A model of referendum

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Abstract

In this article, we provide a theoretical framework to understand how campaign advertising works in a referendum. Direct democracy with regard to such issues as local administration has recently become common in Japan, as in Europe. We present a model that analyzes a referendum with a straight choice between two alternatives, Yes or No. In this model, the parties promise financial benefits to their supporters, which ultimately results in a fiscal cost (e.g., taxes) and, thus, a burden to the citizens themselves. Citizens either pay some of these costs or purchase a policy at some price. We construct a two-party two-stage game in which parties choose a campaign in the first stage and prices in the second stage. We consider a subgame perfect equilibrium of this game.

Keywords. Referendum, Municipal mergers, Campaign advertising.

JEL. D72, D79, H79, L38, O53, R58.

1 Introduction

In Japan, the central government occasionally enacts large-scale municipal mergers across the nation to control the size of its municipal jurisdictions (see, for instance, Nakagawa 2014)[8]. There have been two periods of hectic merger activity after World War 2: the Showa period and the Heisei period. Compared to the Showa mergers, the Heisei mergers are becoming decentralized (see Weese forthcoming)[11]. Furthermore, direct democracy with regard to an issue such as local administration has recently become common in Japan, as in Europe. Municipal jurisdiction mergers in Japan also have a deep impact on the residents in that region. Therefore, during the Heisei consolidation, some municipalities held a referendum via a municipal ordinance to decide on the merger. This was in spite of the fact that the law governing such mergers gave local representative assemblies the power to decide on the merger. In fact, the Osaka merger referendum in 2015, which aimed at reforming the administration of Osaka city into a metropolitan government with five autonomous wards, was the first instance of a referendum being introduced to directly decide on a merger. In this referendum, citizens in Osaka city directly decided on the merger. This referendum was similar to the Scottish independence referendum of 2014 in the United Kingdom, where voters were asked to answer either “Yes”or “No” to one issue. While the Scottish referendum was on whether to become an independent nation, the Osaka referendum was on whether to restructure the city into five special zones and to merge them with Osaka prefecture, which is a kind of municipal merger.

This referendum was essentially a poll on the performance of the local government, i.e. tax and government spending, and the results showed that public opinion was divided. Many studies measure the effects of direct democracy on government spending (see, for example, Funk and Gathmann 2013)[2]. For example, in Osaka, 705,585 voters rejected the merger plan and 694,844 supported it, with a turnout of 66.7%. In this sense, political campaigns can have a strong influence on specific groups (e.g., "Better together" in Scotland and "Let's vote against to if you don't know" in Osaka). We focus on this campaign advertising. In this article, we do not engage in a normative debate, but instead provide a theoretical framework to understand how campaign advertising works in a referendum. The key issue in the literature has traditionally been "information" (see, for instance, Lupia 1992)[7]. Numerous researchers have examined the relationship between information and voting. In particular, Hobolt (2009)[3] provided a high-quality survey and discussion, focusing on the existing literature in referendum. She sorted theoretical models on referendum. As also mentioned in her book, some researchers have provided theoretical models of referendum based on a spatial model of voting behavior by Hotelling (1929)[4] and Downs (1957)[1]. This approach to voting is called the rational choice approach. These models usually assume that voters are informed. Here, we focus on imperfect information: we consider uninformed residents as defined in Salop and Stiglitz (1977)[9].

We construct our model to analyze campaign advertising. The situation that arose during these referendums is partly similar to the setting in the model of sales by Varian(1980)[10]. In Varian's model, consumers are divided into two segments, informed and uninformed, based on whether they respond to the advertising used in a firm's sales campaign. In our model, there are two types of voters: one type strongly supports one side, whereas the second type could switch to either side. The former is thus like an uninformed consumer, while the latter is like an informed consumer in the terminology of Varian's model. Moreover, each party (firm) advertises to all voters (consumers) to promote its position (e.g., Yes or No), which is the same behavior as firms display in Varian's model.

In addition, we assume that there is a difference between informed and uninformed when these two types respond to advertisements. This assumption is natural in a political campaign, as someone who feels enthusiastic about supporting either party would not be persuaded by messages of support for the opposite party's claims. Based on the spatial theory à la Downs, Lemennicier (2005)[6] explained of the polarization of the distribution of French voters. In our model, according to the advertisement of each party, either type of voter pays additional cost td when a voter sees an advertisement. t represents the unit cost per unit distance and d represents the distance, defined as the divergence in the perception between each party's standpoint and each voter's standpoint.

In this article, based on the idea mentioned above, we present a referendum model that focuses on campaign advertising. The remainder is divided into three parts. First, we present the details of our model. Next, we analyze a subgame perfect equilibrium in our model. Lastly, we discuss the implications of an equilibrium.

2 Model

In this model, there are two types of citizens, termed "uninformed" and "informed" as in the models presented by Varian or Salop and Stiglitz. We normalize the number of uninformed citizens to 1, while x denotes the number of informed citizens. In other words, as in Varian's model, citizens are exogenously assigned to groups: group 1 voters vote "Yes" only; group 2 voters vote "No" only; and group 3 voters vote either "Yes" or "No" depending on which option offers the highest net utility. For ease of reference, we call these groups 1-loyal, 2-loyal, and informed, respectively; 1-loyal and 2-loyal citizens are collectively called uninformed citizens. We further assume that $x \geq 1$, namely the group of switching voters is at least as large as the group 1 or 2 citizens.

The parties promise financial benefits to their supporters, which finally results in a fiscal cost (e.g. taxes) and thus a burden on the citizens themselves. Citizens pay some of these costs or purchase a policy at some price. We construct a two-party two-stage game in which parties choose their campaign in the first stage and prices $p_i, (i = 1, 2)$ in the second stage. The two parties compete on policy and price for citizens, who are either loyal or switching. The solution is a subgame perfect equilibrium: political campaigns are set simultaneously in the first stage; in the second stage, the chosen campaign becomes broadly known and the prices of its policy that underlie its campaign are set simultaneously. We solve this game by backward induction.

Let us consider the profit of each party π_i. Uninformed citizens always support one party, whereas informed citizens support either party. Let us consider party 1's profit; party 2's profit can be found analogously. We note that 2-loyal citizens do not purchase from party 1. Let $\pi_1(p_1, p_2)$ denote party 1's profit. This is written as

$$\pi_1(p_1, p_2) = \pi_1^{C_1}(p_1) + \pi_1^{C_3}(p_1, p_2) \tag{1}$$

where $\pi_1^{C_1}(p_1)$ is party 1's profit from 1-loyal citizens and $\pi_1^{C_3}(p_1, p_2)$ is party 1's profit from informed residents. Now, we can calculate each component as follows: $\pi_1^{C_1}(p_1) = p_1$ and $\pi_1^{C_3}(p_1, p_2) = p_1 x$. When both uninformed and informed citizens support party 1's policy, party 1 obtains $p_1(1 + x)$.

The reserve values (resp. densities) of the groups are 1 (1) for loyal citizens and y (x) for informed citizens. Resident utilities can be formulized as shown in Eq. (1), where are the utility for uninformed and informed citizens, respectively. Residents cannot accept negative utility; hence, whenever $u < 0$ from Eq. (1), $u = 0$ instead.

$$u^{uninformed} = 1 - p_i - td, \tag{2}$$

$$u^{informed} = y - p_i - td. \tag{3}$$

Here, td denotes the foot cost of the campaign advertisements as mentioned earlier. Now, we assume $t = 1$, $d = \frac{1}{2}$. Those who fit an advertisement pay no additional cost. If not, an additional cost $\frac{1}{2}$ is incurred. In our model, we do not consider a spatial model such as Downs or Hotelling; however, the explicit location point of each voter, in this case, is considered to be equivalent to the voters' location point in Kamada and Kojima (2014)[5]. Lastly, we also assume that each party provides one advertisement.

3 Price game

In this section, we analyze price subgames given a policy advertisement by each party. Under the assumption of a voter's behavior, subgames are classified into the following three cases: 1) both parties focus on uninformed; 2) both parties focus on informed; and 3) party 1 focuses on informed, whereas party 2 focuses on uninformed.

3.1 Both parties focus on uninformed

Here, both parties focus on uninformed citizens; thus, there is no foot cost in this price subgame. Therefore, we find that both parties can persuade uninformed citizens at $p_i = 1, i = 1, 2$ and can obtain $\pi_i = 1, i = 1, 2$. We obtain each party's profit π_i as follows:

$$p_i(1 + x), \quad p_i \leq 1, p_i < p_j, \tag{4}$$

$$p_i, \quad p_i \leq 1, p_i > p_j, \tag{5}$$

$$p_i x, \quad p_i > 1, p_i < p_j, \tag{6}$$

$$0, \quad p_i > 1, p_i > p_j. \tag{7}$$

Here $i, j = 1, 2, i \neq j$. Even if party i persuades informed citizens at $p_i \leq 1$, because of $p_i(1 + x) \geq 1$, party i does not charge $p_i \leq \frac{1}{1+x}$. When party i charges $p_i > 1$, because it could not persuade uninformed citizens, party i obtains $\pi_i = p_i x$.

Let us consider an equilibrium where either party i persuades informed citizens, without loss of generality. In this equilibrium, party $j, j \neq i$ always charges $p_j = 1$. Now, we obtain $p_i < 1$ when $p_j = 1$ is given. This is because if party i obtains $\pi_i = p_i x$ with $p_i > 1$, from $x \geq 1$, an opponent party $j (\neq i)$ always chooses $1 < p_j < p_i$. Thus, no equilibrium exists such that $p_i > 1, p_j = 1$. Furthermore, we find that $p_i = 1, p_j = 1$ is not an equilibrium price pair when $p_j = 1$.

Moreover, if a party cannot obtain $p_i x > 1$, it chooses $p_i = 1$ and decides to persuade only uninformed citizens with its density 1 because it can always obtain $\pi_i = 1$. It follows that when a party wants to obtain informed citizens, its lower bound price $p_i = \frac{1}{x}$. In addition, it follows that $\frac{1}{x} \leq 1$ from $x \geq 1$. Therefore, we also find that party i can obtain $\pi_i > 1$, which is obtained only from informed citizens when it charges p_i such that $\frac{1}{x} < p_i \leq 1$ and persuades only informed citizens. Here, we also obtain $\frac{1}{1+x} \leq \frac{1}{x}$ from $x \geq 1$. Thus, we find that the lower bound of an undercut price competition is always $\frac{1}{1+x}$ in an equilibrium in which $p_i \leq 1$ is charged.

As mentioned earlier, $p_i = p_j = 1$ is not an equilibrium price. Furthermore, we find that $p_i = \frac{1}{1+x}$ is not the best response when opponent $j \neq i$ charges $p_j = 1$. This is because we obtain $\frac{1}{1+x} \leq \frac{1}{2}$ from $x \geq 1$; thus, party i increases its profit by charging price p_i such that $\frac{1}{1+x} < p_i \leq 1$.

On the contrary, we also find that opponent j's $p_j = 1$ is not the best response when p_i is given such that $\frac{1}{1+x} < p_i \leq 1$. This is simply because j has an incentive to deviate to $p_j = \frac{1}{1+x}$. Finally we show that $p_i = p_j = \frac{1}{1+x}$ is not an equilibrium price. We obtain $\pi_i = \frac{1}{1+x}(1 + \frac{x}{2}) = \frac{1}{2}\frac{x+2}{x+1}$ if $p_i = p_j = \frac{1}{1+x}$. This equation is monotonically decreasing with regard to x; then, we have $\lim_{x\to\infty} \frac{1}{2}\left(1 + \frac{1}{x+1}\right) = \frac{1}{2}$. According to $x \geq 1$, it follows that the maximum of this equation is $\frac{3}{4}$ because it has a maximum value at $x = 1$. For this reason, opponent j deviates to $p_j = 1$.

Similar arguments apply to the case of replacing i and j because i and j are symmetric. Thus, we find that a pure strategy equilibrium in this price subgame does not exist. Let us consider a mixed strategy equilibrium $F^*(p)$ with the following price support, where both parties $i = 1, 2$ obtain π_i^*:

$$\frac{1}{1+x} \leq p_i \leq 1. \tag{8}$$

By solving

$$(1 - F^*(p))p_i(1 + x) + F^*(p)p_i = \pi_i^*, \tag{9}$$

we obtain

$$F^*(p) = 1 - \frac{\pi_i^* - p_i}{p_i x}. \tag{10}$$

3.2 Both parties focus on informed

With regard to informed citizens, both parties are symmetric in that neither has locational advantages, and this competition leads to simple Bertrand competition. Now, we consider whether uninformed citizens support either party because they always support one party or the other. We obtain $p_i \leq \frac{1}{2}, i = 1, 2$ by solving the following equation:

$$1 - p_i - \frac{1}{2} \geq 0. \tag{11}$$

Now, each party is guaranteed to earn profit $\pi_i = \frac{1}{2}, i = 1, 2$, because both can be supported by their uninformed citizens at price $p_i = \frac{1}{2}$. Thus, from $p_i(1+x) \geq \frac{1}{2}$, we find that neither parties charge a price such that $p_i \leq \frac{1}{2(1+x)}$. Here, from $x \geq 1$, $\frac{1}{2(1+x)} \leq \frac{1}{4}$ holds.

Furthermore, if a party charges $p_i > \frac{1}{2}$, it obtains profit $\pi_i = p_i x$ because uninformed citizens abandon it. Now, we consider the condition such that $p_i x > p_i(1+x)$. We obtain $p_i > \frac{1}{2x}(1+x)$ from $p_i x > \frac{1}{2}(1+x)$. Thus, we find that when a party focuses only on informed citizens and charges price $p_i > \frac{1}{2x}(1+x)$, it obtains a higher profit than $\frac{1}{2}(1+x)$. We also obtain $\frac{1}{2} < \frac{1}{2x}(1+x) \leq 1$ from $x \geq 1$.[1]

Thus, we obtain π_i, $i, j = 1, 2, i \neq j$ as follows:

$$p_i(1+x), \quad \frac{1}{2(1+x)} \leq p_i \leq \frac{1}{2}, p_i < p_j, \tag{12}$$

$$p_i x, \qquad p_i > \frac{1}{2x}(1+x), p_i < p_j. \tag{13}$$

Either party always has an incentive to undercut its opponent's price when both parties charge prices such that $p_i x > \frac{1}{2}(1+x)$. This is simple Bertrand competition, which results in $p_i = \frac{1}{2x}(1+x), i = 1, 2$. Now, from $x \geq 1$, we find that $\frac{1}{4}(1+x) - \frac{1}{2} = -\frac{1}{4} + \frac{1}{4}x = \frac{1}{4}(x-1) \geq 0$. This equation means that when this price competition results in the lower bound price, $p_i = \frac{1}{2x}(1+x), i = 1, 2$, both parties are guaranteed to earn a higher profit than 1/2. Moreover, we also obtain $1/2 < \frac{1}{2x}(1+x)$ above; thus, we find that the lower bound price in this competition is higher than 1/2, which is also the price at which the profit is guaranteed from uninformed citizens. However, we obtain $\frac{1}{2x}(1+x)\frac{x}{2} = \frac{1}{4}(1+x) < \frac{1}{2}(1+x)$. Thus, in this competition, both parties finally undercut their prices at $\frac{1}{2}$, because they persuade both uninformed and informed citizens and then earn more profits. Thus, we conclude that $p_i > \frac{1}{2}$ is not charged.

It follows that the upper and lower bounds of price are as follows:

$$\frac{1}{2(1+x)} \leq p_i \leq \frac{1}{2}. \tag{14}$$

No pure strategy equilibrium exists in this price subgame, and we consider a mixed strategy equilibrium $F(p)$ to obtain π_i^*. By solving

$$(1 - F(p))p_i(1+x) + F(p)p_i = \pi_i^*, \tag{15}$$

we obtain

$$F(p) = 1 - \frac{\pi_i^* - p_i}{p_i x}. \tag{16}$$

[1] According to $\lim_{x\to\infty} \frac{(1+x)}{2x} = \frac{1}{2}$, we obtain the lower value of this equation. The upper value is obtained by substituting $x = 1$ into this equation.

3.3 Either one focuses on informed

Because of symmetry, without loss of generality, we assume that party 1 focuses on promotion to informed citizens through intensive advertising. Party 1 always persuades its loyal supporters when it charges $p_1 = \frac{1}{2}$. It follows that party 1 is guaranteed to bring $\pi_1 = \frac{1}{2}$. Thus, party 1 does not charge its price such that $p_1 < \frac{1}{2(1+x)}$.

Informed citizens are indifferent between party 1 and party 2 if

$$y - p_1 - 0 = y - p_2 - \frac{1}{2} \tag{17}$$

holds. We obtain $p_1 = p_2 + \frac{1}{2}$.

Thus, party 1's profit π_1 is obtained as follows:

$$p_1(1+x), \quad \frac{1}{2(1+x)} \leq p_1 \leq \frac{1}{2}, p_1 < p_2 + \frac{1}{2}, \tag{18}$$

$$p_1 x, \quad p_1 > \frac{1}{2}, p_1 < p_2 + \frac{1}{2}. \tag{19}$$

For a given x, let us consider a price that earns an equal profit whether party 1 obtains both informed and uninformed citizens at $p_1 = \frac{1}{2}$ or party 1 obtains only informed citizens. In this case, $p_1 x = \frac{1}{2}(1+x)$ holds. We obtain

$$p_1 = \frac{1}{2x}(1+x). \tag{20}$$

Here, $\frac{1}{2} < \frac{1}{2x}(1+x) \leq y$ holds.

Now, for any x such that $x \geq 1$ holds, $1/2 \leq \frac{1}{2x}(1+x) \leq 1$ holds. Thus, when $p_2 = 1$ is given, for some x, party 1 can find a price p_1 such that its profit increases and $p_1 x \geq \frac{1}{2}(1+x)$ holds. The left-hand side of this equation denotes profit $p_1 x$, which is earned only from informed citizens. The right-hand side of this equation denotes the maximum profit $\frac{1}{2}(1+x)$ gained from both informed and uninformed citizens. In other words, party 1 could abandon 1-loyal citizens.

Now, this deviation improves party 1's profit to an even larger extent because $p_1 x > \frac{1}{2}(1+x)$ holds when party 1 chooses a price p_1 such that $p_1 > \frac{1}{2x}(1+x)$ holds. This finding indicates that $p_1 = \frac{1}{2x}(1+x)$ is not the best response to $p_2 = 1$.

On the contrary, when party 1's chooses its price such that $p_1 > \frac{1}{2x}(1+x)$ holds, $p_2 = 1$ is not the best response. This is because party 2 has an incentive to change its price from $p_2 = 1$ to $p_2 = \frac{1}{1+x}$.

Let us now consider the incentive of party 2. When $p_1 = \frac{1}{2x}(1+x)$ is given, party 2 can obtain informed citizens at $p_2 < 1$ and earn a profit such that $\pi_2 = p_2(1+x) > 1$. Party 2 must choose its price such that $p_2 > \frac{1}{1+x}$ holds in order that it gains a profit such that $\pi_2 = p_2(1+x) > 1$ holds.

Party 2 does not lose its locational advantage for its uninformed citizens, which is equal to the transportation cost margin $\frac{1}{2}$. Because of this transportation cost margin, for party 2 to undercut its opponent by charging $p_2 = \frac{1}{1+x}$, we find it necessary that

$$p_1 - p_2 = \frac{(1+x)}{2x} - \frac{1}{1+x} \geq \frac{1}{2} \tag{21}$$

holds. If $x \geq 1$, this equation holds because by calculating Eq. (21) we obtain

$$\frac{x^2+1}{x(x+1)} \geq 1. \tag{22}$$

However, when $p_2 = \frac{1}{1+x}$ is given, $p_1 > \frac{1}{2x}(1+x)$ is not the best response of party 1 because it has an incentive to change its price because its profit is 0. Let us consider the condition that p_1 is lower than p_2 including the transportation cost margin $1/2$. According to $p_1 \leq p_2 + \frac{1}{2}$ and $p_2 = \frac{1}{1+x}$, we obtain

$$p_1 \leq \frac{1}{2} + \frac{1}{1+x}. \tag{23}$$

By taking $\frac{1}{2} < \frac{1}{2} + \frac{1}{1+x}$ into consideration, party 1 can obtain both informed and uninformed citizens when it charges $p_1 = \frac{1}{2}$. However, $p_2 = 1$ is the best response to this undercutting. In addition, we also find that when $p_2 = 1$ is given, $p_1 = \frac{1}{2}$ is not the best response according to the discussion above.

It follows that no pure strategy equilibrium exists in this price subgame. At the same time, we find that the price support of p_2, now that party 2 focuses on its uninformed citizens, is as follows:

$$\frac{1}{1+x} \leq p_2 \leq 1. \tag{24}$$

On the contrary, party 1 charges price p_1 such that

$$\frac{1}{2} \leq p_1 \leq y \tag{25}$$

holds. By solving

$$(1 - F^*(p))p_i(1+x) + F^*(p)p_i = \pi_i^*, \tag{26}$$

we obtain

$$F^*(p) = 1 - \frac{\pi_i^* - p_i}{p_i x}. \tag{27}$$

In an equilibrium, both parties obtain $\pi_1^* = \frac{1}{2}(1+x), \pi_2^* = 1$ respectively. Here, $(1 - F(p))p_i(1+x) + F(p)p_i = \pi_i^*$ holds.

Finally, we consider the assumption with regard to y. In the discussion above, we consider the case that party 1 charges $p_1 = y$. From $yx > \frac{1}{2}(1+x)$, we obtain $y > \frac{1}{2x}(1+x)$. We also find $1/2 \leq y \leq 1$ from $x \geq 1$. Thus x, y are well defined.

4 Location game

In this section, we solve the first stage of the so-called “location game.” Each party can expect to receive at least those citizens loyal to it, and, further, it earns a profit at least equal to charging the maximum price that those citizens are willing to pay. Thus, when either party that is farther from informed citizens obtains 1, the opponent party that focuses on informed citizens obtains $\frac{1}{2}(1+x)$. When both focus on informed citizens, they obtain 1/2.

We consider a subgame perfect equilibrium of this game. This location game is described by the following 2×2 matrix. Clearly, we find two pure strategy equilibria. In both equilibria, one chooses informed, while the other chooses uninformed. Furthermore, we also find a symmetric mixed strategy equilibrium in which both parties obtain $\pi_i^* = 1$. Let λ be the probability for a party to choose an advertisement to uninformed citizens. By $1\lambda + 1(1-\lambda) = \frac{1+x}{2}\lambda + \frac{1}{2}(1-\lambda)$, we obtain $\lambda^* = \frac{1}{x}$.

	Uninformed	Informed
Uninformed	1, 1	1, $\frac{1+x}{2}$
Informed	$\frac{1+x}{2}$, 1	$\frac{1}{2}$, $\frac{1}{2}$

5 Concluding remarks

In this article, we presented a model that analyzes a referendum with a straight choice between two alternatives, Yes or No. In a pure strategy equilibrium, one party focuses on informed citizens, while the other focuses on uninformed citizens. In other words, the parties shift to more extreme positions (i.e., they become polarized). In this model, we also obtained a mixed strategy equilibrium in addition to the pure strategy equilibria.

Here, we discuss an implication of the mixed strategy equilibrium. Expected profits in an equilibrium are equal to 1. In other words, both parties will not obtain an excess profit more than what they obtain from enthusiastic supporters. Accordingly, both parties focus on informed citizens in a mixed strategy equilibrium and neither party becomes polarized. Furthermore, the probability parameters depend only on the proportion of x. x denotes the number of informed citizens when the number of uninformed citizens is normalized to 1. When x becomes large enough, the probability of favoring uninformed citizens becomes zero, that is, $1/x \to 0$. This means that both parties will ignore uninformed citizens when the number of informed rational voters becomes large enough. However, this is only a theoretical implication of our results. An empirical investigation into whether these phenomena would be observed is planned for future research.

We now consider an extreme case in which each party chooses only either informed citizens or uninformed citizens. However, it is more natural to consider the case in which the continuum interval between the location points of the informed and uninformed citizens is where a party determines the characteristics of its advertisement. For example, a party chooses a mid-way point between uninformed and informed citizens: in other words, he or she chooses its advertisement to have a noncommittal/grey attitude. This theoretical extension to a continuum interval also remains for future research.

Acknowledgements

I would like to thank Tadashi Sekiguchi for his kind advice and long-term support. This paper also has benefited from the comments of workshop participants at JSIAM2015. All remaining errors are my own.

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