On Group Self-Governance: Evidence from Craft Guilds in Late-Medieval England

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Abstract This paper provides a theoretical foundation for group self-governance. Two measures are necessary for a self-governing group: (1) an expulsion mechanism, a mechanism which allows the group to easily maintain a cooperative equilibrium; and (2) a risk-sharing plan (insurance), which serves as both a screening mechanism and a utility-improving measure. This article explains why expulsion and risk-sharing plans prospered in craft guilds in late medieval England. In fact, both expulsion and insurance assure only the low-risk type (more risk averse) agents remain in their groups. This feature explains why the insurance fees within the groups were less by far than those within social groups.

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1 Introduction

Most historical evidence suggests that when potentially profitable opportunities are available, economic agents will form an interest-group. The prevalence of various craft guilds in late-medieval England provides a good example. These guilds, or groups, consist of many self-interested individuals. Divergence between group and individual interests often exists, which may jeopardize both group and individual interests. To secure the underlying profit of every member, the interest-group have to overcome the potential collective action problems inherent in coordinating participation in productive activities. It has to prohibits its self-interested members from devastating infighting. The self-governing problem, i.e., how does group overcome that divergence and archive cooperation, therefore, is of great interest.

The importance of collective action problems in group decisions was highlighted by Mancur Olson in his classic book, *The Logic of Collective Action*, where he analysis the problems that groups will have in convincing individuals to take actions which are costly for themselves, but beneficial for the whole group. Additionally, we are interested in evidence from the craft guilds in late-medieval England. According to the study on the craft guilds in late-medieval England(Epstein, 1998; Richardson 2001, 2004, 2005a, 2005b, 2005c), although the guilds engaged in different businesses in different cities at different times, surprisingly, most of them employed the same measures, say, (1) expelling the members who broke the guild regulation; (2) providing intra-guild insurance; and (3) pursuing religious goals, to carry out this self-governance function.

The literature on the collective action problem, has identified a number of ways that can deal with group self-governance problems. These include the use of ideology and pecuniary benefits (Acemoglu and Robonson, 2005). Pecuniary benefits, in turn, can be usefully disaggregated into two categories, private benefits and exclusion. First, groups may try to indoctrinate their members so that they view participation in activities that are beneficial for the group as a positive action that directly adds to their utility. This type of indoctrination explains why craft guilds in late-medieval England possessed pious features and pursued religious goals. A comprehensive study on this issue is given by Gary Richardson in his paper, *Craft Guilds and Christianity in Late-Medieval England*. Second, groups may attempt to generate private pecuniary benefits for those who participate in collective action. However, in practice, the most common strategy to deal with collective action problem is "exclusion."Exclusion limits the benefits resulting from collective action to only those who take part in the action.

A rich empirical literature has investigated how the group self-governance problem is solved in practice (see, for example, the surveys in Lichbach, 1995, and Moore, 1995). Though there are different ways of classifying putative solutions to this collective action problem (see Lichbach, 1995, pp. 20-21), most scholars emphasize the importance of ideology. Nonetheless, most of the empirical evidence in more about how private benefits and exclusion are used by those trying to organize collective action. Therefore, this article focuses on the first two features of the craft guilds in late-medieval England. The objective of this article is to investigate the rationale behind this phenomenon and gain a better understanding of groups.

We develop an theoretic approach to justify such group self-governance phenomenon. The contribution of this study is three-fold: first, it explains why expulsion is much more popular than the "Cournot punishment"[1]; second, it proves that under certain circumstance, a risk-sharing scheme (insurance)[2] can serve as a screening mechanism which helps the self-governance of the group; third, it provides a means of analysis for questions about infinite horizon games with different agents' types. Additionally, we focus on the interaction among agents with different risk aversions.

[1]To my knowledge, this terminology is first used by H. Cheng. See H. Cheng: Inefficiency in Repeated Cournot Oligopoly Games, IEPR working paper. 2005

[2]Through out this paper, we use "risk-sharing scheme"and "insurance"interchangeably.

This article is organized as follows. The basic model is introduced in section 2, which provides the framework of our following analysis. Section 3 concerns the equilibria of the infinite repeated game. It also compares expulsion with Cournot punishment, presenting the first possible explanation why expulsion is superior to Cournot punishment. In section 4, the risk-sharing function (insurance) of the group is discussed. Subsection 4.1 presents a useful result, which allows us to consider the behavior of different types of agents without specifying the functional form of the utility functions. It facilities the analysis of the risk-sharing function of the group. Subsection 4.2 shows that the insurance scheme may serve as a screening mechanism, which discriminates high-risk group members from low-risk ones. Moreover, it explains how the insurance scheme can make group members better off. Therefore, the importance of the risk-sharing function of the group can not be overstated. A somewhat striking result is also presented in subsection 4.2, which shows that the aggravations of the social environment may actually improve the welfare of group members. Imperfect monitoring is considered in sections 5. It proves that no mixed strategy survives in the imperfect monitoring case. What is more, it shows that when monitoring is imperfect, expulsion is still superior to Cournot punishment. Concluding remarks are in the final section.

2 The Model

Consider a group, consisting of $N \geq 2$ agents, which controls some potentially profitable business[3]. The group provides its members with both marketing and risk-sharing services. Each agent carries out her production process separately, using the same technology. For a given period, say, a year, each agent can only produce one unit of good. Their products are collected by the group and sold out in the market collectively. The group enforces edicts

[3]This model is first discussed by G. Richardson (2005). His research on medieval English craft guilds consists of a large amount of interesting historical phenomena. In fact, the original motivation of this article is to provide a theoretical justification of all those phenomena.

concerning the quality of its products. The hope of increasing income encourages the group members to set high standards for themselves. These incentives arise when the reputation of the group influences the incomes of its members. Indeed, the group's reputation may influence the demand for members' merchandize. The market is assumed to be extremely elastic. Therefore, a group's reputation helps its members to sell all of their products at the market price, which is solely determined by the group's reputation. Group members choose quality as their control variable. The group encourages consumers to purchase their wares by monitoring the quality of members' merchandize, consistently selling defect-free products, and developing reputations for doing so. This assumption is consistent with historical evidence. A typical example comes from the ordinances that London's guild of pewterers adopted in 1348:

> So many person make vessels not in due manner to the damage of the people and the scandal of the trade, that three or four of the most true and cunning in the guild [should] be chosen to oversee the alloys and the workmanship of all... be it understood, that all manner of vessels shall be made of fine pewter with the [proper] proportion of copper to tin, and no one of the guild shall in secret places [make] vessels of lead or of false alloy to sell out of the city at fairs or markets to the scandal of the City and the damage of the good folk of the guild... and if anyone is found carrying such wares to fairs or markets or anywhere else in England... let them forswear the guild for evermore. (Michaelis, 1955: 2-5)

The group is also assumed to manipulate the market by setting an entry barrier. It guarantees the market clearance and stableness. Because of the potential profit, a large number of agents in the market are willing to enter the business. Those agents constitute an applicant pool. Only being acknowledged by the group brings those agents into the business, otherwise they only receive some reserved social benefit[4] y. Therefore, the group plays two roles simultaneously: as a monopoly in the goods market, and as a monopsony in the labor market.

Assume an individual group member's revenue from sales of merchandize is a function $r_i(\cdot)$, which depends only upon the group's reputation. This differs from the canonic assumption made in classic production theory; the revenue function is not dependent on the quantity of output. The group's reputation is represented in this model by the average quality of the merchandize sold by the group. When average quality improves, the revenue received by each member increases, although the marginal return to quality falls as the level of quality rises, i.e.,

$$r_i = r(q); r'(q) > 0; r''(q) < 0,$$

where

$$q = \frac{1}{N}\sum_{i=1}^{N} q_i \tag{1}$$

is the average quality of all group member's products. Here q_i is the quality of the i^{th} group member's products and $q_i > 0$ for all $i = 1, \ldots, N$. $r(\cdot)$ is the function relating quality to revenue from sale, which is the same for all members of the group.

The cost of producing merchandize, $c_i(\cdot)$, depends on the quality of an individual's own merchandize. Cost increases as quality grows, and the increase occurs at an increasing rate. Thus,

$$c_i = c(q); c'(q) > 0; c''(q) > 0.$$

Here, $c(\cdot)$ is the function relating product quality to the cost of production. All members in the group employ the same technology.

Profits are assumed to be positive when quality is zero, i.e., $r(0) - c(0) > 0$, and assumed to increase when quality increases from zero, i.e., $r'(0) - c'(0) \geq 0$. Therefore, agents prefer a

[4]The amount of profit agents are ensured to gain.

positive amount of quality to zero. Since the group consists of self-interested individuals, the members have an incentive to free ride by producing below-average quality products. The group, therefore, needs a self-governing technique to monitor the quality of its members' products and keep the average quality at a profitable level.

3 Preliminaries

Assume monitoring is both perfect and costless (we will drop the assumption about perfectness in section 5 and thereinafter). For member i, the noncooperative Nash equilibrium outcome is given by

$$(2) \qquad q_1^* \in \max_{q_i} r(\frac{1}{N}\sum_{j=1}^{N} q_j) - c(q_i).$$

The first order condition has the form

$$(3) \qquad \frac{1}{N}r'(\frac{1}{N}\sum_{j=1}^{N} q_j) - c'(q_i) = 0.$$

Since we assume group members are identical, there exits a symmetric Nash equilibrium, i.e., $q_i = q^*$, $i = 1, \cdots, N$. This implies that

$$q^* = \bar{q} \equiv \frac{\sum_{i=1}^{N} q_i}{N}.$$

Or,

$$q^* \in \arg\{\frac{1}{N}r'(q) - c'(q) = 0\}.$$

We call q^* the *noncooperative quality* and the outcome that every agents chooses q^* the *noncooperative outcome.*

Alternatively, the agents can act cooperatively and maximize the group's profit. Agents choose quality

$$(4) \qquad q^{**} \in \arg\max_{q}\{r(q) - c(q)\}.$$

The quality is then characterized by

$$r'(q^{**}) - c'(q^{**}) = 0, \tag{5}$$

or,

$$q^{**} = \arg\{r'(q) - c'(q) = 0\}. \tag{6}$$

We call q^{**} the *cooperative quality* and the outcome that every agents chooses q^{**} the *cooperative outcome*. Comparing q^* and q^{**}, one can easily see that $q^{**} > q^*$.

It is obvious that all group members will be better off if they cooperate with each other. The cooperation, however, can not sustain itself without enforcement because every agent has an incentive to deviate, or take advantage of the others. In a one-shot game, therefore, the cooperative equilibrium outcome cannot be achieved.

Although unsustainable in the one-shot game, the cooperative outcome can be enhanced in the infinitely repeated game. In this game, agents can punish noncooperative behavior and eliminate the incentive to deviate from the the cooperative outcome.

Denote the discount factor of utility as δ with $\delta \in (0, 1)$. Agents' expected utilities are then given by

$$\begin{aligned} EU \quad = \quad & E[U\big(r(q^0) - c(q_i^0)\big) + \delta U\big(r(q^1) - c(q_i^1)\big) + \delta^2 U\big(r(q^2) - c(q_i^2)\big) + \\ & + \delta^3 U\big(r(q^3) - c(q_i^3)\big) + \delta^4 U\big(r(q^4) - c(q_i^4)\big) + \cdots], \end{aligned} \tag{7}$$

where q_i^k is the quality chosen by agent i in period k and $q^k \equiv \frac{1}{N}\sum_{j=1}^{N} q_j^k$ is the average quality of the whole group in that period.

Suppose every agent employs a trigger strategy which exerts certain punishment to the deviator who acts noncooperatively (i.e., choosing q^* in some round). This strategy can sustain the cooperative outcome if the punishment is severe enough. Within the framework presented above, the Folk theorem tells us that as long as the discount factor is great enough, there are infinitely many strategies that could achieve this objective. The difference between those trigger strategies is that some of them require greater discount factors than the others to sustain the cooperative outcome. Additionally, we want to compare two possible strategies (punishments): the Cournot punishment (agents punish the deviator by choosing q^* in the next period) and expulsion (agents punish the deviator by expelling her from the group). The strategies under different punishment schemes are given as follows:

1. - **Cournot punishment:** For each group member i, $i = 1, \cdots N$, her strategy σ_i^{c}[5] is given by:

   (8) $$q_i^t = \begin{cases} q^{**} & \text{if } t = 0 \text{ or } q_j^{t-1} = q^{**}, \forall j \neq i \\ q^* & \text{otherwise} \end{cases} , \forall t = 0, 1, 2, \cdots .$$

2. - **Expulsion** (Ostracism[6]): For each group member i, $i = 1, \cdots N$, her strategy σ_i^{e}[7] is given by:

   (9) $$(q_i^t, v_{ij}^t)' = \begin{cases} (q^{**}, 0)' & \text{if } t = 0 \text{ or } q_j^{t-1} = q^{**}, \forall j \neq i \\ (q^{**}, 1)' & \text{otherwise} \end{cases} , \forall t = 0, 1, 2, \cdots ,$$

   where v_{ij}^t is her vote in the tth round upon the expulsion of agent j. Agent j is expelled in the $k + 1$ round if and only if her votes $\sum_{i \neq j} v_{ij}^t > 0$.

Historical evidence suggests that expulsion is a far more popular measure of punishment than Cournot punishment, especially for the guilds in late-medieval England. Several scholars note this important fact (Thomas 1926: 264; Blair and Ramsay 1991: 73; Cherry 1992: 54). Lujo Brentano, one of the first scholars of English guilds, wrote:

> The Gild never assumed a right over the life and limbs of its members: compensation only and fines were used for punishments, the highest penalty being expulsion. (Brentano 1870: ciii)

[5]The superscript c denotes the case of Cournot punishment.

[6]There is some subtle difference between "expulsion" and "ostracism". However, here we follow Hirshleifer and Rasmusen (1989), neglect the difference and use "expulsion" and "ostracism" interchangeably.

[7]The superscript e denotes the case of expulsion.

Expulsion was the worst possible punishment, because as Brentano noted, guilds lacked the sovereign power of the state. Francis Hibbert, who studied the guilds of Shrewsbury, writes:

> The ordinary penalties which the companies might inflict were of money or of wax. . . and, in extreme cases, total expulsion from the Gild. (Hibbert 1981: 44)

One feasible way to compare two trigger strategies is comparing the critical discount factors that sustain the cooperative outcome. Additionally, we give the following definition.

Definition 1 *Consider two trigger strategies σ_1 and σ_2 in an infinitely repeated game. We call σ_1 is* more efficient *than σ_2 if and only if $\delta_1 < \delta_2$, where δ_i, $i = 1, 2$ is the critical discount factor (the infimum of the discount factors that sustain the cooperative outcome) of σ_i.*

A more efficient trigger strategy implies that the cooperative outcome is more likely to achieved for certain agents. Moreover, we have the following lemma.

Lemma 1 *$\delta_1 < \delta_2$ if $EU_o^1 > EU_o^2$, where U_o^i is the utility that an agent receives in the corresponding one-shot game when she is being punished.*

Proof. It is straightforward to compute the expected utility of agent j when she chooses to deviate. Using the notation introduced above, we have

$$EU^i = U(q_j^*, q_{-j}^{**}) + \frac{\delta_i}{1 - \delta_i} EU_o^i, \tag{10}$$

with $i = 1, 2$. By definition of critical discount factor, agent j is indifferent between choosing cooperation and deviation. Therefore, we have $EU^1 = EU^2$, which implies

$$\frac{\delta_1}{1 - \delta_1} EU_o^1 = \frac{\delta_2}{1 - \delta_2} EU_o^2. \tag{11}$$

Or,

$$\frac{\delta_1 - \delta_1\delta_2}{\delta_2 - \delta_1\delta_2} = \frac{EU_o^2}{EU_o^1}. \tag{12}$$

Because the righthand side of (12) is less than one, we must have $\delta_1 < \delta_2$. ■

If no new agent joins the group, agents who remain in the group gain more from expulsion than from Cournot punishment. This additional gain comes from the fact that q^* is monotonically decreasing on the size of the group. This situation, however, rarely happens in the real world, especially in craft guilds in late-medieval England. A much more common situation, as suggested by historical evidence, is that groups pick new members from the applicants pools after expulsions. The procedure goes as follows. When somebody in the group is found deviating (or behaving noncooperatively), she gets expelled from the group. Meanwhile, new members are picked from the applicants pool. The most common case is that the guild picks the same number of new members that were expelled. And this "metabolism"keeps the guild in a fixed scale.

With the fixed number of memberships, the remainders can no longer gain from expulsion through the channel of shrinking the size of group. Comparing expulsion and Cournot punishment from this aspect thus can not land us upon a clear conclusion. However, we have the following proposition.

Proposition 1 *Expulsion is more efficient than Cournot punishment if* $U_i(q^*) > U_i(y)$.

Proof. It is straightforward by Lemma 1. ■

What is more, as we will show, under fairly weak conditions, expulsion rewards cooperative behaviors with higher utilities than Cournot punishment does in the case of deviation.

Proposition 2 *If the discount factor* δ *is great enough, expulsion gives cooperative agents more utilities than Cournot punishment does in the case of deviation.*

Proof. Assume at some stage at least one member of the group chooses noncooperative quality (behaves noncooperatively), i.e. $\exists i$, such that $q_i = q^*$. Within Cournot punishment scheme, every member of the group chooses q^* in each round thereafter. The discounted utility of member j is given by

$$EU_j^c = U_j[q^*] + \delta U_j[q^*] + \delta^2 U_j[q^*] + \cdots = \frac{U_j[q^*]}{1-\delta}. \tag{13}$$

Within the expulsion scheme, the member that deviated from cooperative equilibrium gets expelled and a new member (indexed i) joins the group. Suppose with probability $P \in (0,1)$ the new member will choose Nash equilibrium, the expected utility of every other group member in the next round is given by

$$EU_{j,1}^e = PU_j(q_i^*, q_{-i}^{**}) + (1-P)U_j(q^{**}), \forall j \neq i.$$

When member i chooses q^* (with probability P), an expulsion happens in the following round. Another new member joins the group. Again, assume she will choose q^* with probability P. The expected utility of every other group member in this round is then given by

$$EU_{j,2}^e = P^2 \delta U_j(q_i^*, q_{-i}^{**}) + (1-P)P\delta U_j(q^{**}), \forall j \neq i.$$

This scenario then repeats itself. When the number of the stage approaches infinity, the discounted expected utility of member $j, \forall j \neq i$ is

$$\begin{aligned} EU_j^e &= \sum_{k=1}^{\infty} EU_{j,k}^e \\ &= \sum_{k=1}^{\infty} [P^k \delta^{k-1} U_j(q_i^*, q_{-i}^{**}) + (1-P)P^{k-1}\delta^{k-1} U_j(q^{**})] \\ &= \frac{PU_j(q_i^*, q_{-i}^{**}) + (1-P)U_j(q^{**})}{1-P\delta}. \end{aligned}$$

Comparing EU_j^c and EU_j^e, it is easy to see $EU_j^e > EU_j^c$ is equivalent to

$$\frac{PU_j(q_i^*, q_{-i}^{**}) + (1-P)U_j(q^{**})}{1-P\delta} > \frac{U_j[q^*]}{1-\delta},$$

or

$$P < \frac{(1-\delta)U_j(q^{**}) - U_j(q^*)}{(1-\delta)U_j(q^{**}) - U_j(q^*) + (1-\delta)[U_j(q^*) - U_j(q_i^*, q_{-i}^{**})]}. \tag{14}$$

Notice that when $\delta \to 1^-$, the right hand side of equation (14) approaches 1, while the left hand side of (14) remains unchanged. The definition of P assures that $P < 1$, which guarantees that (14) always holds when δ converges to 1. Therefore, with a large enough discount factor δ, the discounted expected utility of group member j within the expulsion scheme is always greater than that within Cournot punishment scheme. ■

4 When Insurance is Available

Our previous results are based upon the homogeneous agents assumption. We now extend our findings to the heterogeneous agents case. Additionally, we consider the situation that agents have different altitudes towards risks. It allows us to investigate the effect of risk-sharing plans (insurance). Having risk-sharing plans is another prominent feature of craft guilds in late-medieval England. Evidence from primary sources illuminates the essential facts. Craft guilds insured members against the risks of everyday life such as poverty due to accident, illness, or infirmity in old age; property losses due to acts of man and nature; and the costs and uncertainties of litigation. An example illustrates the contingent nature of guilds' guarantees. In 1388, the ordinances of London's tailors' guild stated that:

> If, God forbid, any one of the gild falls into poverty, and has not the means of support, he shall have, every week during his life, seven pence out of the goods of the gild. When one of the guild dies... four wax lights shall be put round the body until burial, and the usual [religious] services and offerings shall be made... on feast days, a mass shall be said for the souls of those who are dead. If any one dies within the city, without leaving the means for burial, the gild shall find the means, according to the rank of him who is dead... If a brother or sister dies outside the city... the brethren... shall do for his soul what would have been done if he died in his own parish. (Smith 1870 pp.179)

Guilds also supported members when they were involved into litigations. In 1388, the ordinances of Lincoln's masons' guild stated that:

> The guild must stand by a brother... charged with any offense... with consul and help, as if they were all children of the same father and mother. (Westlake, 1919 pp.171-173)

Another example also comes from Toulmin Smith's book, English Gilds. In Berwick-upon-Tweed around the year 1283, a number of occupational guilds merged into a single association. The twelfth clause of their ordinances stated that

> If a brother is charged, on a matter of life and limb, outside the borough, two or three gildman shall help him, at the cost of the gild, for two days: afterwards, it must be at the brother's cost. If the brother has been rightly charged, he shall be dealt with as the Aldermen and Brethren think well. (Smith 1870 pp.341)

A more recent study by Gary Richardson gives a comprehensive servery on the risk-sharing plans provided by guilds in late-medieval England.

> Most craft guilds promised [insurance] support. From the corporate census of 1388, returns of forty craft guilds survive. Twenty-one describe the contingent guarantees provided by the guild in considerable detail. More than two-thirds of those guilds promised help to members "in poverty." About one-quarter promised help to members in need due to "sickness," "blindness," "theft," and other acts of God or man. Approximately ten percent promised help without stating the circumstances. (Richardson, 2004, 9)

4.1 A Lemma

When insurance is under concern, generally things get complicated. The measures of risks are correlated with the first and the second order derivatives of utility functions. Without a properly specified utility function, it is difficult to get us meaningful results. In order to conquer this difficulty, we use a reasonable alternate — the discount factor — to capture agents' different attitudes towards risk.

Suppose the agents are of two types, high risk averse type (less risk tolerant) and low risk averse type (more risk tolerant). They have identical discount factors δ. In order to avoid the complexities the first and second order derivatives of the utility functions, we consider an alternative situation that every agent has the same utility function (hence their risk aversions are identical) but different discount factors, denoted δ_H and δ_L. We claim that agents make identical insurance decisions in this two scenarios. In other words, we can not identify what scenario we are in if we only observe agents' insurance decisions. A formal proof goes as follows.

Lemma 2 *An insurance decision can be justified by the following two different combinations of utility functions and discount factors,*

$$\left\{ \begin{array}{c} \textit{identical utility functions} \\ \textit{different discount factors} \end{array} \right\} \ \textit{and} \ \left\{ \begin{array}{c} \textit{different utility functions} \\ \textit{identical discount factors} \end{array} \right\}.$$

Proof. Suppose a insurance scheme takes two stages[8]. The agents receive an identical payoff E at the beginning of each stage. At the first stage, agent i pays money A_i as her insurance fee. Then in the next stage, with probability P, agent i will suffer a total loss E, and get compensation B_i from the insurance scheme. Otherwise, she gets nothing in the second stage. Assume the insurance scheme is actuarially fair, i.e. $A_i = PB_i$. Denote discount factor as δ_i and utility function as $U_i, U_i' > 0, U_i'' < 0$. The agent i is now facing the optimization problem:

$$\begin{aligned} \max_{A_i} E[U_i] &= \max_{A_i} \{U_i(E - A_i) + \delta_i[PU_i(B_i) + (1-P)U_i(E)]\} \\ &= \max_{A_i} \{U_i(E - A_i) + \delta_i[PU_i(\frac{A_i}{P}) + (1-P)U_i(E)]\}. \end{aligned}$$

[8]The following argument holds when the number of stages is finite. When there are infinitely many stages, the derivation requires only minor changes.

The first order condition gives

$$\delta_i U_i'(\frac{A_i}{P}) - U_i'(E - A_i) = 0. \tag{15}$$

By the Implicit Function Theorem,

$$\frac{dA_i}{d\delta_i} = -\frac{U_i'(\frac{A_i}{P})}{U_i''(E - A_i) + \frac{\delta_i}{P} U_i''(\frac{A_i}{P})}. \tag{16}$$

By the assumptions of the utility function, $U_i' > 0$ and $U_i'' < 0$, we know (16) is greater than zero. This means when agents are facing identical risks, high discount factors induce high insurance payments, and vice versa.

We now show that high risk aversion also leads to a high insurance payment. Imagine two agents i and j that face the same risk and insurance scheme. Keep all else unchanged, notice now that the discount factor $\delta_i = \delta_j = \delta \in (0, 1)$ is regarded as a constant. (15) then gives

$$\frac{U_i'(E - A_i)}{U_i'(\frac{A_i}{p})} = \delta_i = \delta = \delta_j = \frac{U_j'(E - A_j)}{U_j'(\frac{A_j}{P})}. \tag{17}$$

Notice $0 < \delta < 1$, then $0 < \frac{U_i'(E-A_i)}{U_i'(\frac{A_i}{P})} < 1$ and $0 < \frac{U_j'(E-A_j)}{U_j'(\frac{A_j}{P})} < 1$. Because U_i' and U_j' are strictly decreasing, we have

$$E - A_j > \frac{A_j}{P} \tag{18}$$

$$E - A_i > \frac{A_i}{P}. \tag{19}$$

Denote the *Arrow-Pratt measure of absolute risk aversion* as $\rho \equiv -\frac{U''}{U'}$. Suppose agent i is less risk averse than agent j. Additionally, we have the relationship $\rho_i < \rho_j$. Pratt's Theorem tells us that $U_j = G(U_i)$ for some increasing strictly concave function G. (17) then becomes

$$\frac{U_i'(E - A_i)}{U_i'(\frac{A_i}{P})} = \frac{G'\big(U_i(E - A_j)\big)U_i'(E - A_j)}{G'\big(U_i(\frac{A_j}{P})\big)U_i'(\frac{A_j}{P})} \tag{20}$$

Suppose some pair (A_i, A_j) such that $A_i \geq A_j$ satisfies (20). Easy to see $E - A_i \leq E - A_j$ and $\frac{A_i}{P} \geq \frac{A_j}{P}$. Because U_i' is strictly decreasing, we have $U_i'(E - A_i) \geq U_i'(E - A_j)$ and $U_i'(\frac{A_i}{P}) \leq U_i'(\frac{A_j}{P})$. Therefore, the following inequality holds.

$$\frac{U_i'(E - A_i)}{U_i'(\frac{A_i}{P})} \geq \frac{U_i'(E - A_j)}{U_i'(\frac{A_j}{P})}.$$

(20) then implies

$$\frac{G'\big(U_i(E - A_j)\big)}{G'\big(U_i(\frac{A_j}{P})\big)} \geq 1. \tag{21}$$

Since G is strictly concave, G' is strictly decreasing. So (21) gives $U_i(E - A_j) \leq U_i(\frac{A_j}{P})$. Notice $U_i' > 0$, we then have $E - A_j \leq \frac{A_j}{P}$, which contradicts (18). We can thus conclude that our assumption about the existence of the pair (A_i, A_j) such that $A_i \geq A_j$ is false and therefore $A_i < A_j$ always holds. Therefore high risk aversion leads to a high insurance payment.

Combining these two results together completes the proof. ■

Lemma 2 guarantees that the discount factor is a reasonable alternate of risk aversion. Therefore, we can discriminate agents by their discount factors to investigate the dynamics among themselves.

4.2 Expulsion and Insurance

For group member i, comparing her utilities of staying in the group and living on reserved benefit gives three possible outcomes:

1. $U_i(q^*) > U_i(y)$;
2. $U_i(q^{**}) \geq U_i(y) \geq U_i(q^*)$;
3. $U_i(y) > U_i(q^{**})$.

The first scenario has already been discussed in the previous section. One should notice that there exists a pooling equilibrium under expulsion scheme — both high-risk and low-risk group members prefer cooperation to deviation.

Rational Individual constraint does not allow the third inequality happen. If reserved benefit offers agents more utility than the maximum profit they can earn from the group, nobody has an incentive to join the group. In fact, this case provides a upper bound of the scale of the group. It is easy to see that when the number of group members approaches infinity, even the cooperative equilibrium dies out. Given that the reserved benefit is positive, at some point nobody wants to join the group. That moment gives the upper bound of the group size. As most historical documents suggest,however, craft groups were prosperous in late medieval England. Therefore, we can rule out this case.

The second scenario is of more interest. In this scenario, the previous argument does not hold. But Proposition 2 tells us the expulsion scheme is still better than Cournot punishment for those group members whose discount factors are great enough. At the same time, Lemma 2 says agents whose discount factors are greater can be regarded as having more risk averse utility functions. So now, there exists a separative equilibrium — high-risk group members choose deviation and low-risk members choose cooperation. The expulsion scheme provides a screening mechanism, which provides another interpretation that expulsion is superior to Cournot punishment.

Proposition 3 *Expulsion provides a screening mechanism when* $U_i(q^{**}) \geq U_i(y) \geq U_i(q^*)$.

Proof. Following the logic in Proposition 1, within the expulsion scheme, group member i is more likely to choose deviate. When a group member is detected deviating, her discount factor should be small, which implies that she is less risk averse by Lemma 2. Expelling her can protect other group members from being taken advantage of by group member i in the sense that other agents are paying more insurance fees to cover agent i's additional risk, which helps the insurance scheme work better. ■

A group distinguishes itself from society by offering its members a higher profit. This profit might come from some monopolistic power (e.g. its brand or trademark). Only members may enjoy this profit, while other agents live on the average social benefit level y. To keep this monopolistic power, the group fixes its scale by limiting its membership. Because of this potential profit, many agents would apply to become a member of the group. The agents are of two types: high-risk and low-risk. Although both types of agents have the same utility function, their discount factors are different. Lemma 2 tells us that $\delta_H < \delta_L$. The high-risk agents have a lower discount factor than low-risk agents. Suppose the probability of a agent being high-risk is $P \in (0, 1)$.

Within the group, an insurance scheme is provided. With probability a a group member will be struck by a disaster. When disaster strikes, the group member suffers a loss b. But she can secure a future income by paying a certain amount of money d as an insurance fee[9]. Assume the insurance scheme is actuarially fair, i.e. $a\delta b = d$, where δ is the average discount factor of all group members.

The following proposition shows that an insurance scheme gives group members a higher utility, which makes the cooperative outcome more likely to be obtained.

Proposition 4 *The insurance scheme gives group members higher utilities when* $U_i(q^{**}) \geq U_i(y) \geq U_i(q^*)$[10].

Proof. Since the game is played identically infinite times, we need only to compare the discounted expected utility of two sequential stages. Proposition 3 guarantees that all group members are the low-risk type, whose discount factors are δ_L. Therefore the average discount factor of all group members is equal to every group members' discount factor, i.e. $\delta = \delta_i = \delta_L$.

[9]The insurance provider covers her loss b when disaster happens.

[10]When $U_i(q^*) \geq U_i(y)$, the insurance may not make both the low-risk and the high-risk agents better off because of potential adverse selection problem.

Consider the case when no insurance is provided. Agent i earns $U_i(q)$ at the first stage. At the second stage, disaster strikes agent i with probability a. When disaster happens, agent i bears loss b. His discounted expected utility is given by[11]

$$EU_i^N = U_i[r(q) - c(q)] + \delta\{aU_i[r(q) - c(q) - b] + (1 - a)U_i[r(q) - c(q)]\}.$$

On the other hand, when a fair insurance scheme is provided, agent i pays insurance fee $a\delta b$ at the first stage to assure her utility being fixed at $U_i[r(q) - c(q)]$, (i.e. when disaster strikes, she gets a compensation b from the insurance provider). His discounted expected utility has the form[12]

$$EU_i^I = U_i[r(q) - c(q) - a\delta b] + \delta U_i[r(q) - c(q)].$$

Comparing EU_i^N and EU_i^I gives us the answer where the insurance scheme might benefit the group members. Notice that $U_i'' < 0$, we have

$$\begin{aligned} EU_i^I - EU_i^N &= U_i[r(q) - c(q) - a\delta b] + \delta U_i[r(q) - c(q)] - U_i[r(q) - c(q)] - \\ &\quad - \delta\{aU_i[r(q) - c(q) - b] + (1 - a)U_i[r(q) - c(q)]\} \\ &= U_i[r(q) - c(q) - a\delta b] - U_i[r(q) - c(q)] + \\ &\quad + a\delta\{U_i[r(q) - c(q)] - U_i[r(q) - c(q) - b]\} \\ &= U_i[r(q) - c(q) - a\delta b] - \{(1 - a\delta)U_i[r(q) - c(q)] + \\ &\quad + a\delta U_i[r(q) - c(q) - b]\} \\ &> 0 \end{aligned}$$

The last inequality comes from Jensen's Inequality. It tells us that when $U_i(q^{**}) \geq U_i(y) \geq U_i(q^*)$, the screening function of the expulsion mechanism helps the insurance scheme to provide a higher utility. Therefore, insuring members against the risks of everyday life helps business groups overcome free rider problems to achieve high product quality from its

[11]The superscript "N"denotes the case when no insurance scheme is provided.
[12]The superscript "I"denotes the case when an insurance scheme is provided.

members. Groups that insure their members can create better reputations, all else being equal, because their members have more to lose, and thus, are more intimidated by the threat of expulsion. ■

Another interesting result can be obtained from this finding. Historical evidence shows, a great social regime shift, such as the Black Death in late medieval Europe, could exert big influence upon the craft guilds. Additionally, taking quality as a metric, historians find that the average quality of groups' products were at a low level before the Black Death, and became high quality thereafter (Richardson, 2005b). We will show that this feature can be justified by our model.

Proposition 5 *When y decreases from $U_i(q^{**}) \geq U_i(y) \geq U_i(q^*)$ to $U_i(q^*) > U_i(y)$, the average product quality q increases, i.e., aggravations of the social environment improve the average quality of group's products.*

Proof. If we take y as a proxy of social regime, as we have shown in Proposition 3, as long as $U_i(q^{**}) \geq U_i(y) \geq U_i(q^*)$, the expulsion mechanism provides a screening function which helps the group to discriminate high-risk agents from low-risk ones. This allows the insurance scheme offered by the group to provide a higher utility level to its members. As long as the condition $U_i(q^{**}) \geq U_i(y) \geq U_i(q^*)$ holds, the insurance fee can be guaranteed to be fair to the group members because they are homogenous. Additionally, the insurance fee is a constant in this case because that: (1) the risk every group member faces remains the same; and (2) the discount factor of every group member does not change. Any members that remain in the group will all behave cooperatively by choosing quality level q^{**}. However, because expulsion might happen, the average quality of the group's product is affected. When an expulsion takes place[13], the group picks a new member randomly from the appli-

[13] Readers may doubt the existence of expulsion. It is true that within our previous settings, expulsions can never happen if all its members are of low-risk type. But a tiny amendment can fix this problem. By incorporating a constant mortality rate β, group members may pass away randomly, which provides the group opportunities to accommodate new members. The mortality rate serves the same function as the

cant pool. As we have assumed, the new member may be of high-risk type with probability P. Once a high-risk agent joins the group, the condition $U_i(q^{**}) \geq U_i(y) \geq U_i(q^*)$ induces her to choose the Cournot equilibrium outcome. Given other group members choosing q^{**}, the new member, denoted i, now faces the optimization problem as follows:

$$q_i^* \in \arg\max_q \{r(q) - c(q_i) - d\}, \tag{22}$$

where $q = \frac{1}{n}\sum_{j=1}^n q_j = \frac{1}{n}[(n-1)q^{**} + q_i]$.

The first order condition of this case is given by

$$\frac{1}{n} r'(\frac{n-1}{n} q^{**} + \frac{1}{n} q_i^*) - c'(q_i^*) = 0. \tag{23}$$

Comparing equation (3), (6), and (23), we have

$$q^{**} > q_i^* > q^*. \tag{24}$$

The first inequality is obvious. The second inequality needs some explanation. Assume $q_i^* < q^*$. Because $c'' > 0$, c' is strictly increasing. Then we have $c'(q_i^*) < c'(q^*)$. Equation (3) and (23) give $\frac{1}{n} r'(\frac{n-1}{n} q^{**} + \frac{1}{n} q_i^*) < \frac{1}{n} r'(q^*)$, or $r'(\frac{n-1}{n} q^{**} + \frac{1}{n} q_i^*) < r'(q^*)$. Since $r'' < 0$, r' is strictly decreasing. We have $\frac{n-1}{n} q^{**} + \frac{1}{n} q_i^* > q^*$. At the same time, we have $q^{**} > q_i^*$, then

$$\frac{n-1}{n} q^{**} + \frac{1}{n} q_i^* > \frac{n-1}{n} q_i^* + \frac{1}{n} q_i^* = q_i^* > q^*,$$

which contradicts to our assumption $q_i^* < q^*$. Therefore, (24) holds.

When a high-risk agent joins the group, we know that the average quality is given by $q_H = \frac{1}{n}\sum_{j=1}^n q_j = \frac{1}{n}[(n-1)q^{**} + q_i^*] < q^{**}$. But when the new member is of low-risk type, the average quality is $q_L = \frac{1}{n}\sum_{j=1}^n q_j = \frac{1}{n}\sum_{j=1}^n q^{**} = q^{**}$. Therefore, the expected (average) average quality of the group's product is

$$q_b = Pq_H + (1-P)q_L = \frac{P}{n}[(n-1)q^{**} + q_i^*] + (1-P)q^{**} < q^{**}\text{[14]}. \tag{25}$$

discount factor. In fact, we can accommodate it into our model without losing any of the results we have derived so far.

[14]The subscript b denotes before the social regime shift.

When a great social regime shift such as the Black Death occurs, the decrease in y is so dramatic that $U_i(q^{**}) \geq U_i(y) \geq U_i(q^*)$ no longer holds. The condition becomes $U_i(y) < U_i(q^*)$. Proposition 1 tells us that expulsion can no longer exert the screening function. Both types of agents, high-risk and low-risk, would like to behave cooperatively by choosing some q^{**}. Since different types of members have different discount factors, the insurance scheme cannot remain to be actuarially fair, although it may be fair on average. The following derivation shows this fact.

For agent i, the insurance scheme is actuarially fair if and only if $a\delta_i b = d$ holds. Because the risk $\{a, b\}$ is unchanged, higher discount factor δ_i will lead group member i paying a higher insurance fee. But right now the group can not observe which type its members are, it has to implement an average insurance fee among the members. Suppose the insurance scheme is on average fair, i.e. $a\delta b = d$, where δ is the average discount factor. One may notice $\delta_L > \delta > \delta_H$. Therefore, low-risk members pay less than they should while high-risk members pay more.

Notice now that the average quality $q_a = \frac{1}{n}\sum_{i=1}^{n} q_i = \frac{1}{n}\sum_{i=1}^{n} q^{**} = q^{**}$[15]. Our previous analysis (25) tells $q_b < q_a$. This completes the proof. ■

5 When Monitoring is Imperfect

In this section, we drop the assumption that monitoring is perfect, although it is still assumed to be costless. We call the monitoring is *imperfect* if there exists some (p_1, p_2) with $0 < p_i < 1$ for $i = 1, 2$, such that

1. with probability p_1, a group member who deviates from the cooperative quality will be caught and expelled; and

2. with probability p_2, a group member who sticks to the cooperative quality will be falsely accused and expelled.

[15] The subscript a denotes after the social regime shift.

Consider the infinitely repeated game. Assume there exists some strictly mixed equilibrium, meaning that for group member i, a strictly mixed strategy maximizes her expected discount utility. Consider the strictly mixed strategy that she plays q_i^1 [16] with probability $1 > g_i > 0$, and chooses some q_i^2 [17] with probability $1 > 1 - g_i > 0$. We suppose q_i^2 is determined by the group, so it is exogenous for group member i. In fact, q_i^2 serves as a yardstick for the group to determine whether group members are deviating. Our previous derivation assures that $q_i^2 \in [q^{**}, q_i^1)$. The decision-making process for agent i can be regarded as follows: she first flips a coin which gives two exclusive outcomes with probability g_i and $1 - g_i$ respectively; after agent i observes the outcome of the flipping, she chooses corresponding quality q_i^1 or q_i^2. Because this strictly mixed strategy is optimal for agent i, it must maximize her expected discount utility. If group member i chooses q_i^2, she survives in the group in the next round with probability $1 - p_2$; if she chooses q_i^1, in the next round she may be caught and expelled with probability p_1, otherwise she survives. If an expulsion happens, the expellee lives on the reserved benefit y thereafter. Therefore, agent i's expected discount utility is given by[18]:

$$\begin{aligned} EU_i &= g_i[U_i(q_i^1, q_{-i}) + p_1\delta_i U_i(y) + (1-p_1)\delta_i EU_i] + \\ &\quad + (1-g_i)[U_i(q_i^2, q_{-i}) + p_2\delta_i U_i(y) + (1-p_2)\delta_i EU_i]. \end{aligned} \tag{26}$$

By collecting like terms, we can simplify equation (26) as

$$\begin{aligned} EU_i &= \frac{1}{1-\delta_i + p_2\delta_i + g_i\delta_i(p_1 - p_2)}\{g_i[U_i(q_i^1, q_{-i}) + p_1\delta_i U_i(y)] + \\ &\quad + (1-g_i)[U_i(q_i^2, q_{-i}) + p_2\delta_i U_i(y)\}. \end{aligned} \tag{27}$$

Notice that because all group members are identical, the game is symmetric. And the existence of the Nash equilibrium requires that all group members should flip the same coin, i.e. $g_i = g_j$, for $\forall i, j \in \{1, 2, \cdots, n\}$. Therefore, we can drop all of the i subscripts.

[16] Regard q_i^1 as some noncooperative quality in the imperfect scenario. q_i^1 may differ from q^*.
[17] Regard q_i^2 as a cooperative quality in the imperfect scenario, q_i^2 may differ from q^{**}.
[18] Here we assume EU_i is finite.

We first prove that if q_i^1 is also exogenously determined[19], almost surely that no strictly mixed strategy survives within the expulsion regime, as declared in the following proposition.

Proposition 6 *When neither cheating nor cooperation can be monitored perfectly, no strictly mixed strategy survives in the expulsion regime if both* q_i^1 *and* q_i^2 *are exogenously determined.*

Proof. When group members are identical and both q^1 and q^2 are exogenous, then within the expulsion regime, agent i will choose the optimal g to maximize her expected discount utility (27). Or

$$\begin{aligned} g &\in \arg\max_g EU_i \\ &= \arg\max_g \{\frac{1}{1-\delta_i+p_2\delta_i+g\delta_i(p_1-p_2)}\{g[U_i(q_i^1,q_{-i})+p_1\delta_i U_i(y)]+ \\ &\quad +(1-g)[U_i(q_i^2,q_{-i})+p_2\delta_i U_i(y)\}\}. \end{aligned}$$

The first order condition is given by

$$\frac{1-\delta+p_2\delta}{\delta}[\frac{U(q_i^1,q_{-i})-U(q_i^2,q_{-i})}{p_1-p_2}+\delta U(y)]=[U(q_i^2,q_{-i})+p_2\delta U(y)]. \tag{28}$$

It has nothing to do with g. Therefore $g=0$ or 1, which means no mixed strategy equilibrium exists. In fact, when $p_1=p_2=p>0$, we have

$$(1-\delta+p\delta)[U(q_i^1,q_{-i})-U(q_i^2,q_{-i})]=0. \tag{29}$$

Because $\delta<1$, $1-\delta+p\delta>0$. It implies that $U(q_i^1,q_{-i})=U(q_i^2,q_{-i})$ or $q_i^1=q_i^2$, which contradicts to the assumption $q_i^1<q_i^2$. ■

Now let us turn to Cournot punishment regime. In Cournot punishment regime, the group does not need to monitor every group members' choice, but only average quality $q=\frac{1}{n}\sum_j q_j$. Once the group detects that $q<q^2$, the punishment begins. However, the monitoring is imperfect, which means that when $q<q^2$, the group may not detect it

[19] For instance, it may be due to some technology constraint.

with probability $1 - p_1$, whereas when $q = q^2$, the group may falsely detect cheating and implements punishment with probability p_2.

Analogous to Proposition 6, we have a similar result for Cournot punishment if both q^1 and q^2 are exogenously given.

Proposition 7 *When neither cheating nor cooperation can be monitored perfectly, no strictly mixed strategy survives in Cournot punishment regime if both q_i^1 and q_i^2 are exogenously determined.*

Proof. Within Cournot punishment regime, when the average quality of group's product is caught to be less than q^2, all other members will exercise Cournot quality q^* forever. Suppose such a strictly mixed symmetric equilibrium exists. And suppose group member i's expected discount utility is finite. By the recursive algorithm, group member i's expected discount utility is given by

$$\begin{aligned} EU_i &= g[U_i(q_i^1, q_{-i}) + p_1\delta_i U_i(q^*) + (1-p_1)\delta_i EU_i] + \\ &\quad + (1-g)[U_i(q_i^2, q_{-i}) + p_2\delta_i U_i(p^*) + (1-P_2)\delta_i EU_i]. \end{aligned} \tag{30}$$

By collecting like terms, we can simplify equation (30) as

$$\begin{aligned} EU_i &= \frac{1}{1-\delta_i + p_2\delta_i + g\delta_i(p_1 - p_2)}\{g[U_i(q_i^1, q_{-i}) + p_1\delta_i U_i(q^*)] + \\ &\quad + (1-g)[U_i(q_i^2, q_{-i}) + p_2\delta_i U_i(q^*)\}, \end{aligned} \tag{31}$$

which is identical to equation (27) except the term $U_i(q^*)$ in (31) takes the place of $U_i(y)$ in (27). The first order condition is given by

$$\frac{1-\delta+p_2\delta}{\delta}[\frac{U(q_i^1, q_{-i}) - U(q_i^2, q_{-i})}{p_1 - p_2} + \delta U(q^*)] = [U(q_i^2, q_{-i}) + p_2\delta U(q^*)], \tag{32}$$

which is again independent of g. Therefore, $g = 0$ or 1, which means no mixed strategy equilibrium exists. In fact, when $p_1 = p_2 = p > 0$, we again have equation (29). It implies $q_i^1 = q_i^2$, which contradicts to the assumption $q_i^1 < q_i^2$. Therefore, with measure one, there is no strictly mixed strategy can survive within the imperfect monitoring Cournot punishment regime if q^1 and q^2 are both exogenously determined. ■

Propositions 6 and 7 tell us that no strictly mixed strategy can survive within both the expulsion regime and Cournot punishment regime if q^1 and q^2 are both exogenously determined. As we have pointed out, q^2 should be solely determined by the group, which is exogenous to every group member. Therefore, the endogeneity of q^1 is a necessary condition for the existence of the strictly mixed strategy within both regimes. It is, however, not sufficient for the existence of the strictly mixed strategy, which is given by the following proposition.

Proposition 8 *No strictly mixed equilibrium exists if the monitoring is imperfect.*

Proof. Suppose there exists a strictly mixed strategy for agent i. Because the game is symmetric, there must exist a strictly mixed symmetric equilibrium. Notice now agent i can predict the average quality of other group members as $gq^1 + (1-g)q^2$, we have

$$q_i^1 \in \arg\max_q \{r\big(\frac{(n-1)gq + (n-1)(1-g)q^2 + q}{n}\big) - c(q)\}. \tag{33}$$

Notice here we are considering the one-shot game, given other group members strategies. In other words, we want to find out what is the optimal quality agent i would like to choose to maximize her one-shot game utility. It differs from the strictly mixed strategy we discussed previously because the strictly mixed strategy is optimal in the infinitely repeated game. This maximization algorithm is reasonable because it tells us that in an infinitely repeated game, given that every agent plays an identical strategy, when agent i flips a coin which tells her to deviate in this round, the optimal quality she should choose.

The first order condition is given by[20]

$$\frac{1}{n}r'\big(\frac{[(n-1)g+1]q^1 + (n-1)(1-g)q^2}{n}\big) - c'(q_i^1) = 0. \tag{34}$$

[20]We don't need to consider the K-T condition because we have assumed that the maximum is achieved on an interior point.

From the Implicit Function Theorem, we have

$$\frac{dq^1}{dg} = -\frac{\frac{1}{n}\left[\frac{(n-1)(q^1-q^2)}{n}\right]r''\left(\frac{[(n-1)g+1]q^1+(n-1)(1-g)q^2}{n}\right)}{\frac{(n-1)g+1}{n^2}r''\left(\frac{[(n-1)g+1]q^1+(n-1)(1-g)q^2}{n}\right) - c''(q^1)} > 0. \tag{35}$$

The last inequality comes from the fact that $q^1 < q^2$, $r'' < 0$, and $c'' > 0$. Therefore, we deduce that with probability g increasing, the noncooperative quality q^1 increases. However, notice that a group member chooses q^1 when $g = 1$ and chooses q^2 when $g = 0$, it is straightforward that $q^1 > q^2$. This contradicts our previous assumption that $q^1 < q^2$. This result means that our assumption that there exists a strictly mixed equilibrium is false. ■

According to Proposition 8, we can assert that no matter what punishment regime is examined, it is almost sure that no strictly mixed equilibrium exists. In other words, Proposition 8 tells us that even in imperfect monitoring case, group members will always choose pure strategies, i.e. $g_i = g = 0$ or 1, and $q_i^1 = q^{***}$. Combining with the assumption all group members are identical, it implies that by the group setting a cooperative quality q^2, either all or no group member will behave noncooperatively.

If the group sets cooperative quality as the average quality of all group's products, we have $q^2 = \frac{1}{n}q_i^1 = q^{***}$, which means no group member will deviate from this equilibrium. Therefore, no expulsion will happen. The same result holds when the group sets some cooperative quality $q^2 \leq q^{***}$. If the group increases the cooperative quality standard to some $q^2 > q^{***}$, group members will compare the expected discount utility of staying at q^2 and choosing q^{***}. It is determined by the functional forms of utility and the reserved benefit y.

Additionally, if the monitoring technologies are identical in both expulsion and Cournot punishment regimes, because all group members will play a pure strategy, the payoff structure given in section 3 will not change, which means Proposition 2 holds in the imperfect monitoring case.

6 Conclusion

The above analysis provides a theoretical foundation of how a group should carry out its self-governance. Two measures are necessary for a self-governing group: (1)an expulsion mechanism, a mechanism which allows the group to easily maintain a cooperative equilibrium. Or, it makes the cooperative outcome more robust; and (2)a risk-sharing plan, which serves as both a screening mechanism and a utility-improving measure. It also presents a justification for why these two measures prospered in craft guilds in late medieval England. In fact, both expulsion and insurance assure that every member remains in the group, who always behaves cooperatively, is more risk averse (low-risk type). Unlike the social groups which also provide insurance schemes only attract less risk averse (high-risk type) agents, the business groups' insurance schemes provide protection to low-risk type agents. This feature explains why the insurance fees within the groups were less by far than those within social groups.

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