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# Individual versus Team Production with Social Preferences

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## Abstract:

This paper examines the impact of social preferences on the choice between individual production and team production. An inequity-averse principal can hire a single or a team of two agents to work on a single project. The agents are inequity-averse with respect to the principal. In this framework we show that even without ‘team synergy’ a moderately inequity-averse principal can opt for team production. Thus we provide an additional rationale for the empirically observed prevalence of team based production in terms of the possible existence of social preferences. Keeping social preferences fixed, we show that team production is likely in long-term employment relationships compared to short-run relationships when the principal is moderately inequity-averse. For sufficiently inequity-averse principal the incentive for team production remains the same across short-term and long-term relationships.

**Keywords:** Other regarding preferences, inequity aversion, team contracts, Synergy.

**JEL:** D86, D21, M52

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## **1. Introduction:**

Joint production or team work is quite common in workplace all over the world. Recent paper by Sanyal & Hisam (2018) studies the impact of team work on faculty members of Dhofar University in Oman. They find strong positive correlation between team work and the climate of trust and increased performance among the faculty. Team work plays a big role in healthcare system as well as improving quality of patient care and in reducing work issues (Lerner et. al. 2009). High-risk jobs like military, fire-fighting, disaster management all require cooperation of teammates to reduce risks. Working in teams can create new ideas through open communication, can solve problems, build up complementary strengths and trust among different co-workers. Ichniowski et. al. (1997) finds that team work achieves substantially higher levels of productivity as compared to traditional strict work rules with hourly wage and close supervision using data from thirty-six homogenous steel production lines of seventeen companies. Boning et. al. (1998) also shows that team work increases productivity using a panel dataset on U.S. mini-mills production lines. They found that problem solving in teams is most common in complex production lines.<sup>3</sup> In short, the above papers highlight the pervasiveness and several advantages of team production over individual production. From a theoretical point of view Itoh (1992) argues that if the agent's cost of effort is convex then it is optimal to assign multiple agents to perform a single task since that can lower the total cost of performance. Hemmer (1995) shows that if there exists direct synergy from performing two tasks, then it might be optimal to assign these tasks jointly instead of separately to exploit the synergy better.

In this paper we investigate the choice of individual versus team production where both the principal and the agents have social preferences. Specifically we focus on an inequity-averse principal's choice of individual vis-à-vis team production where the agent(s) are

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<sup>3</sup> More examples of the prevalence of team production can be found in Che and Yoo (2001).

‘inequity-averse’ with respect to the principal. The principal compares her net payoff to that of the agent(s)’ and so does the agent(s). Thus in this model there is ‘vertical’ social comparison.<sup>4</sup> The structure we use is that of Che and Yoo (2001) with single project (see section-III of their paper) where we incorporate these social preferences. The principal is assumed to be never behind.<sup>5</sup> The principal can hire ‘one’ agent or a ‘team of two agents’ for a project. So, we are in a single project framework. When one agent is hired, we refer to it as ‘individual production’. When two agents are hired then we refer to it as ‘team production’.<sup>6</sup> We show that in a static framework, even without synergy, a sufficiently inequity-averse principal interacting with inequity-averse agent(s) can opt for team production. In case of team production the principal’s total wage payment is higher compared to individual production which makes team production unattractive vis-à-vis individual production; but this also makes the principal less ahead of the team compared to individual production and therefore suffers less from inequity which makes team attractive compared to individual production. Thus, these two effects work in the opposite direction and the second effect might dominate the first for a moderately inequity-averse principal interacting with sufficiently inequity-averse agents and therefore the principal might prefer team production over individual production even without synergy. Thus, the nature of social preferences crucially affects the choice of individual vis-à-vis team production which was not addressed in Che and Yoo (2001) and earlier papers. Interestingly, if the principal is sufficiently inequity-averse she chooses to eliminate inequity altogether and therefore the inequity effects of the agent(s) are also minimized. Under this situation the principal will choose team production if and only if the team has synergy and this is a necessary and sufficient condition. Thus, a sufficiently inequity-averse principal will never choose team production without synergy. Under the special cases, when an inequity-averse principal interacts with self-regarding

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<sup>4</sup> The relevance of vertical comparison is discussed in section 1.2.

<sup>5</sup> This is in line with Dur and Glazer (2008).

<sup>6</sup> This is similar to Che and Yoo (2001).

agent(s) and also when a self-regarding principal interacts with inequity-averse agent(s), the principal will always choose individual production over team production without synergy.

We extend our model to a dynamic framework and find that social preferences crucially affect the choice between individual and team production in the dynamic set up as well. But, *ceteris paribus*, a moderately inequity-averse principal will prefer team production more over individual production compared to the static framework. This, in essence, is similar to the finding of Che and Yoo (2001) which show that dynamic interaction tilts the choice in favour of team production as compared to static interaction. Also, under the repeated setup, ‘team wage’ is lower than the ‘team wage’ of the static setup. Thus the principal is better off under repeated setting than under the static setting. But for a sufficiently inequity-averse principal, the incentive for team production remains the same across short-term and long-term relationships and this is again due to the fact that the principal finds it optimal to remove inequity vis-à-vis the agent(s) completely. Thus social preferences of both the principal and the agent(s) do have a nontrivial impact on the choice of team vis-à-vis individual production even under the dynamic setting.

### **1.1. Some Literature:**

Initially, economic theory on incentives mostly focussed on relative performance contracts which discourages possible cooperation and increases competition among co-workers (for an overview see Hart and Holmstrom (1987)). But this strand of work failed to explain the lack of relative performance contracts that we see in reality over the years.<sup>7</sup> Works by Holmstrom & Milgrom (1990) & Itoh (1993) show that a principal can be better off by offering a team contract that induces cooperation in a static setup. Several other papers such as Varian (1990), Ramakrishnan and Thakor (1991), Macho-Stadler and Perez-Castrillo (1993) and also Itoh (1992) discuss the importance of encouraging employees’ cooperation,

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<sup>7</sup> For more see Jensen and Murphy (1990), Holmstrom and Milgrom (1991, 1994) and also Che and Yoo (2001) for more.

pointing towards the optimality of offering team contracts. Che and Yoo (2001) specifically address this issue and show the optimality of team or joint production over individual production in both static and dynamic framework.

But the literature cited above assumes the principal and the agents to be self-regarding. There is a huge body of literature that examines the optimality of team production vis-à-vis non-team production (specifically relative performance evaluation) in the presence of social preferences. Papers by Itoh (2004), Englmaier and Wambach (2010), Bartling (2011), Bartling and Siemens (2010) show that it might be optimal for the principal to adopt team contracts over other forms of contracts.<sup>8</sup> These papers, in a multi-agent setting, explained the optimality of team production (team incentives) mainly through the existence of inequity aversion among agents. In these papers the agents have social preferences (inequity-averse), but the principal is assumed to be self-regarding. In this paper, on the contrary, we make an attempt to explain the existence of team production in terms of the existence of social preferences both of the principal and the agent which is a crucial difference compared to the above cited papers.<sup>9</sup>

This paper is also related to the dynamic contracting literature. Many employment contracts last for a longer period and the agents face the same decision problem repeated over and over again throughout the span of the contract. Therefore, cooperation might become common in the repeated setup than under static setup. Macleod & Malcomson (1989), Baker et. al. (1994, 1999, 2001), Meyer and Vickers (1997), Schmidt and Schnitzer (1995), Bernheim and Whinston (1998) along with few others deal with dynamic contracting problems with a single agent, whereas we also consider a multi agent environment. Arya

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<sup>8</sup> Other papers that address the effect of social preferences and comparison in multi agent setting are Demougin and Fluet (2006), Goel and Thakor (2006), Neilson and Stowe (2010) and Rey Biel (2008). For more references see Banerjee (2020).

<sup>9</sup> In addition to this, social comparisons within the boundaries of the firm influence the design of the firm through selection of production technologies (see Nickerson and Zenger (2008) and Obloj and Zenger (2017). This paper contributes to this dimension as well.

et.al. (1997) talks about group incentives in a two period dynamic model. Che and Yoo (2001) specifically deal with individual production versus team production in a dynamic framework. We follow the Che and Yoo (2001) approach closely and examine their finding with social preferences.

## **1.2. Some evidence of ‘vertical comparison’:**

In a labour market experiment by Charness and Kuhn (2004) it was found that agents are much more concerned about the employer than other agents in terms of fairness. Earlier papers, such as Akerlof (1982), Rabin (1993) and Dur and Glazer (2008) talk about fairness issues and ‘vertical’ comparison where agents compare themselves with their bosses. Thus people are not only concerned about their own payoffs but also about how much they are better off compared to others, viz. higher-ups.

Our paper is organized as follows. In section 2 we analyse the static model of individual production and team production. Section 3 considers repeated interaction. Section 4 provides some concluding remarks.

## **2. The Static Framework:**

We attempt to extend the work of Che and Yoo (2001) to a more generalized setup with an inequity-averse principal and inequity-averse agent or agents. The principal can hire a single agent to perform a task (referred henceforth as individual production) or can hire a team of two symmetric agents (referred henceforth as team production). The task returns a gross payoff of  $R > 0$  if the project succeeds and 0 if fails. Both the principal and agents are assumed to be risk neutral. The effort(s) put in by the agent(s) are not verifiable and hence non-contractible; however the outcome of the project is verifiable and hence contractible. Agent(s) are paid according to the outcome of the project. Effort is assumed to be discrete.

We assume that the agents cannot be paid a negative amount and therefore a limited liability constraint operates.<sup>10</sup>

In case of individual production the chosen agent makes an effort choice of  $e = 0, 1, 2$  at the cost  $ec$ , where  $c > 0$ .<sup>11</sup> The task succeeds with probability  $q_e$  when the agent puts in effort  $e$ , where  $1 > q_2 > q_1 > q_0 \geq 0$ . Similar to Che and Yoo (2001) we assume that  $q_2 + q_0 \geq 2q_1$  holds which in essence implies that  $q_2 - q_1 \geq q_1 - q_0$ .<sup>12</sup> This ensures that the agent will choose either  $e = 0$  or  $e = 2$ . We refer to  $e = 2$  as ‘work’ and  $e = 0$  as ‘shirk’.<sup>13</sup>

Contrary to this, in case of team production there are two symmetric agents with similar utility and effort cost functions.<sup>14</sup> They work on the same project. In case of team production the agents can either put  $e = 1$  (work) or  $e = 0$  (shirk).<sup>15</sup> The cost function is similar as before. Similar to the individual production case the outcome of the project is contractible but efforts put in by the agents are not. This implies that only a team signal is available, which is nothing but the outcome of the project. Therefore, both agents will receive the same wage depending on the outcome of the project and the principal cannot offer different wages to the agents. Following Che and Yoo (2001), the probability of success is denoted by  $p_{kl}$ , where  $k \in \{0, 1\}$  and  $l \in \{0, 1\}$  represent agent 1 and 2’s effort decisions respectively satisfying  $1 > p_{11} > p_{10} = p_{01} \geq p_{00} \geq 0$ . We assume that  $p_{10} > q_0$  holds, which implies that the project is more likely to succeed with at least one ‘working’ agent in a team compared to when it is

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<sup>10</sup> This limited liability might arise from the freedom of the workers to quit the job at any given time, or it can arise from institutional constraints such as laws that prohibit extraction from workers.

<sup>11</sup> Since the agents are similar, the choice of agents is not an issue.

<sup>12</sup> Thus success probability  $q$  is (weakly) supermodular in individual effort. This implies that success probability (weakly) increases at an increasing rate with increased effort. This is in essence similar to the convexity of  $q$  with respect to effort, here with discrete effort.

<sup>13</sup> We start with 0, 1 and 2 units of effort in case of individual production to maintain parity and comparability with team production where agents putting 0 or 1 unit of effort is possible (as we will see soon). Thus, in our model all three units of efforts are possible ex-ante, 0 and 2 in case of individual production and 0 or 1 in case of team production. (Similar to Che and Yoo (2001)). More as we proceed. Also see footnote 15.

<sup>14</sup> The agents are assumed to be symmetric for simplicity.

<sup>15</sup> This ensures that the total effort is same when an agent works in case of individual production and both agents work in case of team production (Similar to Che and Yoo (2001)). Thus the total effort cost is same in both cases which rules out the cost dimension mentioned in Itoh (1992) and therefore we can focus on the effect of social preferences in the choice of individual vis-à-vis team production.



run by a single ‘shirking’ agent. In line with Che and Yoo (2001) we impose the following supermodularity condition:

$$p_{kl} \text{ is supermodular (weakly) in } (k, l) \text{ if } p_{11} + p_{00} \geq 2p_{01} \text{ holds.} \quad (\text{SUP})$$

The above supermodularity condition implies that an agent’s work increases her partner’s productivity gain from selecting ‘work’.<sup>16</sup> Throughout we assume  $R$  to be sufficiently large such that the principal finds it optimal to elicit ‘work’ in case of individual production and ‘work’ from both the agents in case of team production. This implies that the principal wants to implement the same aggregate effort across both the regimes. We also assume that the outside option of the agent(s) to be equal to zero.<sup>17</sup>

Before proceeding, following Che and Yoo (2001), we spell out certain terminologies that characterize the technology in case of team production. If  $p_{11} > q_2$  holds then the team is said to have ‘synergy’ meaning that a team production is more productive than individual production when in both cases agents are working and also the aggregate effort is same in both cases.<sup>18</sup> If  $p_{00} < q_0$  holds then “each agent’s shirking has a negative externality on his partner’s shirking productivity”. This is referred to as “sabotage”. Given an agent’s effort level as  $k$ ,  $\Delta_k = (p_{k1} - p_{k0})$  gives how much his productivity depends on the effort decision of his peer. Thus  $(\Delta_0, \Delta_1)$  measures the technological interdependence between the agents under team production and a higher value of  $(\Delta_0, \Delta_1)$  implies more technological interdependence. Next, we spell out our major point of departure from Che and Yoo (2001) and we assume that the principal and agent(s) have social preferences (i.e. other-regarding), specifically the principal and the agent(s) to be inequity-averse.

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<sup>16</sup> As we will see this makes both the agent’s mutual sanction through repeated shirking self-enforcing, in case of repeated interaction.

<sup>17</sup> This implies that the participation constraint will be satisfied and will not bind at the optimum.

<sup>18</sup> Synergy can happen from the inherent complementarity of the agents’ efforts and one’s effort has a positive externality/influence on the other’s effort (can also be interpreted in terms of task complementarity given a particular project). It can also stem from work chemistry among the two agents leading to increased probability of success compared to when one is working alone in a project. This latter interpretation points to a behavioural dimension of synergy.

## 2.1. Preferences:

To model social preferences we follow the distributional approach in line with Fehr and Schmidt (1999)'s specifications. In line with Fehr and Schmidt (1999)'s original specification of linear other-regardingness, the principal's utility function in case of individual production can be written as

$$U_p = R_j - w_j - \pi(R_j - 2w_j) \quad \text{where } R_j - w_j \geq w_j; j = s, f. \quad (1a)$$

$s$  and  $f$  denotes success and failure respectively.<sup>19</sup>

In case of team production the principal's utility function can be written as

$$U_p = R_j - 2w_j - \pi(R_j - 4w_j) \quad \text{where } R_j - 2w_j \geq 2w_j; j = s, f. \quad (1b)$$

Once again,  $s$  and  $f$  denotes success and failure respectively.

$\pi$  is the inequity aversion parameter where  $0 < \pi < 1$ . Note that according to the primitives of our model  $R_s = R$  and  $R_f = 0$ .

In case of individual production the principal compares her net payoff  $R_j - w_j$  to her total pay-out  $w_j$  to the chosen agent whereas in case of team production the principal compares her net payoff  $R_j - 2w_j$  to her total pay-out to the team amounting  $2w_j$ . In case of team production since there is only one project outcome and the agents are symmetric,  $w_j$  will be the same for both the agents. Following Dur and Glazer (2008) it is assumed that the principal is always (at least weakly) ahead of the agent(s) in both forms of production. Therefore, in case of team production, the principal being inequity-averse experiences a loss in utility of  $\pi(R_j - 4w_j)$  from being ahead of the team. Thus for the principal, the comparison unit is the particular chosen agent in case of individual production, whereas in case of team production the comparison unit is the team. Thus in this paper we extend the

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<sup>19</sup> For a different approach to modeling inequity aversion see Bolton and Ockenfels (2000).

concept of social preferences vis-à-vis a team as well. Moreover, the principal (weakly) suffers from advantageous inequity in both forms of production.

The agents are assumed to be inequity-averse and are always behind (at least weakly) vis-à-vis the principal. Similar to the principal we model each agent's inequity aversion in terms of Fehr and Schmidt (1999)'s linear other-regardingness and is given below:

In case of individual production it is

$$U_A = w_j - \alpha(R_j - 2w_j), \quad j = s, f \quad (2a)$$

Whereas in case of team production for a particular agent it is

$$U_A = w_j - \alpha(R_j - 3w_j), \quad j = s, f \quad (2b)$$

where  $0 < \alpha < 1$  captures the degree of agent's inequity aversion. Each agent compares principal's  $R_j - w_j$  to her own  $w_j$  in case of individual production whereas principal's  $R_j - 2w_j$  to her own  $w_j$  in case of team production.<sup>20</sup>

Since we focus on contracts where limited liability binds, we will have  $w_f = 0$ . Also for notational convenience we denote  $w_s = w$ . Thus the agent gets  $w$  in case of success and zero wage in case of failure. The above set of assumptions makes our analysis and findings tractable and therefore should not be viewed as a drawback of our analysis.

A point worth noting is that since we are in a single project framework and there is only one project signal, the agents get same wage depending on the project signal. Thus the

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<sup>20</sup> One can introduce the above preferences as "all individuals in the society have identical Fehr and Schmidt (1999) preference with  $\alpha > \pi$  where  $\alpha$  is the coefficient for non-favorable inequity aversion and  $\pi$  is the coefficient for favorable inequity aversion".

That is all individuals have preferences like

$$u_1(x_1, x_2) = x_1 - \alpha \max\{x_2 - x_1, 0\} - \pi \max\{x_1 - x_2, 0\}$$

$$u_2(x_1, x_2) = x_2 - \alpha \max\{x_1 - x_2, 0\} - \pi \max\{x_2 - x_1, 0\}$$

where  $u_1$  is the utility of player 1 and  $u_2$  is the utility of player 2.  $x_1$  and  $x_2$  denotes the net payoffs of player-1 and player-2 respectively. Defining player-1 as the principal and player-2 as the agent and given that the principal is never behind we get  $x_1 - x_2 \geq 0$  and therefore  $x_2 - x_1 \leq 0$ . Thus the preferences effectively become

$$u_P(x_1, x_2) = x_1 - \pi (x_1 - x_2)$$

$$u_A(x_1, x_2) = x_1 - \alpha (x_1 - x_2)$$

where P and A denote principal and agent(s) respectively. This structure is exactly what we have above. Here we do not need the assumption  $\alpha > \pi$  since it does not affect any of our results.

question of agents having social preferences among each other does not really arise. Therefore, in this paper, we only have vertical social comparison, horizontal social comparison among agents is not possible.

Given the above, we now go over to the analysis of individual vis-à-vis team production. The inequity-averse principal has two effects. First is the ‘direct positive’ effect where the principal’s utility increases with reduced wage payment. But there is a ‘negative indirect’ effect which comes from her inequity aversion. Since the principal is never behind, reduced wage payment will make her more ahead and that will lead to a fall in utility. If  $\pi$  is sufficiently large then the ‘negative indirect’ effect will dominate and at the optimum the principal will offer higher wage(s) to the agent(s). Therefore, in this situation, the incentive compatibility of the agent(s) will not bind. But when  $\pi$  is not that large, the ‘negative indirect’ effect will be outweighed by the ‘direct positive’ effect and the principal will find it optimal to pay as less as possible. Thus, when  $\pi$  is not that large, the incentive compatibility constraints of the agent(s) which are  $q_2\{w - \alpha(R - 2w)\} - 2c \geq q_0\{w - \alpha(R - 2w)\}$  in case of individual production and  $p_{11}[w - \alpha(R - 3w)] - c \geq p_{01}[w - \alpha(R - 3w)]$  in case of team production, will bind at the optimum. Therefore, as we proceed, we need to consider the above two possibilities. First, where the principal is moderately inequity-averse in the sense  $\pi < \frac{1}{2}$  and the other is when the principal is sufficiently inequity-averse and therefore  $\pi \geq \frac{1}{2}$  holds.<sup>21</sup> We first consider the case where  $\pi < \frac{1}{2}$  holds.

## 2.2: Case 1: $\pi < \frac{1}{2}$ holds.

When  $\pi < \frac{1}{2}$  holds the principal’s payoff increases with reduced wage in both forms of production and therefore the optimum wage will be determined from the binding incentive

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<sup>21</sup> These thresholds values came be found from the preference functions of the principal (see equations 1(a) and 1(b)).

compatibility constraint(s) of the agent(s). We examine individual production and team production under such a scenario.

### 2.2.1. Individual Production:

In case of individual production the principal engages a single agent for her project. The expected payoff functions of the principal and the agent in individual production will look like the following:

$$U_P^{IP} = q_2[R - w - \pi(R - 2w)] \quad (3a)$$

$$U_A^{IP} = q_2[w - \alpha(R - 2w)] - 2c \quad (3b)$$

The superscript *IP* stands for individual production. Given the above, it will be incentive compatible for the agent to put in  $e = 2$  over  $e = 0$  iff  $q_2\{w - \alpha(R - 2w)\} - 2c \geq q_0\{w - \alpha(R - 2w)\}$  holds, which boils down to  $w \geq \frac{2c + \alpha R(q_2 - q_0)}{(1 + 2\alpha)(q_2 - q_0)}$ . Therefore the principal will

optimally offer  $w^* = \frac{2c + \alpha R(q_2 - q_0)}{(1 + 2\alpha)(q_2 - q_0)}$  in case of success and zero in case of failure. Therefore the principal's net expected payoff in case of individual production will be

$$U_P^{IP} = \frac{q_2}{(1 + 2\alpha)} \left[ R(1 + \alpha - \pi) - \frac{2c(1 - 2\pi)}{(q_2 - q_0)} \right] \quad (4)$$

### 2.2.2. Team Production:

In case of team production the expected payoff functions of the principal and each agent will look like the following:

$$U_P^{TP} = p_{11}[R - 2w - \pi(R - 4w)] \quad (5a)$$

$$U_A^{TP} = p_{11}[w - \alpha(R - 3w)] - c \quad (5b)$$

We conduct similar exercise in case of team production as well. Conditional on the other agent putting  $e = 1$ , it is incentive compatible for an agent to put  $e = 1$  over  $e = 0$  iff  $p_{11}[w - \alpha(R - 3w)] - c \geq p_{01}[w - \alpha(R - 3w)]$ , i.e. if  $w \geq \frac{c + \alpha R(p_{11} - p_{01})}{(1 + 3\alpha)(p_{11} - p_{01})}$  holds. Thus, in

case of team production the principal will optimally offer  $W^* = \frac{c + \alpha R(p_{11} - p_{01})}{(1 + 3\alpha)(p_{11} - p_{01})}$  to each agent in case of success and zero in case of failure. Plugging it into the principal's net expected payoff function we get the optimal expected payoff of the principal in case of team production as

$$U_P^{TP} = \frac{p_{11}}{(1 + 3\alpha)} \left[ R(1 + \alpha - \pi + \alpha\pi) - \frac{2c(1 - 2\pi)}{(p_{11} - p_{01})} \right] \quad (6)$$

Before going into our first result we state the following lemma:

**Lemma 1:**

*Given  $R$  sufficiently large, both  $w^*$  and  $W^*$  are increasing in  $\alpha$ .*

The above lemma can be explained as follows: As  $\alpha$  increases the agent(s)' inequity aversion increases and this leads to a fall in the agent(s)' payoffs. Thus, the principal needs to pay an increased wage to address the inequity concern of the agent and also ensure that at the optimum the incentive compatibility constraint binds, ensuring that the desired effort being elicited. Thus both  $w^*$  and  $W^*$  increases with a ceteris paribus increase in  $\alpha$ .

Comparing (4) and (6) we can state our first proposition:

**Proposition 1:**

*An inequity-averse principal interacting with inequity-averse agent(s) can prefer team production over individual production even without synergy ( $p_{11} \leq q_2$ ) only if the principal's and the agent(s)' inequity aversions are not that low. This is a necessary condition. Otherwise the inequity-averse principal will prefer individual production over team production without synergy.*

**Proof:** Without synergy ( $p_{11} \leq q_2$ ) we get  $(p_{11} - p_{01}) < (q_2 - q_0)$  since  $p_{01} > q_0$ . Also

$\frac{p_{11}}{(1 + 3\alpha)} < \frac{q_2}{(1 + 2\alpha)}$  and  $\frac{2c(1 - 2\pi)}{(p_{11} - p_{01})} > \frac{2c(1 - 2\pi)}{(q_2 - q_0)}$  holds. Comparing (4) and (6) we get that the only

way  $U_P^{TP} > U_P^{IP}$  can hold is if  $R\alpha\pi$  is sufficiently high given  $\pi > 0$  and  $\alpha > 0$ . This can only

happen if both  $\pi$  and  $\alpha$  are not that low. Otherwise an inequity-averse principal will certainly prefer individual production over team production. **QED**

The intuition of the above proposition can be provided as follows: First, if  $p_{11} \leq q_2$ , the team doesn't have synergy and in both the team production and individual production total effort elicited is 2. But to elicit this total effort the principal needs to pay higher total incentive in case of team production over individual production. Thus without bringing in social preferences, without synergy, the principal will choose individual production over team production and this is in essence one of Che and Yoo (2001)'s main result. But if we bring in social preferences things can change. Note that as  $\pi$  increases the principal loses more from inequity aversion in case of individual production than team production since the principal is paying more to the team and is less ahead of the team. This tilts the choice in favour of team production for an inequity-averse principal and therefore with increased  $\pi$  the principal might prefer team production over individual production. If inequity aversion ( $\alpha$ ) of the agent(s) increases then both  $w^*$  and  $W^*$  increases and that raises the cost of the principal in both team and individual production. But this incremental wage increase is more for team production (since wage is paid to both agents) than individual production and therefore an increase in  $\alpha$  hurts the principal more directly in case of team production at the margin. There is a positive effect also since this leads to reduced inequity for the principal at the margin and here the inequity is reduced more in case of team production than in case of individual production. For not so high  $\alpha$  the first effect dominates and the principal is hurt more in case of team production from direct wage increase. Thus for lower  $\alpha$  the principal is likely to prefer individual production over team production. On the other hand, for sufficiently high  $\alpha$  the second effect dominates. Put differently, a sufficiently high  $\alpha$  will tilt the choice in favour of team production and this might happen even without synergy. Thus, overall, the choice between team and individual production crucially depends on the principal's inequity

aversion ( $\pi$ ) and the agent(s)' inequity aversion ( $\alpha$ ). If both  $\pi$  and  $\alpha$  are positive and not too low, the principal will optimally choose team production, otherwise the principal will opt for individual production, without synergy.

The above result shows that even in the static setting, even without synergy, an inequity-averse principal might choose team production. Thus without going into a dynamic setting, in a static framework the existence of team production can be justified. This is an important distinction of this paper compared to Che and Yoo (2001) which rationalized team production in terms of repeated interaction whereas we put forward an additional rationale, viz. the existence of social preferences.

Interestingly, if any one of principal's and agent(s)' inequity aversion becomes very low, i.e. any one effect of inequity aversion goes to zero, without synergy the principal will always prefer individual production. This is captured in the following corollary which is immediate from proposition 1.

**Corollary 1:**

(a). *An inequity-averse principal interacting with self-regarding agent(s) will certainly prefer individual production over team production without synergy. This is a sufficient condition.*

(b). *A self-regarding principal interacting with an inequity-averse agent(s) will certainly prefer individual production over team production without synergy. This is a sufficient condition.*

**Proof:**

(a). When  $\pi > 0$  and  $\alpha = 0$  the payoffs from individual production and team production will be  $U_P^{IP} = q_2 \left[ R(1 - \pi) - \frac{2c(1-2\pi)}{(q_2 - q_0)} \right]$  and  $U_P^{TP} = p_{11} \left[ R(1 - \pi) - \frac{2c(1-2\pi)}{(p_{11} - p_{01})} \right]$  respectively.

Without synergy ( $p_{11} \leq q_2$ ) we get  $(p_{11} - p_{01}) < (q_2 - q_0)$  and therefore  $U_P^{IP} > U_P^{TP}$ . Thus, without synergy, an inequity-averse principal will certainly prefer individual production over team production.



(b). When  $\pi = 0$  and  $\alpha > 0$  we get  $U_P^{IP} = \frac{q_2}{(1+2\alpha)} \left[ R(1 + \alpha) - \frac{2e}{(q_2 - q_0)} \right]$  and  $U_P^{TP} = \frac{p_{11}}{(1+3\alpha)} \left[ R(1 + \alpha) - \frac{2c}{(p_{11} - p_{01})} \right]$  respectively. Once again, with no synergy ( $p_{11} \leq q_2$ ) we certainly get  $U_P^{IP} > U_P^{TP}$  and therefore a self-regarding principal will certainly prefer individual production over team production. **QED**

The above result implies that, without synergy, for team production to be preferred over individual production both the inequity aversion of the agent and the principal needs to be non-trivially positive. Anyone having high inequity aversion and the other having low inequity aversion might not suffice for the optimality of team production over individual production in the absence of synergy and in that situation we get back the Che and Yoo (2001) result.

Given the above analysis we now go over to the situation where the principal is highly inequity-averse.

### 2.3. Case 2: $\pi \geq \frac{1}{2}$ holds.

In this situation, the principal will find it optimum to offer  $w^* = \frac{R}{2}$  in case of individual production such that the loss from inequity aversion is completely eliminated. Since  $R$  is sufficiently large this contract will be incentive-compatible.<sup>22</sup> Thus the inequity-averse principal's payoff under individual production will be  $U_P^{IP} = q_2 \left[ R - \frac{R}{2} \right] = \frac{q_2 R}{2}$ . In case of team production the principal will offer  $W^* = \frac{R}{4}$  to both the agents such that at the optimum the effect of inequity is eliminated.<sup>23</sup> The principal's payoff under team production will be  $U_P^{TP} = p_{11} \left[ R - \frac{R}{2} \right] = \frac{p_{11} R}{2}$ . Thus  $U_P^{TP} > U_P^{IP}$  only if  $p_{11} > q_2$ . This implies that if the team has synergy only then a sufficiently inequity-averse principal will opt for team production

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<sup>22</sup> We need  $R \geq \frac{4c}{(q_2 - q_0)}$  to hold.

<sup>23</sup> We need  $R \geq \frac{4c}{(1-\alpha)(p_{11} - p_{01})}$  for this wage to be incentive compatible in case of team production.

over individual production and this is necessary as well as sufficient. Otherwise, a sufficiently inequity-averse principal will opt for individual production.

The above discussion can be summarized succinctly in our next result.

**Proposition 2:**

*With inequity-averse agent(s), a sufficiently inequity-averse principal will prefer team production over individual production if and only if the team has synergy. Otherwise the principal will prefer individual production.*

**3. Repeated Interaction:**

Thus far we have assumed a static setting where the agents choose effort only once. In this section we consider the strategic interaction of the two agents in a dynamic setup. Specifically, we examine what happens when the agents choose efforts repeatedly (over infinite periods) where the agents can monitor efforts mutually. Similar to Che and Yoo (2001), in case of team production, we assume a trigger strategy for each agent which is: “start and keep playing ‘work’ until an agent shirks in a previous stage, in which case both play ‘shirk’ repeatedly thereon”. For the sake of simplicity we assume that the agents have a common discount factor  $0 < \delta \leq 1$ .

Before proceeding further, three comments are warranted at this point which are also there in Che and Yoo (2001). First, we assume that the agents observe each other’s efforts in each period due to their proximity. The principal can only observe whether the project succeeds or fails which is an imperfect signal of the agents’ efforts and cannot directly communicate with the agents about their efforts. Second, in this dynamic set up the agents only interact through their effort decisions and we rule out side payments or side contracting between the agents. Third, the wage scheme is assumed to be ‘memory-less’ (Chiappori et.al.

(1994)) in the sense that the wage scheme chosen initially applies to all subsequent periods.<sup>24</sup>

This final assumption makes the comparison between individual production and team production easier. The rest remains the same.

Given the above, first consider the case where  $\pi < \frac{1}{2}$  holds. The result of individual production will remain the same as in the previous section in each stage since there is a single agent and no strategic interaction exists. Therefore, in every stage, the wage offered will be  $w^* = \frac{2c + \alpha R(q_2 - q_0)}{(1 + 2\alpha)(q_2 - q_0)}$  and the principal gets  $U_P^{IP} = q_2 \left[ \frac{R(1 + \alpha - \pi)}{(1 + 2\alpha)} - \frac{2c(1 - 2\pi)}{(1 + 2\alpha)(q_2 - q_0)} \right]$  which is given in equation (4). But with repeated interaction among the agents the team production case will change.

In case of team production, two necessary conditions for the previously mentioned trigger strategy to be subgame-perfect given our structure are as follows: First it must be self-enforcing for both agents to shirk repeatedly given that the other agent shirks, i.e. {shirk, shirk} has to be a Nash equilibrium of the stage game. For this we need,  $p_{00}\{w - \alpha(R - 3w)\} \geq p_{10}\{w - \alpha(R - 3w)\} - c$  to hold which implies:

$$w \leq \frac{c + \alpha R(p_{01} - p_{00})}{(1 + 3\alpha)(p_{01} - p_{00})} = \tilde{w} \quad (7)$$

Second, each agent must not shirk when shirking is punished by repeated shirking by the other agent. This happens if  $p_{11}\{w - \alpha(R - 3w)\} - c \geq (1 - \delta)p_{01}\{w - \alpha(R - 3w)\} + \delta p_{00}\{w - \alpha(R - 3w)\}$  holds which in turn implies that the following must hold:

$$w \geq W^*(\delta) \equiv \frac{c + \alpha R[(p_{11} - p_{01}) + \delta(p_{01} - p_{00})]}{(1 + 3\alpha)[(p_{11} - p_{01}) + \delta(p_{01} - p_{00})]} \quad (8)$$

Condition (7) and (8) together gives the range of wage that can support {work, work}<sup>∞</sup> as a subgame-perfect outcome in this dynamic team game. Given super-modularity  $(p_{11} - p_{01}) > (p_{01} - p_{00})$  we see that  $W^*(\delta)$  satisfies (7) and therefore the range is valid.

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<sup>24</sup> This might restrict the contract space, but this can be justified as an equilibrium response by the principal when she finds it impossible to commit to a long term contract. (For more see Che and Yoo (2001)).

Given the above and the ‘memory-less’ wage scheme, the principal, in each period, maximizes

$$U_P^{TP} = p_{11}[R - 2w - \pi(R - 4w)] \quad (9)$$

Subject to  $W^*(\delta) \leq w \leq \tilde{w}$ .

It is straightforward from (7) and (8) that  $W^*(\delta)$  is the lowest possible wage that ensures  $\{\text{work, work}\}^\infty$  as a subgame perfect outcome in this repeated interaction between agents and is therefore the optimal wage.<sup>25</sup> The optimum expected payoff of the principal will be

$$U_P^{TP}(\delta) = \frac{p_{11}}{(1+3\alpha)} \left[ R(1 + \alpha - \pi + \alpha\pi) - \frac{2c(1-2\pi)}{[(p_{11}-p_{01})+\delta(p_{01}-p_{00})]} \right] \quad (10)$$

Since  $(p_{11} - p_{01}) < (p_{11} - p_{01}) + \delta(p_{01} - p_{00})$ , optimal wage received by an agent under repeated setup is lower than what she gets under the static setup, i.e.  $W^*(\delta) < W^*$  for  $\delta > 0$ . Also note that, given  $R$  sufficiently high, an increase in  $\alpha$  will lead to an increase in  $W^*(\delta)$ . Comparing (10) and (6) one can easily check that the expected payoff of the principal under team production is higher in repeated setup than in the static setup. Thus team production becomes more favourable in the repeated setup. Also as  $\Delta_1 + \delta\Delta_0 = (p_{11} - p_{01}) + \delta(p_{01} - p_{00})$  increases,  $U_P^{TP}(\delta)$  increases implying that as the technology becomes more inter-dependent i.e.  $(\Delta_0, \Delta_1)$  increases, the attractiveness of team production increases under repeated interaction. Therefore, we can state our next proposition:

**Proposition 3:**

*For a moderately inequity-averse principal*

(A). *Under dynamic team production,  $\{\text{work, work}\}^\infty$  is implemented with wage  $W^*(\delta)$  which is lower than the wage  $W^*$  of static setup.*

(B). *Given team production, the principal is better off under repeated setting than under the static setting.*

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<sup>25</sup> For all  $0 \leq w < W^*(\delta)$ ,  $\{\text{shirk, shirk}\}^\infty$  will be the sub-game perfect outcome of this repeated interaction.

(C). *Fix the inequity aversion of the principal and the agents. Compared to the static setting, under repeated interaction the principal is more likely to choose team production over individual production and this holds irrespective of whether the team has synergy ( $p_{11} > q_2$ ) or not ( $p_{11} \leq q_2$ ).*

(D). *Given the memory-less wage scheme, more patient agents (higher  $\delta$ ) make team production attractive compared to individual production.*

(E). *Ceteris paribus, the principal will prefer less inequity-averse agent(s) even in the repeated framework and this holds for both individual and team production.*

When the agents interact repeatedly, the fact that one can punish the other by repeated shirking when any one shirks, helps agents sustain cooperation. Put differently, the possibility that both agents can get the success wage with probability  $p_{00}$  which is much lower than either  $p_{11}$  or even  $p_{01}$  keeps them disciplined and the principal can implement by paying a lower wage. The more the agents care for the future, the lower is  $W^*(\delta)$  and the better it is for the principal. The lower is  $p_{00}$ , the better is team production over individual production. That is, in case of sabotage ( $p_{00} < q_0$ ), team production is relatively more likely over individual production and this supports Lazear (1989)'s conjecture that "sabotage possibility makes Relative Performance Evaluation ineffective" and similar to Che and Yoo (2001) we also get that if  $p_{00}$  is sufficiently low, team production (which is in essence similar to 'joint performance evaluation') is optimal.

Also since repeated interaction increases the principal's payoff from team production, with or without synergy, team production is more likely for a moderately inequity-averse principal. Therefore, in essence, repeated interaction of agents tilts the preference of the principal *relatively* towards team production and this holds across production technologies but for moderately inequity-averse principal. Finally with more patient players (increased  $\delta$ )

the principal can implement  $\{\text{work, work}\}^\infty$  by paying a lower  $W^*(\delta)$  and that increases the attractiveness of team production over individual production. Since patient players value the future more, *ceteris paribus*, cooperation in teams becomes more likely. Also the fact that such strategic interaction is absent in case of individual production and therefore  $\delta$  does not affect the principal's payoff from individual production, makes team production attractive over individual production with increased  $\delta$ .<sup>26</sup>

When the principal is sufficiently inequity-averse ( $\pi \geq \frac{1}{2}$ ), the static analysis of individual production will remain and  $w^* = \frac{R}{2}$  will be offered in every stage. The principal's payoff will be once again  $U_p^{IP} = \frac{q_2 R}{2}$  in every period. In case of team production the same static optimal wage  $W^* = \frac{R}{4}$  will be offered in every stage since the principal finds it optimal to remove inequity altogether. For the trigger strategy to be optimal we need the mild parametric restriction that  $R < \frac{4c}{(1-\alpha)(p_{01}-p_{00})}$ , otherwise  $\{\text{shirk, shirk}\}$  will not be a Nash equilibrium of the stage game.<sup>27 28</sup> Once again, given  $W^* = \frac{R}{4}$  being offered in every stage,  $\{\text{work, work}\}^\infty$  will be the subgame-perfect outcome of this repeated interaction if  $R \geq \frac{4c}{(1-\alpha)[(p_{11}-p_{01})+\delta(p_{01}-p_{00})]}$  holds and given  $\delta > 0$ , the range  $\frac{4c}{(1-\alpha)[(p_{11}-p_{01})+\delta(p_{01}-p_{00})]} \leq R < \frac{4c}{(1-\alpha)(p_{01}-p_{00})}$  exists. Therefore,  $\{\text{work, work}\}^\infty$  as a sub-game perfect outcome is achieved under the trigger strategy and the payoff of the principal will be  $U_p^{TP} = \frac{p_{11}R}{2}$  in every stage. Therefore, the principal will choose individual over team production if and only if the team has synergy which is exactly similar to the condition of the static scenario. Thus for

<sup>26</sup> Once again this is due to the 'memory-less' wage scheme.

<sup>27</sup> This can be calculated from the incentive compatibility constraint of the agent(s).

<sup>28</sup> Given supermodularity  $\frac{4c}{(1-\alpha)(p_{11}-p_{01})} < \frac{4c}{(1-\alpha)(p_{01}-p_{00})}$ . So  $R \geq \frac{4c}{(1-\alpha)(p_{11}-p_{01})}$  and  $R < \frac{4c}{(1-\alpha)(p_{01}-p_{00})}$  together are possible (see footnote 22).

sufficiently inequity-averse principal the incentive for team production remains the same both under static and dynamic interactions.

**Proposition 4:**

*A sufficiently inequity-averse principal's incentive for team production remains the same under both static and dynamic interactions and will prefer team production over individual production if and only if the team has synergy.*

Since a sufficiently inequity-averse principal prefers to remove inequity at the optimum, under both individual and team production, the wage is set accordingly. Thus the effect of strategic interaction among the agents does not play any role in this scenario. As a consequence we get back the results of our static model which is similar to Che and Yoo (2001) since the effect of social preferences is also minimized as well.

**4. Conclusion:**

In this paper we examine how the choice of production organizational structure crucially depends on the social preferences of economic agents. Specifically we look at the choice of individual versus team production where the principal is inequity-averse with respect to the agent(s) and the agents are inequity-averse with respect to the principal. We showed that, in a static framework, a moderately inequity-averse principal interacting with an inequity-averse agent(s) might opt for team production even without team synergy. If the team doesn't have synergy then an inequity-averse principal interacting with self-regarding agent(s) will certainly choose individual production over team production. Similarly a self-regarding principal will definitely choose individual production over team production while interacting with inequity-averse agent(s) without synergy. Under such special cases the principal can only choose team production if and only if the team has synergy. On the contrary when the principal is sufficiently inequity-averse she will choose team production if and only if the

team has synergy and this is a necessary and sufficient condition. Our results point to the fact that in organizations where the employer is inequity-averse, those might go for work teams even without the existence of team synergy. Thus this paper provides an additional rationale for the empirically observed prevalence of team based production in many modern organizations in terms of the possible existence of social preferences. This is a crucial difference of our approach compared to Che and Yoo (2001). In a dynamic framework we show that for a moderately inequity-averse principal, *ceteris paribus*, team production is more attractive over individual production compared to the static framework. Thus this paper predicts that employment practices that work well in short term organizations need not work well in long-term organizations. Long-term employment relationships call for team based production practices compared to short-term employment relationships. But for a sufficiently inequity-averse principal the attractiveness of team production remains the same under both static and dynamic interactions. Thus social preferences crucially affects the choice of team vis-a-vis individual production both in static and dynamic framework and this paper contributes in this direction.

From an empirical point of view the prevalence of team based production now have an additional justification in terms of the existence of social preferences. Even without synergy, controlling for other factors, if team production is observed, one can possibly explore and justify it in terms of the existence of social preferences. A carefully crafted empirical study might throw some light on that.

A comment on ‘status-seeking’ principal deserves special mention. One can easily analyse the incentives of a status-seeking principal by assuming  $\pi < 0$ . A status seeking principal enjoys being ahead and therefore will always prefer to pay the agent(s) less. Thus for a status-seeking principal both the effects mentioned earlier work in the same direction and the principal will optimally set the wage such that the agent(s)’ incentive compatibility constraint



binds. This, in essence, will be similar to the case of  $< \frac{1}{2}$ , i.e. the case of a moderately inequity-averse principal and similar results and intuitions will follow.

Finally, one can think of synergy in a different way also. A job might have two tasks, but the tasks does not have separate outcome signal, only a team signal is available. Given this, is it optimal for the producer to entrust a single agent to carry out both the tasks? Or is it optimal to entrust two separate agents to carry out a task each? If the tasks have strong complementarity, which one can view as ‘synergy with a different interpretation’, then hiring a single individual to perform both the tasks might be optimal. But if the tasks are substitutable, it might be optimal to hire two agents for two different tasks. So, given this interpretation, synergy might lead to individual production. But this is an entirely different perspective of synergy that we are talking about and this might lead to an opposite prediction. In this paper synergy is defined as when the tasks are performed by two individuals is more productive than a single individual performing both tasks, i.e.  $p_{11} > q_2$  and in both cases the aggregate effort is  $e = 2$ . So two individuals have a positive externality on each other’s work and does a better job than one agent doing both. Put differently, a single agent putting in two units of effort is less efficient corresponding to two different agents putting in one unit of effort each with certain positive externality. This view of synergy leads to team production being optimal. Therefore, the alternative view of synergy mentioned above is interesting and a careful analysis of that constitutes our future research agenda.<sup>29</sup>

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