Eurasian Journal of Economics and Finance, 4(3), 2016, 43-53
DOI: 10.15604/ejef.2016.04.03.004

EURASIAN JOURNAL OF ECONOMICS AND FINANCE

http://www.eurasianpublications.com

INVESTMENT IN ANTI-COUNTERFEIT LABEL FOR BRANDED FIRM — TAKE MAOTAI AS AN EXAMPLE

Ran Wang
Corresponding Author: Georgia Institute of Technology, USA
Email: wangran2010@gmail.com

Weiwei Yang
Georgia Institute of Technology, USA

Abstract

The paper examines the anti-fake investment for the branded product market. Through the analysis of the special branded market, the conditions for the sustainable naturalized anti-fake equilibrium and subsidized anti-fake equilibrium are given. The paper shows that when the profit loss with entry deterrence is small, naturalized anti-fake equilibrium exists. When profit loss is intermediate, subsidized equilibrium exists. However, when profit loss with entry deterrence is really large, it would be beneficial to the society to have some degree of fake product and anti-fake is harmful to the society.

Keywords: Naturalized Anti-fake Equilibrium, Subsidized Anti-fake Equilibrium, Entry Deterrence

1. Introduction

Maotai is one of the best wine brands in China. Since the profit is really large due to its brand reputation and great taste, there are a lot of counterfeit "Maotai" products from many small illegal firms. These small illegal firms can produce wine at a very low cost, but sell them at the same price with real Maotai under the name of Maotai. What is even worse, most of the counterfeit products are harmful for the consumer's health. So, it is potentially beneficial to deter all fake product "Maotai" both for the political reason and healthy reason.

The traditional method to deter entry by expanding capacity is not realistic for this branded firm since its capacity is constrained by its complicated production process. So, it is better to invest in anti-fake label to make it more easily to recognize by the consumer or competing with rivals in price. However, competing through price is not a rational strategy for the branded firm because its relatively high production and other associated costs. For Maotai firm, investment in anti-fake label might be a more reasonable and efficient strategy to deter the entry of fake products. This paper focuses on how to make decisions on investment in anti-fake label in order to deter the entry of the fake firm. The objective of the paper is to examine the conditions under which the anti-fake is realized by the firm or by the subsidy of the government. Also, we check the condition under which anti-fake is harmful to the society, in which case no anti-fake activity will be taken by either the branded firm or the government. There are some

studies that analyze the impact of how government policy affects firm behavior, such as Wuthisatian (2014) and Yilmaz and Buyuklu (2016).

There is little related existing literature for anti-fake, however, the research related with Intellectual Property Protection (IPP) and entry deterrence is popular. Also we pay attention to some studies related to product differentiation since in this paper the branded make investments to make the anti-fake label differentiated from the fake label in order to fight against the fake products. As for the studies on IPP, there are many theoretical and empirical studies with respect to the benefits and costs analysis, methods to protect and government's incentive for IPP. Grossman and Lai (2004) investigate the incentives that governments have to protect intellectual property in a trading world economy. They consider a world economy with ongoing innovation in two countries that differ in market size, in their capacities for innovation, and in their absolute and comparative advantage in manufacturing by associating the strength of IPR protection with the duration of a country's patents that are applied with national treatment. They state that harmonization of patent policies is necessary or sufficient for global efficiency. Rapp and Rozek (1990) show the benefits and costs of Intellectual Property Protection in Developing Countries. Also Lee and Mansfield (1996) empirically analyze the effects of IPP on foreign direct investment for the multinational enterprise. From above studies, we can see the importance of the IPP, we extend this importance into the anti-fake strategy for the branded firm.

Additionally, the studies of entry deterrence and entry accommodation shed light on this paper since we aim at examining the entry deterrence of the fake products. Wang *et al.*(2009) shows the pricing behavior of supermarkets under oligopoly market structure in order to deter potential entry of other supermarket. Dixit (1979) investigates the condition of the incumbent firm choose large capacity to deter the entry of potential firms by constructing the fixed cost Stackelberg model. Similarly, in our paper, we follow Dixit (1979) to deter the condition under which the branded firm decides to deter the entry of fake products. However, we model a totally different market from Dixit (1979) due to the specialty of the branded product market. Donnenfeld and Weber (1995) examine the entry deterrence case under limit qualities. Seamans (2012) investigated how private firms respond to potential entry from public firms using cable TV industry as an example. Kutlu and Wang (2015a), Kutlu and Wang (2015b), Wang and Yang (2016a) and Wang (2016) discuss the pricing strategies in U.S. airline industry in order to deter new entry and compete with existing airlines. Wang and Yang (2016b) shows the firm behavior in automobile industry.

Among the different entry deterrence strategies, product differentiation plays a more and more important role. Lutz (1997) shows the relationship between vertical product differentiation and entry deterrence. The vertical product differentiation serves as an effective strategy to deter entry. Schmalensee (1982) gives the effect of product differentiation for pioneering Brands. Similar results are given by these studies that product differentiation has positive effect on entry deterrence. Ellison and Ellison (2011) examined the investment behavior in the pharmaceutical industry as an instrument of strategic entry deterrence and found that non-monotonic investment in market size. Turut and Ofek (2012) showed the effect from innovation strategy on entry deterrence. And the innovation is one of the most effective way to improve product differentiation. So in this paper, we assume that the R&D investment in anti-fake label will lead to the higher differentiation degree of the label. And the larger differentiation leads to higher fraction of the consumers who can tell the branded product from the fake product.

The creative point of the paper is to build up a model for the branded product market to analyze the incentive for the branded firm and government to invest in the anti-fake label R&D. Two kinds of anti-fake equilibrium are defined in the paper: naturalized anti-fake equilibrium and subsidized anti-fake equilibrium. Naturalized anti-fake equilibrium is a sustainable equilibrium for the firm to overinvest in R&D to deter the entry of the fake product without any subsidy from the government. And subsidized anti-fake equilibrium is sustainable equilibrium such that fake product is deterred if only if there is subsidy from the government. We examine the conditions required for naturalized and subsidized anti-fake equilibriums.

The main findings of this paper are as follows. First, when choosing between competing in price and investing in anti-fake label, it is always optimal to choose the latter strategy since

the branded firm will be kicked out of the market if competing in price. Second, without considering deterring the fake product, the branded firm's investment incentive only increase with the number of consumers when the number is sufficiently large. And the incentive in R&D investment decreases with the initial fraction of consumers that can tell the branded product from the fake product. Third, if the potential profit loss from entry deterrence is small enough, the naturalized anti-fake equilibrium is sustainable. In this case, anti-fake is beneficial for the society. If the potential profit loss from entry deterrence is intermediate, the subsidized anti-fake equilibrium is sustainable and this anti-fake investment and subsidy also benefit the society. But the interesting case is when the potential profit loss from the entry deterrence is large enough; it would harmful to the society if the government subsidizes the anti-fake investment. In this case, both the naturalized and subsidized anti-fake equilibrium fails, and there is always fake product for the branded product.

The remaining of the paper is organized as follows. In Part Two, we describe the basic setting of the market structure as well as the assumptions. Part Three is the main part of the paper since it analyzes the condition for the two kinds of equilibrium as well as the failure of the anti-fake activity. In Part Four, the main conclusions are given. Also we discuss the limitations and extensions of this model.

2. Theoretical Framework

In this section, we will first describe the basic setting of this special branded product market. Then we continue to analyze the objective function of the branded firm, the fake firm as well the government.

2.1. Basic Setting

There is one branded firm, which is denoted by firm$R$, has the market power to fix the price of its product *A* at p, and the variable production cost is $C_R(q)$. So, for branded firm, the market is a monopoly market with some special features, which we will discuss later. Also there is some potential firms that can produce fake products. Here we normalized all the potential fake firm number to be 1, which is denoted by firm F. And we assume that potential firm F can produce fake product *A* at lower variable production cost $C_F(q)$, that is $C_F(q) < C_R(q)$. But it still sells fake product at price p to pretend to be branded product. If the fake firm does not sell the product at price p, the consumers would recognize the fake product, so the demand will drop to zero. So the best strategy for the fake firm is to set the same price as the branded firm. Furthermore, we assume that the fixed production cost is F_0, which is sunk cost for the branded firm, not sunk for the potential entry firm. That is, if the fake firm enters the market, it will pay the fixed cost before the production of fake products.

There are some special characteristics with the demand side of the branded product market. It is assumed that the demand for the branded product is fixed. And the consumer size is N. But not all the consumers can tell the branded product from the fake product. It is assumed that among the N consumers, only λ fraction can tell between the true and fake product (they can tell according to the product features), the remaining $1-\lambda$ fraction cannot tell their differences. It is further assumed that the consumers who can tell the difference will always buy branded product, and the rest of the consumers will buy the product according to Hoteling model. In that sense, $\frac{1-\lambda}{2}$ fraction will buy the branded product and the other $\frac{1-\lambda}{2}$ fraction will buy the fake product.

Without any investment in R&D investment in anti-fake label, the initial fraction of the N consumers that can tell the difference is λ_0. And λ depends on the investment in R&D investment in anti-fake label, I, as well as the initial value λ_0. So we have $\lambda = \lambda(\lambda_0, I)$. The investment in anti-fake label can improve the differentiation degree level of the branded firm label, leading to the increase of the easy-recognition level of branded product. So it is assumed that λ is increasing in I and it is concave in I since the marginal revenue of the investment in R&D decreases as investment increases. Also λ is increasing in λ_0 since higher initial level of

fraction of consumer who can tell the difference will lead to higher final fraction of consumer who can tell the difference after label investment. Assume that the consumers' valuation for the true product is V. And the valuation for the fake product is 0 for simplicity. And this simplified assumption might lead to the potential limitation of our model since there should be some product differentiation of fake product with value belongs to certain types of distribution. By assuming this, the results would be more realistic. However, we just normalize all the fake products to one product and assume that the valuation for the fake product is 0, as the average of all the fake products to make things simple.

2.2. Objective Function

For the branded firm, it tries to maximize its profit which can be expressed as equation.

$$\begin{aligned}\Pi^R &= p\{\lambda(\lambda_0, I) + \frac{1}{2}(1-\lambda(\lambda_0, I))\}N - C_R(\lambda(\lambda_0, I)N + \frac{1}{2}N(1-\lambda(\lambda_0, I))) - I \\ &= \tfrac{pN}{2}\big(1+\lambda(\lambda_0, I)\big) - C_R\left(\tfrac{N}{2}\big(1+\lambda(\lambda_0, I)\big)\right) - I \end{aligned} \quad (1)$$

The first term is the revenue from sales to the sum of consumers who can tell the differences and half of the ones that cannot tell the difference. The second item is the variable cost (also total cost since the fixed cost is sunk for the branded firm) from production, and the last term is the investment amount in anti-fake label. From here, we see that the profit of the branded firm is increasing in the fraction of consumer that can tell the difference ($\frac{\partial \Pi^R}{\partial \lambda_0} > 0$) since it is assumed that $p - C_R \geq 0$. Consider an extreme case when $\lambda_0 = 1$, that is all the consumers could tell the branded product from the fake product, the profit would be maximized since it is a monopoly market for the branded firm. However, whether the profit of the branded firm's profit increases or decreases with the investment level depends on the structure of the cost function as well as the structure of $\lambda(\lambda_0, I)$. Assume that C_R is not a function of I, we would have profit increase in I if $\frac{\partial \lambda}{\partial I} > \frac{2}{N(p-C_R)}$, otherwise, we have profit decreases in I.

For the fake firm, we assume that there is no capacity constraint for fake firm, that is, the fake firm will satisfy all the demand from the consumers that cannot tell the true product from the fake product due to the low production cost. And the profit for the fake firm is given by

$$\begin{aligned}\Pi^F &= p\left\{\frac{1}{2}\big(1-\lambda(\lambda_0, I)\big)\right\}N - C_F\left(\frac{1}{2}N\big(1-\lambda(\lambda_0, I)\big)\right) - F_0 \\ &= \tfrac{pN}{2}\big(1-\lambda(\lambda_0, I)\big) - C_F\left(\tfrac{N}{2}\big(1-\lambda(\lambda_0, I)\big)\right) - F_0 \end{aligned} \quad (2)$$

The first term is the revenue from the sales of fake products, the second term is the variable cost from production and the third term is the fixed cost that will occur when the fake firm entries. And this part of fixed cost is sunk cost for the branded firm, not sunk for the fake firm. Also, we assume that this model is just one period static model, not dynamic model. So the fake firm cannot make any investment to imitate the anti-fake label of the branded firm under this setting. We should notice that when we allow the fake firm to make investment into imitating the label after observing the anti-fake label by the branded firm, the result should be totally different. We expect a decrease in incentive for the branded firm to invest in R&D if the dynamic response happens, but this is not in our model.

The objective of the special government (such as consumer union in China) is to maximize the consumer surplus from the consumption. As assumed in above section, the consumer pay the same price for the fake product but the utility from consumption of fake product is 0 (in most cases, it is even negative since most fake product are harmful for people's health). Since the utility from consumption of fake product is 0, any positive consumption will hurt the consumer surplus. And the consumer surplus is given by

$$CS = \frac{N}{2}(1+\lambda)(V-p) + \frac{N}{2}(1-\lambda)(0-p) = \frac{NV}{2}(1+\lambda) - p \quad (3)$$

In next section, we will analyze the motivation of the government to fight against the fake products.

3. Anti-Fake Equilibrium

We further assume that there are two types of anti-fake equilibrium: naturalized anti-fake equilibrium and subsidized anti-fake equilibrium. It is naturalized anti-fake when the branded firm chooses the investment level I to deter the fake product entry without any subsidy from the government. Naturalized anti-fake deterrence occurs either because the profit might be maximized when the branded firm chooses the entry deterrence strategy against the fake firm or because the side effect for reputation is too bad (since it is one period model, we do not take it into account) from the fake products. Also this exclusion of the bad-reputation effect from the fake product underestimates the investment level of the branded firm since the firm will strategically overinvest in R&D to deter the entry of fake products when considering the bad-reputation effect.

3.1. Naturalized Anti-Fake Equilibrium

In this paper, we assume that it is always profitable for the fake firm to enter the market if the branded firm does not make any investment in the anti-fake, that is $I = 0$. That is equal to have $\frac{pN}{2}(1-\lambda_0)\} - C_F(\frac{1}{2}N(1-\lambda_0)) > F_0$. There are two types of anti-fake strategy that can be taken by the branded firm: pricing competition and make R&D investment in anti-fake label to make the branded product easier to tell from the fake product. However, it is proved that the price competition is not beneficial for the branded firm, which is given by proposition 1.

Proposition 1: It is always not desirable for the branded firm to compete in price to fight against the fake firm.

The intuition for Proposition 1 is quite simple. Since we assume that the variable production cost function is less convex than the branded firm's production cost function, it is natural that the fake firm has comparative advantage in the production cost. When competing in price, in the Bertrand market, the winner is always the one that has lower cost, here we assume that F_0 is not large. So if competing in price, the branded firm will be kicked out of the market, which is not desirable for both the branded firm and the consumers.

Then, without considering deterring the fake products, branded firm will choose investment in R&D in anti-fake label to fight against the fake products and earn more market share from the consumers that cannot tell the differences, which is the accommodation level of the investment in Dixit (1979).The branded firm chooses R&D investment in anti-fake label, I^A, to maximize its profit. So the optimal investment level is given by

$$\mathrm{I}^A \equiv argmax\left\{\frac{pN}{2}\left(1+\lambda(\lambda_0, I)\right) - C_R\left(\frac{N}{2}\left(1+\lambda(\lambda_0, I)\right)\right) - I\right\} \quad (4)$$

From here we can get the condition for optimal investment is given by

$$\frac{\partial\lambda}{\partial \mathrm{I}^A} = \frac{2}{N(p-C_R{}')} \quad (4.1)$$

We will move on to analyze the effect of the parameters, including λ_0 and N, on the investment level by branded firm if the accommodation strategy is chosen by the branded firm. Total differentiation of the first order condition w.r.t. I and λ_0 as well as N, we get.

$$\frac{d\mathrm{I}^A}{d\lambda_0} = \frac{\frac{N}{2}C_R{}'' \frac{\partial\lambda}{\partial \mathrm{I}}\frac{\partial\lambda}{\partial\lambda_0} - \frac{\partial^2\lambda}{\partial I\partial\lambda_0}(p - C_R{}')}{\frac{\partial^2\lambda}{\partial I^2}(p - C_R{}') - \frac{N}{2}C_R{}''(\frac{\partial\lambda}{\partial \mathrm{I}})^2} < 0$$

Here, we assume that $\frac{\partial^2\lambda}{\partial I\partial\lambda_0} < 0$. So, the investment incentive for the branded firm decreases in the initial fraction of consumers who can tell the difference between true and fake.

$$\frac{d\mathrm{I}^A}{dN} = \frac{[\frac{N}{4}(1+\lambda)C_R{}'' - \frac{1}{2}(p - C_R{}')]\frac{\partial\lambda}{\partial \mathrm{I}}}{\frac{\partial^2\lambda}{\partial I^2}(p - C_R{}')\frac{N}{2} - \frac{N^2}{4}C_R{}''(\frac{\partial\lambda}{\partial \mathrm{I}})^2}$$

So $sign\left(\frac{d\mathrm{I}^A}{dN}\right) = -sign(\frac{N}{4}(1+\lambda)C_R{}'' - \frac{1}{2}(p - C_R{}'))$. With further calculation, we can show that when N is sufficiently large, the increase in consumer number will increase the branded firm's incentive to increase its R&D research level. For not so large consumer population, it might not improve the branded firm's incentive to invest. This result is contradictory to our intuition. The investment incentive for the branded firm does not increase in the number of consumers when the number is not so large. This can be explained by the high cost in the investment that cannot be covered by the increase purchase of the small amount consumer if λ is too concave in I.Also higher level of initial fraction of consumers that can tell the difference will reduce the incentive to invest. We can just consider an extreme case when the initial fraction is 1. Then all consumers can tell the difference and all buy the branded product. There would be no necessary to make this investment. And we conclude these comparative statistics with Proposition 2.

Proposition 2: The branded firm's incentive to invest in anti-fake label is decrease in initial fraction of consumer who can tell the branded product from the fake ones, λ_0; only for sufficient large number of the consumer, the increase in number of consumerwill induce the R&D investment in anti-fake label.

We further assume that λ_0 is not so larger and N is large enough, so that the branded firm will fight against the firm by setting $\mathrm{I}^A > 0$ and $\frac{\partial\lambda}{\partial \mathrm{I}^A} = \frac{2}{N(p - C_R{}')}$. Under this condition, the potential firm decide whether or not entry the market. If $\frac{pN}{2}\left(1 - \lambda(\lambda_0, I^A)\right) < F_0 + C_F\left(\frac{N}{2}\left(1 - \lambda(\lambda_0, I^A)\right)\right)$, the fake firm will not enter the market, entry is deterred. But this case is not so realistic since F and the variable production cost is not large enough for the fake firm in the real world to deter this entry. And we are not interested in this case. If $\frac{pN}{2}\left(1 - \lambda(\lambda_0, I^A)\right) > F_0 + C_F\left(\frac{N}{2}\left(1 - \lambda(\lambda_0, I^A)\right)\right)$, then entry occurs when the branded firm set $I = I^A$. There might be some possibility that the branded firm will find it profitable to deter the entry of potential fake firm by overinvest in R&D by setting $I = I^D > I^A$. With further calculation, we can get the condition under which the branded firm will deter entry of the fake firm. And this result is given in Proposition 3.

Proposition 3: The branded firm will overinvest in R&D investment setting $I = I^D > I^A$in anti-label, if only if the profit from entry deterrence is greater than from entry accommodation, that is $\Pi^{RD} > \Pi^{RA}$

$$pN - C_R(N) - I^D \geq \frac{pN}{2}\left(1 + \lambda(\lambda_0, I^A)\right) - C_R\left(\frac{N}{2}\left(1 + \lambda(\lambda_0, I^A)\right)\right) - I^A$$

and,

$I^D = Min\{I \equiv \frac{pN}{2}\left(1-\lambda(\lambda_0, I)\right) - C_F\left(\frac{N}{2}\left(1-\lambda(\lambda_0, I)\right)\right) = F, \lambda(\lambda_0, I) = 1\}$, that is $I^D \equiv \Pi^F = 0$, $\mathrm{I}^A \equiv argmax\{\frac{pN}{2}(1+\lambda(\lambda_0, I)) - C_R(\frac{N}{2}(1+\lambda(\lambda_0, I))) - I\}$. Otherwise, the branded firm will choose accommodation investment I^A, and we call this market failure in naturalized anti-fake.

The intuition behind Proposition 3 is quite simple, that is, if the profit from deterrence is greater than the profit from accommodation, then the naturalized anti-fake equilibrium exists and there would not be any entry of the potential fake firm. If the profit after deterrence is smaller than the accommodation profit, the branded firm will not have incentive to overinvest in the anti-fake label to deter the fake products. So, the naturalized anti-fake equilibrium does not sustain under the condition of $\Pi^{RD} < \Pi^{RA}$. The special point here that we want to mention is that it is not necessarily the investment level that makes $\lambda(\lambda_0, I) = 1$ that reaches anti-fake deterrence.

There is some possibility that when $\lambda(\lambda_0, I) < 1$ and $I^D \equiv \frac{pN}{2}\left(1-\lambda(\lambda_0, I^D)\right) - C_F\left(\frac{N}{2}\left(1-\lambda(\lambda_0, I^D)\right)\right) = F$, the entry is deterred. So the anti-fake deterrence level is the minimum between the investment level that can make all consumers tell the true product from the fake product and the investment level that makes the profit of fake firm to zero. However, there is a positive λ that makes the profit of the fake firm to be zero, the naturalized deterrence investment is just the investment level that makes the fake firm unprofitable to entry. And we finish this part with check the effect of the consumer number as well as the fixed cost and initial fraction that can tell the difference on the investment level of anti-fake deterrence. And the results are given in Proposition 4.

Proposition 4: The naturalized anti-fake investment level. I^D is increasing in the total number of consumers, N, and decreases in the fixed cost of the fake firm, F_O and the initial fraction of the consumer that can tell the true product from the fake ones, λ_0. That is

$$\frac{\partial I^D}{\partial N} = \frac{(1-\lambda)(p - C_F{}')}{N((p - C_F{}')\frac{\partial \lambda}{\partial I} + C_F{}')} > 0$$

$$\frac{\partial I^D}{\partial F_O} = \frac{-2}{N((p - C_F{}')\frac{\partial \lambda}{\partial I} + C_F{}')} < 0$$

$$\frac{\partial I^D}{\partial \lambda_0} = \frac{-\frac{\partial \lambda}{\partial \lambda_0}(p - C_F{}')}{(p - C_F{}')\frac{\partial \lambda}{\partial I} + C_F{}'} < 0$$

So, there are some differences in the comparative statistics between the entry accommodation investment and the entry deterrence investment. For any number of consumers, the increase in the volume of consumer will increase the incentive to overinvest, compared to that only sufficiently large volume of consumer will induce the investment level. And if the fixed cost is too large, the deterrence investment level is really low.

3.2. Subsidized Anti-Fake Deterrence

Consider further that $pN - C_R(N) - I^D < \frac{pN}{2}(1+\lambda(\lambda_0, I^A)) - C_R(\frac{N}{2}(1+\lambda(\lambda_0, I^A))) - I^A$, that is$\Pi^{RD} < \Pi^{RA}$, and F_O is not so large and the branded firm will not overinvest in anti-fake label to deter the entry because the high investment cost cannot be covered by the revenue. However, it is not always beneficial for the society when fake products exist in the market as we discussed in the objective for the government. Since the fake firm will not register legally, the income does not go into the total GDP. Also the consumer will pay the same price for the fake product but the utility from consumption of fake product is 0 (in most cases, it is negative since most fake

product are harmful for people's health). Since the valuation for fake product is 0, any positive consumption will hurt the consumer surplus.

$$CS = \frac{N}{2}(1+\lambda)(V-p) + \frac{N}{2}(1-\lambda)(0-p) = \frac{N}{2}(1+\lambda) - p$$

From here, we can see that consumer surplus will be maximized at $\lambda = 1$, when the potential fake firm's entry is deterred. So the existence of fake product is harmful to the society. The government will subsidize the R&D investment in anti-fake label to deter the entry of the fake firm if the branded firm did not choose the deterrence investment.

In this part, we try to get the condition under which the government will subsidize the anti-fake deterrence and under what condition anti-fake is harmful for the society, so there is always some degree of fake products. Also, we give the optimal subsidy rate as well as the comparative statistics. In this section, we assume that the government has the right to transfer some money as subsidy to the branded firm when the branded firm fails in anti-fake investment. There is a two-stage game in which the government is the Stackelberg leader. The sequence of the game is like this. In the first stage, the government makes a take-it-or-leave-it offer: the subsidy rate for the per capita subsidy rate to the R&D investment in anti-fake label, s. And this subsidy will be given if only if entry of fake product is deterred. In the second stage, the branded firm choosesthe optimal R&D investment level, I, such that the potential entry firm decides not to enter the market if branded firm decides to obey the regulation. Otherwise, it chooses the previous I^A and receives no subsidy from the government.

The government's objective is deter fake products and to maximize the indirect utility of the consumer, that is

$$CS = \frac{N}{2}\big(1+\lambda(\lambda_0, I)\big) - p - sI$$

The branded firm's objective is to maximize its profit after subsidy if it accepts offer

$$\Pi^R = pN - C_R(N) - I + sI$$
$$s.t. \frac{pN}{2}\big(1-\lambda(\lambda_0, I)\big) - C_F\left(\frac{N}{2}\big(1-\lambda(\lambda_0, I)\big)\right) \le F_0$$

If it rejects the offer, the profit for the branded firm is

$$I = I^A \; and \; \Pi^R = \Pi^{RA}$$

Using backward induction method, we can get the equilibrium for which the branded firm accepts the offer by the government. The constrain condition always binds since branded firm's profit increases in λ. Looking at the F.O.C. by branded firm if it accepts the offer, is given by

$$F.O.C. = \frac{N}{1-\lambda} C_F^{'}\left(\frac{N}{2}\big(1-\lambda(\lambda_0, I)\big)\frac{\partial \lambda}{\partial I} - 1 + s\right.$$

Whether the branded firm's profit decreases or increases in investment that depend on the cost efficiency of the entry firm. And we give the results as Proposition 5.

Proposition 5: If $0 < \Delta\Pi^{AD} = \Pi^{RA} - \Pi^{RD} \le \frac{NV}{2}(1-\lambda(\lambda_0, I^A))$, the government will subsidize the anti-fake label investment for branded firm. And the optimal subsidy rate is given by $s = \frac{\Delta\Pi^{AD}}{I^D}$. If $\Delta\Pi^{AD} \ge \frac{NV}{2}(1-\lambda(\lambda_0, I^A))$, the government will not subsidize the anti-fake label investment for the branded firm since its offer will be objected by the branded firm. In this case, there would always be fake product. And anti-fake activity will hurt the society in this case.

Proposition 5 shows that whether there would be subsidy from the government depend on the profit difference between accommodation profit and deterrence profit of the branded firm. Here we define it as the profit loss due to the entry deterrence $\Delta\Pi^{AD} = \Pi^{RA} - \Pi^{RD}$. If the profit loss is too large, the subsidy from the government will hurt the consumer surplus too much, and the branded firm rejects any subsidy rate since the subsidy cannot cover the profit loss. For a rational government, there will not be any subsidy policy. Since anti-fake activity hurts the society in this case, the existence of fake products is beneficial to the society. There is no need to deter this kind of entry. And with further calculation, we can see that when the cost is highly efficient for the fake firm, the government and firm fails to deter the entry of fake products. If this profit loss is not too large, then the government will subsidize the anti-fake investment and the optimal subsidy is positively related to the profit difference. Also, it is proved in section 3.1 that when the profit loss is negative, the naturalized anti-fake equilibrium is sustainable.

We finish this paper with the comparative statistics of subsidized anti-fake. Here we assume that $0 < \Delta\Pi^{AD} \leq \frac{NV}{2}(1 - \lambda(\lambda_0, I^A))$, then the optimal subsidy rate is $s = \frac{\Delta\Pi^{AD}}{I^D}$. In Proposition 6, we give the effect of parameters.

Proposition 6: The per capita subsidy rate s decreases with the fixed production cost F_0, decreases in the initial fraction of consumer that can tell the branded product from the fake product, λ_0, but increases in the total consumer size. That is, $\frac{\partial s}{\partial F_0} < 0; \frac{\partial s}{\partial \lambda_0} < 0; \frac{\partial s}{\partial N} > 0.$

The understanding of the Proposition 6 is quite simple. The subsidy rate decreases with the fixed cost. If the fixed cost is very large, the loss for fake firm will be large. In this sense, the comparative advantage for the branded firm is large when fixed cost is high. The government will offer so small subsidy rate. If the initial fraction of people who can tell the difference is big, the consumers do not want to transfer the money to the branded firm to subsidize the anti-fake investment. So subsidy rate decreases in λ_0. Additionally, when the branded firm has a larger size of market, that is, the consumer number N increases, more consumers are willing to transfer the money to support the investment. So, the subsidy rate will increase.

To summarize, in this part, we analyze the three cases. In the first case, branded firm choose naturalized anti-fake equilibrium. In second case, government transfers money to support the branded firm's anti-fake. In case three, anti-fake is not beneficial for the whole society. And the comparative statistics are given for the three cases.

4. Conclusions and Extensions

This paper defines two kinds of anti-fake deterrence: naturalized anti-fake deterrence and subsidized anti-fake deterrence. Also we examine the conditions under which the naturalized anti-fake deterrence sustains and conditions for the subsidy anti-fake deterrence. Also we get the optimal subsidy rate that can maximize the consumer surplus and deter the entry of fake products.

Three cases are analyzed in the paper. First case is the market failure and government failure in anti-fake, that is, the profit loss from the anti-fake deterrence is really large that no subsidy is provided and even if the subsidy is provided, the branded firm will reject it. In this case, any anti-fake activity will hurt the society. In this sense, allowing some degree of fake products is "beneficial" for the society. The second case is that there is intermediate level of profit loss from anti-fake deterrence. Since the loss will be covered by the increased revenue and subsidy from the government, the subsidized anti-fake equilibrium sustained. The third case is that the profit loss is small so that the firm will cover the loss since the revenue increases. Then the naturalized anti-fake equilibrium sustains. Also, we give the comparative analysis to analyze the parameter effect.

There are some limitations of the model in the paper. Firstly, the assumption that the branded firm has sufficient market power to fix the price is too simplified. This might not be realistic since there are always competitions from the rivals. Secondly, it is assumed that demand is inelastic since we set the consumer number is N. Thirdly, the model is just static model, so the equilibrium is not sustainable when consider the dynamic model. If there might be

R&D investment in imitating the anti-fake label from the fake firm after observing the R&D level by the branded firm. The result should be different. Also when the branded firm consider the bad-reputation effect for next period when we consider infinite repetition game, there would be overinvest strategic use of the R&D in anti-fake label to deter the entry of fake products.

The extensions of the paper could be in many ways. First, we can further extend the model into oligopoly market, not monopoly market for the branded firm, and allowing the branded firms to collude in R&D investment to deter the entry of fake product. Here, we expect the collusion case will make the investment less costly for an individual branded firm, so the probability of the branded firm chooses naturalized anti-fake investment is much higher. Second, we can analyze the case with elastic demand and make some comparisons with the case we analyze in the paper. Thirdly, we can construct the model as dynamic model by allowing the imitation of fake firm. It is expected that this will reduce the incentive of the branded firm to invest in anti-fake label. Finally, we can analyze the case when the potential profit loss is really large, so anti-fake is harmful to the consumer. So both consumer union and branded firm choose not to deter the entry of fake products. However, in the long run, the bad-reputation effect will destroy the branded firm. This is also our future work to build the model to explain this intuition.

References

Dixit, A., 1979, A model of duopoly suggesting a theory of entry barriers. *Bell Journal of Economics*, 10, pp.20-32. http://dx.doi.org/10.2307/3003317

Donnenfeld, S.and Weber, S., 1995, Limit qualities and entry deterrence. *Rand Journal of Economics*, 35, pp.113-130. http://dx.doi.org/10.2307/2556038

Ellison, G., and Ellison, S.F., 2011, Strategic entry deterrence and the behavior of pharmaceutical incumbents prior to patent expiration. *American Economic Journal: Microeconomics*, 3(1),pp.1-36. http://dx.doi.org/10.1257/mic.3.1.1

Grossman, G.M., and Lai, E.L.-C., 2004, International protection of intellectual property. *American Economic Review*, 94(5), pp.1635-1653. http://dx.doi.org/10.1257/0002828043052312

Kutlu, L. and Wang, R., 2015a. Price dispersion, competition, and efficiency in the U.S. airline industry. [online] Available at: <http://ssrn.com/abstract=2612265> [Accessed 29 May 2015].

Kutlu, L. and Wang, R., 2015b. Estimation of cost efficiency without cost data. [online] Available at: <http://ssrn.com/abstract=2607280> [Accessed 16 May 2015].

Lee, J.-Y. and Mansfield, E., 1996. Intellectual property protection and U.S. foreign direct investment. *The Review of Economics and Statistics*, 78(2), pp.181-186. http://dx.doi.org/10.2307/2109919

Lutz, S., 1997. Vertical product differentiation and entry deterrence. *Journal of Economics*, 65(1), pp.79-102. http://dx.doi.org/10.1007/BF01239060

Rapp, R. and Rozek, R., 1990, Benefits and costs of intellectual property protection in developing countries. *Journal of World Trade*, 24(5), pp.75-102.

Schmalensee, R.,1982, Product differentiation advantages of pioneering brands. *TheAmerican Economic of Review*, 72(3), pp.349-365.

Seamans, R. C., 2012. Fighting city hall: entry deterrence and technology upgrades in cable TV markets. *Management Science*, 58(3), pp.461-475. http://dx.doi.org/10.1287/mnsc.1110.1440

Turut, O. and Ofek, E., 2012, Innovation strategy and entry deterrence. *Journal of Economics & Management Strategy*, 21(3), pp.583-631. http://dx.doi.org/10.1111/j.1530-9134.2012.00342.x

Wang, R. and Yang, W., 2016a. Estimation of demand and supply in US airline industry. Unpublished Working Paper.

Wang, R. and Yang, W., 2016b. What influences the pricing of automotive in U.S. market? *International Journal of Liberal Arts and Social Science*, 4(5), pp.88-97.

Wang, R., 2016. Revenue efficiency and dynamic pricing in airline industry. Unpublished Working Paper.

Wang, R., Han, N, Zhang, Y., and Zhang P., 2009. What influences pricing behavior of foreign supermarkets in Tianjin? *Management Observer*, 34, pp. 58-61.

Wuthisatian, R., 2014. Government resource subsidy and its spillover effects: Evidence from the excessive oil consumption in China. *Eurasian Journal of Economics and Finance*, 2(1), pp.1-12.

Yilmaz, C. and Buyuklu, A.H., 2016. Impacts of corporate governance on firm performance: Turkey case with a panel data analysis. *Eurasian Journal of Economics and Finance*, 4(1), pp.56-72. http://dx.doi.org/10.15604/ejef.2016.04.01.004