economy" is absolutely smaller than that of "continued economy".

We consider this result in detail. First, the utility of households choosing non-scrambling, $\theta^* \leq \theta$, absolutely decreases as follows:

$$U^{SN}(\theta) - U^C(\theta) = -\theta V [\gamma s_P]^2 \omega \theta^* p_P < 0$$

This result indicates that the choice of scrambling by some households decreases the revenue of the public broadcasting company, which decreases the quality of its programs. The quality decreases then reduces the utility of households choosing non-scrambling. Second, even the utility of households choosing scrambling can decrease. We compare $U^{SS}(\theta)$ to $U^C(\theta)$ as follows:

$$U^{SS}(\theta) - U^C(\theta) = \ln \frac{I}{I - F_L} - \theta V [\gamma s_P]^2 \omega F_L$$

We can easily confirm that this equation is negative (positive) when $\theta = \theta^*$ ($\theta = 0$). We define θ^{**} as satisfying $U^{SS}(\theta^{**}) = U^C(\theta^{**})$ as follows:

$$\theta^{**} = \frac{1}{X}.$$

Households having $\theta^{**} \leq \theta < \theta^*$ prefer the "continued economy" to the "scrambled economy". This implies that the marginal benefit of choosing scrambling is less than the marginal cost for households having $\theta^{**} \leq \theta < \theta^{*}$ as long as the quality of the public broadcasting company is kept as $q_P = s_P \left[\omega F_L\right]^{\frac{1}{2}}$. However, the quality decreases because of the decrease in revenue from the license fee as follows: $q_P = s_P \left[\omega \left[1-\theta^{*}\right] F_L\right]^{\frac{1}{2}}$. This effect makes households having $\theta^{**} \leq \theta < \theta^{*}$ choose scrambling reluctantly. Third, households having $\theta < \theta^{**}$ willingly choose scrambling because they are not interested in watching TV. Their utility increases because they no longer undertake wasteful expenditure. Equation (26) implies that the first and second effects dominate the third effect. [14]

When we obtain the "scrambled economy", the horizontal line ($\frac{1}{X}$) should be smaller than the maximum value of the inverted U curve in Figure 1. As the maximum value of $\theta\left[1-\theta\right]$ is $\frac{1}{4}$ within $0 \leq \theta \leq 1$, $\frac{1}{X} = \frac{1}{V\left[\gamma s_P\right]^2 \omega F_L} \ln \frac{I}{\left[I-F_L\right]} \leq \frac{1}{4}$ should be satisfied when the "scrambled economy" is realized. In this case, households watch a large amount of TV program (large V), households regard the public broadcasting company as important (large γ), the public broadcasting company is managed efficiently (large $\left[s_P\right]^2 \omega F_L$), and the license fee is appropriate relative to household income (large $\ln \frac{I}{\left[I-F_L\right]}$), which is to say that the public broadcasting company is valued by many households. Then, not all households choose scrambling, and the public broadcasting company continues to operate although its scale is reduced. As $\theta^{**} = \frac{1}{X}$ is satisfied, the "scrambled economy" is realized when fewer than 25% of households prefer the "scrambled economy" to the "continued economy", $U^{SS}\left(\theta\right) > U^{C}\left(\theta\right)$, and we obtain the following proposition. [15]

Proposition 3.1. *When we consider uniformly distributed heterogeneity of preferences for watching TV, and when fewer than 25% of households prefer the "scrambled economy" to the "continued economy", we obtain the following results.*

- *Granting the option to choose scrambling reduces the scale of the public broadcasting company; however, the company is not disbanded because enough households choose non-scrambling: the "scrambled economy" is realized.*

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[14] The aggregate utility-difference of households having $0 \leq \theta < \theta^{**}$ is $\int_0^{\theta^{**}} \left[U^{SS}\left(\theta\right) - U^{C}\left(\theta\right)\right] g\left(\theta\right) d\theta = \frac{1}{2}\left[\theta^{**}\right]^2 V \left[\gamma s_P\right]^2 \omega F_L$, that of households having $\theta^{**} \leq \theta < \theta^{*}$ is $\int_{\theta^{**}}^{\theta^{*}} \left[U^{SS}\left(\theta\right) - U^{C}\left(\theta\right)\right] g\left(\theta\right) d\theta = -\frac{1}{2}\left[\theta^{*}\right]^4 V \left[\gamma s_P\right]^2 \omega F_L$, and that of households having $\theta^{*} \leq \theta \leq 1$ is $\int_{\theta^{*}}^{1} \left[U^{SC}\left(\theta\right) - U^{C}\left(\theta\right)\right] g\left(\theta\right) d\theta = -\frac{1}{2}\left[1-\left[\theta^{*}\right]^2\right] V\theta^{*} \left[\gamma s_P\right]^2 \omega F_L$. Summing up these equations, we obtain (25).

[15] As we assume a uniform distribution, the percentage preferring the "scrambled economy" is calculated as $\int_0^{\theta^{**}} d\theta = \theta^{**}$.

- *Welfare is absolutely smaller than the case where every household pays a license fee.*

When the need index for public broadcasting company is small, the horizontal line ($\frac{1}{X}$) becomes larger than the maximum value of the inverted U curve, which is depicted in Figure 2.

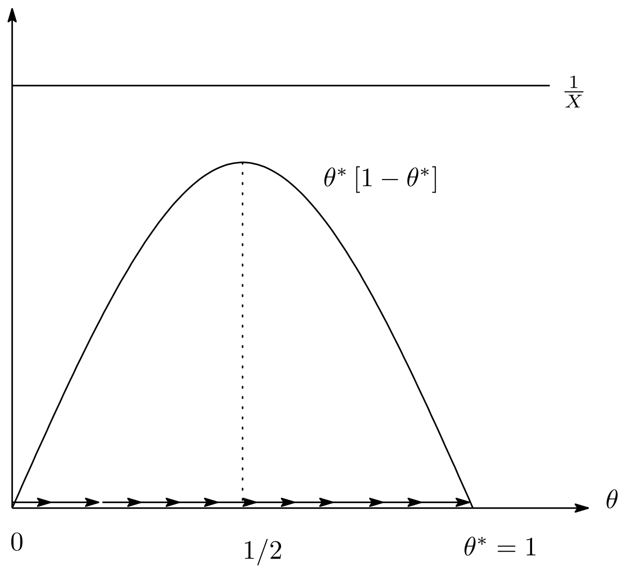

Figure 2: Determination of θ^* at the corner equilibrium

As depicted in Figure 2, if $\frac{1}{X}$ is too large to intersect $\theta^* [1-\theta^*]$, the LHS of equation (22) is smaller than the RHS for any θ. In this case, the marginal benefit of choosing scrambling is greater than the marginal cost for every household. Therefore, θ^* increases until it reaches the maximum region, and we obtain the following corner solution:

$$\theta^* = 1, \tag{27}$$

Then all household choose scrambling, and the revenue of the public broadcasting company goes to zero. In this case, the public broadcasting company cannot continue to manage, and we call this economy the "disbanded economy". In this economy, the equilibrium value of welfare is as follows:

$$U^D = \int_0^1 U^{SS}(\theta)\, g(\theta)\, d\theta. \tag{28}$$

Substituting (1) and (19) into the above equation, we obtain:

$$U^D = \ln I - \ln \left[\bar{P} + \alpha [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}} \right] + \frac{1}{2} V \left[[n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{4}{2-\beta}} \right]. \tag{29}$$

Now we compare U^D to U^C as follows:

$$U^D - U^C = \ln \frac{I}{I - F_L} - \frac{1}{2} V \left[\gamma s_P\right]^2 \omega F_L \tag{30}$$

The sign of equation (30) can be positive or negative. The reason why (30) can be negative is the existence of households reluctantly choosing scrambling, as discussed above. Households having $\theta > \theta^{**}$ prefer the "continued economy", $U^D(\theta) < U^C(\theta)$; however, they choose scrambling because of the reduction in quality. From (30), on the one hand, we can confirm that when

$$\frac{1}{4} \leq \frac{1}{X} < \frac{1}{2}$$

is satisfied, the "disbanded economy" is realized, and the welfare is smaller than that for the "continued economy". On the other hand, when

$$\frac{1}{2} \leq \frac{1}{X}$$

is satisfied, the "disbanded economy" is realized, and the welfare is larger than that for the "continued economy".

As $\theta^{**} = \frac{1}{X}$ is satisfied, the "disbanded economy" is realized when more than 25% of households prefer the "scrambled economy" to the "continued economy", $U^{SS}(\theta) > U^C(\theta)$. Moreover, the welfare of the "disbanded economy" is greater (smaller) than that of the "continued economy" when more (less) than 50% of households prefer the "disbanded economy" to the "continued economy", and we obtain the following proposition.

Proposition 3.2. *When we consider the uniformly distributed heterogeneity of preferences for watching TV, and when more than 25% of households prefer the "scrambled economy" to the "continued economy", we obtain the following results.*

- *Granting the option to choose scrambling causes a disbanding of the public broadcasting company: the "disbanded economy" is realized.*
- *When fewer (more) than 50% of households prefer the "disbanded economy" to the "continued economy", welfare is smaller (larger) than the case where every household pays a license fee.*

Propositions 1 and 2 offer two simple but strong messages. First, the public broadcasting company should be disbanded when more than 50% of households approve of this plan; otherwise, the government should not grant the option to choose scrambling. Second, the equilibrium where only some households choose scrambling, but other households choose non-scrambling, is undesirable.

If fewer than 50% of households approve of disbanding of the public broadcasting company, should it continue to operate as usual without carrying out any reform of present system? The answer is "No". It should propose an appropriate license fee and aim for more efficient operation. From (18), we obtain the social optimal values of F_L and ω as follows:

$$\begin{array}{rcl} F_L^{SO} & = & I - \frac{2}{V[\gamma s_P]^2 \omega} \\ \omega^{SO} & = & 1 \end{array}. \tag{31}$$

The public broadcasting company should then reduce the license fee if it is too high relative to the desirable level, and it should eliminate wasteful expenditure, which unambiguously increases welfare.

If the public broadcasting company acts appropriately, should it operate indefinitely? The answer is also "No". If (31) is satisfied, we obtain:

$$\frac{1}{V\left[\gamma s_P\right]^2 \omega^{SO} F_L^{SO}} \ln \frac{I}{I - F_L^{SO}} = \frac{1}{IV\left[\gamma s_P\right]^2 - 2} \ln \frac{IV\left[\gamma s_P\right]^2}{2}.$$

Even in this case, if the following condition is satisfied, welfare increases if the public broadcasting company is disbanded.

$$\frac{1}{2} \leq \frac{1}{IV\left[\gamma s_P\right]^2 - 2} \ln \frac{IV\left[\gamma s_P\right]^2}{2}.$$

This condition is satisfied when $IV\left[\gamma s_P\right]^2 \leq 2$ is satisfied. In recent years, the amount of time spent watching TV has been decreasing because of increased use of the Internet. [16] This result causes a decrease in $IV\left[\gamma s_P\right]^2$. If this tendency continues, our model suggests that the public broadcasting company should be disbanded sooner or later even if it acts appropriately. It is natural that the role of the public sector changes following technological development and maturity of the economy, as seen in various industries around the world, and thus we obtain the following proposition.

[16] According to Ministry of Internal Affairs and Communications Japan (2018), on the one hand, the average amount of time watching TV on weekdays was 168.3 minutes per day in 2013, which decreased to 159.4 minutes per day in 2017. This tendency is prominent in younger generations. That among teenagers was 102.5 minutes per day in 2013, which decreased to 73.3 minutes per day in 2017. That among people in their 20s was 127.2 minutes per day in 2013, which decreased to 91.8 minutes per day in 2017. That among people in their 30s was 157.6 minutes per day in 2013, which decreased to 121.6 minutes per day in 2017. On the other hand, the average amount of time using the Internet on weekdays was 77.9 minutes per day in 2013, which increased to 100.4 minutes per day in 2017.

Proposition 3.3. *If hours spent watching TV continues to decrease, the need index for public broadcasting company continues to decrease, and the roles of the public broadcasting company will end sooner or later even if it acts appropriately.*

In this section, we compare "continued economy" with "scrambled economy" and "disbanded economy". One may think that other policies exist that are superior to the policy granting the option to choose scrambling. In the next section, we thus consider the effect of privatization of public broadcasting company.

3.3 Privatized economy

In the many previous studies examining privatization, X-inefficiency, the Averch–Johnson effect, soft budget constraint and regulatory capture are central issues. [17] It seems that privatization of the public broadcasting company is related to the Averch–Johnson effect, soft budget constraint and regulatory capture. [18] Although these points are important and interesting, they are beyond the scope of this paper, and we thus leave these to future work.

In our model, we regard privatization of the public broadcasting company as a combination of disbanding of the public broadcasting company and the establishment of one commercial broadcasting company. [19] When the public broadcasting company is privatized, households no longer need to pay a license fee and enjoy TV programs from $n+1$ commercial broadcasting companies. We refer to this economy as a "privatized economy", and its utility is then expressed as:

$$U^P(\theta) = \ln I - \ln\left[\bar{P} + \alpha\,[n+1]^{\frac{\beta}{2-\beta}}\,[s_C]^{\frac{2\beta}{2-\beta}}\right] + \theta V\,[n+1]^{\frac{\beta}{2-\beta}}\,[s_C]^{\frac{4}{2-\beta}}\,, \tag{32}$$

and welfare is expressed as:

$$U^P = \int_0^1 U^P(\theta)\, g(\theta)\, d\theta.$$

[17]X-inefficiency is an inefficiency caused by a lack of competitive pressure, which was introduced by Leibenstein (1966). The Averch–Johnson effect is the tendency of regulated companies, such as public companies, to accumulate excessive amounts of capital, which was introduced by Averch and Johnson (1962). Soft budget constraint is a phenomenon in which inefficient state-owned enterprises survive through financial subsidies or other instruments, which was first discussed by Kornai (1979). Regulatory capture is a situation in which authority is co-opted by regulated firms such as state-owned enterprises, which was introduced by Stigler (1971).

[18]Public broadcasting companies have multiple channels, including satellite broadcasting, which may be excessive. It is said that the soft budget constraint of public broadcasting companies may cause an increase in the charge for the right to broadcast particular events. An undesirable policy may be adopted because of lobbying by a public broadcasting company.

[19]According to Stiglitz (2015), there are two main differences between a public company and a private company: First, whether or not the manager of the company is elected using a public process; and second, whether or not the company has a legal entitlement to collect a fee. Our model captures the second point that the source of income of the public broadcasting company is forcibly collecting a license fee.

Substituting (1) and (32) into the above equation, we obtain:

$$U^P = \ln I - \ln \left[\bar{P} + \alpha \left[n+1 \right]^{\frac{\beta}{2-\beta}} \left[s_C \right]^{\frac{2\beta}{2-\beta}} \right] + \frac{1}{2} V \left[n+1 \right]^{\frac{\beta}{2-\beta}} \left[s_C \right]^{\frac{4}{2-\beta}} .$$

The difference in welfare between the "privatized economy" and the "continuation economy" is then expressed as:

$$\begin{aligned} & U^P - U^C \\ & = \left[\ln \tfrac{I}{I-F_L} - \tfrac{1}{2} V \left[\gamma s_P \right]^2 \omega F_L \right] + \left[\tfrac{1}{2} V \left[\left[n+1 \right]^{\frac{\beta}{2-\beta}} - \left[n \right]^{\frac{\beta}{2-\beta}} \right] \left[s_C \right]^{\frac{4}{2-\beta}} - \tfrac{\alpha\beta}{2-\beta} \ln \frac{\left[\bar{P} + \alpha [n+1]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}} \right]}{\left[\bar{P} + \alpha [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}} \right]} \right] . \end{aligned} \tag{33}$$

Comparing (30) and (33), a second set of brackets is added, which expresses the marginal effect of an increment in the number of commercial broadcasting companies. The first term in the second set of brackets is the marginal benefit. An increment in the number of commercial broadcasting companies provides an increment in the number of TV programs, which increases the utility of households. The second term in the second set of brackets is the marginal cost. An increment the number of commercial broadcasting companies increases advertising costs, which raises the price of the consumption goods. Households reduce their consumption because of the high price of the consumption good, which decreases household utility. If the marginal benefit of an increment in the number of commercial broadcasting companies is larger than the marginal cost, U^P is greater than U^D.

Proposition 3.4. *If the number of commercial broadcasting companies is smaller than the social optimum number, the "privatized economy" is superior to the "disbanded economy".*

4 Considering another distribution

In the previous section, we confirmed that the welfare of the "scrambled economy" is less than that of the "continued economy". We also confirmed that the "disbanded economy" is realized when more than 25% of households prefer the "scrambled economy" to the "continued economy", and that the welfare of the "disbanded economy" is higher than that of the "continued economy" when more than 50% of households prefer the "disbanded economy" to the "continued economy". Although these results derived from a uniform distribution are clear and significant, it is natural to wonder whether they are influenced by the shape of the distribution of θ. Thus, in the next subsection we consider another distribution.

4.1 Linear distribution

On the one hand, there are many households with $\theta < \theta^{**}$ when the distribution density is concentrated around a small value of θ. Under this distribution, welfare may increase substantially because of an increment of utility of households with $\theta < \theta^{**}$ not paying a license fee by granting the option to choose scrambling. On the other hand, there are small households with $\theta < \theta^{*}$ when the distribution density is concentrated around a large value of θ. Under this distribution, the decrease in the revenue of the public broadcasting company is mitigated because the number of households choosing scrambling ($\theta < \theta^{*}$) is small. In this case, welfare may decrease a little because of the decrease in the quality of public broadcasting company programs. To confirm how these two conflicting effects influence our results, in this subsection, we specify a linear distribution instead of (1) as follows:

$$g(\theta) = a\theta + 1 - \tfrac{1}{2}a \quad 0 \leq \theta \leq 1 \ , \tag{34}$$

where $-2 \leq a \leq 2$ is a parameter determining the shape of distribution as depicted in Figure 3. If $a > 0$ ($a < 0$), the distribution density is concentrated at a large (small) value of θ compared with $a = 0$.

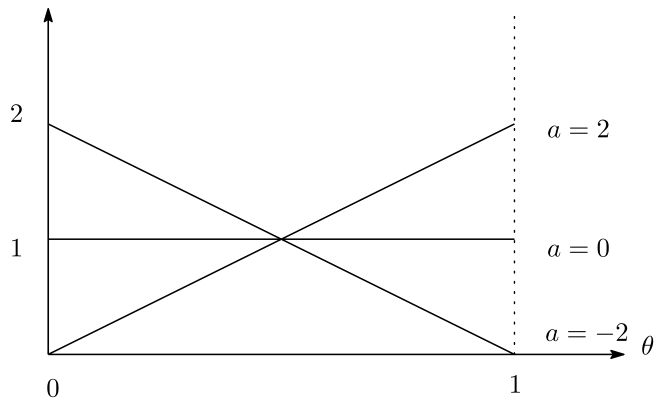

Figure 3: The shape of the distribution

Under this distribution, (21) changes as follows:

$$\zeta = \int_{\theta^*}^{1} \left[a\theta + 1 - \frac{1}{2}a\right] d\theta = 1 - \frac{1}{2}a\left[\theta^*\right]^2 - \left[1 - \frac{1}{2}a\right]\theta^*, \tag{35}$$

and (23) changes to:

$$\frac{1}{2}\theta^{*}\left[1-\theta^{*}\right]\left[a\theta^{*}+2\right]=\frac{1}{X}, \tag{36}$$

In Figure 4, we depict the determination of θ^* in the interior equilibrium when $a = 2$, $a = 0$ and $a = -2$.

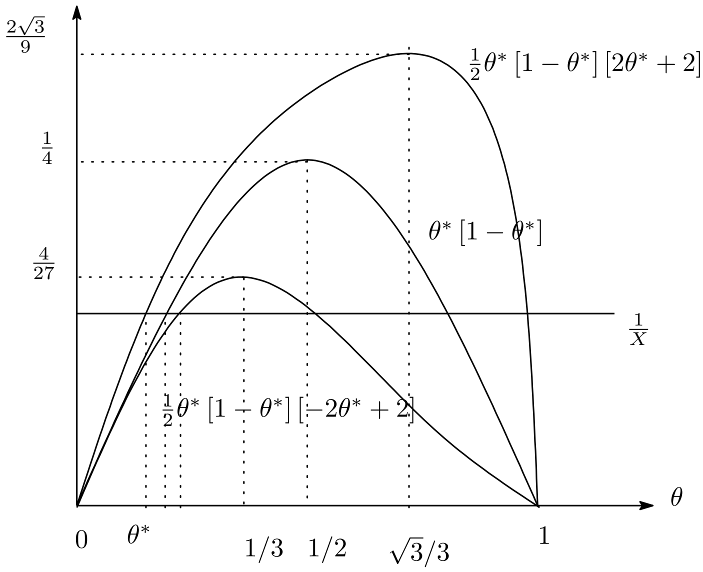

Figure 4: Determination of θ^* at the interior equilibrium

When $a = 0$, the inverted U-shaped curve is the same as that depicted in Figure 1. From Figure 4, we can confirm two points. First, if $a > 0$ ($a < 0$), the equilibrium value of θ^* is smaller (larger) than the case where $a = 0$ with the same value of $\frac{1}{X}$. This means that a smaller (larger) number of households tend to choose scrambling when $a > 0$ ($a < 0$) compared with $a = 0$. Second, if $a > 0$ ($a < 0$), the line does not intersect the inverted U-shaped curve at a higher (lower) value of $\frac{1}{X}$ compared with $a = 0$. This means that it is hard (easy) to realize the "disbanded economy" when $a > 0$ ($a < 0$) compared with $a = 0$.

Welfare under the "continued economy", (18), changes as follows:

$$U^{C} = \begin{array}{l} \ln\left[I-F_{L}\right]-\ln\left[\bar{P}+\alpha\left[n\right]^{\frac{\beta}{2-\beta}}\left[s_{C}\right]^{\frac{2\beta}{2-\beta}}\right] \\ +\left[\frac{1}{2}+\frac{1}{12}a\right]V\left[\left[n\right]^{\frac{\beta}{2-\beta}}\left[s_{C}\right]^{\frac{4}{2-\beta}}+\left[\gamma s_{P}\right]^{2}\omega F_{L}\right] \end{array} . \tag{37}$$

Welfare under the "scrambled economy", (25), changes as follows:

$$U^S = \begin{array}{l} \left[\frac{1}{2}a\left[\theta^*\right]^2+\left[1-\frac{1}{2}a\right]\theta^*\right]\ln\frac{I}{I-F_L}+\left[\ln\left[I-F_L\right]-\ln\left[\bar{P}+\alpha\left[n\right]^{\frac{\beta}{2-\beta}}\left[s_C\right]^{\frac{2\beta}{2-\beta}}\right]\right] \\ +\left[\frac{1}{2}+\frac{1}{12}a\right]V\left[\left[n\right]^{\frac{\beta}{2-\beta}}\left[s_C\right]^{\frac{4}{2-\beta}}+\left[\gamma s_P\right]^2\omega\left[1-\frac{1}{2}a\left[\theta^*\right]^2-\left[1-\frac{1}{2}a\right]\theta^*\right]F_L\right] \\ -\left[\frac{1}{3}a\left[\theta^*\right]^3+\frac{1}{2}\left[1-\frac{1}{2}a\right]\left[\theta^*\right]^2\right]V\left[\gamma s_P\right]^2\omega\left[1-\frac{1}{2}a\left[\theta^*\right]^2-\left[1-\frac{1}{2}a\right]\theta^*\right]F_L \end{array}, \tag{38}$$

and (26) changes to:

$$U^S-U^C=V\left[\gamma s_P\right]^2\omega F_L\left[\theta^*\right]\left[\begin{array}{l} \frac{1}{2}\left[\theta^*\right]\left[a\theta^*+2\right]\left[1-\theta^*\right]\left[\frac{1}{6}a\left[\theta^*\right]+\frac{1}{2}\left[1-\frac{1}{2}a\right]\right] \\ -\left[\frac{1}{2}+\frac{1}{12}a\right]\left[\frac{1}{2}a\left[\theta^*\right]+\left[1-\frac{1}{2}a\right]\right] \end{array}\right] \tag{39}$$

We confirm that the sign of the above equation is negative in Appendix 1. The "scrambled economy" is then worse off than the "continued economy" even though we consider a monotonic upward (downward) distribution.

Next, we examine the threshold where the "disbanded economy" is realized by granting the option to choose scrambling. We consider two extreme cases where $a = -2$ and $a = 2$ are satisfied. In the former (latter) case, the density of θ is most concentrated around a small (large) value of θ within the linear distribution. From (36), the condition for generalizing the "scrambled economy" is as follows:

$$\begin{array}{lll} \frac{1}{X}\leq\frac{4}{27} & when & a=-2 \\ \frac{1}{X}\leq\frac{2\sqrt{3}}{9} & when & a=2 \end{array}. \tag{40}$$

We can confirm θ satisfying $U^{SS}\left(\theta^{**}\right) = U^C\left(\theta^{**}\right)$ is calculated as $\theta^{**} = \frac{1}{X}$. We can then find the threshold as follows:

$$\begin{array}{lllll} \int_0^{\frac{4}{27}}\left[-2\theta+2\right]d\theta & = & \frac{200}{729} & when & a=-2 \\ \int_0^{\frac{2\sqrt{3}}{9}}\left[2\theta\right]d\theta & = & \frac{4}{27} & when & a=2 \end{array}. \tag{41}$$

This equation means that the "disbanded economy" is realized when more than 27% (15%) of households prefer the "scrambled economy" to the "continued economy" when $a = -2$ (a = 2). From (40), because $\frac{4}{27} < \frac{2\sqrt{3}}{9}$ is satisfied, it is easy (difficult) to realize the "disbanded economy" with the same level of $\frac{1}{X}$ when $a = -2$ ($a = 2$) compared with $a = 0$. From (41), because $\frac{200}{729} > \frac{4}{27}$ is satisfied, a larger (smaller) percentage of households prefer the "scrambled economy" to the "continued economy" at the threshold where the "disbanded economy" is realized when $a = -2$ ($a = 2$) compared with $a = 0$. When (40) is not satisfied, the "disbanded economy" is realized. In this case, the equilibrium value of welfare (29) changes as follows:

$$U^D = \ln I - \ln \left[\bar{P} + \alpha \left[n\right]^{\frac{\beta}{2-\beta}} \left[s_C\right]^{\frac{2\beta}{2-\beta}} \right] + \left[\frac{1}{12} a + \frac{1}{2} \right] V \left[\left[n\right]^{\frac{\beta}{2-\beta}} \left[s_C\right]^{\frac{4}{2-\beta}} \right]. \tag{42}$$

and (30) changes to:

$$U^D - U^C = \ln \frac{I}{I - F_L} - \left[\frac{1}{2} + \frac{1}{12} a \right] V \left[\gamma s_P\right]^2 \omega F_L \tag{43}$$

The sign of equation (43) can be positive or negative. We can show the condition where the welfare of the "disbanded economy" is larger than that of the "continued economy" as follows:

$$\begin{array}{lll} \frac{1}{3} < \frac{1}{X} & when & a = -2 \\ \frac{2}{3} < \frac{1}{X} & when & a = 2 \end{array}. \tag{44}$$

We can then find the threshold where the "disbanded economy" is better off than the "continued economy" as follows:

$$\begin{array}{lcll} \int_0^{\frac{1}{3}} \left[-2\theta + 2\right] d\theta & = & \frac{5}{9} & when \quad a = -2 \\ \int_0^{\frac{2}{3}} \left[2\theta\right] d\theta & = & \frac{4}{9} & when \quad a = 2 \end{array} \tag{45}$$

This equation means that the "disbanded economy" is better off than the "continued economy" when more than 55% (44%) of households prefer the former economy when $a = -2$ (a = 2). From (44), because $\frac{1}{3} < \frac{2}{3}$ is satisfied, it is easy (difficult) to increase welfare by granting the option to choose scrambling with the same level of $\frac{1}{X}$ when $a = -2$ ($a = 2$) compared with $a = 0$. From (45), because $\frac{5}{9} > \frac{4}{9}$ is satisfied, a larger (smaller) percentage of households prefer the "disbanded economy" to the "continued economy" at the threshold where the "disbanded economy" is better than the "continued economy" when $a = -2$ ($a = 2$) compared with $a = 0$.

From the above discussion, we obtain the following proposition:

Proposition 4.1. *When we consider the heterogeneity of preferences for watching TV under a linear distribution, we get the following results.*

- *The welfare of the "scrambled economy" is absolutely smaller than that of the "continued economy"* *even when we consider a monotonic upward (downward) distribution.*

- *Compared with the uniform distribution case, it is easy (difficult) to realize the "disbanded economy" with the same level of $\frac{1}{X}$ when the density of θ is concentrated around a small (large) value of θ.*
- *Compared with the uniform distribution case, a larger (smaller) percentage of households prefer the "scrambled economy" to the "continued economy" at the threshold where the "disbanded economy" is realized when the density of θ is concentrated around a small (large) value of θ.*
- *Compared with the uniform distribution case, it is easy (difficult) to increase welfare by granting the option to choose scrambling with the same level of $\frac{1}{X}$ when the density of θ is concentrated around a small (large) value of θ.*
- *Compared with the uniform distribution case, a larger (smaller) percentage of households prefer the "disbanded economy" to the "continued economy" at the threshold where the "disbanded economy" is better off than the "continued economy" when the density of θ is concentrated around a small (large) value of θ.*

This proposition suggests that the shape of the distribution has an impact on the level of $\frac{1}{X}$ at which the "disbanded economy" is realized and preferred. Moreover, the required percentage of households that hope the public broadcasting company is disbanded for the "disbanded economy" is also influenced by the shape of the distribution. However, we cannot find any result that the "scrambled economy" produces better outcomes than the "continued economy" even when we generalize to the linear distribution.

5 Conclusion

In this paper, we constructed a tractable model to examine the effect of scrambling, disbanding and privatization of a public broadcasting company. Our model provided six interesting results. First, the situation where every household pays a license fee (the "continued economy") is superior to the situation where only some households choose scrambling (the "scrambled economy") and where the public broadcasting company is disbanded (the "disbanded economy") when the need index for the public broadcasting company is sufficiently high. Second, there is no case where the "scrambled economy" is superior to the "continued economy" in our model. Third, the "disbanded economy" is superior to the "continued economy" when the need index for the public broadcasting company is low. Fourth, the "disbanded economy" is superior to the “continued economy” even if the public broadcasting company acts appropriately when the need index for the public broadcasting company is sufficiently low. Fifth, the “disbanded economy” is superior to the “continued economy” when more than half of households approve of the disbanded public broadcasting company under a uniform distribution; however, this percentage is crucially dependent on the shape of the distribution. Sixth, the “privatized economy” is superior to the “disbanded economy” if the number of commercial broadcasting companies is smaller than the social optimum number.

Although these results are clear and intuitive, there is potential to extend our models. As we aim to construct a tractable model, we adopted some simplifying assumptions: no consideration of dynamic effect, omitted labor markets, no consideration of substitution between watching TV and enjoying other leisure activities, no consideration of externalities, etc. Changing these assumptions may change our results, which is worth investigating in the future.

Our model is simple enough to allow extensions in several directions. For example, one may consider the heterogeneity among commercial broadcasting companies, and examine another issue: how the strategic behavior of heterogeneous commercial broadcasting companies, such as negotiation on viewer rating and advertising revenue, affects the key endogenous variables. Another may consider the effect of advertising in order to examine how the competitive environment among commercial broadcasting companies influences the price of consumption goods. Finally, we could thoroughly consider the inefficiency of public broadcasting companies under, for example, the Averch–Johnson effect, soft budget constraints and regulatory capture. Consideration of such factors would provide valuable insights into the privatization process.

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A Appendix A

In this appendix, we confirm $U^S - U^C < 0$ under a linear distribution, $g(\theta) = \left[a\theta + 1 - \frac{1}{2}a\right]$. We set

$$Z(\theta) \equiv \frac{1}{2}\theta\left[1-\theta\right]\left[a\theta+2\right].$$

Note that $Z(\theta)$ intersect the horizontal axis at $\theta = 0$, $\theta = 1$ and $\theta = -\frac{2}{a}$. Differentiating the above equation with θ, we obtain:

$$Z'(\theta) = \frac{1}{2}\left[-3a\theta^2 + \left[2a-4\right]\theta + 2\right],$$

then $Z(\theta)$ takes the maximum or minimum value at $\hat{\theta} = \frac{a-2}{3a} \pm \left[\left[\frac{a-2}{3a}\right]^2 + \frac{2}{3a}\right]^{\frac{1}{2}}$.

When $-2 \leq a < 0$, $-\frac{2}{a} \geq 1$ is satisfied, and then $Z(\theta)$ takes the maximum value at $\hat{\theta} = \frac{a-2}{3a} - \left[\left[\frac{a-2}{3a}\right]^2 + \frac{2}{3a}\right]^{\frac{1}{2}}$ within $0 \leq \theta \leq 1$. Differentiating $\hat{\theta} = \frac{a-2}{3a} - \left[\left[\frac{a-2}{3a}\right]^2 + \frac{2}{3a}\right]^{\frac{1}{2}}$ with a, we obtain:

$$\frac{\partial\hat{\theta}}{\partial a} = \frac{6}{\left[3a\right]^2}\left[1 + \frac{1}{2}\left[a^2+2a+4\right]^{-\frac{1}{2}}\left[a+4\right]\right].$$

The sign of the above equation is positive within $-2 \leq a < 0$.

When $0 < a \le 2$, $-\frac{2}{a} < 0$ is satisfied, and then $Z(\theta)$ takes the maximum value at $\hat{\theta} = \frac{a-2}{3a} + \left[\left[\frac{a-2}{3a}\right]^2 + \frac{2}{3a}\right]^{\frac{1}{2}}$. Differentiating $\hat{\theta} = \frac{a-2}{3a} + \left[\left[\frac{a-2}{3a}\right]^2 + \frac{2}{3a}\right]^{\frac{1}{2}}$ with a, we obtain:

$$\frac{\partial\hat{\theta}}{\partial a} = \frac{6}{[3a]^2}\left[1 - \frac{1}{2}\left[a^2 + 2a + 4\right]^{-\frac{1}{2}}[a+4]\right].$$

Differentiating $-\frac{1}{2}\left[a^2 + 2a + 4\right]^{-\frac{1}{2}}[a+4]$ with a, we obtain:

$$\begin{aligned}&\tfrac{\partial}{\partial a}\left[-\tfrac{1}{2}\left[a^2 + 2a + 4\right]^{-\frac{1}{2}}[a+4]\right]\\&= -\tfrac{1}{2}\left[a^2 + 2a + 4\right]^{-\frac{1}{2}}\left[1 - \tfrac{\left[a^2+5a+4\right]}{\left[a^2+2a+4\right]}\right]\end{aligned}.$$

The sign of the above equation is positive within $0 < a \le 2$, then $-\frac{1}{2}\left[a^2 + 2a + 4\right]^{-\frac{1}{2}}[a+4]$ takes the minimum value at $a = 0$ within $0 \le a \le 2$ as:

$$\lim_{a \to 0}\left[1 - \frac{1}{2}\left[a^2 + 2a + 4\right]^{-\frac{1}{2}}[a+4]\right] = 0,$$

then the sign of $\frac{\partial\hat{\theta}}{\partial a}$ is positive within $0 < a \le 2$. Therefore, we can confirm the following:

$$\tfrac{\partial\hat{\theta}}{\partial a} > 0 \quad for \quad -2 \le a \le 2 \ \cdot \tag{46}$$

When θ takes the maximum value, $\left[a\hat{\theta} + 2\right]\left[1 - \hat{\theta}\right] = \hat{\theta}\left[2a\hat{\theta} - a + 2\right]$ is satisfied. Substituting this equation into $Z(\theta)$, we obtain:

$$Z\left(\hat{\theta}\right) = \frac{1}{2}\left[\hat{\theta}\right]^2\left[a\left[2\hat{\theta} - 1\right] + 2\right],$$

Differentiating the above equation with a, we obtain:

$$\frac{\partial Z\left(\hat{\theta}\right)}{\partial a} = \frac{1}{2}\hat{\theta}\left[\hat{\theta}\left[2\hat{\theta} - 1\right] + 2\left[a\left[3\hat{\theta} - 1\right] + 2\right]\frac{\partial\hat{\theta}}{\partial a}\right].$$

When $a > 0$, $\hat{\theta} > \frac{1}{2}$ and $\frac{\partial\hat{\theta}}{\partial a} > 0$ are satisfied, and then $\frac{\partial Z(\hat{\theta})}{\partial a} > 0$ is satisfied.

When $-2 \le a < 0$, $\frac{\partial\hat{\theta}}{\partial a} = \frac{6}{[3a]^2}\left[1 + \frac{1}{2}\left[a^2 + 2a + 4\right]^{-\frac{1}{2}}[a+4]\right]$ is satisfied. Substituting this equation into $\frac{\partial Z(\hat{\theta})}{\partial a}$, we obtain:

$$\frac{\partial Z\left(\hat{\theta}\right)}{\partial a} = \frac{1}{2}\hat{\theta}\left[\hat{\theta}\left[3\hat{\theta}-1\right] + 6\frac{\left[a\left[3\hat{\theta}-1\right]+2\right][a+4]}{[3a]^2\left[a^2+2a+4\right]^{\frac{1}{2}}} + \frac{12a\left[3\hat{\theta}-1\right]+24-[3a]^2\left[\hat{\theta}\right]^2}{[3a]^2}\right].$$

The first term is nonnegative because $\hat{\theta} \geq \frac{1}{3}$ is satisfied when $-2 \leq a$. The second term is also positive because $a\left[3\hat{\theta}-1\right]+2$ takes the smallest value 1 at $a=-2$ and $\hat{\theta}=\frac{1}{2}$ within $-2 \leq a < 0$, $\frac{1}{3} \leq \hat{\theta} \leq \frac{1}{2}$. The numerator of third term is rewritten as follows:

$$-9\left[a\hat{\theta}-2\right]^2 - 12a + 60,$$

which takes the smallest value at $\hat{\theta}=\frac{1}{2}$ within $\frac{1}{3} \leq \hat{\theta} \leq \frac{1}{2}$, $a < 0$. Then the following condition is satisfied:

$$-9\left[a\hat{\theta}-2\right]^2 - 12a + 60 \geq -\frac{9}{4}\left[a-\frac{4}{3}\right]^2 + 28.$$

The RHS of this equation takes the smallest value at $a=-2$ within $-2 \leq a \leq 0$, and we can confirm it is positive. Then the third term is also positive, and we confirm that $\frac{\partial Z(\hat{\theta})}{\partial a} > 0$ within $-2 \leq a < 0$. Therefore, we confirm the following:

$$\frac{\partial Z(\hat{\theta})}{\partial a} > 0 \quad for \quad -2 \leq a \leq 2 \ \cdot \tag{47}$$

From (46) and (47), $Z(\theta) = \frac{1}{2}\theta[1-\theta][a\theta+2] < \frac{1}{4}$ is satisfied within $-2 \leq a < 0$, $0 \leq \theta < \frac{1}{2}$. Then from (39), the following condition is satisfied:

$$U^S - U^C < V[\gamma s_P]^2 \omega F_L[\theta^*]\left[\begin{array}{l} \frac{1}{4}\left[\frac{1}{6}a[\theta^*]+\frac{1}{2}\left[1-\frac{1}{2}a\right]\right] \\ -\left[\frac{1}{2}+\frac{1}{12}a\right]\left[\frac{1}{2}a[\theta^*]+\left[1-\frac{1}{2}a\right]\right] \end{array}\right].$$

Rewriting the above equation, we obtain:

$$U^S - U^C < V[\gamma s_P]^2 \omega F_L[\theta^*]\left[\left[-\frac{5}{24}-\frac{1}{24}a\right]a[\theta^*] + \left[-\frac{3}{8}-\frac{1}{12}a\right]\left[1-\frac{1}{2}a\right]\right].$$

As $\left[-\frac{5}{24}-\frac{1}{24}a\right]a > 0$ within $-2 \leq a < 0$, the above equation takes the maximum value at $\theta^* = \frac{1}{2}$ within

$\frac{1}{3} \leq \theta^* \leq \frac{1}{2}$, and we obtain:

$$\begin{aligned} & U^S - U^C \\ & < V\left[\gamma s_P\right]^2 \omega F_L\left[\theta^*\right] \left[\left[-\tfrac{5}{24} - \tfrac{1}{24}a\right] a \left[\tfrac{1}{2}\right] + \left[-\tfrac{3}{8} - \tfrac{1}{12}a\right]\left[1 - \tfrac{1}{2}a\right]\right] \cdot \\ & = V\left[\gamma s_P\right]^2 \omega F_L\left[\theta^*\right]\left[\tfrac{1}{48}a^2 - \tfrac{3}{8}\right] \end{aligned}$$

The above equation takes the maximum value at $a = -2$ within $-2 \leq a < 0$, and we obtain:

$$U^S - U^C < V\left[\gamma s_P\right]^2 \omega F_L\left[\theta^*\right]\left[\frac{1}{12} - \frac{3}{8}\right] < 0.$$

From (46) and (47), $\frac{1}{2}[\theta][a\theta + 2][1 - \theta] \leq \left[\frac{1}{3}\right]^{\frac{1}{2}}\left[\frac{2}{3}\right]$ is satisfied within $0 < a \leq 2$. Then, from (39), the following condition is satisfied:

$$U^S - U^C \leq V\left[\gamma s_P\right]^2 \omega F_L\left[\theta^*\right]\left[\begin{array}{c} \left[\frac{1}{3}\right]^{\frac{1}{2}}\left[\frac{2}{3}\right]\left[\frac{1}{6}a\left[\theta^*\right] + \frac{1}{2}\left[1 - \frac{1}{2}a\right]\right] \\ -\left[\frac{1}{2} + \frac{1}{12}a\right]\left[\frac{1}{2}a\left[\theta^*\right] + \left[1 - \frac{1}{2}a\right]\right] \end{array}\right].$$

Rewriting the above equation, we obtain:

$$U^S - U^C \leq V\left[\gamma s_P\right]^2 \omega F_L\left[\theta^*\right]\left[\left[\left[\frac{\sqrt{3}}{27} - \frac{6}{24}\right] - \frac{1}{24}a\right] a\left[\theta^*\right] + \left[\left[\frac{\sqrt{3}}{9} - \frac{4}{8}\right] - \frac{1}{12}a\right]\left[1 - \frac{1}{2}a\right]\right].$$

We can confirm that the above equation is unambiguously negative within $0 < a \leq 2$. Therefore, we can confirm the following condition:

$$U^S - U^C < 0 \quad for \quad -2 \leq a \leq 2 \ \cdot \tag{48}$$

B Appendix B

One may doubt that the existence of households that unwillingly choose scrambling, $\theta^{**} \leq \theta \leq \theta^*$, is a key reason why the "scrambled economy" is worse off than the "continued economy". In this appendix, we then consider the situation where only two types of households exist as follows:

$$\begin{array}{lll} \theta = \theta_L & with & \delta \\ \theta = \theta_H & with & 1-\delta \end{array}, \tag{49}$$

where $0 \leq \theta_L < \theta_H$ is satisfied. In this discrete setting, the welfare of the "continued economy" is expressed as:

$$U^C = \delta \left[\begin{array}{l} \ln [I - F_L] - \ln \left[\bar{P} + \alpha [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}} \right] \\ +\theta_L V \left[[n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{4}{2-\beta}} + [\gamma s_P]^2 \omega F_L \right] \end{array} \right] + [1-\delta] \left[\begin{array}{l} \ln [I - F_L] - \ln \left[\bar{P} + \alpha [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}} \right] \\ +\theta_H V \left[[n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{4}{2-\beta}} + [\gamma s_P]^2 \omega F_L \right] \end{array} \right]. \tag{50}$$

When households have the option to choose scrambling, there are three equilibrium.

First, if $\theta_L \geq \frac{1}{X}$ is satisfied, both households having $\theta = \theta_L$ and households having $\theta = \theta_H$ choose non-scrambling. In this case, the welfare of the economy is the same as in (50).

Second, if $\theta_L < \frac{1}{X} \leq [1-\delta]\,\theta_H$ is satisfied, households having $\theta = \theta_L$ choose scrambling, however, households having $\theta = \theta_H$ choose non-scrambling. In this case, the "scrambled economy" is realized, and the welfare is expressed as follows:

$$U^S = \delta \left[\begin{array}{l} \ln I - \ln \left[\bar{P} + \alpha [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}} \right] \\ +\theta_L V [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{4}{2-\beta}} \end{array} \right] + [1-\delta] \left[\begin{array}{l} \ln [I - F_L] - \ln \left[\bar{P} + \alpha [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}} \right] \\ +\theta_H V \left[[n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{4}{2-\beta}} + [\gamma s_P]^2 [1-\delta] \omega F_L \right] \end{array} \right]. \tag{51}$$

Third, if $[1-\delta]\,\theta_H < \frac{1}{X}$ is satisfied, both households having $\theta = \theta_L$ and households having $\theta = \theta_H$ choose scrambling. In this case, the "disbanded economy" is realized, and the welfare is expressed as follows:

$$U^D = \delta \left[\begin{array}{l} \ln I - \ln \left[\bar{P} + \alpha [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}} \right] \\ +\theta_L V \left[[n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{4}{2-\beta}} \right] \end{array} \right] + [1-\delta] \left[\begin{array}{l} \ln I - \ln \left[\bar{P} + \alpha [n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{2\beta}{2-\beta}} \right] \\ +\theta_H V \left[[n]^{\frac{\beta}{2-\beta}} [s_C]^{\frac{4}{2-\beta}} \right] \end{array} \right]. \tag{52}$$

Now we compare U^C and U^S. From (50) and (51), the welfare of the "continued economy" is greater than that of the "scrambled economy", $U^C > U^S$, if the following condition is satisfied:

$$\theta_L < \frac{1}{X} \leq \theta_L + \theta_H [1-\delta].$$

When the "scrambled economy" is realized, $\theta_L < \frac{1}{X} \leq [1-\delta]\,\theta_H$ is satisfied, and the above condition is definitely satisfied. Therefore, even considering the discrete distribution, we cannot find situation that the "scrambled economy" is superior to the "continued economy". In this case, the effect that the utility of households having $\theta = \theta_L$ increases because they do not pay a license fee is smaller than the effect that the utility of households having $\theta = \theta_H$ decreases because of the decrease in the quality of public broadcasting company programs.

Finally, we compare U^C and U^D. From (50) and (52), the welfare of the "continued economy" is greater than that of the "disbanded economy", $U^C \geq U^D$, if the following condition is satisfied:

$$[1-\delta]\,\theta_H < \frac{1}{X} \leq \delta\theta_L + [1-\delta]\,\theta_H.$$

When the above condition is satisfied, households having $\theta = \theta_H$ prefer the "continued economy" to the "disbanded economy", $\frac{1}{X} < \theta_H$. Furthermore, the effect that the utility of households having $\theta = \theta_L$ increases because they do not have to pay a license fee is smaller than the effect that the utility of households having $\theta = \theta_H$ decreases because they unwillingly choose scrambling.

Even when $\frac{1}{X} < \theta_H$ is satisfied, the welfare of the "disbanded economy" can be greater than that of the "continued economy", $U^D > U^C$, if the following condition is satisfied:

$$\theta_H - \delta\,[\theta_H - \theta_L] \leq \frac{1}{X} < \theta_H.$$

In this case, the effect that the utility of households having $\theta = \theta_L$ increases because they do not have to pay a license fee is greater than the effect that the utility of households having $\theta = \theta_H$ decreases because they unwillingly choose scrambling.

When households having $\theta = \theta_H$ prefer the "disbanded economy" to the "continued economy", $\theta_H < \frac{1}{X}$, the welfare of the "disbanded economy" is greater than that of the "continued economy". This is because the utility of both households having $\theta = \theta_L$ and households having $\theta = \theta_H$ increases because they do not have to pay a license fee.