A Game Theory Approach on Managerial Teams: Career Concerns and Informativeness Revisited

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submitted 2001; preliminary draft

JEL classification: D73, L22, D82, D83

Keywords: Moral Hazard, Adverse Selection, learning.

[1] This thesis was motivated by a PhD reading course on dynamic modelling that I took with Prof. Greg LeBlanc. I thank Prof. LeBlanc for his comments, critics and discussions for many versions of this paper, however, all remaining errors are mine.

Abstract

In this essay, we show that in an Alchian-Demsetz firm, even in a finite period game setting, cooperative effort level amongst team members can be achieved when the output depends not only agents' effort but also their ability and that may explain why teams merit to sustain.

Résumé

Dans cet essai, nous montrons cela dans une entreprise Alchian-Demsetz, même dans un cadre du jeu de la période fini, le niveau de l'effort coopératif parmi équipiers peut être accompli quand la production dépend l'effort d'agents pas seul mais aussi leur capacité et cela peut expliquer pourquoi mérite des équipes soutenir.

\The team concept is a nice idea, but when you put the teams under pressure, it becomes a damn e®ective way to divide workers."

| | | a dissident union leader in the NUMMI[2] plant

1 Introduction

The study of teams can be traced back in Alchian and Demsetz (1972), where in order to eliminate or minimize free-riding, monitoring is essential and this role is performed by a monitor who turns to a residual claimer. Alchian and Demsetz (1972) show how team production results in organizations commonly called as the \classic ¯rm". The point they emphasize is that in team production, the jobs done by workers are not perfectly separable. It is hence not feasible to compensate workers based on their marginal contributions. The workers therefore have an incentive to shirk, to free-ride on other team members' e®ort. The well known reason is that the cost of shirking is born by the entire team. The result is that market contracting with individuals is not possible, rather, this free-riding problem is overcome only by the \classic ¯rm" in which worker are paid by wage and a principal supervises or monitors the workers. It is then optimal to let the principal be the residual claimant. By this arrangement,

[2]New United Motor Manufacturing, Inc. (NUMMI), the Toyota-GM joint venture in California is a big success in automobile assembly industry where the success is attributed to teams, and indeed, there is some evidence that the entire plant functions as one team where monitoring is very much done by peers or coworkers.

the incentive compatibility of the residual claimant is satis¯ed and team members' free-riding is attenuated as the monitor is assigned with the authority to dismiss any slackers. They are right by awaring the free-riding but it seems subjective to conclude that monitoring the agents by the principal is the only remedy.

Holmstrom (1982) o®ers alternative reasons for a residual claimant to be exist to prevent the team from falling apart by free-riding, is that it is the credible group penalty that induces e±cient e®ort level but not the monitoring per se. Holmstrom shows that collective punishments and rewards may provide the necessary incentives for workers to exert the desired level of e®ort without the need of a monitor. The feature is that the penalties or rewards required to ensure e±cient production are not budget-balancing. Thus the role of the principal of a ¯rm or the owner of it is to break the budget-balancing constraint rather than monitoring. The conclusion is that the capitalistic ¯rms in which the owners do not provide labor services have advantages over proprietorship because of the owners' ability to ¯nance budget-breaking schemes. It o®ers a deeper understanding on the di®erence between a team and a commune. Moreover, it explains why the residual claimant generally does not involve in supervision while the supervisor who ful¯lls the monitoring role is commonly salaried. Rasmusen (1987), McAfee and McMillan (1991) follow this approach. However, the organizational design suggestions and pay structure recommendations are sometimes very weird and rarely used. For instance, scapegoat penalty in Rasmusen (1987) or large lump-sum upfront commitment fee payment in McAfee and McMillan (1991) were almost never seen in practice[3].

In neither of these approaches, mutual monitoring among the agents was addressed and discussed. In performance comparison literature[4], mutual monitoring is considered but the mechanism proposed to correct incentives in teams is to make each team member's pay not only depend on his own output but also on his peer's output if they are correlated. This is suspicious for two reasons, ¯rst, the individual contribution in a managerial team cannot usually be distinguished from an outsider if she does not involve in the production process; second, teams emphasize cooperation and synchronization instead of harsh competition, at least it appears to be. Indeed, Proposition 1 of Meyer and Vickers (1997) shows a su±cient and necessary condition for the relative performance evaluation to be e±cient. Meyer and Vickers also noticed that a ratchet e®ect, which may arise, would cause further welfare loss, stated in Proposition 3. Moreover, because of the lack of strategic interactions between the agents, relative performance evaluation could not be a good cure. In pro-tournament models, tournaments cause collusion and hence not coalition proof.

Amihai, Glazer and B. Segendor® (2001) considers reputational e®ect in teams and

[3] The main reason here that we understood is that the credit market is highly rationed so that despite an individual's risk attitude, persons who do not pose entrepreneurship can not acquire capital to ¯nance himself upfront.

[4] See Meyer, Margeret (1994), Meyer, Margeret and J. Vickers (1997) for details.

they conclude that if the production must be carried out by a two person team, it is better to have a low ability partner if one cares about his reputation. Their model is simple and illustrative but self-formed partnerships only take a small proportion of the whole lot of the firms. In most cases, the managerial team is not self-selected, instead appointed by the Board of Directors and the agents are obligated to work together as a corporate norm.

The technical setup of Breton, Michele, P. St-Amour and D. Vencatachellum (2001) is mostly related to ours. In Breton et al (2001), the wages of the agents are directly reputation-based in a dynamic stochastic framework. Three organizational forms, compulsory individual performance evaluation, compulsory teams, and elective teams are studied. Also the authors differentiate common shocks and idiosyncratic shocks in production. Welfare analysis is also presented. In some sense, Breton et al (2001) is comprehensive, especially when teams are formed endogenously and inter-generational grouping is available given de facto reputation for each candidate is common knowledge. For instance, in academic research in a university, no scheme is levied either to foster or impair team formation. However, in Breton et al (2001), all agents are risk neutral and the compensation is a random binary variable. These assumptions make the model different from the facts documented or commonly seen and we argue risk aversion is important because team provides insurance effect against correlated shocks although our model is not solely based on risk aversion.

Relationship between managers or workers, in real world, appear much cooperative than portrayed by the existing theory on incentives, emphasizing competition among the agents or candidates. Whether this cooperative behaviours are induced or instructed by the contract provided by the principal or inherited from noncooperative, competing nature of the parallel positions, the answer is embedded in our model with moral hazard on top of adverse selection.

Secondly, much of the existing literature on incentives models the principal-agent relationship in a static setting, neglecting the repeated nature of most employment relationships, procurement and partnership. The relationship either between the owner of the business and the manager of it, or, the colleagues themselves, are long term and repeated rather than one-shot.

Furthermore, adverse selection and moral hazard are rarely considered together, in fact, a ¯rm's output is a function of management's abilities and e®ort exerted, not one of those alone. Therefore, both hidden information and hidden actions taken by the managers as well as the interaction between the two will a®ect the aggregate output.

Finally, in an optimal incentive scheme, not only are there explicit incentives, but also numerous types of implicit incentives as well. Therefore an insensitive compensation scheme is not as ine±cient as one perceives. The low powered pay scheme and a simple multiagent ¯rm may have the virtues to approximate ¯rst best outcome with implicit incentives. Careless policy suggestions that neglect this fact would very possibly undermine the optimal or suboptimal incentive already provided in the scheme.

This essay addresses the above four issues ensemble by focusing the mutual observability between peers and the repeated nature of working relationships in ¯rms. These four elements: A. implicit side-contract behind the cooperative outlook of a team; B. repeated environment; C. combination of hidden action and hidden information; D. the advantage of passivity of the principal, combined together, enable us to explain how cooperative behaviors among agents can be sustained by a self-enforcing mechanism. Our model is consistent with many stylized features of the team-oriented pro¯t organizations observed. We consider this is largely due to the combined assumptions we imposed. We will ¯nd that reputational or career concerns play a major role in the implementation of optimal compensation scheme.

To this end, we consider a two period model of managerial teams where only the total output is observable to the principal but individual output for each period is known to the team members by the end of the period. This information structure essentially captures the nature of mutual monitoring and mutual observability in a small size team. Output is additive and is aggregate of e®ort, ability and random shocks. The team members have the option to quit and work on their own at the beginning of the second period if the information provided through output level indicates the her colleague shirked and/or is low ability type.

Unlike the usual two period model in which the subgame perfect Nash equilibrium outcome yields an inefficient output level in the second period and free riding in the first period, the latter will not occur in our model because learning of the agents' ability and quitting as a credible threat makes first period Pareto output level possible and prevent teams from collapse because of free riding, and hence also makes teaming more attractive than separated because teaming provides more insurance effect relative to individual case[5].

We invoke the career concern model framework[6], but our model differs from others in the sense that career concerns here are for peers reciprocally, not for the principal who does not participate in the production but is just a residual claimant.

Our findings are summarized as follows.

First, we find group output based compensation scheme could approximate first best in earlier period. We eliminate technological synergy[7] between the teammates in

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[5] The insurance effect by teaming is not so novel as aggregation also provides insurance effect. Think for an extreme case, when an insurance company insures all the individuals in a sufficiently large economy, it will face no risk.

[6] Bengt Holmstrom (1999), Dewatripont et al (1999), Gibbons and Murphy (1992) etc.

[7] For instance, Suppose a job is to lift up a heavy rock which weights 250lbs with irregular shape, one man cannot do it whatsoever effort he exerts, but with one extra man, this job can be easily done, therefore the marginal output for the second man is infinity in this extreme case. For heavier rock, the entrepreneur can consider hiring the third man, or 4th and so on. We do not want mix this

teams to isolate the incentive in career concerns and make the problem nontrivial. By treating teams just as aggregations of individual production, we are hoping to provide other robust reasons for teams to survive, such as insurance e®ect. Many researchers realized that in a repeated setting, a competitive scheme, such as tournament, will not be optimal as coalition even without side-payment will arise. In our case, since individual output can not be observed, tournament is naturally ruled out, but similar schemes, such as a penalty introduced when output falls below some critical level, will not be optimal either[8]. Indeed, a moderate, passive scheme in which strategic collusion between agents will not be bene¯cial and hence muted, will do good. More importantly, joint performance evaluation in a repeated environment creates not only

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with organizational advantages together, therefore, we simply assume linear aggragate production technology. Same thing happens in a software development team for example, where having peers will make locating a bug in a subroutine much faster than if not. This is the common wisdom why a team outperforms a decentralized enterprise in practice. We, on the other hand, eliminate this fact by assuming additive production technology in order to make the problem non-trivial. Therefore, in our case, the worker can upload the stu® alone by costlessly cut or repack the stu® and with half productivity of a team's in terms of loading. In the latter case, the team will save the mean debugging time just by half with one additional team member. In NUMMI, a team oriented car assembly plant, wages are among the highest in the automobile industry, but its labor costs are substantially lower than average because it takes about half as many labor hours to assemble a car in the plant.

[8]We say it is similar becuase agents can communicate and form a coalition. Therefore tournament and group penalty/reward are similar in this sense.

an incentive for agents to monitor each other but, with abilities attributed to the output, career concerns will force agents to work harder in their earlier careers than that of a one-shot relationship.

Second, likewise in the single agent career concern models, we ¯nd that incentive provided by the optimal contract between the principal and the agents should increase over time to balance out the implicit incentives restored by reputational concerns between team members. This is a natural corollary from the ¯rst ¯nding. However, further comparisons between team setting and a single agent setting give us some other results. Our ¯ndings are: 1, both ¯rst and second period incentive power in team performance evaluation is lower than that of individual performance evaluation if output °uctuations are positively correlated; 2, team setting provides insurance e®ect compared with single agent case, and this is Pareto e±cient as the trade-o® of incentive and insurance between the principal and the agent is improved by adding another agent; 3, team equilibrium piece rate evolves faster than that of a single agent case. In a coarse language, one can say that team made everything modest except the incentive evolution speed.

Third, our ¯ndings imply that decentralizing the authority in a certain degree could be bene¯cial to the ¯rm. In Aghion and Tirole (1997), decentralization could be good if it facilitates the agent's investment in acquiring information about decision alternative if the principal and agent's interests are su±ciently congruent. We agree with this conjecture. Here the problem is two-fold, first, how sufficiently congruent the interests are and do they diverge with decentralization, second, will moral hazard which is harmful for the firm's goal arise and get severe with the decentralization. The optimal level of decentralization can be then characterized for future research with these considerations.

Our innovation is powered by the combination of the four major considerations above mentioned. We believe that only a careful study with a more realistic and enriched environment can lead sensible policy recommendations on optimal compensation scheme design, grouping, multitask design, and best allocation of the authority. We do not provide bizarre or careless policy suggestions, rather, try to provide an alternative explanation for why an Alchian-Demsetz[9] firm would triumph in the real world and why the pay-to-performance ratio is low in explicit contracts. Nevertheless, our approach can be extended into a variety of directions including grouping and authority allocation and policy suggestions can be carried out in further research.

2 The Model

The firm (or a project) is operated by a two person managerial team, each contributes with an effort and intrinsic ability. The intrinsic ability, which follows a certain prob-

[9] However the firm in our model differs slightly from Alchian-Demsetz (1972) in the sense that the role of monitoring the effort is replaced by peers instead of the principal.

abilistic distribution, known to the principal and the agents a prior. The value of own and cross intrinsic ability is known to the agents themselves after the first period output is realized. The principal, commonly the owner of the firm, does not participate in production or decision making, except setting up a linear incentive compensation scheme to the agents, or sometimes called team members. The project lasts for two periods where random shocks enter production additively. The individual output is not observable or verifiable to the principal in either period but observable to the team members themselves immediately after the period ends. The principal offers two schemes that different in incentive sensitivities and fixed payments to the two agents at the beginning of the game, one for each period. After first period elapsed, the total output is revealed to all players; agents have the option to continue in this team or quit but work alone. Finally, because of the competitiveness of the labour market, the principal make zero expected profits.

Team member i's contribution to output[10] at period t is,

$$y_{it} = \eta_i + a_{it} + \xi_{it}; \qquad i = 1; 2 \tag{2.1}$$

where η_i is the agent's inborn entrepreneurial ability, a_{it} is the i's effort exerted in period t, ε_t is a common shock to all the team members at period t and ξ_{it} is the individual shock at t, and $a_{it}; \xi_{it}; \eta_i \in R^1_+$. Team members' utility is negative

[10] This production technology follows Dewatripont, Jewitt and Tirole (1999).

exponential[11], ie.,

$$u_i(\cdot) = \sum_{t=1} \delta^{t-1}\{-\exp(-r\{[w_{it} - g(a_{it})]\})\}; \tag{2.3}$$

where w_{it} is the earning of agent i at t and $g(a_{it})$ is the disutility of effort for agent i

[11]Examples of other utility functions are Cobb-Douglas, or HARA utility, proposed by Merton (1971) first. However we adopt the CARA utility function as it is widely accepted in the literature and it will bring us closed form solutions, just for recent reference, please see Holmstrom and Milgrom (1987); Sung (1997) "Corporate Insurance and Managerial Incentive" JET 74, 297-332; Gibbons (1998); Prendergast and Topel (1996); Garen (1994) "Executive Compensation and Principal-Agent Theory" JPE 102: 1175–1194. Typically, results from exponential preference is generally treated as "risk-averse" case, especially for econometricians, see Aggarwal and Samwick (1999) "The Other Side of the Trade-off: the Impact of Risk on Executive Compensation", JPE 107: 65-101.

CARA utility does not impose any biased assumption in risk aversion. In most of the cases, we only care if the player is risk averse or not, but not the details of the curvature his utility. In all there are two reasons, first, we do not know any restrictive assumption on player's risk aversion other than CARA will be convincing; second, exponential utility has nice feature in taking differentiations and hence brings the ease in computation.

The HARA utility in Merton (1971) is

$$u(s) = \frac{\alpha}{1-\alpha}\left(\frac{\beta}{\alpha}s + \gamma\right)^{1-\alpha}; \quad \text{for } s > -\frac{\alpha\gamma}{\beta} \tag{2.2}$$

where $\beta > 0$; $\gamma = 1$ if $\alpha = +\infty$: It converges to risk neutral when $\alpha \to 0$ and exponential when $\alpha \to +\infty$ but needless to say, it will make the computation extremely complex. See Merton, Robert, Optimum Consumption and Portfolio Rules in a Continuous-time Model, J.E.T. 3 (1971): 373-413 for details.

at t. We assume as usual that $g'(\cdot) > 0; g''(\cdot) > 0$ and $g'(0) = 0; g'(\infty) = \infty:$

For this two period game we assume linear incentive scheme, by the argument of Holmstrom and Milgrom (1987)[12]. A simple linear incentive scheme may perform well across a wide range of environments as well as having low writing costs. Non-linear schemes are designed for the purpose of inducing agents to exert effort in the principal's best interest in particular environments. However these fine-tuning complex incentive schemes are not very realistic for at least two reasons: first, they could hardly maintain their optimality for even a slightest change in the information structure or technological change; secondly, intricate schemes are hard to be implemented: agents would take advantage of the complexity of the contracts by arbitrage-taking like behaviours, and this situation can be exaggerated by multiple agents because collusion and deviating from optimal reciprocal help level will be their options[13].

Linear incentive compensation schemes do not require precise knowledge of the agents' preference and the production technologies they control, and they automatically adjust to environmental changes without renegotiation[14]. In a step function

[12] The robustness of compensation linearity was studied in Holmstrom and Milgrom (1987). Linear contracts are intuitive and widely accepted, we agree linearity and presume it. For a rigorous proof of optimality of linear contracts in teams, see the authour's another essay on this issue.

[13] If free disposal of the output is feasible, a practical scheme then has to be monotone despite any other argument on either information structure or stochastic production technology it may have.

[14] Mirrlees (1974) shows that instead of a simple linear scheme, the first-best outcome can be approached arbitratily close by a suitable chosen sequence of step functions if output is lognormally

scheme, a slight change in the industry's benchmark will immediately make the current scheme inefficient. For other nonlinear schemes, one can approximate by a polynomial of higher order terms. Positive coefficients on these terms can have two effects: incentive improving effect and insurance dampening effect. In another study by the author, it is proved that these coefficients should be zero, implying nonlinear terms in a compensation contract would worsen the tradeoff between insurance and incentive. Furthermore, they substantially reduce the transaction costs associated with customized contingent schemes.

Next, consider the total output for the team in each period is

$$Y_1 = y_{11} + y_{21} = \eta_1 + \eta_2 + a_{11} + a_{21} + \xi_{11} + \xi_{21} \quad (2.4)$$

for period one and

$$Y_2 = y_{12} + y_{22} = \eta_1 + \eta_2 + a_{12} + a_{22} + \xi_{12} + \xi_{22}; \quad (2.5)$$

for period two, where the principal's prior belief on team members' entrepreneurial

distributed. However since a solution does not exist, it is called the "Mirrlees Problem". The optimality of the step functions proposed by Mirrlees depends on several strong assumptions: 1, output is lognormally distributed; 2, it is assumed that the first-order-approach is valid; 3, an economy with large number of agents. Moreover, transaction costs must be sufficiently small. See Mirrlees (1974), Notes on Welfare Economics, Information and Uncertainty, in Essays on Economic Behaviour under Uncertainty.

abilities follows

$$\eta_i \sim N(m_0; \sigma_0^2); \qquad \text{with correlation } corr(\eta_i; \eta_j) = 0; \text{ for } i \neq j;$$

and random shocks in each period follow

$$\xi_{it} \sim N(0; \sigma_\xi^2); \qquad \text{with correlation } corr(\xi_{it}; \xi_{jt}) = \rho; \text{ for } i \neq j:$$

The total expected utility[15] for agent 1 is then

$$\begin{aligned} E[u_1(\cdot)] &= -E[\exp\{-r[\alpha_1 + \beta_1 Y_1 - g(a_{11})]\}] - \delta E[\exp\{ \\ &\quad -r[\alpha_2 + \beta_2 Y_2 - g(a_{12})]\}]; \end{aligned} \tag{2.6}$$

if no one quits in the second period[16].

[15] A more appealing expression would be $E[u_i(\cdot)] = -E[\exp\{-r\{\alpha_1 + \beta_1 Y_1 - g(a_1)\}\}] - \delta r\{\alpha_2 + \beta_2 Y_2 - g(a_2)\}\}]\}$; for single agent case in Gibbons and Murphy (1992). Even though the functional form of utility in this setting may sound not reasonable in intertemporal Macroeconomic sense, it does not change the qualitative results in the setting of this paper, as simple algebra shows that $g'(a_1) = \beta_1 + \delta \frac{\partial \alpha_2}{\partial a_1}$ in the first order condition of the alternative setting where $g'(a_1) = \beta_1 + \delta \frac{u_2}{u_1}\frac{\partial \alpha_2}{\partial a_1}$ in our setting, where $u_1 = -E[\exp\{-r\{\alpha_1 + \beta_1 Y_1 - g(a_1)\}]$ and $u_2 = \delta\{-E[\exp\{-r\{\alpha_2 + \beta_2 Y_2 - g(a_2)\}]\}$: We know given equilibrium levels of $a_1; a_2$; the value of $\frac{u_1}{u_2}$ is fixed and positive, implying equilibrium level of a_1 at standard setting is higher than non-time-separable setting. Therefore, results from our standard setting are consistent with that from the alternative setting.

[16] If one agent quits by the end of the first period, the second period incentive scheme will differ from the team one, it is discussed in Section 6.

One very important assumption about the timing on learning of ability is that managers themselves learn their own ability by the end of ¯rst period where it is still unknown to the principal. The agents also know how much e®ort they exerted in equilibrium, therefore they improve the belief on their colleague's ability[17].

The competitiveness of the managerial market induces the principal[18] (could be shareholders) to make zero expected pro¯ts[19], i.e., $\alpha_t = (\frac{1}{2} - \beta_t)E[Y_t]$: The intercept

[17] A menu of contracts may be suggested to mitigate this adverse selection problem, however, the principal will avoid to do so, because this cream skimming like sheme will force the agent to lose the rent in the second period and therefore lose interest to over-exert their e®ort in the ¯rst period. Furthermore, we are trying to explain why team sustains, not trying to o®er alternative schemes, in other words, obviously, teams outperform unsynchronized mills because of the technological synergy, the reason we eliminated the synergy is to see if it is the synergy is balanced or enhanced by the virtue of this organizational form, not to change the problem into pure adverse selection model. Also, if a menu can be o®ered by the end of ¯rst period, it can be o®ered at the very beginning too, if a reimbursement rule is there.

[18] The passive role of a principal in our setting as someone who utilizes the team member mutual observability in contract design and serves as a rule keeper can be a substitute to Holmstrom's budget breaking role of the principal. Our claim is that the the repeated nature of the cooperation caused simply by the elapse of time, and insurance make loosely supervised teams robust as an organization choice, not necessarily budget balance breaking reasons. Since the principal only sets up the scheme and then just sits there and watch, the role of a principal in our setting, is more like a government in Adam Smith' s Wealth of Nations.

[19] The expected pro¯t is assumed zero within period instead of lifetime is because there is no binding constraint to restrict the agent from quitting the ¯rm, nor punitive penalties. Again this

® and incentive term ¯ are set by the principal but not arbitrarily, in fact, they are endogenous as we will see below. We use backwards induction to ¯nd subgame perfect equilibrium. The principal only observes aggregate output by the end of period one and she uses it in learning the aggregate ability; team members will exert e®ort noncooperatively in the second period and this fact is common knowledge. Assuming peers will observe individual output by the end of the ¯rst period but not the principal, quitting and working alone in the subsequent periods would be a credible punishment to their partner if the partner ever shirks in the ¯rst period or his ability is too low. The principal desires cooperative production levels in the ¯rst period, because our setting of the game is not renegotiation proof, the principal can hold-up some stakes or payments once she observes at least one party quits in the second period. This is realistic because cash °ows in the ¯rm generally have time delays and court may in favorite to the ¯rm owner if one or some of the managers quit voluntarily however the penalty is limited[20].

Furthermore, because production technology is additive and team members are risk averse, working alone will expose too much risk relative to working in a team.

is due to the competitiveness of the market, suppose if a contract overpays the agent in the ¯rst period, he will quit in the second period and join a new ¯rm, or if he is underpaid in the ¯rst period, he will not accept the o®er anyhow, but to seek a fair deal in the market.

[20]Generally the loss of control rights and other incumbent bene¯ts will su±ce to make the punishment credible.

Therefore the team members' ¯rst period choice on hidden actions is a trade-o® between free-riding and loss of control plus team insurance e®ect. It is then possible that team members exert e®orts at the level that the principal dictates through the incentive contract.

3 Equilibrium

We use backwards induction to derive the second period e®ort level and the parameters of the optimal incentive contractual form. In the second period, which is also the last period, the team members will exert e®ort noncooperatively and they maximize the payo® for the that period. Because the decision is symmetric, we study the case for agent 1. Agent 1 maximizes the following when the second period commences and assuming he decides to stay in this team:

$$\max_{a_{12}} -E[\exp\{-r(\alpha_2 + \beta_2(\eta_1 + \eta_2 + a_{12} + a_{22} + \xi_{12} + \xi_{22}) - g(a_{12}))|Y_1\}]. \tag{3.1}$$

then the ¯rst order condition yields[21]

$$\beta_2 = g'(a_{12}). \tag{3.2}$$

[21] Note the ¯rst period decision has no impact on the second period's. In our model it is assumed that the agents capture all the expected output, therefore the ¯rst period choice of e®ort a®ects second period only in utility level through the intercept term of a linear compensation scheme. This is why even a non-time-separable preference does not yield correlated e®orts across periods.

By the assumption that individual output can be observed to the agents by the end of each period, principal's learning could be only on the aggregate terms, ie.,

$$E\{\eta_1 + \eta_2 | Y_1\} \equiv 2m_1 = \frac{2(1+\rho)\sigma_\xi^2 m_0 + \sigma_0^2(Y_1 - \hat{a}_{11} - \hat{a}_{21})}{2(1+\rho)\sigma_\xi^2 + \sigma_0^2}. \tag{3.3}$$

The conditional variance of $\eta_1 + \eta_2$ is then

$$Var[\eta_1 + \eta_2 | Y_1] \equiv \frac{2(1+\rho)\sigma_\xi^2 \sigma_0^2}{(1+\rho)\sigma_\xi^2 + \sigma_0^2}, \tag{3.4}$$

Denote $\sigma_1^2 = \frac{2(1+\rho)\sigma_\xi^2\sigma_0^2}{(1+\rho)\sigma_\xi^2+\sigma_0^2}$, the variance of $(\eta_1 + \eta_2 + \xi_{12} + \xi_{22}|Y_1)$ is then

$$\sigma_2^2 \equiv \sigma_1^2 + 2(1+\rho)\sigma_\xi^2, \tag{3.5}$$

therefore the above maximand[22] can be rewritten as

$$\max_{a_{12}} -E[\exp\{-r(\alpha_2(\beta_2) + \beta_2(\eta_1 + \eta_2 + a_{12} + a_{22} + \xi_{12} + \xi_{22}) - g(a_{12}^*(\beta_2))|Y_1\}]$$

$$= -\exp\{-r(m_1(Y_1, \hat{a}_{11}, \hat{a}_{21}) + \frac{1}{2}\hat{a}_{12}(\beta_2) + \frac{1}{2}\hat{a}_{22}(\beta_2) - g(\hat{a}_{12}(\beta_2)) - \frac{1}{2}r\beta_2^2\sigma_2^2)\} \tag{3.6}$$

where $\hat{a}_{12}(\beta_2)$ and $\hat{a}_{22}(\beta_2)$ are equilibrium levels and $\hat{a}_{12}(\beta_2) = \hat{a}_{22}(\beta_2)$.

First order condition of the utility maximization problem yields

$$\beta_2 = \frac{1}{2 + 2r\sigma_2^2 g''(a_{12})}. \tag{3.7}$$

By the end of first period, the team member's individual contribution to the output is revealed to himself and because production technology is additive, his peer's output

[22]Readers only interested in our main results can skip this part and go to (3.12) directly. Steps here leading to the intermediate result (3.7) are for the purpose of illustrating the impact of individual observability on optimal incentive provision.

is therefore observed as well. While the above analysis gives a seemingly efficient incentive contract for the team in the last period, the actual efficient contract is deduced from a subgame perfect equilibrium effort level through individual learning. By the virtue of individual observability, we have the following for agent 2,

$$\begin{aligned}
&\max_{a_{22}} -E[\exp\{-r(\alpha_2 + \beta_2(\eta_1 + \eta_2 + a_{12} + a_{22} + \xi_{12} + \xi_{22}) - g(a_{22}))|Y_1; y_i; y_j\}] \\
= &\max_{a_{22}} -E[\exp\{-r(\frac{1-2\beta_2}{2}E[Y_2|Y_1] + \beta_2(\eta_1 + \eta_2 + a_{12} + a_{22} + \xi_{12} + \xi_{22}) \\
&- g(a_{22}))|Y_1; y_i; y_j\}] \qquad (3.8)
\end{aligned}$$

which is equivalent to maximizing the following,

$$\begin{aligned}
&-r\{\frac{1}{2}(\eta_2 + m_3) + \beta_2(\eta_1 - m_3) + \frac{1}{2}(\hat{a}_{12} + \hat{a}_{22}) - g(\hat{a}_{22}) \qquad (3.9) \\
&- \frac{1}{2}r\beta_2^2 var(\eta_1 + \xi_{12} + \xi_{22}|Y_1; y_i; y_j)\}
\end{aligned}$$

where

$$m_3 \equiv E[\eta_1|y_{11}; y_{21}] = \frac{(1-\rho^2)\sigma_\xi^2 m_0 + \sigma_0^2(y_{21} - \hat{a}_{21} - \rho\hat{\xi}_{21})}{(1-\rho^2)\sigma_\xi^2 + \sigma_0^2}; \qquad (3.10)$$

and

$$\sigma_5^2 \equiv var(\eta_1 + \xi_{12} + \xi_{22}|Y_1; y_i; y_j) = \frac{(1-\rho^2)\sigma_\xi^2\sigma_0^2}{(1-\rho^2)\sigma_\xi^2 + \sigma_0^2} + 2(1+\rho)\sigma_\xi^2. \qquad (3.11)$$

(3:10) is derived from the following lemma.

Lemma 1 (Mao et al (1998)) Let $X = \begin{pmatrix} X_1 \\ X_2 \end{pmatrix} \sim N\left(\begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix}; \begin{pmatrix} \Sigma_{11} & \Sigma_{12} \\ \Sigma_{21} & \Sigma_{22} \end{pmatrix}\right).$

Then given that $X_2 = x_2$, the conditional distribution of X_1 is

$$N\left(\mu_1 + \Sigma_{12}\Sigma_{22}^{-1}(x_2 - \mu_2);\ \Sigma_{11} - \Sigma_{12}\Sigma_{22}^{-1}\Sigma_{12}'\right).$$

The first order condition to the certainty equivalent yields

$$\hat{\beta}_2 = \frac{1}{2 + 2r\sigma_5^2 g''(a_{22})}. \tag{3.12}$$

It is easy to show that $\sigma_2^2 > \sigma_5^2$ when $\rho > 0$; $\sigma_2^2 < \sigma_5^2$ when $\rho < 0$; therefore, obviously,

$$\beta_2 < \hat{\beta}_2 \qquad \text{if } \rho > 0. \tag{3.13}$$

Proposition 2 $\beta_2 < \hat{\beta}_2$ Team incentive is powered partially by mutual observability.

Remark 1 For an illustrative example of Proposition 1, a central government who cares about units of a good medicine per dollar that it spends on public hospitals and research units may want to encourage coupling medical schools with hospitals and make the funding contingent on the patients' duration or survival rate on new medicines. For example, Royal Victoria of McGill University and Jewish General Hospital team on AIDS R & D, if Roal VIctoria finds that Jewish General is completely ignorant about AIDS, they might very possible to quit from this team even on the cost of accepting a lower powered incentive compensation scheme alone. Also, from the moral hazard point of view, even if Jewish General is good at the pathology of AIDS but they are constantly reluctant in R & D investment or participation de facto which cannot be observed by the government, Royal Victoria will force them to improve just by the fact they can oberve Jewish General's input on this matter using quit as an instrument. Therefore, altough the government does not see the e®ort they exert in a team, it still can use a high powered incentive scheme based on aggregate results because the government knows that they oberve and they will interact. Same logics even applies to a parent who works in the day hiring her kids to mow her lawn regularly in summer, the renumeration could be based on the ¯nal visual e®ect in the backyard, not having kids' individual contribution in mind. Also, for the case of two-man cops teams, the promotion can be based on the pair's aggregate output, not to count only on who cu®s the suspect in the crime scene. A man who is unwilling to expose for danger, or always miss the target in gun shooting may be repugnant to his partner and being thrown into bench and regroup with someone comparable to him. Therefore the sheri® does not have to worry distinguishing who indeed (in a two-man team) was essential in capturing the suspect. On the contrary, incentive is low in one shot projects. For example, in organizing celebration parties or community event services, or one-shot fund raising, although team work is also essential but the compensation is often °at rate or even voluntary. On the other hand, for a mutual fund broker, a type of fund raiser, the salary is contingent on his clients' contribution and his team mates, often subordinates. The reason is that this business is routine and repeated, relative to one shot fund raising.

Now the expected utility for the representative agent, agent 1, at the first period perspective is

$$-E[\exp\{-r(\alpha_1 + \beta_1(\eta_1 + \eta_2 + a_{11} + a_{21} + \xi_{11} + \xi_{21}) - g(a_{11})) \tag{3.14}$$
$$- r\delta(\alpha_2(\hat{\beta}_2) + \hat{\beta}_2(\eta_1 + \eta_2 + \hat{a}_{12} + \hat{a}_{22} + \xi_{12} + \xi_{22}) - g(\hat{a}_{12}))\}]$$

where

$$\alpha_2 = \frac{1 - 2\hat{\beta}_2}{2}\left[\frac{(1+\rho)\sigma_\xi^2 m_0 + \sigma_0^2(Y_1 - \hat{a}_{11} - \hat{a}_{21})}{(1+\rho)\sigma_\xi^2 + \sigma_0^2} + \hat{a}_{12} + \hat{a}_{22}\right].$$

Therefore, the first order condition with respect to a_{11} is then adjusted accordingly to the following,

$$g'(a_{11}) = \beta_1 + \delta(1 - 2\hat{\beta}_2)\frac{\sigma_0^2}{2(1+\rho)\sigma_\xi^2 + 2\sigma_0^2}$$

where the second term of RHS depicts the career concern effect. Denote $B_1 \equiv g'(a_{11}) = \beta_1 + \delta(1 - 2\hat{\beta}_2)\frac{\sigma_0^2}{2(1+\rho)\sigma_\xi^2 + 2\sigma_0^2}$.

The principal maximizes total welfare, which is a monotonic transformation of aggregate utility and can be written as the following,

$$E[-\exp\{-r\{2m_0 + a_{11}(\beta_1) + a_{21}(\beta_1) - g(a_{11}(\beta_1)) - g(a_{21}(\beta_1)) \tag{3.15}$$
$$+ \xi_{11} + \xi_{21}) + \delta(2m_0 + \hat{a}_{12}(\hat{\beta}_2) + \hat{a}_{22}(\hat{\beta}_2) - g(\hat{a}_{12}(\hat{\beta}_2)) - g(\hat{a}_{22}(\hat{\beta}_2)) + \xi_{12} + \xi_{22}\}\}].$$

Let σ_4^2 denote the variance of the expression inside the inner curly braces of (3.15). Then (3.15) can be rewritten as

$$-\exp\{-r[2m_0 + a_{11}(\beta_1) + a_{21}(\beta_1) - g(a_{11}(\beta_1)) - g(a_{21}(\beta_1))] \tag{3.16}$$
$$- r\delta(2m_0 + \hat{a}_{12}(\hat{\beta}_2) + \hat{a}_{22}(\hat{\beta}_2) - g(\hat{a}_{12}(\hat{\beta}_2)) - g(\hat{a}_{22}(\hat{\beta}_2))\} \cdot \exp\{\frac{1}{2} r^2 \sigma_4^2\}.$$

where

$$\begin{aligned}
\sigma_4^2 \equiv\ & \mathrm{var}[\beta_1(\eta_1 + \eta_2) + \beta_1(\xi_{11} + \xi_{21}) + \delta\frac{(1 - 2\beta_2)}{2} \\
& \times \left(\frac{(1+\rho)\sigma_\xi^2 m_0 + \sigma_0^2(Y_1 - \hat{a}_{11} - \hat{a}_{21})}{(1+\rho)\sigma_\xi^2 + \sigma_0^2} + \hat{a}_{12} + \hat{a}_{22} \right) + 2\beta_2\delta(\xi_{12} + \xi_{22})] \\
& + \delta^2 \mathrm{Cov}[\xi_{12}, \xi_{22}] + \mathrm{Cov}[\xi_{11}, \xi_{21}].
\end{aligned}$$

We assume that the random disturbances are not serial correlated, i.e., $\mathrm{Cov}[\xi_{i1}, \xi_{i2}] = 0$ and $\mathrm{Cov}[\xi_{i1}, \xi_{j1}] = 0$, where $i, j = 1, 2$ and $i \neq j$. Notice also $Y_1 - \hat{a}_{11} - \hat{a}_{21} = \eta_1 + \eta_2 + \xi_{11} + \xi_{21}$, we have

$$\begin{aligned}
\sigma_4^2 \equiv\ & 2\left(2\beta_1 + 2\delta(1 - 2\beta_2)\frac{\sigma_0^2}{2(1+\rho)\sigma_\xi^2 + 2\sigma_0^2} + 2\delta\beta_2\right)^2 (\sigma_\xi^2 + \sigma_0^2) \\
& - 8\delta\beta_2\sigma_\xi^2 B_1 + 8\rho\beta_2^2\sigma_\xi^2 + 8\rho\sigma_\xi^2 B_1^2
\end{aligned}$$

where $B_1 = \beta_1 + \delta(1 - 2\hat{\beta}_2)\frac{\sigma_0^2}{2(1+\rho)\sigma_\xi^2 + 2\sigma_0^2}$.

Maximizing (3.16) with respect to β_1 gives the following first order condition

$$a_1'(\beta_1) - g'(a_{11})a_{11}'(\beta_1) + a_{21}'(\beta_1) - g'(a_{21})a_{21}'(\beta_1) - \frac{1}{2} r \frac{\partial \sigma_4^2}{\partial \beta_1} = 0. \tag{3.17}$$

Note in the first period, the principal and team members have the same knowledge over the team members abilities, therefore the only conflict between the principal and the team members is that the principal maximizes aggregate objectives while team members tend to maximize private objectives causing possible discrepancies in effort levels.

Evaluating the derivative of variance σ_4^2 with respect to β_1, we have

$$
\begin{aligned}
\frac{\partial \sigma_4^2}{\partial \beta_1} &= 8\left(\beta_1 + \delta(1-2\beta_2)\frac{\sigma_0^2}{2(1+\rho)\sigma_\xi^2 + 2\sigma_0^2} + \beta_2\delta\right)(\sigma_\xi^2 + \sigma_0^2)] \qquad (3.18)\\
&\quad - 8\beta_2\delta\sigma_\xi^2 + 8\beta_1\rho\sigma_\xi^2 + 4\rho\delta\sigma_\xi^2(1-2\beta_2)\frac{\sigma_\xi^2\sigma_0^2}{(1+\rho)\sigma_\xi^2 + \sigma_0^2}.
\end{aligned}
$$

Note the first order condition to (3.14) with respect to a_{i1} is

$$
g'(a_{11}) = g'(a_{21}) = \beta_1 + \delta(1-2\beta_2)\frac{\sigma_0^2}{2(1+\rho)\sigma_\xi^2 + 2\sigma_0^2}. \qquad (3.19)
$$

Substituting (3.18) and (3.19) into (3.17) and adjusting incentive power for each team member yield

$$
\begin{aligned}
\hat\beta_1 &= \frac{1}{2 + 4r[\sigma_\xi^2 + \sigma_0^2 + \rho\sigma_\xi^2]g''(a_{11})} - \frac{\delta(1-2\beta_2)\sigma_0^2}{2(1+\rho)\sigma_\xi^2 + 2\sigma_0^2} \qquad (3.20)\\
&\quad - \frac{r\delta[\frac{1}{2}\sigma_0^2 + 2\beta_2\sigma_\xi^2]g''(a_{11})}{1 + 2r[\sigma_\xi^2 + \sigma_0^2 + \rho\sigma_\xi^2]g''(a_{11})}.
\end{aligned}
$$

Proposition 3 $\hat\beta_1 < \hat\beta_2$.

Proof. $\beta_2 < \hat\beta_2$ is proven earlier. To prove $\hat\beta_1 < \hat\beta_2$, it suffices to prove $\hat\beta_1 < \beta_2$, and it is therefore sufficient to show

$$
2\left(\sigma_\xi^2 + \sigma_0^2 + \rho\sigma_\xi^2\right) \geq \sigma_2^2
$$

given the assumption that $g'''(\cdot) \geq 0$. The relationship that $2\left(\sigma_\xi^2 + \sigma_0^2 + \rho\sigma_\xi^2\right) \geq \frac{(1-\rho)\sigma_\xi^2\sigma_0^2}{(1-\rho)\sigma_\xi^2 + \sigma_0^2} + 2(1+\rho)\sigma_\xi^2$ is obvious. ∎

4 Comparison with Classical Capitalistic Firms

We refer the term classical capitalism as individual performance evaluation where team based evaluation and any teamwork are abandoned.

Proposition 4 Second period incentive power in team performance evaluation is lower than that of individual performance evaluation if output fluctuations are positively correlated, i.e., $2\hat{b}_2 < b_2$ if $\rho > 0$.

Proof. Notice that

$$b_2 = \frac{1}{1 + r\left(\sigma_\varepsilon^2\; g''(a_2)\right)};$$

then

$$\sigma_\varepsilon^2 < \frac{(1-\rho)\sigma_\varepsilon^2\sigma_0^2}{(1-\rho)\sigma_\varepsilon^2 + \sigma_0^2} + 2(1+\rho)\sigma_\varepsilon^2.$$

■

Lemma 5 First period incentive power in team performance evaluation is lower than that of individual performance evaluation if output fluctuations are positively correlated and team insurance effect is greater than that of the single agent case, $2\hat{b}_1 < b_1$ if $\rho > 0$ and

$$\frac{r\delta[\frac{1}{2}\sigma_0^2 + 2\beta_2\sigma_\varepsilon^2]g''(a_{11})}{1 + 2r[\sigma_\varepsilon^2 + \sigma_0^2 + \rho\sigma_\varepsilon^2]g''(a_{11})} > \frac{r\delta b_2\sigma_0^2 g''(a_1)}{1 + r[\sigma_\varepsilon^2 + \sigma_0^2]g''(a_1)}$$

where $b_2; a_1$ is the incentive term and effort level of the first period in single agent case, respectively.

Proof. Note that in the single agent case,

$$b_1 = \frac{1}{1 + r[\sigma_\xi^2 + \sigma_0^2]g''(a_1)} - \frac{\delta(1 - b_2)\sigma_0^2}{\sigma_\xi^2 + \sigma_0^2} - \frac{r\delta b_2\sigma_0^2 g''(a_1)}{1 + r[\sigma_\xi^2 + \sigma_0^2]g''(a_1)}. \qquad (4.1)$$

If $\rho > 0$, then,

$$2\frac{\delta(1 - 2\beta_2)\sigma_0^2}{2(1 + \rho)\sigma_\xi^2 + 2\sigma_0^2} > \frac{\delta(1 - b_2)\sigma_0^2}{\sigma_\xi^2 + \sigma_0^2}$$

and $2r[\sigma_\xi^2 + \sigma_0^2 + \rho\sigma_\xi^2] > r[\sigma_\xi^2 + \sigma_0^2]$. Therefore, given that

$$\frac{r\delta[\frac{1}{2}\sigma_0^2 + 2\beta_2\sigma_\xi^2]g''(a_{11})}{1 + 2r[\sigma_\xi^2 + \sigma_0^2 + \rho\sigma_\xi^2]g''(a_{11})} > \frac{r\delta b_2\sigma_0^2 g''(a_1)}{1 + r[\sigma_\xi^2 + \sigma_0^2]g''(a_1)},$$

we have $2\hat{b}_1 < b_1$. ■

Corollary 6 The evolution of equilibrium piece rate in a managerial team is faster than that of a single manage case, i.e.,

$$\frac{\hat{b}_2 - \hat{b}_1}{\hat{b}_2 + \hat{b}_1} > \frac{b_2 - b_1}{b_2 + b_1}.$$

Proof. (Sketch) To prove $\frac{\hat{b}_2 - \hat{b}_1}{\hat{b}_2 + \hat{b}_1} > \frac{b_2 - b_1}{b_2 + b_1}$, it is sufficient to prove $2(\hat{b}_2 - \hat{b}_1) > b_2 - b_1$ as $2(\hat{b}_2 + \hat{b}_1) < b_2 - b_1$. After a few algebraic manipulations, we can further simplify the condition into

$$4\frac{2\sigma_0^2 + (1 - \rho)\sigma_\xi^2}{\sigma_0^2 + (1 - \rho)\sigma_\xi^2} > \frac{\sigma_\xi^2}{\sigma_\xi^2 + \sigma_0^2}$$

and it obviously holds. ■

Corollary 5 is consistent and even strengthens the claim that an efficient managerial incentive contractual arrangement should put more explicit incentives in their earlier careers relative to those in their later careers.

5 Endogenous Cooperative Behaviours

So far we completed the derivation of equilibrium strategy set and gained some intuition about career concern and informativeness in a dynamic managerial team. However these presentations are still fairly "static". In this section, as we discuss the off-equilibrium paths, we will make our point more clear.

Consider for a certain player with some particular entrepreneurial ability, he faces 3 strategies in the first period: to exert effort according to what $\hat{\mathbf{b}}_1$ implicitly instructs; deviating by shirking in the first period; deviating by overworking in the first period. In either of the latter two cases, he is hoping the gain from deviation in the first period could cover the loss in the second period, in expected terms.

Suppose agent 1 is the one who deviates. We consider the case that agent 1 shirks in the first period in an attempt for instant benefit. Because adverse selection only occurs when the second period begins, agent 2 does not change his learning rule and therefore his estimate on his peer's ability after the first period is lower than if he would not have shirked. Agent 2 then might find working alone may beneficial than staying in this team with agent 1. Therefore there is an incentive for agent 2 to leave if agent 1 shirks in the first period. Agent 2 will break up with his partner if

$$CE_{22}|_{stay} > CE_{22}|_{quit};$$

where $CE_{it}|_k$ is agent i's certainty equivalent at period t given event(or decision) k:

Given that any of the two managers decided to break up happened, the principal instantly know that very possibly someone has shirked, therefore, she will not even apply learning on gross output. Hence, there is another contract for individual evaluation in the second period in the case of breaking up. It is obtained by the following maximand,

$$\max_{a_{22}} -E[\exp\{-r(\tilde{\alpha}_2 + \tilde{\beta}_2(\eta_2 + a_{22} + \varepsilon_{22}) - g(a_{22})|y_{11} \text{ lower than agent 2 expected}\}]$$
$$= \max_{a_{22}} -r\left[m_0 + \tilde{a}_{22} - g(\tilde{a}_{22}) - \frac{1}{2} r \tilde{\beta}_2^2 \sigma_\varepsilon^2\right]:$$

Because

$$\sigma_\varepsilon^2 < \frac{(1-\rho)\sigma_\varepsilon^2\sigma_0^2}{(1-\rho)\sigma_\varepsilon^2 + \sigma_0^2} + 2(1+\rho)\sigma_\varepsilon^2;$$

we easily establish

$$\tilde{a}_{22} > \hat{a}_{22};$$

where $\tilde{a}_{22}$ is the effort level that agent 2 exerts if he decides to work on his own in the second period.

Team member 2's decision on whether to leave to stay with his peer depends on if $CE_{22}|_{stay} \gtrless CE_{22}|_{quit}$ and it is equivalent to the following,

$$\frac{\eta_2}{2} + \frac{m_3}{2} + \hat{a}_{22} - g(\hat{a}_{22}) - \frac{1}{2} r \hat{\beta}_2^2 \sigma_5^2 - \eta_2 - \tilde{\alpha}_{22} - g(\tilde{a}_{22}) - \frac{1}{2} r \tilde{\beta}_2^2 \sigma_\varepsilon^2 \gtrless 0: \qquad (5.1)$$

where

$$m_3 \equiv E[\eta_1|y_{11}; y_{21}] = \frac{(1-\rho)\sigma_\varepsilon^2 m_0 + \sigma_0^2(y_{11} - \hat{a}_{11})}{(1-\rho)\sigma_\varepsilon^2 + \sigma_0^2}:$$

Therefore depending on agent 1's first period performance, agent 2 learns if his peer's ability is too low to work with in the sense that his partner takes too much of his expected contribution to the output.

The short run expected gain from myopic behaviour(shirking in the first period) for agent 1 is $CE_{11}(\underline{a}_{11}) - CE_{11}(\hat{a}_{11})$ which is equivalent to

$$\frac{\underline{a}_{11}}{2} - \frac{\hat{a}_{11}}{2} - g(\underline{a}_{11}) + g(\hat{a}_{11})$$

where $\underline{a}_{11}$ is the short run optimal private effort level for agent 1 and it is obtained from the following UMP,

$$\max_{a_{11}} -E[\exp\{-r(\alpha_1 + \beta_1(\eta_1 + \eta_2 + a_{11} + \hat{a}_{21} + \xi_{11} + \xi_{21}) - g(a_{11})\}] \quad (5.2)$$
$$= \max_{a_{11}} -[\exp\{-r(m_0 + \frac{a_{11}}{2} + \frac{\hat{a}_{21}}{2} - g(a_{11}) - \frac{1}{2} r\hat{\beta}_1^2(2(1+\rho)\sigma_\xi^2 + \sigma_0^2)\}]:$$

$\underline{a}_{11}$; the solution to (5:2); solves the following,

$$a_{11} = \frac{r\hat{\beta}_1[(1+\rho)\sigma_\xi^2 + \sigma_0^2]}{1 - 2g'(a_{11})}:$$

The expected loss to agent 1 at the first period's perspective is

$$-P(CE_{22}|_{stay} < CE_{22}|_{quit})\, E[\frac{\eta_1}{2} + \frac{m_0}{2} + \hat{a}_{12} - g(\hat{a}_{12}) - \frac{1}{2} r\hat{\beta}_2^2\sigma_5^2 - \eta_1 - \hat{\alpha}_{12} - g(\hat{e}_{12}) - \frac{1}{2} r\hat{e}_2^2\sigma_\xi^2]$$

where $P(CE_{22}|_{stay} < CE_{22}|_{quit})$ is the probability of $CE_{22}|_{stay} < CE_{22}|_{quit}$; and it is obtained by converting η into a standard normal random variable and checking cumulative Z table for (5:1):

As we discussed in this chapter, cooperative behaviours are endogenous in a dynamic team. This may explain why team as an organizational choice, with apparent drawbacks in the first glance, like exposure to free-riding, still robust in real corporate life. Indeed, we show that team is a device to eliminate free-riding through mutual monitoring by its members and the illusion of potential free-riding in teams is because previous research neglected the dynamic nature of business partnerships. In fact, team could be more efficient than ordinary principal supervision in the existence of mutual observability as people in the play have a more precise vision of the business and his partner's entrepreneurship than outsiders or even some pseudo insiders like the members of the board of directors or major shareholders.

6 Discussion (to be extended)

We consider another case where agents know their own abilities upfront, in other words, adverse selection emerges at the very beginning of the game.

7 Concluding Remarks

Apart from career concerns that we discussed throughout, we emphasize the informativeness and authority allocation within a firm. Our findings are consistent with Kim(1995)'s claim that complete retrieval of information is not always necessary. Individual output, even though available to the principal, may not be desired as if the correlation of the random shocks are not known to the principal, it will levy more risk to the agents which worsen the trade-o® between incentive and insurance e®ect. Therefore, although detailed accounting information may be acquired under a low cost, it may not be e±cient as making the pay contingent on coarser information might induce the team members to work harder. Our model also suggests that if the principal's and agents' objectives or interests are su±ciently congruent, it may be bene¯cial to let the agents have more control rights, in particular, mutual monitoring might be Pareto superior than supervision in a traditional capitalistic ¯rm. Our ¯ndings are robust because our model does not rely on synergy or synchronization, nor any other strong conditions imposed. We ¯nd that the repeated nature of partnership is the reason why teams sustain.

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