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USING SOCIAL CONNECTIONS AND FINANCIAL INCENTIVES TO SOLVE COORDINATION FAILURE: A QUASI-FIELD EXPERIMENT IN INDIA'S MANUFACTURING SECTOR

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Abstract

Production processes are often organized in teams, yet there is limited evidence on whether and how social connections and financial incentives affect productivity in tasks that require coordination among workers. We simulate assembly line production in a lab-in-the-field experiment in which workers exert real effort in a minimum-effort game in teams whose members are either socially connected or unconnected and are paid according to the group output. We find that group output increases by 18%, and coordination improves by 30-39% when workers are socially connected with their co-workers. These findings can plausibly be explained by the higher levels of pro-social motivation between co-workers in socially connected teams.

JEL Classification: C93, D20, D22, D24, J33

Keywords: caste-based networks, social incentives, Financial incentives, minimum effort game, output, coordination

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Using Social Connections and Financial Incentives to Solve Coordination Failure: A Quasi-Field Experiment in India's Manufacturing Sector*

Farzana Afridi† Amrita Dhillon‡ Sherry Xin Li§ Swati Sharma¶

January 24, 2020

Abstract

Production processes are often organized in teams, yet there is limited evidence on whether and how social connections and financial incentives affect productivity in tasks that require coordination among workers. We simulate assembly line production in a lab-in-the-field experiment in which workers exert real effort in a minimum-effort game in teams whose members are either socially connected or unconnected and are paid according to the group output. We find that group output increases by 18%, and coordination improves by 30-39% when workers are socially connected with their co-workers. These findings can plausibly be explained by the higher levels of pro-social motivation between co-workers in socially connected teams.

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1 Introduction

It is well acknowledged that labor productivity in developing countries is low compared to the developed world (Bloom et al. (2013)). Recent literature has looked inside the black-box of the factory to understand the determinants of worker performance, including the important roles of social networks (Bandiera et al. (2009)), management practices (Bloom et al. (2013)), and worker ethnicity (Hjort (2014)). New research documents significant variation in the productivity of teams within the same factory and its correlation with changes in team composition (Afridi et al. (2019)). In this paper, we investigate whether exogenous changes in social connections between workers in a team, pre-determined by caste and residential segregation, affect individual and group performance in a coordination task using a lab-in-the-field experiment in India's garment manufacturing sector.[1] Unlike the existing literature, our focus is on production processes characterized by complementarities between workers, as in assembly lines in manufacturing units. We not only highlight the potentially positive role of social connections in tasks requiring coordination, but also throw light on the role of financial incentives in improving group productivity and coordination.

Our experiment randomly assigns subjects to teams with or without pre-existing social ties in an incentivized coordination task which replicates assembly line production using garment factory workers as subjects. We make social ties salient through a one shot announcement of the group composition which contains information on workers' caste and residential address. Our experiment is, thus, designed to focus on how the pre-existing connections of co-workers belonging to the same social networks affect coordination and productivity. Furthermore, we examine the role of financial incentives as an instrument for overcoming coordination failure (Brandts and Cooper

[1] As we discuss later, workers also reside in residential neighborhoods that are highly segregated by caste. Same caste workers are, therefore, more likely to belong to the same social networks.

(2006), Brandts and Cooper (2007)) by introducing a lump sum bonus, if a threshold level of group output is produced, that incentivizes a feasible focal point for the workers.

Motivated by the large assembly lines in garment factories in India, where team composition changes frequently due to high worker absenteeism, turnover (Ministry of Textiles, GOI (2018)) and limited scope for communication or repeat interactions among co-workers, we shut down the observability of effort and communication among workers. We, therefore, abstract from peer effects which have been shown to lead to conformism in worker productivity (e.g. Mas and Moretti (2009), Bandiera et al. (2009)). Our experimental design allows us to measure individual and group output simultaneously, giving us a precise measure of coordination or wasted effort within groups directly as a result of our treatments.

In the context of developing countries, where social networks are very strong, the question of how social connections affect productivity is key to the development process (Munshi (2014)). Social ties among co-workers are particularly relevant when workers are organized in groups, such as assembly lines, and when firms are concerned with group rather than individual outputs. In such a setting, if some workers put in low effort it can lead to the entire team being trapped in a low effort equilibrium. Munshi (2014) notes that members of social networks may respond to the threat of social sanctions by sacrificing individual gain (i.e., by incurring higher effort cost) in favor of group objectives. On the other hand, individuals may feel altruistic towards group members or trust co-workers with whom they are socially connected (Basu (2010)), resulting in greater cooperative behavior when they are matched with workers who are in the same social network.

In our setting of a minimum effort production function, subjects respond positively to being with co-workers with whom they have social connections – being in a socially connected group leads to 18% higher *group* output, although *individual* output increases insignificantly relative to the unconnected. Furthermore, there is a 30-39% decline in wasted individual output and within-group output dispersion vis-a-vis an unconnected group. Our findings, therefore, suggest that stronger social connections among co-workers can enhance coordination when incentives are group based. Since we eliminated peer effects and did not allow for any communication within group members in our experiment design, the estimates we obtain here might be a lower bound for the impact of social connections on individual and group productivity in our context (for instance, Menzel (2018) who does allow communication, shows an increase in the assembly-line production in garment factories in Bangladesh).

The impact of our bonus incentive is statistically insignificant overall, suggesting that higher financial incentives neither increase (individual or group) output nor improve within-group coordination, irrespective of social connectedness of the groups. This may not be surprising given the findings of Brandts and Cooper (2006) who show that financial incentives work only to improve coordination if they are large enough, or if agents are allowed to learn over time. Our real-effort minimum-effort game is one shot, which may explain the lack of immediate impact of stronger financial incentives on output and coordination of the group. However, we find that high powered monetary incentives may help increase individual effort of groups which produce below the bonus threshold, irrespective of within-group connectedness.

We show theoretically that our results can plausibly be explained by pro-social behavior driven by network contingent social preferences (Basu (2010), Chen and Li (2009), Chen and Chen (2011)) in socially connected teams.[2] When peer effects and communication channels are absent we argue that the mechanism underlying our

[2]Note that defining social connections based on caste, which is determined at birth, allows us to circumvent any selection issues. For example, social connections that arise endogenously may result in connected groups that are sorted on ability or preferences.

results is beliefs about co-workers' effort levels. When ability levels are heterogeneous the lowest ability worker, who constrains the maximum output of a group, is willing to put in higher effort in the connected group because he internalises the lower cost of other higher ability workers. Thus the *group* output increases due to the higher effort of the lowest ability worker in the socially connected group. Hence *individual* effort, on average, may not be higher in the connected than unconnected groups, but group coordination and output are.

A closely related literature has examined the role of social networks on worker productivity. Bandiera et al. (2010) study a UK based soft fruit producing firm and find that having a more able, self-reported friend as a co-worker increases productivity of lower ability workers by 10% but decreases productivity of higher ability workers. Overall, in the presence of individual piece rates, heterogeneous ability types, and substitutability in production, their findings indicate that social networks may not improve team productivity if peer pressures lead to conformity on a low effort norm. Our research question, in contrast, is centred on understanding whether coordination can improve in assembly lines when workers belong to the same social networks. Thus we focus on the effect of social networks in the absence of peer effects with complementarity in production and team based incentives.

Laboratory experiments on group identity, in general, show that manipulating the saliency of group membership contributes to higher level of within-group cooperation or coordination (Eckel and Grossman (2005), Charness et al. (2007), Goette et al. (2006), Chen and Li (2009), Chen and Chen (2011)). In a rare field experiment on group identity, Hjort (2014), examines the ethnic homogeneity of production teams in a flower assembly plant with a sequential production process in Kenya. He finds that inter-ethnic rivalries in Kenya lowers allocative efficiency in the plant, particularly during a period of ethnic conflict. Shifting from fixed pay to performance pay based on group output reduces allocative inefficiencies in multi-ethnic teams. Unlike this literature, however, our paper does not prime group identity but rather the social connections among team members. Theoretically, our approach yields similar predictions as Chen and Chen (2011), but to the best of our knowledge, this is the first paper to conduct a lab-in-the field experiment with a real-effort task on the minimum effort game.

Our study, thus, attempts to bridge the disconnect between field experiments on social networks and labor productivity, which have focused on non-complementary production functions, and the large literature on laboratory experiments on coordination games.[3] Unlike Bandiera et al. (2009, 2010) who study team incentives when workers are substitutes in production or Hjort (2014) who examines team incentives in settings where production is sequential and there is both substitutability and complementarity in production, our study design is suited to contexts where workers simultaneously engage in a production task and may not be able to observe each other's effort or communicate to coordinate on output.

The findings of our paper not only extend the literature on worker incentives but also speak to the existing research on management practices and firm behavior. First, our results suggest that management practices that create avenues for co-worker interactions to foster affinity among them can further enhance group productivity if individual payoffs are contingent on group output. Second, Brandts and Cooper (2006) show that increasing marginal rewards to effort acts as a coordinating device to move to the efficient equilibrium. Our attempt to replicate the bonus design from

[3]Minimum-effort (or weak-link) coordination game with multiple Pareto-ranked equilibrium effort levels was first introduced by (Van Huyck et al. (1990)), and has been widely used in the laboratory to understand coordination problems faced by organizations (Brandts and Cooper (2006), Weber (2006)). In addition, much of the experimental literature has focused on how to improve coordination and efficiency by altering the payoff structure of the game (Brandts and Cooper (2007), Goeree and Holt (2003), Devetag and Ortmann (2007), Van Huyck et al. (2007)), or by introducing communication (Blume and Ortmann (2007), Brandts et al. (2007), Kriss et al. (2016)) or group identity salience (Chen and Chen (2011)).

the factory settings, however, suggests that the bonus instead creates a focal point which may not always lead to higher group output, unless the threshold for the bonus is sufficiently high. Finally, our findings have implications both for large assembly lines with limited scope for communication and for emerging contemporary work practices such as O-Desk where work is performed in online teams and where face-to-face interactions and scope for communication is limited. In such settings, our results point to the increased productivity from team-based social incentives.

The remainder of the paper is organized as follows. Section 2 outlines the context and background of the study while section 3 discusses the theoretical framework that we take to the data. We describe the experiment design in detail in section 4. The empirical methodology and results are discussed in section 5 while section 6 concludes.

2 Context and Background

Historical and economic factors suggest that formation of social networks based on caste and homophily is salient in the Indian context. Chandavarkar (1994) documents that historically migration to industrial hubs occurred within the framework of caste, kinship, and village connections in India.[4] Migrants to the city lived with their co-villagers, caste-fellows, and relatives and sought work with their assistance (Gokhale (1957), Cholia (1941), Burnett-Hurst (1925)). Thus caste and kinship formed indivisible social networks in the city's working-class neighborhoods. As industrialization progresses, social networks continue to play a significant role in the functioning of labor markets (Afridi et al. (2015a)) and in ensuring migrants' economic mobility in the modern age in low income countries (Munshi (2014), Beaman and Magruder (2012)). Migrants tend to find employment through referrals from their caste-based networks and hence often locate within the same residential units post migration.

[4] 30% of the Indian population has migrated from another part of the country at some point, of which almost 15% migrate for employment purposes (Census, GOI (2011)).

Given this sociological context, we focus on co-worker connections based on the caste system in India.[5]

In our study we draw on India's textile industry, specifically, garment manufacturing, which employed more than 45 million people in 2016-17.[6] Labor-intensive, assembly line production technology is common in garment manufacturing, making it the most prominent employer in manufacturing and also a major contributor to exports not only in India but also in other developing countries such as Bangladesh, Pakistan, and China (Lopez-Acevedo and Robertson (2016)). This sector thus provides a natural choice for advancing our understanding of worker performance in the Indian and other developing country context.

Garment production entails the strongest type of complementarity, and performance of the weakest worker determines overall firm productivity. In a typical garment factory, production is organized into vertical assembly lines, with each line operating as a team. Often these lines have 30-50 workers who can be classified into operators who sit behind one another on sewing machines and are responsible for stitching. Each worker is allotted a machine and is responsible for performing at least one operation, producing a targeted level of output per hour, usually higher than he can achieve.[7] Multiple workers in the assembly line simultaneously produce different pieces of a garment, e.g. while one worker produces collars, another stitches the cuffs of a shirt. With each operation a part of the garment is made. Pieces of

[5]Introduced thousands of years ago, the caste system has continued to socially stratify Indians even today into four hierarchical categories (*varnas*), each of which is further sub-divided into *jatis* having a common origin in terms of occupation, language, and social practices. At the top of the social hierarchy are *Brahmins* (the priestly caste), followed by the *Kshatriyas* (the warrior caste), *Vaishyas* (the trading caste), and finally *Shudras* (the service caste such as farmers and craftsmen) in the *varna* system of social categorization. The caste system is endogamous, and hence one's caste is determined at birth. Inter-caste marriages are virtually non-existent even today (India Human Development Survey, 2014 (https://ihds.umd.edu/)).

[6]Ministry of Textiles, GOI (2018), (http://www.texmin.nic.in/study-garment-sector-understand-their-requirement-capacity-building)

[7]Our ongoing research on garment factories in the National Capital Region suggests that tight work schedules do not permit workers to check on the performance of other workers in the line – indeed workers barely get a few minutes to have their lunch.

the garment are then assembled to produce the entire apparel, viz. a shirt. The line composition changes across work days due to absenteeism and turnover amongst primarily migrant workers (more than 65% of the workforce in the National Capital Region (NCR) factories). Thus communication and repeated interactions among co-workers play a limited role in generating workplace cooperation. Workers are aware of co-workers located physically close to them in the line even though they may not know the composition of the entire line. Managements often offer lump sum bonuses if a threshold level of output is reached by an assembly line to encourage workers to meet production targets, particularly since low worker productivity is quite common.

Using worker-level productivity data gathered from two garment factories in the National Capital Region (NCR) of Delhi, Afridi et al. (2019) find significant variation in the productivity of workers and assembly lines across production days. Taking advantage of the idiosyncratic variation in the daily caste composition (as a proxy for workers' social ties) of assembly lines due to worker absenteeism, they show that the higher the proportion of own caste workers in the line (Figure 1a) and the more homogeneous the caste composition of the line on a work day (Figure 1b), the higher the productivity of the worker and the assembly line on that day. In Table A1 in Appendix A, using garment factory data Afridi et al. (2019) show that a 1 percentage point increase in the caste homogeneity of the assembly line increases individual worker efficiency by 9.5-10 percentage points and the efficiency of the assembly line by 11-16 percentage points. This is robust to individual and assembly line fixed effects, respectively.[8] It suggests that pre-existing social connections among co-workers, mediated through caste, can indeed have a significant impact on group productivity.

There are, however, several channels that could generate the above observations

[8]Note that the average worker efficiency is low at about 31.2%. There are insignificant differences in productivity by caste groups (Table A2, Appendix A).

– peer effects, social preferences or information on co-worker ability. In this paper, we highlight the role of pro-social motivations among socially connected workers as a salient feature that affects output and coordination within groups. We formally elaborate on the challenge of coordinating workers' effort in a minimum effort game in our theoretical model next.

3 Theory

Motivated by the stylised facts in Section 2, we build on a version of the coordination problem in a minimum effort game (Van Huyck et al. (1990)), which captures the strong complementarities in an assembly line setting.[9] In the standard minimum effort game, workers are homogeneous and choose effort to maximize their own payoffs which depend on group production, which in turn depends only on the lowest effort (output) among workers. The game has multiple Nash equilibria which can be Pareto ranked. Thus groups that are able to coordinate on a higher ranked equilibrium perform better. In our modification, we introduce heterogeneous (ability) types, which is more realistic in our setting and also allows us to distinguish between group and individual effort, as well as conceptualise wasted effort in symmetric equilibria.

Formally, workers are characterised by – first, their ability type: high ability denoted by $\bar{\theta}$ and low ability denoted by $\underline{\theta} < \bar{\theta}$, and second, their social connectedness.[10] Workers may or may not be socially connected to co-workers depending on their caste, i.e. High (**H**), Middle (**M**) or Low (**L**) caste, and residential location – as in our experiment. We assume that there is perfect information on the game and that the distribution of ability is the same across caste groups (as confirmed by our data, see

[9]We consider a one-shot game to account for the low scope for communication or repeat interactions among co-workers due to daily changes in group composition in garment factories.

[10]Formally, we do not need to assume heterogeneity in ability – workers can be heterogeneous in the degree of pro-social motivation as well. In this case, our key assumption would be that the distribution of social preferences for connected workers first order stochastically dominates the distribution for unconnected workers. The results would be qualitatively the same.

Table A2, Appendix A). In addition, workers are equally likely to be low ($\underline{\theta}$) or high ability ($\bar{\theta}$).

Workers are matched randomly on ability to form teams of size 2. Teams can be either socially connected, i.e. belong to the same social network (defined by same caste and residence), or unconnected (where caste types are mixed). Thus a high (low) ability worker is equally likely to be matched with a high or low ability worker, implying that the ability distribution is the same between connected and unconnected teams. The ability match between two workers in the (connected or unconnected) team is either *homogeneous*, i.e. $\theta_i = \theta_j$, or *heterogeneous* i.e $\theta_i \neq \theta_j$.[11] Note that homogeneous teams can be either high ability or low ability. Workers choose effort $e_i \in \{\bar{e}, \underline{e}\}$, where $\bar{e} > \underline{e} > 0$. Each worker produces individual output $y_i = \theta_i e_i$. The production function is a minimum output one: group output is equal to the minimum production across workers in the team, $Y = min[\theta_i e_i, \theta_j e_j]$.

The salient characteristic of social networks that we focus on in the model is the degree of pro-social motivation towards other team members. This takes the form of maximizing a weighted sum of one's own payoff and the other player's payoffs, with weights α_i and $1 - \alpha_i$, respectively. It is formally the same as a group-contingent social preferences model that has been shown (theoretically) to increase cooperation/coordination in groups with salient group identity (see e.g. Basu (2010), Chen and Chen (2011), Chen and Li (2009)). Such pro-social motivation is present to a lesser degree in the socially unconnected groups.[12] α_i reflects the degree of selfishness of worker i. We will assume that $\alpha_i = \alpha_j$ for all members i, j in a group. Thus,

[11] Of course, in reality there will never be cases where all workers have exactly the same ability but this is a stylised representation of two different cases: one where the difference in ability between workers is small and the other when it is relatively large.

[12] Laboratory experiments on coordination allow for repetitions of the game to check convergence to different equilibria. In contrast, we have a one shot announcement of group composition because our main interest is to understand how knowledge of group composition affects worker productivity and coordination. This is why much of the analysis is framed in terms of the probability of converging to a particular equilibrium.

denote by α^C (α^U), the weight on own payoffs for connected (unconnected) groups. We have $\alpha^C < \alpha^U$.[13] In effect this implies that the marginal cost of effort is lower for the connected group ($c\alpha^C < c\alpha^U$). We assume that the utility function for worker i is $U_i = \alpha_i(DY - ce_i) + (1 - \alpha_i)(DY - ce_j) = DY - c(\alpha_i e_i + (1 - \alpha_i)e_j)$.[14] $c > 0$ is a constant that affects the marginal cost of effort, and $D > 0$ measures the strength of financial incentives (group based piece rates).

In Table 1 we depict the game between workers who can either be socially connected or not, when the match is homogeneous, $\theta_i = \theta_j$.[15] In the standard minimum effort game, when $\alpha_i = 1$, it is well known that when $D\underline{\theta} - c > 0$, there are two symmetric pure strategy Nash equilibria: one where both players coordinate on the higher effort, another where they coordinate on the lower effort, as well as a mixed strategy equilibrium. This result carries over to our homogeneous game, even when $\alpha < 1$. Both pure strategy equilibria are stable. Which equilibrium is more likely to occur depends on the basin of attraction. Let p_j denote the probability on high effort by player j and $EU_i(e)$ denote the expected utility of player i when his effort level is e. Let $\underline{p} = \{\min p_j | EU_i(\bar{e}) > EU_i(\underline{e})\}$, where $\underline{p}$ denotes the minimum expected probability (belief) of the opponent playing high effort, which would lead to each player playing high effort.[16] $\underline{p}$ is increasing in the rewards to high effort – D and θ – and decreasing in c and α.

For our purposes, the key parameter is α which affects the beliefs about other workers choice of effort. Thus the lower is α, the lower is $\underline{p}$ and the higher the beliefs

[13] Note that modelling social preferences in an additive way is not necessary for the results – we only need that the cost of effort is lower when the partner is from the same network, see e.g. Bandiera et al. (2010) who also model social preferences in worker productivity in the same way.

[14] For n players the corresponding utility function is a convex combination of own payoff and the average payoff of other players.

[15] We use linear payoffs as this is a tractable way to show our results and this is the format that has been used in the literature on minimum effort games.

[16] Note that by symmetry of the game, $\underline{p}$ is the same for both players if they are of the same type.

about others putting in high effort.[17] The lower is $\underline{p}$ the more likely it is that the high effort equilibrium is selected – this is because players believe that others are more likely to choose high effort, which in turn creates positive incentives to choose high effort themselves. Clearly, coordination on the high effort equilibrium is higher when $\underline{p} \to 0$, and coordination on the low effort equilibrium is higher when $\underline{p} \to 1$. We denote by $\underline{p}^U$ ($\underline{p}^C$) the minimum expected probability (belief) of the opponent playing high effort, in the unconnected (connected) game. We will say that coordination is higher for a selected equilibrium when the corresponding condition on $\underline{p}$ is satisfied. For example, if the selected equilibrium is the high effort equilibrium then coordination is higher on high effort for the connected group if and only if $\underline{p}^C < \underline{p}^U$.[18]

Next, we depict the game when the match between workers is heterogeneous in Table 2. The row player is assumed to have low ability, and the column player has high ability. We assume that $\bar{\theta}\underline{e} > \underline{\theta}\bar{e}$. Assuming, without loss of generality, that $\frac{D\underline{\theta}}{c} > \alpha$, it turns out that this game has a unique equilibrium where the low ability worker plays $\bar{e}$, and the high ability worker plays $\underline{e}$.

Exploiting the fact that unconnected groups have relatively higher marginal costs from higher effort than connected groups, we show that under some conditions on α^C and α^U equilibrium selection in the connected group leads to higher group output (across the four possible ability matches) and lower wasted output, on average, than the unconnected group. However, though average individual output (across the four possible ability matches) is higher in the connected group for the low ability worker,

[17] Even if we assumed that a single player has pro-social preferences and this is common knowledge, we would still get a higher push towards the high effort equilibrium. To see this, note that in the limit as $\alpha_j \to 0$ it becomes a dominant strategy for the other player to choose $\bar{e}$ and given that, the optimal choice for own effort is also $\bar{e}$. Besides reducing own cost of effort, pro social motivation also reduces strategic uncertainty.

[18] If one group is more likely to choose high effort while the other is more likely to choose low effort we can still compare coordination in the two groups by checking whether $\underline{p}^j$ is greater or smaller than $(1 - \underline{p}^k)$ for two groups j and k.

for the high ability worker it is no different in connected and unconnected groups.[19]

Intuitively, note that the returns from putting in high effort depend on (a) the probability that the worker affects the outcome (i.e., is pivotal) – this is lower for the high ability type than the low ability type, given our assumption that $\bar{\theta}\underline{e} \geq \underline{\theta}\bar{e}$, (b) conditional on being pivotal, the returns from high effort – these are higher for high ability type than the low ability type. Finally, note that the marginal costs of high effort are lower for connected groups than unconnected groups. The difference in marginal costs together with (a) and (b) imply that group output is higher for connected groups because it is the low ability worker who determines group output more often than the high ability worker (i.e. low ability worker is pivotal and has lower cost in the connected group). High ability workers are not as affected by the difference in marginal costs because they are less likely to be pivotal, and, even when they are, they anyway have higher marginal benefits from high effort.

Claim 1 in Appendix B shows that when the parameter values satisfy $\alpha^U > \frac{D\underline{\theta}}{c} \geq \alpha^C$ then using risk dominance for equilibrium selection, the connected group has on average higher group output than the unconnected group, driven by the difference between α^C and α^U (and corresponding marginal costs). Moreover, wasted effort is lower in the connected group because the low ability worker is putting in high effort in the connected heterogeneous match, as opposed to low effort in the unconnected heterogeneous match ($\bar{\theta}\underline{e} - \underline{\theta}\bar{e} < (\bar{\theta} - \underline{\theta})\underline{e}$). However, the cost advantage may not be as important in the case of the homogeneous high ability match. Here the returns to high effort are higher since $\bar{\theta} > \underline{\theta}$, and each player is pivotal. Therefore, the cost difference between connected and unconnected games is less important leading to high group and individual output for both groups in this match. As a result, the high ability type chooses high effort in the homogeneous game, regardless of being

[19]The full characterisation of equilibria along with proofs is provided in Appendix B.

connected or not, as long as $\alpha^U < \frac{D\bar{\theta}}{2c}$. Together with the fact the the high ability worker chooses low effort in the the heterogeneous match, we have that there is no difference in the effort (output) of the high ability worker when comparing connected and unconnected games. This leads to our two main predictions:

(1) *Socially connected groups coordinate on a higher group output on average (across all possible ability matches) than unconnected groups. Individual output is higher on average in connected groups, but only for low ability workers.*

(2) *Wasted output is lower on average (across all possible ability matches) in connected groups than unconnected groups.*

In our experiment, we introduce a lump sum bonus, B, which is given when team output is above a certain threshold, T. The bonus increases the marginal gain when moving from below threshold to the threshold output, thus it will increase incentives for higher effort at this point only. In general, it will have an effect only if the group was producing below the threshold, and the group has sufficiently low marginal costs. Therefore, whether socially connected groups perform differently from unconnected groups depends on the exact location of group output before the bonus. Given the nature of the coordination game, however, and the importance of beliefs on other workers' effort levels, a second effect of the bonus is to create a focal point for individuals to coordinate at. This leads to our third prediction:

(3) *A discrete lump sum bonus given above a threshold level of output will increase the output of groups/individuals who were producing below T before bonus, if it is sufficiently large relative to the marginal cost of effort. If the threshold creates a focal point, it implies, in addition, that it leads to an increase (decrease) in output of those groups/individuals who were producing below (above) T to begin with.*

These results can be generalized to more than 2 workers and multiple effort levels (for proof and extensions see Appendix B).

In the real world, there can be several mechanisms that can result in higher team output and better team coordination, as discussed previously. We therefore design a controlled lab-in-the field experiment described in detail next.

4 Experiment Design

Since our research question is how team productivity is influenced by workers' social connections and financial incentives, our lab-in-the-field experiment (Harrison and List (2004)) uses a 2x3 factorial, between-subject design. Each session consisted of a work team of 4 subjects of the *same* gender. In the Socially Connected treatment, the team had the same caste based network. In the Socially Unconnected treatment, the team members belonged to different caste based networks. In addition, we used two different incentive schemes – Piece Rate and Bonus (with two different framings—Gain Framing and Loss Framing). The experimental design is outlined in Table 3. We conducted both men and women only sessions in our experiment but focus on the men only sessions due to the cultural constraints in priming women's social connections.[20]

Subjects and recruiting The subjects of our experiment were garment factory workers, with at least primary education, in the NCR's garment factory hub. The experiment was conducted between May and July 2016. Recruiting pamphlets were distributed among the workers during our visits to their factories and residential clusters (see Figure A1, translated from Hindi into English, in Appendix A). The advertisement mentioned Rs.200 as participation fee which was about the

[20]We conducted 64 women only sessions (30 Socially Connected and 34 Socially Unconnected). We exclude these sessions from our analysis for two reasons. First, in India's patriarchal society women are typically referred to using a generic last name of *Devi* or *Kumari* (i.e. lady or girl) which would not signify their *jati* to other group members. Since caste is determined by birth and inter-caste marriages are virtually non-existent even today, we primed caste-based social connections by announcing a woman's first and generic last name followed by the first and last name of the man whose wife or daughter she was, and her residential address. Since our priming for women is indirect it may not be salient enough to activate her social connection. Second, safety concerns and restricted physical mobility of women due to which most women came to the sessions accompanied by other women they knew. Hence the probability of knowing someone even in the socially unconnected group was high for women.

daily wage of garment factory workers in our sample.[21] Workers registered over phone, and the information on their residential address, native state, caste, sub-caste or *jati*, and gender were collected at the time of registration.

We classified subjects on two dimensions to proxy for social networks. First, each subject was categorized according to his *jati* into one of the three main caste groups using the official categorization by his native state: (1) **L** type consisted of the historically marginalised *jatis* that belonged to Scheduled Castes (SC), the lowest in the social hierarchy; (2) **M** type constituted the other backward castes (OBC) that were socially and economically disadvantaged; and (3) the **H** type were subjects whose *jatis* belonged to the high castes.[22]

The second dimension of subject categorization was current residence. A residential cluster, in our context, represented a lane or *mohalla* in a particular worker colony. For instance, lane number 7 of Kapashera slum formed a residential cluster in our study. Visits to residential clusters during the study indicated that migrant workers of the same *jati* and native village resided in the same neighborhood. Hence the probability of workers sharing the same caste ethnicity and being socially connected as friends, relatives, and/or co-workers was high if they had the same residential address. To sum, social connections were determined by both caste and residential proximity in our experiment.

Subjects were given a specific date and time to visit the experiment site which was in a building in the garment manufacturing hub where most of these subjects worked. A subject was allowed to participate only once and was required to show his

[21] Note 1 USD was worth Rs.67 approximately in 2016.

[22] Both the L and M type typically have public sector jobs and political positions reserved for them under India's affirmative action policies (Deshpande (2013)). Factory jobs in the private sector are coveted by all castes and social groups of migrants in urban areas. Data collected by us from garment factories in the National Capital Region show that almost 50% of the workers were H type, 30% M type, and the remainder L type.

garment factory employment ID at the time of experiment.

Task and incentives The experimental task involved subjects independently stringing beads on beading wires of a specific length in their private workstations partitioned by opaque curtains. To capture purely the effect of pre-existing social connections and beliefs about other workers in the team, neither communication amongst subjects nor information on the productivity of subjects was made public at any time during the experiment.[23] This design also conforms to the actual factory assembly line setting where workers have low probability of coordinating effort and output level through verbal communications or repeat physical interactions, as discussed in Section 2.

In each session the 4 subjects of a team were randomly assigned ID numbers from 1 to 4 which further mapped into their private workstations and their allotted bead colors - red, blue, green or white. Their ID numbers, workstation numbers, and bead colors were kept private to ensure anonymity of their individual performance throughout the experiment. The subjects were also informed that the identity of individual performances would not be disclosed at any point during or after the session. This was done to be able to assess the role of pro-social motivations on group coordination, as well as rule out threat of social sanction post-experiment as a determinant of effort on the assigned task. Note that since each session consisted of only one group we use the term "session" and "group" interchangeably.[24]

The experiment started with each subject being seated at his assigned workstation with a covered bowl containing beads of a single color and equal size along with a bunch of 20 cm long wires.[25] The subjects were told that their task was to string

[23] See experiment instructions, translated from Hindi into English, in Appendix C.

[24] In each session there was one main instructor and an assistant instructor of different genders. Both instructors were graduate students whose caste categories were kept private throughout the experiment.

[25] The bowl was covered so the bead color could not be seen while the experimental instructions were being delivered.

the wire with the beads in privacy such that the wire was fully covered with beads. The beaded strings of the four colors were to be combined to make bracelets by the experimenter at the end of the experiment. In other words, each bracelet – the team product – consisted of 4 strings of 4 colors, each string made by a subject. Thus, the minimum number of strings (of a color) produced would determine the number of bracelets per team and thus the team output (see Figure A2 in Appendix A for a completed bracelet). By experimental design, therefore, group productivity was determined by the least productive worker of the team.

Once the task was explained and demonstrated using beads and a wire by the experimenter, information on the payoff functions were given. We used two financial incentive schemes – Piece Rate and Bonus (see Table 4). All the payoffs were based on the team output – the number of bracelets.[26] Under Piece Rate every subject received Rs.100 per completed bracelet produced by the team. For instance, if 5 red, 6 green, 4 blue, and 8 white strings were produced in a session the team's output would be 4 bracelets, and the payoff would be Rs.400 for each subject.

Our bonus incentive was motivated by the typical bonus schemes used in garment factories. Managements incentivize production of a target level of group output by offering a discrete bonus if the target is achieved by the line. In view of this factory setting, our experimental Bonus scheme offered each subject a bonus of Rs.150 above and beyond the Rs.100 piece rate if they reached a group output of 5 or more bracelets. This design feature was motivated by our finding in our pilot experiment, using Piece Rate payments, that the median performance of a team was 4 bracelets. We, therefore, used 5 bracelets as the threshold for the Bonus scheme. Given that the average daily wage of the subjects was approximately Rs.200, the bonus incentive was high powered.

[26] Although workers receive fixed wages based on their daily attendance at work in most garment factories in NCR, in the real world factory setting the presence of the assembly line supervisor implicitly creates team based productivity incentives, as the supervisor is interested in line level output.

Since such a scheme could also create a focal level of output, it provided us with a weak test of the impact of financial incentives on raising group output to a feasible level.

The Bonus framing used was different, however. Under Bonus with Gain Framing, it was announced that if their team made 5 or more bracelets, each team member would receive a coupon of Rs.150 which could be encashed at the time of payment. In contrast, under Bonus with Loss Framing, for instilling a sense of loss, each subject was given a coupon equivalent to Rs.150. But if their team made less than 5 bracelets the Rs.150 coupon would be taken away so they would lose this extra money and only get paid Rs.100 for each bracelet. Every subject in his workstation was given a payoff table corresponding to the assigned incentive scheme. The experimenter gave specific examples that elucidated the calculation of individual payoffs. Before proceeding with the experiment, each subject was provided with a sheet and a pen to answer several questions to ensure their understanding of the payoff calculation.

Social connections To study how team productivity is influenced by workers' social connections at work, we manipulated the caste and residence composition of the 4-person team in the sessions. Subjects were randomly assigned into the Socially Connected and the Socially Unconnected treatments. In a Socially Connected session, all 4 subjects belonged to the same caste category and currently resided in the same residential cluster to ensure that they shared similar social backgrounds. Specifically, they belonged either to the same or similar *jati* in the low caste category (**L** type), the middle caste category (**M** type), or the high caste (or **H** type). In contrast, a Socially Unconnected session consisted of subjects belonging to different caste categories and different residential clusters. We used the following criteria in selecting four subjects for the Socially Unconnected sessions – one L, one

M, and one H type. The fourth subject could belong to any of the three types.[27]

One crucial part of our design was to make the subjects aware of the caste composition and thereby the strength of social connections of their work team. Since in India the last name of a person reflects the *jati* (i.e., sub-caste) of an individual, this was done through public announcements of each subject's name and residential address. After ensuring that the task and payoffs had been clearly understood by the subjects, the experimenter announced in public the first and last name as well as the residential address of each subject with the workstation curtains drawn apart so that the subjects could see each other. Each subject raised his hand when the name was called.[28] Note that the degree of social connections of the team was made public in both the Socially Connected and the Socially Unconnected treatments. Subjects were not matched solely on caste identity but on both caste and residential status. Hence we made social connections, rather than identity, salient.[29]

Procedure Once the task was explained and the experimenter announced the subjects' names and addresses, curtains were drawn and subjects remained in separate, adjacent work stations during the rest of the experiment. Subjects were then asked to remove the cover on the bowls containing their allotted color of beads and practice the beads stringing task with one string. Thereafter, 10 minutes were given to subjects to string beads in as many wires as they desired. After 10 minutes, beaded wires were collected one by one by the experimenter in an opaque envelope and kept in front of the workstations on a desk.

[27]For instance, a socially connected session of M type may have consisted of 4 Yadav *jati* or 3 Yadav and 1 Kurmi *jati* subjects, all of who are 'other backward castes' in the state of Uttar Pradesh. The within session variation in the *jati* of the 4 subjects in the socially connected sessions was 0.37 as opposed to 1.23 in the Socially Unconnected sessions, different at 1% significance level.

[28]In all sessions the main experimenter followed a prepared script and said the following: "Now I will announce your name and your residential address. As I call out your names please raise your hand. If there is any error in the announcement, please tell us."

[29]Unlike some previous studies that use subjects' names as identity prime (Hoff and Pandey (2006), Afridi et al. (2015b)) this study uses public announcement of names and residential addresses to ensure common knowledge of the caste composition and related social connections among the team members.

Subjects were then requested to complete a post-experiment survey on additional information such as age, caste, religion, employment status, relationship (if any) with their team members, and beliefs about the productivity of co-workers they knew before the experiment.[30] Once all four subjects completed their questionnaires, the partition curtains were drawn apart. The envelopes with the beaded strings were opened one by one, and the number of complete strings of each color was counted without revealing each subject's performance. The number of bracelets produced by the team was determined. Subjects received their payment in cash and were dismissed.

As shown in Table 3, we conducted 67 independent sessions consisting of male subjects, including 33 Socially Connected sessions and 34 Socially Unconnected sessions. Among these sessions, 16 used Piece Rate, and 51 used the Bonus Incentive including 25 sessions with Gain Framing and 26 sessions with Loss Framing. Between-subject design was used, hence no subject participated in more than one session. The experiment lasted about one hour. The average individual output was 4.5 beaded wires, and the average group output was 3.5 bracelets. The average payment was Rs.565.8 (including the Rs.200 participation fee) which was more than twice the average daily wage of the subjects.[31]

5 Data, Methodology, and Results

5.1 Data

The summary statistics from the post-experiment survey are shown in Table 5. Our subjects were approximately 29 years old with almost 89% Hindu. The proportion of Hindus was comparable across treatments.[32] Marginally fewer men had completed

[30]Post-experiment questionnaires, translated from Hindi into English, are attached in Appendix D.

[31]See Appendix E for discussions of the conduct and findings of women only sessions.

[32]In this study, 11% of our subjects were Muslim. Of these, 53% were M type while the remaining were H type. Although the caste system is a feature of Hinduism, social identities are strong even amongst

high school or more in the Socially Unconnected treatments. Almost the entire sample consisted of migrants from outside Delhi of which more than $\frac{1}{2}$ had migrated from the north-eastern state of Bihar. We were successful in recruiting subjects who were currently working (more than 97%), 98.5% of whom were currently employed in garment factories. Subjects' perception of task difficulty did not differ by treatment. Subjects knew almost 2 (1.9 out of possible 3) co-workers by name in the Socially Connected treatments, significantly more than in the Socially Unconnected treatments (by design). 93% (31%) of the known subjects had the same state of origin, 54% (0%) came from the same state-district and 90% (0%) shared their *jati* in the Socially Connected (Unconnected) treatments.[33] There was no variation in the caste group (i.e. H, M and L) of subjects within the Socially Connected treatments as designed. The experiment design was, therefore, effective in creating the connected and unconnected groups. Overall, Table 5 indicates that most of the average subject characteristics are comparable across treatments, which suggests successful randomization of subjects into treatments. In our analyses we, nevertheless, control for the observable characteristics of the subjects that either are different across treatments or may influence the outcomes in our study.[34]

We are interested in two categories of outcomes – output and coordination. They are summarized in Figure 2 for the Socially Connected and Socially Unconnected treatments, respectively. Output is measured at the individual level by the number of completed wires (Figure 2(a)) and at the group level by the minimum individual

religious minorities who are often SCs and STs who converted to Islam or Christianity. In the Socially Connected treatment sessions we held religion constant. Hence, M (H) Muslim subjects were matched with M (H) Muslims. Nevertheless, throughout our analysis we control for religion. Our results are also robust to restricting the sample to Hindus.

[33]The co-subjects known by name in the Socially Connected treatments were most often described as neighbor (94%), followed by friend (84%), co-worker (32%), and relative (30%) in the post-experiment survey which allowed for multiple relationships between subjects (see Appendix D).

[34]In Table A3, Appendix A, we show the average characteristics of subjects by the financial incentive.

performance in each group (Figure 2(b)). Coordination is measured at the individual level by excess individual output (which is individual output minus the group output, Figure 2(c)) and at the group level by within-group output dispersion (which is the standard deviation of individual completed wires within the group, Figure 2(d)). Since an individual's output above and beyond the minimum output of his group is not counted toward the group output any excess individual output would be wasted. Therefore, lower level of excess individual output (or wasted output) or within-group output dispersion signifies better coordination.

Figures 2(a)-(b) show that subjects respond positively to social connectedness by producing a higher level of output both individually ($p < 0.10$) and as a group ($p < 0.05$) in the Socially Connected treatments than the Unconnected ones. Figures 2(c)-(d) show that they also coordinate better, resulting in lower excess output and within-group output dispersion ($p < 0.01$ for both cases), when they are socially connected, rather than unconnected, with their co-workers.[35]

5.2 Empirical methodology and results

We use the following OLS specification to study the impact of social and financial incentives on the above mentioned outcomes:

$$Y_{is} = \alpha_0 + \alpha_1 \mathit{Socially\ Connected}_s + \alpha_2 \mathit{Bonus\ Incentive}_s + \alpha_3 \mathbf{Z}_{is} + \epsilon_{is} \qquad (1)$$

The dependent variable is Y_{is}, i.e., individual *i's* output or excess output in session s, for the individual-level analysis. 'Socially Connected' is a dummy variable for the Socially Connected treatments (with the Socially Unconnected treatments in the

[35] In the Socially Unconnected (Connected) sessions with piece rate, more than 52% (25%) of subjects and more than 88% (71%) of groups produced less than 5 bracelets. 36% of groups made exactly 4 bracelets. Hence there was substantive scope for the lump-sum bonus to raise the average group output to or above 5 bracelets.

omitted category). 'Bonus Incentive' is the treatment dummy variable for the high powered bonus incentive (with Piece Rate in the omitted category).[36] $\mathbf{Z}$ is a vector of individual characteristics such as separate dummy variables for the H and M caste categories (with L in the omitted category), age, religion, native state, employment status, and education. The coefficient α_1 gives an estimate for the average effect of being in a socially connected group on the individual or group outcomes relative to the socially unconnected group, unconditional on the financial incentives. Similarly, the coefficient α_2 provides an estimate of the average effect of the Bonus Incentive relative to Piece Rate, unconditional on the social incentives. The standard errors are clustered at the session (i.e. the group) level for individual-level outcomes.

Equation 1 can be further augmented by incorporating the interaction terms between the social and financial incentives:

$$
\begin{aligned}
Y_{is} &= \beta_0 + \beta_1 Socially\ Connected_s + \beta_2 Bonus\ Incentive_s \\
&+ \beta_3 Socially\ Connected_s * Bonus\ Incentive_s + \beta_4 \mathbf{Z}_{is} + \epsilon_{is} \qquad (2)
\end{aligned}
$$

Note that subscript i drops out for the group-level analysis (i.e., group s's output or within-group output dispersion) in both equations 1 and 2.

Table 6 reports the results of equation 1 on individual and group output. We find that although social connectedness leads to a positive but insignificant effect on individual output ($\alpha_1 = 0.114$, $p > 0.10$ in column 1), it has a positive and statistically significant effect on group output ($\alpha_1 = 0.574$, $p < 0.05$ in column 2). Since these estimates are unconditional on the financial incentives, they show that for the piece rate and bonus schemes on average, being in a socially connected group increases *qualitatively* the individual outgroup by 0.114 bracelets (or 2.6%) and

[36] We find little evidence on the effect of the framing and thus pool the data in the Bonus Gain and Loss framing treatments in the analysis.

increases significantly the group output by 0.574 bracelets (or 18%).[37]

Table 7 focuses on coordination. We find that the coefficient estimate of 'Socially Connected' is -0.457 for excess individual output ($p < 0.01$ in column 1) and -0.325 for within-group output dispersion ($p < 0.05$ in column 2). That is, on average across the two financial incentives, social connectedness leads to 39% decrease in the wasted output and 31% decrease in the within-group dispersion. These findings indicate that subjects coordinate significantly better when they are with co-workers with whom they feel more socially connected.[38]

The findings in Tables 6 and 7, therefore, validate the theoretical predictions 1 and 2.[39] They lead to Results 1 and 2.

Result 1: Being in a socially connected group leads to a significant increase in the group output and only a qualitative, but statistically insignificant, increase in the individual output.

Result 2: Being in a socially connected group improves within-group coordination.

Note that the coefficients of 'Bonus Incentive' are statistically insignificant throughout in Tables 6 and 7, suggesting that higher financial incentives neither increase (individual or group) output nor improve coordination within a group, irrespective of social connectedness amongst workers. Next, we analyze the effect of social connectedness conditional on the financial incentives using equation 2. The results on

[37] These estimates are lower for individual output but higher for group output, compared to the 11-16 percentage point increase suggested by the factory data, given average minimum line efficiency of 5% in Table A1 (columns 4-6), Appendix A.

[38] Our results are unaltered when we include additional control variables in the analysis, e.g. dummy variables for "having done similar kind of task earlier" and the months when the experiment was conducted. These robustness checks with the estimates of all the explanatory variables are reported in Tables A4 and A5, Appendix A. The conclusions are unchanged when we bootstrap the standard errors.

[39] We explore heterogeneity of the impact of social connectedness by caste category in Table A6 in Appendix A. Interestingly, the L type respond significantly to being socially connected by raising individual output. The H type significantly improve their group output and reduce within-group dispersion when they are socially connected than when unconnected.

output are reported in Table 8. The coefficient of 'Socially Connected' β_1 indicates that under the piece rate incentive, social connectedness leads to an increase in individual output by 0.561 bracelets ($p < 0.10$, column 1) and an increase in group output by 1.172 bracelets ($p < 0.05$, column 2), relative to being in a socially unconnected group. Conditional on the high powered bonus incentive, however, the impact of social connectedness is statistically insignificant for individual output ($\beta_1 + \beta_3 = -0.029$, $p = 0.845$, column 1) and for group output ($\beta_1 + \beta_3 = 0.407$, $p = 0.170$, column 2). Therefore, the positive impact of social connectedness on group output summarized in Result 1 is mainly driven by its impact under Piece Rates. Interestingly, we also find that conditional on social connectedness, individual output may be *lower* under the bonus incentive than under piece rate ($\beta_2 + \beta_3 = -0.411$, $p = 0.052$, column 1 of Table 8), and the same pattern seems to hold for the group output ($\beta_2 + \beta_3 = -0.869$, $p = 0.102$, column 2).[40]

To evaluate these results related to our theoretical prediction 3, we estimate the impact of the Bonus relative to two subsamples under Piece Rate: (1) less productive individuals/groups, i.e. those who produce less than the focal point of 5 completed wires/bracelets in Piece Rate, and (2) more productive ones, i.e. those who produce 5 or more in Piece Rate. We compare these two subsamples of Piece Rate to Bonus, respectively, and conduct the analysis as in Table 9. This comparison allows us to infer how the output of the less (more) productive individuals/groups would be affected had they been offered the Bonus, conditional on the degree of the group's social

[40] In Table A7, Appendix A, we estimate equation 2 for the coordination outcomes. Column 1 shows that the excess individual output is lower and hence individual coordination is better in the Socially Connected treatment than in the Socially Unconnected treatment under Piece Rate ($\beta_1 = -0.275$ in column 1, $p > 0.10$) and conditional on the Bonus Incentive ($\beta_1 + \beta_3 = -0.515$, $p = 0.002$). It suggests that social connectedness effectively reduces workers' wasted output and promotes their coordination, but insignificantly under high powered financial incentives ($\beta_3 = -0.239$ in column 1, $p > 0.10$). Column 2 of Table A7 further shows that the impact of social connectedness is along the same lines for the within-group output dispersion ($\beta_1 = -0.359$, $p > 0.10$ for Piece Rate; conditional on the Bonus $\beta_1 + \beta_3 = -0.316$, $p = 0.029$ but $\beta_3 = 0.043$, $p > 0.10$ for Bonus).

connectedness. Table 9 shows that, indeed offering the Bonus incentive can increase individual output significantly ($\beta_2 = 1.165$, $p = 0.040$, column 1) and group output insignificantly ($\beta_2 = 0.111$, $p = 0.774$, column 2) when we compare them to those individuals or groups whose output was less than 5 under Piece Rate. The impact of the Bonus relative to those producing 5 pieces or more under Piece Rate is the opposite ($\beta_2 = -0.894$ for individual output, $p = 0.000$, column 3; $\beta_2 = -1.736$ for group output, $p = 0.053$, column 4). Note that the above effect of the Bonus relative to Piece Rate does not depend on the degree of social connnectedness, however, as β_3 is statistically insignificant for all columns of Table 9. They highlight the fact that the Bonus, as devised by managements to incentivize workers, could serve as a double-edged sword – increasing the productivity of less productive workers/groups but lowering the productivity of those producing above the threshold. These findings in Table 9 lead us to our final result.

Result 3: In line with theoretical prediction 3, the bonus incentive increases (decreases) individual output significantly and group output insignificantly, relative to individuals/groups whose output was below (above) the threshold level under piece rate, irrespective of social connectedness of subjects.

To summarize, our main results show that socially connected groups produce higher group output due to better coordination, but not higher individual output, than the unconnected groups, as predicted by our theoretical model. Introducing a lump-sum bonus, on average, does not enhance the advantage that the socially connected groups have over the socially unconnected, since it creates a focal point for all workers to coordinate on. A bonus of this kind, therefore, is likely to reduce variation in productivity across teams but will only lead to higher overall firm output if it is aimed sufficiently high.[41]

5.3 Discussion of results

As elucidated by the theoretical model, group contingent social preferences among co-workers in socially connected teams can plausibly explain our results. When workers know that their co-workers belong to the same network, they believe that others are going to put in high effort ($\underline{p}$ is lower). As a result, their own incentive to put in high effort increases. We test for these beliefs by eliciting expected productivity of co-workers. In our post-experiment survey we asked subjects to state how many beaded wires they expected a co-worker, whom they knew by name before the experiment, to make in the allotted 10 minutes. Subjects overestimated the productivity of the co-workers they knew by name before the experiment. The difference between the expected and actual co-worker output was 0.40 ($p < 0.001$) for 248 unique connections in the Socially Connected treatments.[42] This provides some suggestive evidence for our explanation. In addition, survey data from a census of workers employed in two garment factories in the catchment area of our experiment indicates greater levels of pro-social motivation between socially connected workers. Specifically, 32% (24%) of workers who have a co-worker with whom they are socially connected (viz. neighbor/relative/fellow villager), as opposed to 16% (18%) of those with a co-worker friend who they met on the job recently, report lending Rs.500 or more to that friend (asked for help in medical emergency.)

There may be alternative explanations for our findings, however. One may be

[41] We did not find any consistent effect of the Bonus on group coordination around the threshold. Further, Table A8 in Appendix A shows little effect of the Bonus framing. The only exception is that the Bonus with Loss framing lowers individual output, relative to Piece Rate, for the socially connected groups (column 1, $\beta_4 + \beta_5 = -0.462$, $p = 0.037$). This may be because the bonus incentive is offered based on the group performance, rather than individual performance as in previous field experiments. Our finding adds to the literature which shows mixed evidence on the framing of incentives, with a positive impact in some (e.g., Hossain and List (2012)) and a small effect in other studies (e.g., List and Samek (2015)).

[42] The number of connections in the Socially Unconnected treatments were negligible, by design.

concerned that workers in the connected groups may have more information on others' abilities; such informational advantage may improve group coordination. On the one hand, it is important to note that informational advantage is not a necessary condition for higher group output and coordination in our theoretical model. Pro-social motivations can lead to better outcomes for the connected groups even in the absence of informational advantage. On the other hand, our experiment was designed to minimize the potential confounds due to informational advantage on ability. Specifically, it involved a real-effort task that subjects had not engaged in collectively before, and thus it was difficult to guess others' abilities even among the connected co-workers. The correlation between the predicted and actual output for the connected workers is 0.175 in the Socially Connected treatments – economically small, albeit, statistically significant ($p < 0.001$). Hence we cannot conclude, either theoretically or empirically, that knowledge about co-worker ability *alone* is the driver of both higher group output and better coordination seen in the connected groups in our experiment.

Another possible explanation is that our experimental design merely sorts on ability, i.e., if L, M, and H types have differential abilities the socially connected groups would produce both higher group output and show better coordination just by experimental design. But we do not find significant differences in productivity (or ability) by caste types either in our experiment (Socially Unconnected treatments) or in the real world factory data (see Table A2 in Appendix A). Moreover, our results are robust after we control for ability by including a dummy variable for whether the subject has previous experience of performing the assigned task.[43]

[43] As elucidated earlier, our experiment design did not prime group identity *per se*, but rather gave information on co-subjects' social connections. Hence our results do not speak purely to social identity as a possible mechanism, unlike previous studies such as Hjort (2014), Chen and Li (2009), and Chen and Chen (2011).

Finally, it may be argued that group based incentives together with the potential threat of sanctions for low effort in socially connected groups might also lead to higher group output. If socially connected subjects have a better idea of who is holding down output in their group, then such subjects may put in higher effort due to fear of punishment by the team, raising both group output and improving coordination. Our experimental design guards against this possibility since the information on individual performance was kept private throughout the experiment, and subjects were informed so upfront. Furthermore, as discussed above, workers' expectations of their co-workers' effort were only weakly correlated with the actual individual output in the connected groups. By ruling out these alternative explanations, we, therefore, conclude that our experimental helps us identify the role of group-contingent social preferences among connected co-workers.

6 Conclusion

We conduct a lab-in-the-field experiment to study the impact of caste-based social connections on output and coordination among workers engaged in a minimum effort game. Our results suggest that being socially connected to co-workers significantly improves group coordination and output though not individual productivity. Further, we find that high powered incentives such as a lump-sum bonus may not lead to higher group productivity and coordination, regardless of social connectedness among co-workers.

These findings can be explained by pro-social motivations among socially connected workers. However, in our survey of garment factory workers we find that 16% of workers report having no friends in the workplace, while the average worker reports less than 2 co-workers as friends. These data and our findings underline the need for managements to create avenues for greater social interactions among co-workers at the work place to enhance productivity.

Our research not only connects the laboratory literature on group coordination with the field experiments on labor productivity, it adds to the growing body of work on the relevance of personnel economics within firms to economic growth. Our results provide strong evidence of the role of co-worker relationships in resolving coordination issues inside the workplace, particularly in contexts where average worker productivity is poor, as is true in most low income countries. Future research could study how worker coordination evolves over time in teams with heterogeneous ability and social connectedness to better understand why some firms become more productive over time and others don't.

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Table 1: Minimum effort game with homogeneous ability type

	$\overline{e}$	$\underline{e}$
$\overline{e}$	$D\theta\overline{e} - c\overline{e}$ $D\theta\overline{e} - c\overline{e}$	$D\theta\underline{e} - c(\alpha\overline{e} + (1-\alpha)\underline{e})$ $D\theta\underline{e} - c(\alpha\underline{e} + (1-\alpha)\bar{e})$
$\underline{e}$	$D\theta\underline{e} - c(\alpha\underline{e} + (1-\alpha)\bar{e})$ $D\theta\underline{e} - c(\alpha\overline{e} + (1-\alpha)\underline{e})$	$D\theta\underline{e} - c\underline{e}$ $D\theta\underline{e} - c\underline{e}$

Table 2: Minimum effort game with heterogeneous ability type

	$\overline{e}$	$\underline{e}$
$\overline{e}$	$D\underline{\theta}\overline{e} - c\overline{e}$ $D\underline{\theta}\overline{e} - c\overline{e}$	$D\underline{\theta}\bar{e} - c(\alpha\overline{e} + (1-\alpha)\underline{e})$ $D\underline{\theta}\bar{e} - c(\alpha\underline{e} + (1-\alpha)\bar{e})$
$\underline{e}$	$D\underline{\theta e} - c(\alpha\underline{e} + (1-\alpha)\bar{e})$ $D\underline{\theta e} - c(\alpha\overline{e} + (1-\alpha)\underline{e})$	$D\underline{\theta e} - c\underline{e}$ $D\underline{\theta e} - c\underline{e}$

Note: The row player is assumed to have low ability ($\underline{\theta}$), and the column player is high ability ($\bar{\theta}$).

Table 3: Experiment design and sample

	Number of sessions			Number of Subjects
Financial Incentive	**Socially Connected**	**Socially Unconnected**	**All**	
Piece Rate	7	9	16	64
Bonus	26	25	51	204
Bonus with Gain Framing	13	12	25	100
Bonus with Loss Framing	13	13	26	104
	33	34	67	268

Note: 'Bonus' includes both 'Bonus with Gain Framing' and 'Bonus with Loss Framing'. The break-up of bonus sessions by framing is described in rows 3 and 4.

Table 4: Financial incentives and payoffs

Number of bracelets produced by group	Subject payoff (Rs.)	
	Piece Rate	**Bonus**
1	100	100
2	200	200
3	300	300
4	400	400
5	**500**	**500 + 150 =650**
6	600	600 + 150 =750
7	700	700 + 150 =850
….	…	…

Note: Each subject was given Rs.200 as participation fees in all sessions. As depicted above, the payment scheme was the same in Bonus with Gain Framing and Bonus with Loss Framing. The only difference was that in the Bonus with Loss Framing the payment schedule was presented to subjects in the reverse order, i.e. starting with 7 or more bracelets and moving down to 1 bracelet to produce a sense of 'loss' if they did not meet the threshold of 5 bracelets.

Table 5: Summary statistics by gender and social connectedness

Characteristics	**Socially Connected**	**Socially Unconnected**	**Difference**
	[N=132]	[N=136]	
	(1)	(2)	(2) - (1)
Age (years)	28.341	29.022	0.681
	(0.583)	(0.594)	(0.833)
Hindu	0.878	0.897	0.018
	(0.028)	(0.026)	(0.039)
Married	0.727	0.713	-0.014
	(0.039)	(0.039)	(0.055)
Completed high school or more	0.333	0.228	-0.105*
	(0.041)	(0.036)	(0.055)
Migrant from Bihar	0.598	0.691	0.092
	(0.042)	(0.040)	(0.058)
Currently employed	0.977	0.971	-0.007
	(0.013)	(0.014)	(0.020)
Found task easy	0.742	0.654	-0.088
	(0.038)	(0.041)	(0.056)
Knew at least one team member by name	0.848	0.080	-0.767***
	(0.031)	(0.023)	(0.039)
Number of co-workers known by name	1.894	0.125	-1.769***
	(0.098)	(0.041)	(0.105)
Caste dispersion in a session	0.000	1.184	1.184***
	(0.000)	(0.026)	(0.027)

Note: Standard errors reported in parentheses. t tests of differences reported in column 3. Significant at *10%, **5%, and ***1%.

Table 6: Impact of group composition on output (unconditional estimates)

	Individual Output	Group Output
	(1)	(2)
Socially Connected (α_1)	0.114	0.574**
	(0.129)	(0.261)
Bonus Incentive (α_2)	-0.062	-0.353
	(0.194)	(0.315)
Constant	5.605***	6.186***
	(0.592)	(1.873)
Mean for Socially Unconnected	4.375	3.206
Number of observations	268	67
Number of sessions	67	67
R^2	0.102	0.196

Note: In column 1 the dependent variable is *individual* output defined as the number of completed wires made by a subject. In column 2 the dependent variable is *group* output defined as the number of bracelets (i.e., the minimum number of completed wires) made by a group. 'Bonus Incentive' is a dummy that equals 1 if the bonus was offered to the group and 0 if the incentive was piece rate. Other control variables include age, Hindu, dummy for H type, dummy for M type, and dummies for primary schooling complete, native state Bihar and currently employed. The estimates of these control variables are omitted for brevity but are similar to those in the analysis of robustness checks reported in Table A4 in Appendix A. Standard errors (clustered at the session level in column 1) are reported in parentheses. Significant at *10%, **5%, and ***1%.

Table 7: Impact of group composition on coordination (unconditional estimates)

	Excess Individual Output	**Within-Group Output Dispersion**
	(1)	(2)
Socially Connected (α_1)	-0.457***	-0.325**
	(0.154)	(0.124)
Bonus Incentive (α_2)	0.112	-0.027
	(0.183)	(0.15)
Constant	1.411***	0.757
	(0.524)	(0.89)
Mean for Socially Unconnected	1.169	1.056
Number of observations	268	67
Number of sessions	67	67
R^2	0.087	0.132

Note: In column 1 the dependent variable is the excess *individual* output defined as individual output minus group output. In column 2 the dependent variable is within-*group* output dispersion defined as the standard deviation of individual output within a group. 'Bonus Incentive' is a dummy that equals 1 if the bonus was offered to the group and 0 if the incentive was piece rate. Other control variables include age, Hindu, dummy for H type, dummy for M type, and dummies for primary schooling complete, native state Bihar and currently employed. The estimates of these control variables are omitted for brevity but are similar to those in the analysis of robustness checks reported in Table A5 in Appendix A. Standard errors (clustered at the session level in column 1) are reported in parentheses. Significant at *10%, **5%, and ***1%.

Table 8: Impact of group composition on output by incentive (conditional estimates)

	Individual Output	Group Output
	(1)	(2)
Socially Connected (β_1)	0.561*	1.172**
	(0.331)	(0.549)
Bonus Incentive (β_2)	0.179	-0.104
	(0.300)	(0.372)
Bonus Incentive x Socially Connected (β_3)	-0.590	-0.765
	(0.383)	(0.619)
Constant	5.465***	6.378***
	(0.584)	(1.871)
Mean for Socially Unconnected	4.375	3.206
Number of observations	268	67
Number of sessions	67	67
R^2	0.115	0.218

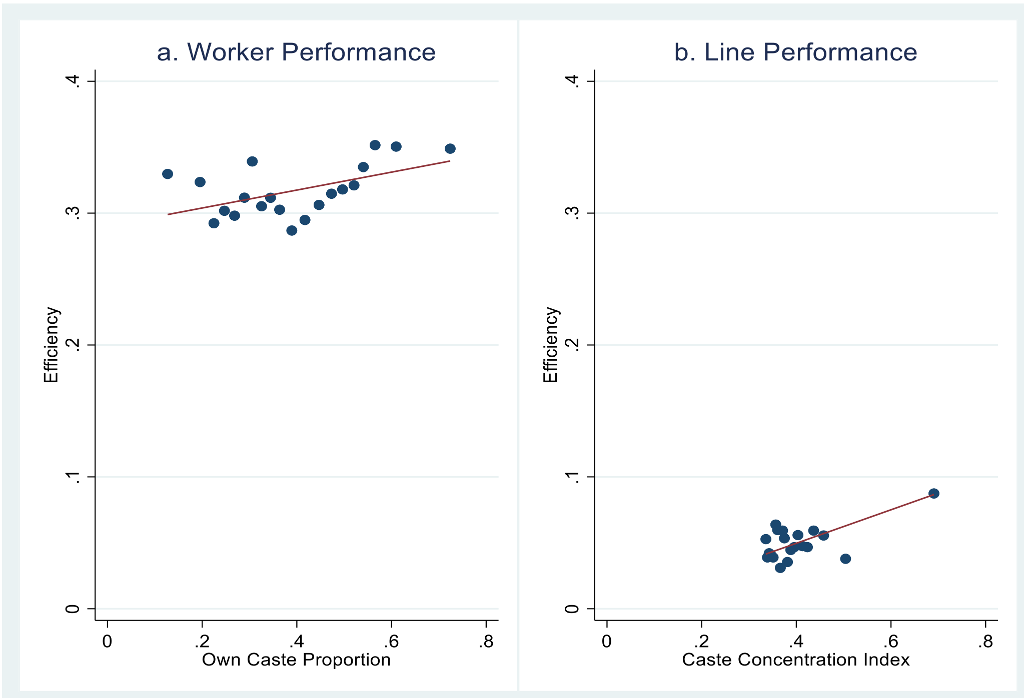
Note: as elucidated in Table 6 above.

Table 9: Impact of group composition on output by incentive (conditional estimates)

	Relative to less than 5 output in Piece Rate		Relative to 5 or more output in Piece Rate	
	Individual Output	**Group Output**	**Individual Output**	**Group Output**
	(1)	(2)	(3)	(4)
Socially Connected (β_1)	0.420	1.035*	-0.208	0.365
	(0.408)	(0.570)	(0.189)	(1.217)
Bonus Incentive (β_2)	1.165***	0.111	-0.894***	-1.736*
	(0.394)	(0.383)	(0.147)	(0.874)
Bonus Incentive x Socially Connected (β_3)	-0.431	-0.621	0.227	0.049
	(0.456)	(0.637)	(0.259)	(1.238)
Constant	4.519***	6.262***	6.569***	8.062***
	(0.530)	(1.825)	(0.591)	(2.099)
All controls	Yes	Yes	Yes	Yes
Number of observations	230	64	242	54
R^2	0.216	0.207	0.205	0.315

Note: as elucidated in Table 6. In column 1 (column 3) we drop *individuals* who produced 5 or more (less than 5) beaded wires under Piece Rate from the sample. In column 2 (column 4) we drop *groups* that produced 5 or more (less than 5) bracelets under Piece Rate from the sample. Standard errors clustered at the session level are reported in parentheses (except in columns 2 and 4 where the unit of analysis is the group). Significant at *10%, **5%, and ***1%.

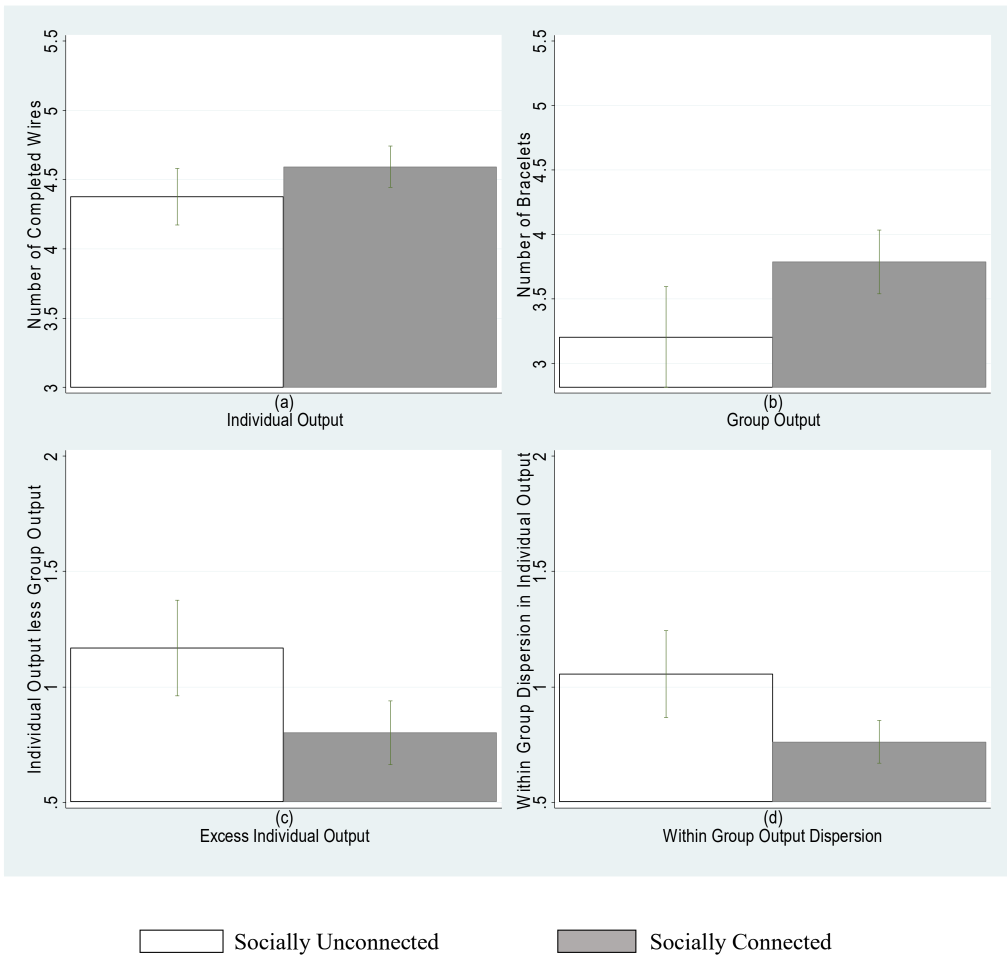
Figure 1: Caste connections and efficiency in garment manufacturing



Note: Fig. 1(a) shows worker level efficiency for 34,641 worker days. Worker efficiency = Daily output / Daily target output for each worker. Average efficiency per worker is 0.312. Own caste proportion = Number of workers belonging to own caste category / Total number of workers in the line on a day; Fig. 1(b) shows the minimum worker efficiency in an assembly line on a production day for 1043 line days. Average minimum efficiency per line is 0.05. Caste concentration index=$\sum c_i^2$, i.e. the sum of squared share of each caste group (L, M, or H) among the workers in an assembly line on a day. Linear fit depicted in both figures using the 'binscatter' command in STATA dividing the data into 20 bins, plotting the mean X and Y values for each bin. The sample consists of 1744 workers in 37 assembly lines in two garment factories. Worker level production data obtained for September-October 2015 from factory records and caste data collected through a census survey of workers during August-October 2015.

Source: Afridi, Dhillon, Sharma (2019)

Figure 2: Output and coordination by group composition



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APPENDIX A

Table A1: Caste composition, worker and assembly line productivity

	Worker efficiency			Line efficiency		
	(1)	(2)	(3)	(4)	(5)	(6)
Own caste proportion	0.103**	0.103**	0.095**			
	(0.047)	(0.046)	(0.045)			
Caste concentration index				0.113**	0.121***	0.158**
				(0.045)	(0.028)	(0.042)
Constant	0.276***	0.259***	0.328***	0.214*	0.232**	0.163*
	(0.018)	(0.075)	(0.071)	(0.123)	(0.103)	(0.085)
Number of observations	34,641	34,641	34,641	1043	1043	1043
R^2	0.550	0.550	0.555	0.484	0.588	0.700
Individual FE	√	√	√			
Factory floor FE		√			√	
Assembly line FE			√			√

Note: In columns 1-3, Worker efficiency = Daily output/Daily target where target varies by style operation for each worker. Own caste proportion = Number of workers belonging to own caste category/ Total number of workers in the line on a day. In columns 4-6, Line efficiency is minimum of efficiency of workers sitting in line l on day d. Caste concentration index=$\sum c_i^2$, i.e. the sum of squared share of each caste (c) group (L, M, or H) among the workers in an assembly line on a day. The dependent variable in columns 1-3 is worker productivity on a day in a line (in person days). Controls in column 1 include worker characteristics such as age, gender, native state, education and experience. In columns 4-6 the dependent variable is the minimum of worker efficiency in a production line on a production day (in line days). Line level characteristics such as average age, proportion of females, proportion of Hindus, proportion of married works and average experience are controlled for. The average worker efficiency is 0.312 and the average minimum line efficiency is 0.05. Data collected by the authors on daily worker productivity and worker characteristics for 1744 workers in 37 assembly lines in 2 garment factories in NCR, Delhi from August-October 2015. Standard errors clustered at assembly line level in parentheses. Significant at *10%, **5%, and ***1%.

Source: Afridi, Dhillon, Sharma (2019)

Table A2: Average productivity by caste

	Factory data		Experiment data	
	Number of workers	Efficiency	Number of subjects in socially unconnected group	Number of completed wires
All	1744	0.312	136	4.375
		(0.005)		(0.104)
L	384	0.308	30	4.300
		(0.010)		(0.215)
M	543	0.300	60	4.550
		(0.009)		(0.131)
H	817	0.321	46	4.196
		(0.007)		(0.212)

Note: 34,641 person days map into 1744 workers in our factory data. No significant differences (at 5% level of significance) are found in average efficiency of workers by caste. The *p*-values of all pair-wise differences range from 0.06 to 0.58 in the factory data and 0.14 to 0.74 in the experiment data.

Table A3: Summary statistics by financial incentive

Characteristics	Piece Rate	Bonus with Gain Framing	Bonus with Loss Framing
	[N=64]	[N=100]	[N=104]
	(1)	(2)	(3)
Age (years)	28.44	28.86	28.67
	(0.846)	(0.654)	(0.701)
Hindu	0.78	0.88	0.96
	(0.052)	(0.033)	(0.019)
Married	0.69	0.75	0.71
	(0.058)	(0.043)	(0.045)
Competed high school or more	0.20	0.27	0.34
	(0.051)	(0.045)	(0.047)
Migrant from Bihar	0.66	0.69	0.60
	(0.060)	(0.046)	(0.048)
Currently employed	0.97	0.99	0.96
	(0.022)	(0.010)	(0.019)
No. of beaded wires	4.53	4.46	4.47
	(0.157)	(0.105)	(0.092)
Found task easy	0.72	0.72	0.66
	(0.057)	(0.045)	(0.047)
Knew at least one team member by name	0.42 (0.062)	0.44 (0.050)	0.50 (0.049)
Number of co-workers known by name	0.77 (0.129)	0.96 (0.125)	1.17 (0.129)
Caste dispersion in a session	0.93	0.76	0.78
	(0.052)	(0.055)	(0.054)

Note: Standard errors are reported in parentheses.

Table A4: Effect of group composition on output with additional controls

	Individual Output	Group Output
	(1)	(2)
Socially Connected	0.117	0.585**
	(0.129)	(0.263)
Bonus incentive	-0.046	-0.315
	(0.193)	(0.354)
Age	-0.038***	-0.04
	(0.012)	(0.043)
Married	0.098	0.092
	(0.171)	(0.653)
Hindu	-0.444	-1.229**
	(0.291)	(0.542)
Currently employed	0.025	-0.238
	(0.484)	(1.404)
Primary education complete	0.278	-0.617
	(0.169)	(0.693)
Migrant from Bihar	0.277**	0.478
	(0.128)	(0.367)
Done similar task earlier	-0.414	-0.912
	(0.262)	(0.588)
June	0.000	0.000
	(.)	(.)
July	-0.124	-0.203
	(0.149)	(0.282)
H type	-0.380	-1.089
	(0.236)	(0.692)
M type	0.098	-0.241
	(0.185)	(0.552)
Constant	5.777***	6.296***
	(0.615)	(1.982)
Number of observations	268	67
Number of sessions	67	67
R^2	0.122	0.233

Note: Standard errors (clustered at the session level in column 1) are reported in parentheses. Significant at *10%, **5%, and ***1%.

Table A5: Effect of group composition on coordination with additional controls

	Excess Individual Output	Within-Group Output Dispersion
	(1)	(2)
Socially Connected	-0.462***	-0.329***
	(0.156)	(0.123)
Bonus incentive	0.053	-0.008
	(0.207)	(0.166)
Age	-0.030***	-0.124
	(0.010)	(0.305)
Married	0.148	-0.124
	(0.166)	(0.305)
Hindu	0.145	0.288
	(0.274)	(0.254)
Currently employed	0.047	-0.028
	(0.476)	(0.656)
Primary education complete	0.462**	0.201
	(0.192)	(0.324)
Migrant from Bihar	0.091	-0.095
	(0.163)	(0.171)
Done similar task earlier	-0.077	0.580**
	(0.233)	(0.275)
June	0.000	0.000
	(.)	(.)
July	0.098	0.059
	(0.160)	(0.132)
H type	-0.019	0.198
	(0.198)	(0.324)
M type	0.151	0.145
	(0.168)	(0.258)
Constant	1.506***	0.572
	(0.525)	(0.927)
Number of observations	268	67
Number of sessions	67	67
R^2	0.092	0.198

Note: Standard errors (clustered at the session level in column 1) are reported in parentheses. Significant at *10%, **5%, and ***1%.

Table A6: Impact of group composition on effect and co-ordination conditional on caste

	Individual Output	Group Output	Excess Individual Effort	Within-Group Output Dispersion
	(1)	(2)	(3)	(4)
Socially Connected (α_1)	0.445*	0.004	-0.403*	0.650
	(0.247)	(1.260)	(0.222)	(0.589)
H type (α_2)	-0.219	-3.178*	-0.006	1.874**
	(0.325)	(1.826)	(0.251)	(0.854)
M type (α_3)	0.166	-0.005	0.164	0.842
	(0.240)	(1.492)	(0.248)	(0.698)
H type x Socially Connected (α_4)	-0.568	2.115	-0.0435	-1.804**
	(0.460)	(1.865)	(0.328)	(0.872)
M type x Socially Connected (α_5)	-0.294	-0.272	-0.0719	-0.806
	(0.278)	(1.602)	(0.285)	(0.749)
Constant	5.596***	7.283***	1.392**	-0.489
	(0.628)	(2.323)	(0.534)	(1.087)
Effect of caste conditional on social connectedness:				
L type (α_1)	0.445*	0.004	-0.403*	0.650
	(0.247)	(1.260)	(0.222)	(0.589)
M type ($\alpha_1 + \alpha_5$)	0.151	-0.268	-0.474**	-0.156
	(0.160)	(0.724)	(0.230)	(0.339)
H type ($\alpha_1 + \alpha_4$)	-0.123	2.120**	-0.446*	-1.154**
	(0.355)	(1.022)	(0.246)	(0.478)
Number of observations	268	67	268	67
Number of sessions	67	67	67	67
R^2	0.109	0.231	0.087	0.195

Note: Controls include age, dummy for Hindu, primary schooling complete, native state is Bihar, and currently employed. Standard errors clustered at session level in parenthesis, except when the unit of analysis is the group. Significant at *10%, **5% and ***1%.

Table A7: Impact of group composition on coordination by incentive (conditional estimates)

	Excess Individual Output	Within-Group Output Dispersion
	(1)	(2)
Socially Connected (β_1)	-0.275	-0.359
	(0.319)	(0.265)
Bonus Incentive (β_2)	0.210	-0.041
	(0.253)	(0.179)
Bonus Incentive x Socially Connected (β_3)	-0.239	0.043
	(0.338)	(0.298)
Constant	1.355**	0.747**
	(0.515)	(0.901)
Mean for Socially Unconnected	1.169	1.056
Number of observations	268	67
Number of sessions	67	67
R^2	0.089	0.132

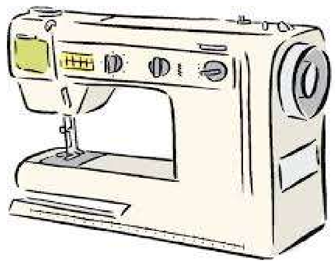
Note: as elucidated in Table 7.

Table A8: Impact of group composition on output by incentive (conditional estimates)

	Individual Output	Group Output
	(1)	(2)
Socially Connected (*β_1*)	0.553	1.123**
	(0.333)	(0.555)
Bonus (Gain Framing) (*β_2*)	-0.004	-0.361
	(0.322)	(0.421)
Bonus (Gain Framing) x Socially Connected (*β_3*)	-0.335	-0.458
	(0.409)	(0.675)
Bonus (Loss Framing) (*β_4*)	0.360	0.154
	(0.318)	(0.421)
Bonus (Loss Framing) x Socially Connected (*β_5*)	-0.822**	-0.991
	(0.404)	(0.681)
Constant	5.522***	6.357***
	(0.592)	(1.902)
Number of observations	268	67
Number of sessions	67	67
R^2	0.127	0.242

Note: as elucidated in Table 6.

Figure A1: Recruitment advertisement



ATTENTION!!!

OPERATORS/ TAILORS/HELPERS/PRESSMEN!!!

Garment factory operators, helpers and pressmen volunteers are required for a training-cum-research project. Participants will receive Rs.200 as show-up payment and can earn between Rs. 500-1000 in 30 to 45 minutes on the spot. Please register yourself by calling on following numbers:

9205369718

8800254317

Figure A2: A finished bracelet

APPENDIX B

Claim 1 *Assume that* $\bar{\theta}\underline{e} \geq \underline{\theta}\bar{e}$*, and that parameter values satisfy:* $\min(\frac{D\bar{\theta}}{2\alpha^U}, \frac{D\underline{\theta}}{\alpha^C}) \geq c > \frac{D\underline{\theta}}{\alpha^U}$.[44] *Then we have the following risk dominant equilibria in the connected game:* $\bar{e}, \bar{e}$ *in the homogeneous types case, and high effort for the low ability worker with low effort for the high ability worker in the heterogeneous abilities case. In the unconnected game we have the following risk dominant equilibria:* $\bar{e}, \bar{e}$ *in the high ability homogeneous types case,* $\underline{e}, \underline{e}$ *in the low ability homogeneous types case as well as in the heterogeneous abilities case. Moreover, conditional on the higher output in the connected game (i.e homogeneous low ability case, and heterogeneous ability case), coordination is also higher in the connected game, if* α^C *is sufficiently smaller than* α^U.[45]

Proof of Claim 1

Proof. We use two lemmas to prove Claim 1
First we show the equilibria in the homogeneous ability game in the following lemma:

Lemma 1 *(1) Let* $k \in \{C, U\}$*. Assume that* $\frac{D\theta}{\alpha^k} \geq c$ *(or* $\frac{D\theta}{c} \geq \alpha^k$*). There are two pure strategy equilibria - (*$\bar{e}, \bar{e}$*) and (*$\underline{e}, \underline{e}$*). Worker i prefers to play* $\bar{e}$ *iff the opponent has a probability* $p_j \geq \underline{p}^k = \frac{\alpha^k c}{D\theta}$ *of playing* $\bar{e}$*. If* $c < \frac{D\theta}{2\alpha^k}$*, then the high effort equilibrium is risk dominant. Moreover as the piece rate, D, increases the probability of playing the high effort equilibrium increases. (2) Assume that* $\frac{D\theta}{\alpha^k} < c$ *then, there is a unique low effort equilibrium in this game.*

Proof. (1) It is easy to see from the game that there are two pure strategy equilibria. Worker i strictly prefers to play $\bar{e}$ iff

$$D\theta(p_j\bar{e}+(1-p_j)\underline{e})-c(p_j\bar{e}+(1-p_j)(\alpha^k\bar{e}+(1-\alpha^k)\underline{e}) \geq D\theta\underline{e}-c(p_j(\alpha^k\underline{e}+(1-\alpha^k)\bar{e})+(1-p_j)\underline{e})$$

This is true iff $p_j \geq \underline{p}^k = \frac{c\alpha^k}{D\theta}$. Risk dominance requires $\underline{p}^k < \frac{1}{2}$ and this is the case iff $\frac{c\alpha^k}{D\theta} < \frac{1}{2}$, or $c < \frac{D\theta}{2\alpha^k}$. $\frac{\partial \underline{p}^k}{\partial D} = -\underline{p}^k \frac{1}{\theta D}$, so as piece rates increase, $\underline{p}^k$ decreases. (2) The high effort equilibrium exists iff $p_j = 1 \geq \underline{p}_k$ i.e. $D\theta \geq c\alpha^k$. The low effort equilibrium exists if $p_j = 0$ – in this case low effort is always a best response.

[44] These restrictions are equivalent to $\alpha^U > \frac{D\underline{\theta}}{c} \geq \alpha^C$ and $\alpha^U \leq \frac{D\bar{\theta}}{2c}$, used in the main text.

[45] Most of the results of Claim 1 do not depend on the restrictions on parameters. The assumption that $\bar{\theta}\underline{e} \geq \underline{\theta}\bar{e}$, is not necessary for our results. Indeed, connected groups are always more likely to converge to the higher group output equilibrium since $\underline{p}^C < \underline{p}^U$, (which is driven by $\alpha^C < \alpha^U$). Moreover the result that individual effort need not be significantly different depends on the parameter restrictions – the parameters have been chosen to ensure that unconnected groups can coordinate on the high effort equilibrium in the high ability case. However as long as the difference, $\bar{\theta} - \underline{\theta}$ is sufficiently high, the result holds even without these restrictions. Lemmas 1 and 2 provide a characterization of the pure strategy equilibria for all parameter values.

■

Second we now show the equilibria in the heterogeneous ability (one high and one low ability worker) game in the following lemma where we assume that $\bar{\theta}\underline{e} \geq \underline{\theta}\bar{e}$, i.e $\frac{\bar{\theta}}{\underline{\theta}} \geq \frac{\bar{e}}{\underline{e}}$.

Lemma 2 *Assume that $\bar{\theta}\underline{e} \geq \underline{\theta}\bar{e}$, and $\frac{D\underline{\theta}}{\alpha^k} \geq c$. There is a unique pure strategy equilibrium where the high ability worker plays $\underline{e}$ and the low ability worker plays $\bar{e}$.*

Proof. If the high ability worker puts in high effort she gets $D\underline{\theta}(p_j\bar{e} + (1 - p_j)\underline{e}) - c(p_j\bar{e} + (1 - p_j)(\alpha^k\bar{e} + (1 - \alpha^k)\underline{e})$ while if she puts in low effort she gets $D\underline{\theta}(p_j\bar{e} + (1 - p_j)\underline{e}) - c(p_j(\alpha^k\underline{e} + (1 - \alpha^k)\bar{e}) + (1 - p_j)\underline{e})$. Clearly low effort is better for any p_j, hence $\underline{p}_B \geq 1$ (low effort is a strictly dominant strategy). If the low ability worker puts in high effort she gets $D\underline{\theta}\bar{e} - c(p_j\bar{e} + (1 - p_j)(\alpha^k\bar{e} + (1 - \alpha^k)\underline{e}))$ while if she puts in low effort she gets $D\underline{\theta}\underline{e} - c(p_j(\alpha^k\underline{e} + (1 - \alpha^k)\bar{e}) + (1 - p_j)\underline{e})$. This holds for any $p_j \geq 0$, as long as $\frac{D\underline{\theta}}{\alpha^k} \geq c$. Hence $\underline{p}_S = 0$, i.e. high effort is a strictly dominant strategy for the low type. ■

Table T1 below illustrates the equilibria derived from Lemmas 1 and 2 when $\alpha \in \{\alpha^C, \alpha^U\}$.

Table T1: Risk dominant equilibria (homogenous game) assuming $\frac{D\bar{\theta}}{2} > D\underline{\theta}$

	$\frac{D\underline{\theta}}{2\alpha} \geq c \geq 0$	$\frac{D\underline{\theta}}{\alpha} \geq c > \frac{D\underline{\theta}}{2\alpha}$	$\frac{D\bar{\theta}}{2\alpha} \geq c > \frac{D\underline{\theta}}{\alpha}$	$c > \frac{D\bar{\theta}}{2\alpha}$
$\underline{\theta},\bar{\theta}$	$\bar{e},\underline{e}$	$\bar{e},\underline{e}$	$\underline{e},\underline{e}$	$\underline{e},\underline{e}$
$\bar{\theta},\bar{\theta}$	$\bar{e},\bar{e}$	$\bar{e},\bar{e}$	$\bar{e},\bar{e}$	$\underline{e},\underline{e}$
$\underline{\theta},\underline{\theta}$	$\bar{e},\bar{e}$	$\underline{e},\underline{e}$	$\underline{e},\underline{e}$	$\underline{e},\underline{e}$

Claim 1 follows from the following table which compares the equilibria (connected vs unconnected) for each combination of types when the parameters are restricted to $\min(\frac{D\bar{\theta}}{2\alpha^U}, \frac{D\underline{\theta}}{\alpha^C}) \geq c > \frac{D\underline{\theta}}{\alpha^U}$.[46]

Table T2: Comparison of selected equilibrium in Connected vs Unconnected game

	$\frac{D\underline{\theta}}{\alpha^U} \geq c$	$\min(\frac{D\bar{\theta}}{2\alpha^U}, \frac{D\underline{\theta}}{\alpha^C}) \geq c \geq \frac{D\underline{\theta}}{\alpha^U}$
$\underline{\theta},\bar{\theta}$	$\bar{e},\underline{e}$ vs $\bar{e},\underline{e}$	$\bar{e},\underline{e}$ vs $\underline{e},\underline{e}$
$\bar{\theta},\bar{\theta}$	$\bar{e},\bar{e}$ vs $\bar{e},\bar{e}$	$\bar{e},\bar{e}$ vs $\bar{e},\bar{e}$
$\underline{\theta},\underline{\theta}$	$\bar{e},\bar{e}$ vs $\bar{e},\bar{e}$	$\bar{e},\bar{e}$ vs $\underline{e},\underline{e}$

[46]These restrictions are equivalent to $\alpha^U > \frac{D\underline{\theta}}{c} \geq \alpha^C$ and $\alpha^U \leq \frac{D\bar{\theta}}{2c}$, used in the main text.

Based on the comparison in Table T2, we can see that in the second column, group output in the connected game is larger than in the unconnected game, wasted effort is smaller (when types are heterogeneous, then wasted output in the connected game is $\bar{\theta}\underline{e} - \underline{\theta}\bar{e}$ which is smaller than wasted effort in the unconnected game, $\bar{\theta}\underline{e} - \underline{\theta}\underline{e}$) and individual output is higher but by less than group output. We show the computations below.

Recall that each combination of types is equally likely by assumption. Therefore we can compute the average group output, average individual output and average wasted effort and compare the difference for connected vs unconnected groups. In the connected game group output is $\frac{1}{4}\bar{\theta}\bar{e} + \frac{3}{4}\underline{\theta}\bar{e}$, while in the unconnected game it is $\frac{1}{4}\bar{\theta}\bar{e} + \frac{3}{4}\underline{\theta}\underline{e}$. The difference in group output for connected vs unconnected groups is therefore $\frac{3}{4}\underline{\theta}(\bar{e} - \underline{e})$. Coming to the individual output, note that there is no difference in the output of the high ability individual between connected and unconnected groups. However the difference is in the output of the low ability individual: $\underline{\theta}\bar{e}$ in the connected case and $\underline{\theta}\underline{e}$ in the unconnected case. The average worker output difference between connected vs unconnected is therefore $\frac{1}{4}\underline{\theta}(\bar{e} - \underline{e})$, which is smaller than the difference in group output.

Moving to the expected wasted output in the heterogeneous game, the connected game has average wasted output of $\frac{1}{2}(\bar{\theta}\underline{e} - \underline{\theta}\bar{e}.)$ In the unconnected game average wasted output is $\frac{1}{2}(\bar{\theta} - \underline{\theta})\underline{e}$. The difference in average wasted effort in connected vs unconnected groups is therefore $\frac{1}{2}\left(\bar{\theta}\underline{e} - \underline{\theta}\bar{e} - (\bar{\theta} - \underline{\theta})\underline{e}\right) = -\frac{1}{2}\underline{\theta}(\bar{e} - \underline{e})$.

Note, however, that we have another measure of coordination when the games are homogeneous, i.e. $\underline{p}$. Claim 1 shows that conditional on higher output in the connected homogeneous game, $\underline{p}^C < \underline{p}^U$ for the high effort equilibrium. Thus wasted effort should be lower even off equilibrium in the high ability homogeneous connected game relative to the high ability homogeneous unconnected game. In the low ability homogeneous game, the coordination on low effort equilibrium is higher, the higher is $\underline{p}$. Therefore coordination is higher in the low ability homogeneous connected vs unconnected game if $\underline{p}^C < 1 - \underline{p}^U$. This holds iff $\frac{c\alpha^C}{D\underline{\theta}} < 1 - \frac{c\alpha^U}{D\underline{\theta}}$, or $\frac{c\alpha^C}{D\underline{\theta}} < \frac{D\underline{\theta} - c\alpha^U}{D\underline{\theta}}$, or if $\alpha^C + \alpha^U < \frac{D\underline{\theta}}{c}$. ∎

Extensions

Extending the result to many players and a continuum of effort levels is more complicated. However, it is well known that the risk dominant equilibrium in a 2X2 game coincides with the one that maximizes the "potential" of the game (Young (1993)). Andersen, Goeree and Holt (2001) generalised the concept of risk dominance for games with more than 2 players and more than two effort (but finite) levels. They use the idea of potential games adapted to the minimum effort game (Monderer and Shapley (1996)), but add some noise in players' behaviour. They show that the resulting refinement of Nash equilibrium - the "logit equilibrium" for the minimum effort game is unique and symmetric and maximizes the stochastic potential of a game. Chen and Chen (2011) further adapt the concept of a stochastic potential game to study a minimum effort game where players can be "in group", "neutral" or "outgroup". The adapted minimum effort game with a continuum of effort levels and $n > 1$ players is a potential game according to the Monderer and Shapley (1996) definition and has the potential function shown in equation (5) of Chen and Chen (2011) and reproduced below. Let $e_j \geq 0$ denote worker j's effort in the group:

$$P(e_1, e_2, ..., e_n) = D \min(e_1, e_2, ..., e_n) - \frac{c}{a} \sum_{1}^{n} \alpha e_i \tag{3}$$

where $\alpha < 1$ denotes the level of selfishness in the group according to Chen and Chen (2011). They assume that the in-group has a lower α than the neutral group which has a lower α than the outgroup. $D > 0$ represents any incentive payments as before. We can use the unique potential maximizing equilibrium as our prediction for the case of many effort levels, our predictions would be the same as Chen and Chen (2011). Our Claim 1 then follows from Chen and Chen (2011).

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