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Fragmentation of licensing right, bargaining and the tragedy of the anti-commons

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Abstract This paper investigates how the fragmentation of licensing right and bargaining affect the occurrence of the "tragedy of anti-commons" in the procedure of enterprise licensing. As found in this paper, if no bargaining is allowed, then greater fragmentation of licensing right can cause greater tragedy of the anti-commons. However, the bargaining between the bureaucracies and enterprise can greatly ease or even eliminate the tragedy of the anti-common under public information, but the relative bargaining power and the extent of fragmentation will affect the distribution of total surplus between the enterprise and the bureaucracies. Yet in the case of private information, bargaining itself may not work efficiently, and interestingly, lower fragmentation of licensing right might enhance the efficiency loss of bargaining, instead of easing the tragedy of the anti-commons.

Keywords Anti-commons · Bargaining · Incomplete Information

JEL Classifications C78 · D73 · H41

1 Introduction

Recently, the theory of anti-commons introduced by Heller (1998) has attracted wide interests from scholars in both economics and law. Previous studies have pointed out that the tragedy of the anti-commons exists in many areas, such as patent regimes (Heller and Eisenberg 1998), intellectual property rights (Murray and Stern 2005)

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and cyberspace (Hunter 2003). As pointed out in Heller (1998), tragedy of the anti-commons is a mirror-image of Hardin's (1968) well known tragedy of the commons. In situations where multiple individuals are endowed with the privilege to use a given resource without an effective way to monitor and constrain each other's use, the resource is vulnerable to overuse: a problem known as the tragedy of commons. Symmetrically, when multiple owners hold rights to exclude others from a scarce resource and no one exercises an effective privilege to use it, the resource might be prone to under-use: a problem known as the tragedy of the anti-commons.

In contrast to the model of commons, Buchanan and Yoon (2000) develop a formal economic model of anti-commons, in which they take price as the control variable and assume the demand function to be continuous and linear. Schultz et al. (2003) builds up a more general model by taking the quantity as the control variable. They suggest that the results of underutilization of joint property increase monotonically in both the extent of fragmentation, and the foregone synergies and complementarities between the property fragments. Depoorter and Vanneste (2007) design some controlled experiments to empirically test this result, and they find supportive evidences.

The earlier models focused on the non-cooperative game among multiple holders of exclusion rights, but neglected the possible cooperative relationship between the third party purchasers and the exclusion right holders. This paper goes beyond this limitation to discuss the more realistic mechanism when the third party purchaser (i.e., entrepreneurs) can bargain with each exclusion right holder (i.e., licensing bureaucrat). In addition to the complete information case, we will emphasize more on the case of asymmetric information where both the entrepreneur and the licensing bureaucrats are unsure of each other's reservation price. Take the multi-bureaucrats entrepreneur licensing procedure as an example, this paper shows the relationship among the fragmentation of exclusion right, bargaining and the economic efficiency. As found in this paper, more bargaining among the entrepreneur and the licensing bureaucrats will ease the tragedy of the anti-commons under complete information. However, if there is asymmetric information, bargaining has net efficiency loss and lower fragmentation of licensing right might enlarge instead of reduce the efficiency loss.

The arrangement of the paper is as follows: Sect. 1 makes an introduction of the paper; Sect. 2 describes the benchmark model; Sect. 3 discusses the bargaining model under symmetric information, while Sect. 4 presents the bargaining model under asymmetric information. Finally, we provide conclusions and policy implications in Sect. 5.

2 A benchmark model of the tragedy of the anti-commons

Assume an entrepreneur has an investment project with a discounted present value is V, and no externalities. Under a multi-bureaucratic enterprise licensing regime, the entrepreneur must apply to a "track" of bureaucrats and get approvals from each of them in order to start a project. Suppose there are M bureaucrats in the whole licensing procedure and each one has an independent right to veto the project. Similar to Shleifer and Vishny (1993), we assume that the objective function of each bureaucrat is to maximize his/her profit from providing the license.[1] As a benchmark model, it is firstly assumed that no bargaining is allowed and each bureaucrat gets a fixed share of the licensing fee from the investment project. For simplicity, each bureaucrat is supposed to get an identical share. As to the licensing cost, the licensing bureaucrats usually bare a larger workload and higher screening costs to approve, rather than veto a project. The model normalizes bureaucrat i's cost of exercising veto power to be zero, and assume the relative approval cost to be W_i, which is strictly positive, i.e., $W_i > 0$. Thus, when bureaucrat i chooses to approve the project, his/her profit function is

$$P_i = tF(x)/M - W_i$$

where t represents the total licensing fee rate, $0 < t < 1$, and

$$F(x) = \begin{cases} V, & \text{If } x_j = 1 \text{for any} j \\ 0, & \text{Otherwise} \end{cases}$$

The binary variable x_j is bureaucrat j's strategy, where $x_j = 1$ implies that bureaucrat j approves the project and $x_j = 0$ signifies bureaucrat j vetoes the project. If bureaucrat j exercises his/her veto power, then his/her profit function is $P_i = 0$.

To examine the effect of fragmentation in licensing approval, we assume that the total approval costs remain the same regardless of the number of bureaucrats, i.e., $\sum_{i=1}^{M} W_i = W$. Subsequently, if the licensing right is totally controlled by one bureaucrat, then the project will be approved under the condition

$$tV > W \tag{1}$$

In other words, the total licensing fee must be greater than the approval cost.

If the licensing right is fragmented and held by two bureaucrats, then the payoff matrix is as follows:

	Bureaucrat 2	
	Approve	Veto
Bureaucrat 1		
Approve	$tV/2 - W_1$, $tV/2 - W_2$	$-W_1$,0
Veto	0, $-W_2$	0, 0

It can be seen that$(x_1, x_2) = (1, 1)$, i.e., both bureaucrats approve the project, will be a Nash Equilibrium, if and only if the following condition is satisfied:

$$\begin{gathered} tV/2 - W_1 \geq 0 \quad \text{and} \quad tV/2 - W_2 \geq 0 \\ \text{i.e.,} \, tV \geq 2 \max \{W_1, W_2\} \end{gathered} \tag{2}$$

Compared with (1), inequality (2) is harder to satisfy, given the assumption that

[1] Shleifer and Vishny (1993) assume that the objective function of bureaucrats is to maximize the benefit from providing government goods.

$$\sum_{i=1}^{2} W_i = W,\ W_1 \neq W_2$$

Obviously, another pure strategy Nash Equilibrium exists in which both burearcrats veto the project, i.e., $(x_1, x_2) = (0, 0)$. Even if inequality (2) is satisfied, it is hard to tell which equilibrium would actually occur. Thus, when the licensing rights are fragmented, it will be more difficult for the project to be approved even when the total expected approval costs are kept the same, leading to the tragedy of the anti-commons.

If the licensing right is even more fragmented, held by three or more bureaucrats, $M \geq 3$, then $(x_1, x_2, x_3,\ldots) = (1, 1, 1, \ldots)$ will be a Nash equilibrium if and only if the following condition holds:

$$tV > M \max\{W_i, i = 1, \ldots M\}(M \geq 3) \tag{3}$$

Similar to the discussion regarding the case of two bureaucrats, condition (3) is much stricter than the condition under the case of one "integrated" bureaucrat, condition (1), even if the total expected approval cost remain the same. And the larger the number of bureaucrats is, the less likely that condition (3) will be satisfied.

Furthermore, even if condition (3) holds, there is another pure strategy Nash equilibrium in which all bureaucrats veto the project, i.e., $(x_1, x_2, x_3, \ldots) = (0, 0, 0, \ldots)$. It can be proved that the larger the number of bureaucrats is, the more likely that $(x_1, x_2, x_3, \ldots) = (0, 0, 0, \ldots)$ is the risk dominant equilibrium.[2] From the evolutionary game theory's point of view, the risk dominant equilibrium is most likely to be chosen (Kandori et al. 1993; Young 1993). Therefore, the entrepreneur's value enhancing project is more likely to be denied when the number of bureaucrats is larger, i.e., greater fragmentation of licensing right causes easier occurrence of the tragedy of the anti-commons. The above analysis can be concluded into the following proposition:

Proposition 1 *If each licensing bureaucrat can only benefit from a fixed share of the licensing fee without any bribes, then greater fragmentation of licensing right will lead to easier occurrence of the tragedy of the anti-commons.*

Proposition 1 confirm and reiterate the results of previous studies. Even where each bureaucrat gets a fixed share of the licensing fee without any bribes, fragmentation of excluding rights can lead to the tragedy of the anti-commons (Heller 1998; Buchannan and Yoon 2000; Schult et al. 2003). As pointed out in De Soto (2000), informal property rights in land title systems and multi-agents licensing problems are commonly seen in some developing countries. De Soto emphasizes that the lack of an integrated system of property rights and licensing in today's developing nations makes it impossible for the poor to leverage their informal ownerships into capital. Proposition 1 confirms De Soto's idea in a different way by highlighting the anti-commons problem in the multi-bureaucrats licensing procedures. However, what if

[2] The proof is omitted here; it can be delivered by email correspondence if desired. The definition of risk dominant equilibrium is proposed by Harsanyi and Selton (1988).

the entrepreneur can bribe each bureaucrat by negotiation? Using bargaining model, the following two sections discuss this question under symmetric information case and asymmetric information case respectively.

3 Bargaining model under symmetric information

Now suppose the entrepreneur can offer bribes by negotiation to every bureaucrat with veto power in the licensing procedure. Assume it is a Nash style cooperative game when the entrepreneur bargains with each bureaucrat successively. Further assume that the number of bureaucrats M, the entrepreneur's project value V and each bureaucrat's approval cost W_i are all public information. To make the bargaining worthwhile, we also make the assumption that there is a positive net surplus to be allocated in the first place, i.e., $V > \sum W_i$. During each bargaining game between the entrepreneur and one of the bureaucrats, the net reservation price of the entrepreneur is the total value of the investment project minus the total expected bribes supposed to be given to all the other bureaucrats, while the reservation price of the bureaucrat is its approval cost. Sharing the same symmetric information set, the involved bureaucrat and the entrepreneur in each negotiation will agree on the same expectation on the bribes that the entrepreneur is supposed to give to all other bureaucrats. For simplicity, we assume that every bureaucrat has the same bargaining power β, where $0 < \beta < 1$. When any bureaucrat, say bureaucrat i, is bargaining with the entrepreneur, the Nash cooperative bargaining problem is:

$$\underset{P_i}{\text{Max}}[V - \sum_{j \neq i} E_i(P_j)]^{1-\beta}[P_i - W_i]^{\beta}$$

Then the negotiated price would be as follows:

$$P_i = W_i + \beta\left(V - \sum_{j \neq i} E_i(P_j) - W_i\right), \text{for } \forall_i \tag{4}$$

After the negotiation, the negotiated price is revealed to all the other bureaucrats. However, it is assumed that the entrepreneur and the bureaucrat will not exercise the negotiation price immediately. Instead, they can wait to decide whether to exercise it or not after all the negotiated prices to other bureaucrats are revealed. If all the revealed negotiated bribes to other bureaucrats are just the same as expected, i.e., $E_i(P_j) = p_j$, for any j, then the negotiated price will be exercised. Otherwise, either the bureaucrat or the entrepreneur can refuse to exercise the negotiated price, since it is not as satisfactory as expected. They will renegotiate to achieve a new contract based on the revealed prices to the other bureaucrats. The process of negotiation goes on until it reaches the equilibrium, when

$$E_i(P_j) = p_j, \text{ for any } i \text{ and } j \tag{5}$$

Substitute Eq. (5) into (4), we can solve out the equilibrium bribe to any bureaucrat i as:[3]

[3] See the Appendix for the detailed solution.

$$P_i^* = \frac{\beta(V - \sum W_i)}{1 + \beta(M - 1)} + W_i \tag{6}$$

From Eq. (6) and the assumption that $V > \sum W_i$, it can be easily seen that every bureaucrat will get the same positive surplus $\frac{\beta(V - \sum W_i)}{1+\beta(M-1)}$.

Furthermore, sum up Eq. (5), we can get the total bribes as follows:

$$\sum P_i = \frac{\beta MV + (1 - \beta) \sum W_i}{1 + \beta(M - 1)} \tag{7}$$

The entrepreneur also gets a positive surplus as:

$$V - \sum P_i = \frac{(1 - \beta)(V - \sum W_i)}{1 + \beta(M - 1)} > 0 \tag{8}$$

Therefore, so long as preset assumption $V > \sum W_i$ applies, the cooperative bargaining under symmetric information will yield an equilibrium which is acceptable for all participants in the game. Besides, if all the rational participants can foresee the equilibrium price P_i^*, they may achieve the equilibrium price at one step without renegotiating. In such a frictionless bargaining game, all the worthwhile projects satisfying $V \geq \sum W_i$ will be approved no matter how large M is, and thus no tragedy of the anti-commons will occur. Furthermore, from Eqs. (6) and (8), we also know that the entrepreneur gets $\frac{(1-\beta)}{1+\beta(M-1)}$ share of the total surplus $V - \sum W_i$, while the rest of the surplus, $\frac{\beta M}{1+\beta(M-1)}$ share of $V - \sum W_i$, goes to the bureaucrats, and each bureaucrat gets an equal share $\frac{\beta}{1+\beta(M-1)}$. Obviously, the higher M is, the lower share that the entrepreneur gets, and the higher share that the bureaucrats obtain in total. Especially, when $M \to \infty$, the entrepreneur tends to get no surplus. Moreover, higher bargaining power of the bureaucrats directs more surplus to the bureaucrats and less surplus to the entrepreneur.

It should be noted that the above analysis does not consider any bargaining cost or friction, which may actually lead to net efficiency loss. Suppose the entrepreneur bares a fixed bargaining cost, then it might outweigh the entrepreneur's share of surplus which could be very small when the fragmentation of licensing right is high enough. In this case, he/she will refuse to take part in the bargaining to invest in the socially beneficial project (i.e., $V \geq \sum W_i$), causing the tragedy of the anti-commons. Nevertheless, comparing to the no bargaining case, it remains true that more bargaining might deter the tragedy of the anti-commons, if not eliminate it. The above results can be concluded as:

Proposition 2 *When information is symmetric, more bargaining between the entrepreneur and the licensing bureaucrats on the licensing fees or bribes can ameliorate or even eliminate the tragedy of the anti-commons. However, the extent of fragmentation and the relative bargaining power will influence the distribution of total surplus among the entrepreneur and the licensing bureaucrats. A higher fragmentation extent of the licensing right or a lower bargaining power of the* *entrepreneur will lead to a smaller share for the entrepreneur, but higher licensing fees or bribes to the bureaucrats.*

Proposition 2 implicates that if the third party purchaser can bargain with exclusion rights holders with no or little friction, then higher fragmentation of exclusion right will not necessarily lead to greater tragedy of the anti-commons. This result is different from the conclusion of previous researches (Heller 1998; Buchanan and Yoon 2000; Schultz et al. 2003), which only consider the non-cooperative interactions among exclusion right holders but neglect the possible cooperative relationship between the third party purchaser and each exclusion right holder. Meanwhile, Proposition 2 also supports Leff (1964) on the point that corruption can increase efficiency in some situations.[4] Furthermore, Proposition 2 indicates that the excluding bureaucrats receive more revenues in total when they make decision independently comparing to the case under collusion, while Shleifer and Vishny (1993) holds just the opposite view. This is also because they do not consider the possibility that the entrepreneur can bargain with the excluding bureaucrats.

The above analysis has assumed that there is no punishment on bribes. What if there is a "whistle blowing statute"? Cooter and Garoupa (2000) suggests a "whistle-blower" mechanism to set up prisoner dilemmas that might deteriorate cooperation in corruption settings. However, proposition 2 argues that such a mechanism to deteriorate cooperation in corruption will not be necessarily beneficial for the economic efficiency when there are multi exclusion rights holders, because the tragedy of the anti-commons might be more likely to occur without the cooperation.

4 Bargaining model under asymmetric information

The assumption of symmetric information in the previous section is unrealistic in many cases. Sometimes neither the entrepreneur nor the bureaucrats are completely certain of other players' reservation prices besides his/her own, especially when there are a large number of bureaucrats. Similar as the symmetric information case, we keep the assumption that the total approval cost remains the same regardless of the number of bureaucrats and the way the licensing right is fragmented. For simplicity, the true total approval cost is normalized to be one. i.e., $\sum W_i = 1$. However, suppose the entrepreneur knows the expected value of the bureaucrats' total approval cost, $E(\sum W_i) = 1$, but he/she is not sure of the exact value of the total approval cost nor how it is distributed among different bureaucrats. The entrepreneur can only estimate that any bureaucrat i's reservation price W_i follows a uniform distribution in the range [0, 2/M]. On the other hand, each bureaucrat estimates that the entrepreneur's reservation price V follows a uniform distribution in the range [0, 2]. Further assume that after each negotiation, the negotiated price

[4] Corruption also has many negative effects though. This paper does not argue that corruption is socially desirable. Corruption is never a first-best choice: it undermines the concept of social justice and may distort market competition and resource allocation. What it does argue is that corruption may become one of the second-best solutions, given the fragmentation of the licensing right or the multi-agent examination and approval system in some developing countries. Some good entrepreneurs are forced to do bribes too. A through discussion of corruption is out of the scope of this paper.

will not be revealed to other bureaucrats, but kept asymmetric information between the involved bureaucrat and the entrepreneur.

For simplicity, we assume that the entrepreneur and bureaucrat i have equal bargaining power $\beta = \frac{1}{2}$ in the bargaining process. The entrepreneur bids a price P_b^i while the bureaucrat i asks a price P_s^i. If and only if $P_b^i > P_s^i$, the bargaining succeeds, and the negotiated price is determined as $p = \frac{1}{2}(P_s^i + P_b^i)$. According to the above assumptions, bureaucrats i' maximization problem is as below:

$$\text{Max}\left\{\frac{1}{2}\left(P_s^i + E\left[P_b^i(V)|P_b^i(V) > P_s^i\right]\right) - W_i\right\}\text{Prob}\left[P_b^i(V) > P_s^i\right] \tag{9}$$

where $E\left[P_b^i(V)|P_b^i(V) > P_s^i\right]$ is bureaucrat i's expectation of the entrepreneur's bidding price.

The entrepreneur's maximization problem is as below:

$$\underset{\left\{P_b^i:i=1,2\cdots M\right\}}{\text{Max}}\left[V - \frac{1}{2}\left(\sum P_b^i + \sum E\left[P_s^i(W_i)|P_b^i > P_s^i(W_i)\right]\right)\right]\prod_{i=1}^{M}\text{Prob}\left\{P_b^i > P_s^i(W_i)\right\} \tag{10}$$

There may be multiple Bayesian equilibriums in the above bargaining, but Myerson and Satterthwaite (1983) have proved that in the case of uniform distribution, the surplus of linear strategy is higher than the surplus of other Bayesian equilibriums. Therefore, our discussion below will only be limited to the situation of linear strategy. Suppose that both the bureaucrats and the entrepreneur adopt a linear strategy as follows.

$$P_s^i(W_i) = \alpha_s^i + \beta_s^i W_i \tag{11}$$

$$P_b^i(V) = \alpha_b^i + \beta_b^i V \tag{12}$$

Since V is subjected to a uniform distribution at [0, 2], then P_b^i follows a uniform distribution at $[\alpha_b^i, \alpha_b^i + 2\beta_b^i]$. The probability that bureaucrat i expects entrepreneur's bidding price higher than his asking price is as below:

$$\begin{aligned}\text{Prob}\left\{P_b^i(V) > P_s^i\right\} &= \text{Prob}\left\{\alpha_b^i + \beta_b^i V > P_s^i\right\}\\ &= \text{Prob}\left\{V > \tfrac{P_s^i - \alpha_b^i}{\beta_b}\right\} = \tfrac{\alpha_b^i + 2\beta_b^i - P_s^i}{2\beta_b^i}\end{aligned} \tag{13}$$

The conditional expectation of bureaucrat i of the entrepreneur's bidding price is as follows:

$$E\left[P_b^i(V)|P_b^i(V) > P_s^i\right] = \frac{\frac{1}{2\beta_b^i}\int_{P_s^i}^{\alpha_b^i+2\beta_b^i} x dx}{\text{Prob}\left\{P_b^i(V) > P_s^i\right\}} = \frac{1}{2}\left(P_s^i + \alpha_b^i + 2\beta_b^i\right) \tag{14}$$

Substituting Eqs. (13) and (14) into bureaucrat i's objective function (9), we can have the maximization problem as follows:

$$\underset{P_s^i}{\text{Max}}\left\{\frac{1}{2}\left[P_s^i + \frac{1}{2}\left(P_s^i + \alpha_b^i + 2\beta_b^i\right)\right] - W_i\right\}\frac{\alpha_b^i + 2\beta_b^i - P_s^i}{2\beta_b^i} \tag{15}$$

The first order condition is:

$$\text{F.O.C. } P_s^i = \frac{1}{3}\left(\alpha_b^i + 2\beta_b^i\right) + \frac{2}{3}W_i \tag{16}$$

Similarly, the probability that the entrepreneur expects his/her bidding price to be higher than the asking price of bureaucrat i is as below:

$$\text{Prob}\left\{P_b^i > P_s^i(W_i)\right\} = \text{Prob}\left\{P_b^i > \alpha_s^i + \beta_s^i W_i\right\} = \frac{M}{2}\frac{P_b^i - \alpha_s^i}{\beta_s^i} \tag{17}$$

Thus, the Entrepreneur's conditional expectation of bureaucrat i's asking price is as below:

$$E\left[P_s^i(W_i)|P_b^i > P_s^i(W_i)\right] = \frac{1}{2}\left(\alpha_s^i + P_b^i\right) \tag{18}$$

Substituting Eqs. (17) and (18) into the entrepreneur's objective function (10), it is seen:

$$\underset{\left\{P_b^i:i=1,\ldots,M\right\}}{\text{Max}} \left\{V - \frac{1}{2}\left[\sum_{i=1}^{M} P_b^i + \frac{1}{2}\sum_{i=1}^{M}\alpha_s^i + \frac{1}{2}\sum_{i=1}^{M} P_b^i\right]\right\}\prod_{i=1}^{M}\frac{P_b^i - \alpha_s^i}{\beta_s^i} \tag{19}$$

The first order condition is as below:

$$\text{F.O.C. } P_b^i = \frac{2}{3}V + \frac{1}{3}\alpha_s^i - \frac{1}{2}\sum_{j\neq i}^{M} P_b^j - \frac{1}{6}\sum_{j\neq i}\alpha_s^j \ (\text{for} \quad \forall_i = 1,\ldots,M) \tag{20}$$

Sum up Eq. (20) for i and simplifying reveals that:

$$P_b^i = \frac{4}{3(M+1)}V + \frac{3M-1}{3(M+1)}\alpha_s^i - \frac{4}{3(M+1)}\sum_{j\neq i}\alpha_s^j \tag{21}$$

From Eqs. (11), (12), (16) and (21):

$$\beta_b^i = \frac{4}{3(M+1)}, \ \beta_s^i = \frac{2}{3} \tag{22}$$

and

$$\begin{cases} \frac{1}{3}\left[\alpha_b^i + \frac{8}{3(M+1)}\right] = \alpha_s^i \\ \frac{3M-1}{3(M+1)}\alpha_s^i - \frac{4}{3(M+1)}\sum_{j\neq i}\alpha_s^j = \alpha_b^i \end{cases} \tag{23}$$

The solution of Eq. (23) is as below:

$$\begin{cases} \alpha_s^i = \frac{4}{5M+3} \\ \alpha_b^i = \frac{12-4M}{3(M+1)(5M+3)} \end{cases} \tag{24}$$

From Eqs. (22) and (24), the linear strategies of the entrepreneur and bureaucrat i are as follows:

$$P_s^i = \frac{4}{5M+3} + \frac{2}{3}W_i \tag{25}$$

$$P_b^i = \frac{4}{3(M+1)}V + \frac{12-4M}{3(M+1)(5M+3)} \tag{26}$$

The condition under which the entrepreneur and the bureaucrats make a successful negotiation is as follows:

For any i, $P_b^i > P_s^i$, i.e. $\frac{4}{3(M+1)}V > \frac{2}{3}W_i + \frac{16M}{3(M+1)(5M+3)}$, i.e.,

$$V > \frac{4M}{5M+3} + \frac{M+1}{2}\text{Max}\{W_i\} \tag{27}$$

When $M = 1$, the problem is simplified into the basic bilateral trading. Substituting $M = 1$ and the previous assumption $\sum W_i = 1$ into (27), we get the successful negotiation condition under bilateral trading as: $V > \frac{3}{2}$. However, under complete information, the successful negotiation condition should be $V > 1$. Therefore, those socially beneficial project with a present value between 1 and $\frac{3}{2}$ will be denied under asymmetric information, causing a net efficiency loss.

When $M \geq 2$, If the total approval cost is distributed equally among the bureaucrats. i.e., $W_i = \frac{1}{M}$ for any i, then (27) turns to be

$$V > \frac{4M}{5M+3} + \frac{M+1}{2M} \tag{28}$$

Firstly, it is easy to verify that the inequality (28) is stricter than $V > 1$ irrespective of the value of M. Besides, it can also be verified that the right side of inequality decreases with M. This implicates that a higher extent of fragmentation will make the negotiation easier which in turn increases economic efficiency. Alternatively, if at least one of the true W_i reaches the maximum possible value $\frac{2}{M}$, ($M \geq 2$), then (27) turns to be

$$V > \frac{4M}{5M+3} + \frac{M+1}{M} \tag{29}$$

Again it is easy to verify that the successful negation condition is stricter than that under complete information ($V > 1$), but a higher M will make the negotiation easier and increase economic efficiency. Therefore, whether the total approval cost is distributed among bureaucrats equally or not, higher extent of fragmentation in licensing right might increase economic efficiency if the entrepreneur and the bureaucrats are bargaining under asymmetric information. In other words, lower fragmentation of the licensing right will counter-intuitively worsen economic efficiency further. This result challenges the conclusion of previous studies (e.g., Schultz et al. 2003) which suggest that higher fragmentation of exclusion rights reduces economic efficiency. The above discussion can be concluded as:

Proposition 3 *If the entrepreneur and the bureaucrats are both unsure about the reservation prices of each other, then the bargaining between the entrepreneur and the bureaucrats has a net efficiency loss. In this case lower fragmentation of the licensing right might contrarily enlarge the efficiency loss instead of reducing it.*

Proposition 3 is astonishing since it is quite different from previous studies (e.g., Schultz et al. 2003) which argue that higher fragmentation of property right will surely lead to lower economic efficiency. What's the intuition behind proposition 3?

As proved above in this paper as well as in Myerson and Satterthwaite (1983), asymmetric information will cause efficiency loss in the bilateral trading. The intuitive reason is that both of the agents in the bilateral trading will have gambling incentive under asymmetric information: The buyer will only offer a relatively low price, gambling that the reservation price of the seller is low, while the seller wants to charge a relatively high price, gambling that the reservation value of the buyer is high. As a result, the bargaining might fail to achieve an agreement even if the buyer's true reservation value is higher that the reservation price of the seller, and thus causes a net efficiency loss. In this paper, an increase in the fragmentation of licensing right will reduce the gambling incentive of both the entrepreneur and the bureaucrats, because each of them knows that he/she has a smaller space to gamble when the fragmentation of licensing right is higher, since a finally successful trade requires that every negotiation between the entrepreneur and each bureaucrat reaches an agreement. As a result, both the entrepreneur and the bureaucrats as a whole may report a more conservative price, and thus increase the success rate of the bargaining and the economic efficiency.

Nevertheless, it should be noted that the above explicit example only shows the possibility that an increase of the fragmentation of licensing right might raise economic efficiency, but it dose not verify or propose the necessarily. Actually, the result is based on some strict assumptions which might not hold in some situations in reality. However, in some other situations, the model setting in this paper does mimic the reality. Therefore, the answer whether the fragmentation of licensing right will truly increase the economic efficiency under asymmetric information may depend on the exact information structure and the payoff structure, which have many possibilities in reality.

5 Conclusion

This paper investigates the relationship among the fragmentation of licensing right, bargaining, and the tragedy of the anti-commons under different information structures. It is found that if each licensing bureaucrat can only get a fixed share of the licensing fee, then the fragmentation of licensing right can easily cause the tragedy of the anti-commons. Alternatively, if the entrepreneur can bribe each bureaucrat by negotiation under symmetric information, then the anti-commons tragedy and the loss of economic efficiency can be prevented or ameliorated, but the extent of fragmentation and the relative bargaining power will influence the distribution of total surplus among entrepreneur and bureaucrats. A higher fragmentation extent will lead to a lower share for entrepreneur, but higher share for the bureaucrats. However, if the entrepreneur and the licensing bureaucrats are not sure of each others' reservation price, then the bargaining can not completely avoid the net efficiency loss, and a lower fragmentation of licensing right might contrarily reduce economic efficiency further, which is a astonishing conclusion comparing to previous studies.

The model in this paper would apply to some real situations such those in some fast emerging countries like China, where the fragmentation of licensing right is still commonly seen. Generally speaking, agencies should have the right incentives to prevent the tragedy of the anti-commons and underutilization. Given the presence of fragmentation of the licensing right or the multi-agent examination and approval system in some developing countries, corruption may become one of the second-best solutions to provide the bureaucrats the right incentives in some cases. However, bribes are only one way, but surely there must be other, more legitimate ways, to improve incentives, such as performance standards etc. Above all, in the long run, the best way might be eliminating the origin of the tragedy of the anti-commons, i.e., reducing the fragmentation of licensing right or even canceling some unnecessary licensing procedures. Nevertheless, the policy makers should keep cautious in the process of carrying out licensing procedure reforms and the anti-corruption measures, because as shown in this paper, the effects of the fragmentation of licensing right, bribes and the information structure are closely connected.

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Appendix

$$P_i = W_i + \beta\left(V - \sum_{j\neq i} P_j - W_i\right), \text{ for } \quad \forall_i \tag{A1}$$

$$\Rightarrow \sum_{j\neq i} P_i = \sum_{j\neq i} W_j + \beta\left[(M-1)V - (M-2)\sum_{j\neq i} P_j - (M-1)P_i - \sum_{j\neq i} W_j\right]$$
$$\Rightarrow \sum_{j\neq i} P_j = \frac{\beta(M-1)V + (1-\beta)\sum_{j\neq i} W_j - \beta(M-1)P_i}{1+\beta(M-2)} \tag{A2}$$

Substituting (A2) into (A1), we have

$$P_i = W_i + \beta\left[V - \frac{\beta(M-1)V + (1-\beta)\sum_{j\neq i} W_j - \beta(M-1)P_i}{1+\beta(M-2)} - W_i\right]$$
$$\Rightarrow P_i = \frac{\beta(1-\beta)\left(V - \sum W_i\right) + (1-\beta)[1+\beta(M-1)]W_i}{-(M-1)\beta^2 + (M-2)\beta + 1}$$
$$= \frac{\beta\left(V - \sum W_i\right)}{1+\beta(M-1)} + W_i$$

References

Buchanan, J. M., & Yoon, Y. J. (2000). Symmetric tragedies: Commons and anti-commons. *Journal of Law and Economics, 43*, 1–13.

Cooter, R., & Garoupa, N. (2000). The virtuous circle of distrust: A mechanism to deter bribes and other cooperative crimes, *Berkeley Program in Law and Economics, Working Paper Series #32*.

Depoorter, B., & Vanneste, S. (2007). Putting humpty dumpty back together: Pricing in anticommons property arrangements. *Journal of Law, Economics and Public Policy*. Available at http://works.bepress.com/bendepoorter/4/

De Soto, H. (2000). *The mystery of capital: Why capitalism triumphs in the west and fails everywhere else*. New York: Random House.

Hardin, G. (1968). The tragedy of commons. *Science, 162*, 1243.

Harsanyi, J. C., & Selten, R. (1988). *A general theory of equilibrium selection in games*. Cambridge, MA: MIT Press.

Heller, M. A. (1998). The tragedy of the anti-commons: Property in the transition from Marx to markets. *Harvard Law Review, 111*, 621–688.

Heller, M. A., & Eisenberg, R. S. (1998). Can patents deter innovation? The anti-commons in biomedical research. *Science, 280*, 698–701.

Hunter, D. (2003). Cyberspace as place, and the tragedy of the digital anti-commons. *California Law Review, 91*(2), 439–520.

Kandori M., Mailath, G. J., & Rob, R. (1993). Learning, mutation, and long-run equilibria in games. *Econometrica, 61*, 29–56.

Leff, N. (1964). Economic development through bureaucratic corruption. *American Behavioral Scientist, 8*(3), 8–14.

Murray, F., & Stern, S. (2005). Do formal intellectual property rights hinder the free flow of scientific knowledge? An empirical test of the anti-commons hypothesis, *NBER Working Paper*, 11465.

Myerson, R. B., & Satterthwaite, M. A. (1983). Efficient mechanisms of bilateral trading. *Journal of Economic Theory, 28*, 265–281.

Schutz, N., Parisi, F., & Depooter, B. (2003). Fragmentation in property: Towards a general model. *George Mason University Law & Economics, Working Paper Series* #02-03.

Shleifer, A., & Vishny, R. W. (1993). Corruption. *The Quarterly Journal of Economics, 3*, 599–617.

Young, H. P. (1993). The evolution of conventions. *Econometrica, 61*, 57–84.