Team Incentives and Worker Heterogeneity: An Empirical Analysis of the Impact of Teams on Productivity and Participation

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Abstract

This paper identifies and evaluates rationales for team participation and for the effects of team composition on productivity using novel data from a garment plant that shifted from individual piece rate to group piece rate production over three years. The adoption of teams at the plant improved worker productivity by 14% on average. Productivity improvement was greatest for the earliest teams and diminished as more workers engaged in team production, providing support for the view that teams utilize collaborative skills, which are less valuable in individual production. High productivity workers tended to join teams first, despite a loss in earnings in many cases, suggesting non-pecuniary benefits associated with teamwork. Finally, more heterogeneous teams were more productive, holding average ability constant, which is consistent with explanations emphasizing mutual team learning and intra-team bargaining.

Keywords: Teams, productivity, free-riding, learning, bargaining, sorting, compensating differentials, collaborative skills, social skills

JEL Classifications:

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During the past 30 years the use of teams has become a mainstay for the organization of work. Many firms use teams or have implemented team-type incentive systems for a wide variety of productive activities. For example, Lazear (1998) argues that forming teams is economically desirable when they make possible gains from complementarities in production among workers, facilitate gains from specialization by allowing each worker to accumulate task-specific human capital, or encourage gains from knowledge transfer of idiosyncratic information that may be valuable to other team members. These gains notwithstanding, economists studying teams, beginning with Alchian and Demsetz (1972), have focused on the free-rider problem, which arises when actions taken by team members are not observable. The theoretical literature has studied under what conditions the first-best outcome will be achieved, what incentive schemes will achieve the first best or the second best outcome or what parameters affect the relative efficiency of teamwork.[1] Unfortunately, in contrast to this extensive theoretical literature on moral hazard problems, few empirical studies have systematically examined the impact of teams on output.[2] Consequently, relatively little is known about issues such as the magnitude of team incentive effects. A further weakness of the theoretical literature is that it provides no implication for the effect of team composition (i.e., worker heterogeneity) on team productivity or worker selection for, and participation in, teams.

[1] For example, see Holmstrom (1982), Rasmesen (1987), McAfee and McMillan (1991), Itoh (1991,1992), Legros and Matthews (1993).

[2] Empirical studies of the impact of teams on productivity have tended to focus on law firms or medical group partnerships (e.g., Encinosa, Gaynor, and Rebitzer (2000); Gaynor and Gertler (1995); Leibowitz and Tollison (1980)), while others have used experimental data (Nalbantian and Schotter (1997)). A few studies have looked at manufacturing or service firms, such as Boning, Ichniowski, and Shaw (1998) and Hansen (1997).

The lack of empirical studies and the potential for worker heterogeneity raises a number of questions about the effect of team incentives on productivity and participation that goes beyond moral hazard issues. To what extent does the adoption of teams increase or decrease productivity? How does team composition affect productivity? Are teams more productive if the members are homogeneous, or should teams be formed with a mix of high-ability and low-ability workers? Will high-ability workers leave the firm when it implements a team production system?

This paper empirically explores these questions. The objective is to determine the extent to which observed team behavior is consistent with a variety of models of worker behavior. Despite obvious concerns about moral hazard, many firms do in fact introduce teams even when individual task assignment is feasible, and provide team-based incentives in the hope of improving productivity.[3] This suggests that we need to analyze other behavioral responses to team structure and team incentives in addition to free-riding predicted by principal-agent models. Our analysis of the effects of worker heterogeneity on team productivity and worker participation in teams provides rich implications for other behavioral responses.

Worker heterogeneity could shape team productivity by facilitating mutual learning or by influencing the group production norm. Mutual learning suggests that more-able workers (e.g., those that are more productive under individual piece rates) may be able to teach the less-able workers to be more productive thereby enhancing team productivity. Kandel and Lazear (1992) suggest that free riding may be mitigated by peer pressure to achieve a group norm. Such norms may arise, we argue, from intra-team bargaining where worker heterogeneity affects group norms through different threat points among workers.

In both cases, the effects of worker heterogeneity on productivity critically depend on worker participation in teams, a decision that has not been considered in the literature. Workers might join teams on their own accord for three reasons. First, low-ability workers could expect that teaming up with higher-ability workers would raise their pay. However, since high-ability workers would think the opposite way, this creates an adverse selection problem. Second, teamwork may call upon additional worker abilities (e.g., teamwork may benefit from "collaborative" skills involving communication and leadership in addition to "technical" abilities used in piece rate production) that expand production possibilities, thereby increasing surplus and incentives for cooperation. Finally, teamwork may offer compensating differentials due to the non-pecuniary benefits of less boring work, more social interaction, and income smoothing (Rosen (1986)).

Empirical analysis of the relationship between team incentives, worker participation, worker heterogeneity, and productivity faces many challenges. While data at the firm level may be available, comparing firms utilizing team incentives to those that do not leads to many difficulties. The most obvious is self-selection. Participation in teams is unlikely to be exogenous with respect to firm output, implying a biased estimate of the impact of teams on productivity. Second, estimates may be contaminated by the introduction of other human resource and production practices at the same time teams are implemented. For example, Dunlop and Weil (1996) find that new information technology was often introduced at the same time as teams in the garment industry. Third, adverse selection issues may arise. Firms using teams may attract a different quality workforce than firms that rely on individual production. Consequently, estimates of the impact of teams on output may be biased by differences in

[3] For instance, Knez and Simester (2001) describe the implementation of a team incentive scheme at Continental

worker quality. Finally, analysis of worker reaction to and participation in teams requires individual data, which is rarely available, rather than firm-level data.

Our approach to the empirical analysis of teams follows in the spirit of Lazear's (2000) study of the impact of piece-rate incentive schemes on productivity and turnover at the Safelite Glass Corporation. Our analysis utilizes the personnel records of workers employed between 1995 and 1997 at a garment factory operated in Napa, California, by the Koret Company. The facility initially used progressive bundling system production, in which sewing is divided into independent tasks and seamstresses are paid piece rates. Between 1995 and 1997, the facility changed the organization of its sewing activity to module production, in which autonomous work teams of typically six to seven workers receive a group piece rate and perform all sewing tasks. Because we observe productivity on a weekly basis in the data set, we are able to compare productivity under individual and team production for the same worker. Hence, we are able to account for bias induced by unobserved worker ability across firms that plagues more aggregated firm-level data. Moreover, between 1995 and 1996 both team and individual production was employed side-by-side under the same management and union, sewing essentially identical garments, mitigating issues of contamination bias. Finally, participation in teams was voluntary during much of our observation period, thus providing rich information about workers' participation and preferences toward teams. Overall, this setting provides a unique laboratory to analyze the relationship between teams and productivity and participation.

Our findings, which are based on weekly productivity data over the years 1995-1997 for 288 employees at Koret, are surprising and highlight the degree to which the benefits of teams can be substantial. The introduction of teams at Koret was associated with an 18% increase in

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Airlines.

productivity, on average. Moreover, panel data estimates suggest that approximately one-fifth of this effect was due to the fact that high-ability workers at Koret were more likely to join teams. The remaining 14% increase reflects a team effect. Because these results run counter to simple models arguing that free-riding leads to lower team output (compared to individual productivity), we examined the choice of workers to join a team. Somewhat surprisingly, teams formed early on attracted relatively high-ability workers, where ability is based individual productivity under individual piece-rate incentives. These early teams also realized a larger team productivity effect. High-ability workers were no more likely to leave the firm than low-ability workers after joining a team, as might be the case if free-riding was of paramount concern. The participation of high-ability workers on early teams and the larger productivity improvement of early teams, as well as the fact that productivity of three teams exceeded the productivity of their highest ability worker, indicate that team production may expand production possibilities by utilizing collaborative skills. Such skills differ from and are not necessarily perfectly correlated with the more technical ability associated with individual piece rate production, in which collaborative skills are likely to be less valued.

We also find that some workers joined teams despite an absolute decrease in pay, suggesting that teams offer non-pecuniary benefits to workers. Koret thus reaped the benefit of decreased turnover and higher average productivity when teams were introduced. Our final set of results indicates that the composition of the team has a strong impact on its productivity. Not surprisingly, teams with high-ability members, on average, are more productive. More notably, teams with a greater spread in ability (holding the average constant) also are more productive. It is also the case that the most able team member has a stronger impact on team productivity than the least able member. The last two results are consistent with a bargaining explanation for team behavior, in which high-ability workers are able to impose a higher team norm level of output. The findings also are consistent with the predictions of a mutual learning model in which more able workers teach their less able colleagues to be more productive.

I. Theoretical Background

Several formal economic models have explored the productivity implications of teams and focused on the extent to which free-riding and measurement problems inhibit first-best outcomes. The free-rider problem can be attenuated when team members can effectively monitor and punish their peers. There are two theoretical approaches to explain how the problem is mitigated. One approach is to use an explicit threat of discontinuing cooperation in dynamic settings (see Radner (1986) for example). As the folk theorem suggests, if the gain from cooperative team production is large enough for members, none of them will deviate to maximize his/her one-shot payoff and induce less efficient Nash equilibrium outcome or prescribed punishment in the subsequent periods.

The other approach is less formal and uses the notions of external peer pressure and internal pressure. Kandel and Lazear (1992) establish a framework to analyze the effectiveness of peer pressure while distinguishing internal pressure[4] (guilt) from external pressure (shame and social punishment). In their model, peer pressure arises when individuals depart from the team norm and other workers impose disutility on them for the extent of their departures. Peer pressure may take the form of mental or physical harassment in the case of external pressure, and the equilibrium effort is higher than it would be without peer pressure. Since the peer pressure

[4] Rotemberg (1994) modeled the internal pressure for cooperative behavior as altruism. In his model, workers can choose to become altruistic and commit to the level of altruism they have chosen. As long as workers' inputs are complements and workers can observe the others' choice of preference, altruism arises endogenously as a rational choice of workers. Since employers benefit from high levels of altruism, they also have an incentive to pay for socialization among the workers.

function is exogenously given in their model, however, it is not clear how individuals develop preferences incorporating peer pressure, and how "norms" will be established.

With either a credible threat or peer pressure, the requirement of mutual monitoring to induce cooperative behavior implies that the distance between workers in production sites and the similarity of tasks affect the teams' ability to police free-riding. Hence, free-riding will be less serious in smaller teams or when workers engage in closely related activities. Cross training also helps to reduce free-riding by improving the workers' ability to monitor each other.

Models of free-riding typically view teamwork as the sum of individual worker efforts: this may not be correct. For instance, teamwork may call upon additional worker abilities that expand production possibilities thereby increasing surplus and incentives for cooperation. Consider the case where separable and individual production may rely on technical ability, commitment, energy, manual dexterity, and a willingness to tolerate boring repetition (hereafter referred to in sum as technical ability) in exchange for monetary rewards, whereas team production may additionally rely on collaborative abilities that involve communication and leadership abilities as well as the flexibility to rotate through multiple jobs.[5] If so, then team production can benefit from both technical and collaborative ability where separable production can benefit only from technical skills. Such collaborative skills may not only improve coordination but also facilitate the discovery of ways to assign, organize, and perhaps alter tasks to produce more efficiently.[6] Such efficiency gains from teamwork might offset the negative impact of free riding.

[5] In a different context Lommerud (1987) suggests that an employee's productivity may depend on both "technical" and "social" ability, where social ability is the refers to adapting to a firms' external network of contacts, and to extract information, business proposals etc. from this network.

[6] We thank an anonymous referee for recommending a discussion of technical and collaborative abilities.

While the past literature has done much to establish the relationship between free-riding and team production, it offers few insights about how heterogeneity of worker ability affects team productivity. One possible benefit of heterogeneity derives from mutual learning. For instance, if workers possess technical abilities, more skillful workers might be able to teach the less skillful how to execute tasks better and more quickly. This mutual learning explanation is consistent with the results of Berg et al. (1996), who find that informal training by other team members is almost universal in teams in garment facilities. If the mutual learning effect, which equates to knowledge transfer among workers, is significant, teams that are initially more heterogeneous in ability will perform better because high-ability workers pull up the productivity of low-ability workers.[7] Also, such mutual learning may benefit when workers on the team posses collaborative skills that facilitate learning.

A relationship between worker heterogeneity and team performance also could be the result of forming a team norm, which we conceptualize as intra-team bargaining.[8] Suppose the outside options of workers depend on their ability and high-ability workers have better outside options. The formation of a team norm is the bargaining process in which workers negotiate over the common work pace.[9] Assume that side-payments are not allowed,[10] and that there is a significant efficiency gain by teams or non-pecuniary benefits from joining teams to make sure

[7] Mutual learning or information sharing should make the workers' initial skills more substitutable as discussed in Owan (2001). With additional assumptions, we can prove that, when skills are substitutes, assigning heterogeneous workers into teams is optimal. A similar mechanism can be found in Kremer (1993) and Prat (1998). Kremer shows that firms will match together workers of similar skills when they have an O-ring production function, which makes workers' skills complements, whereas Prat argues that a team should be composed of workers with heterogeneous information structures when their actions are substitutes in the production function.

[8] Although workers' tenure (and thus perhaps their social status in the workplace) and racial and cultural backgrounds could affect the possible norm formed in a given team, our primary interest is the influence of diversity of worker ability.

[9] Working at the same pace seems desirable and expected in the factory under analysis because work-in-process inventory has to be kept low in teams.

[10] Therefore, we assume bargaining in a non-transferable utility game.

that agreement is feasible for many teams. Although we do not base our entire discussion on a particular bargaining model, the following features of this bargaining structure give us reasons to believe that skill heterogeneity will significantly affect the bargaining outcome.[11] First, for each proposed work norm, the worker whose payoff is lower than his outside option can credibly threat to opt out, or the worker whose payoff is closer to his outside option is more likely to reject the proposal. This implies that, in the process of forming a team norm, the highest-ability or the lowest-ability worker should gain relatively stronger bargaining power because only their outside options genuinely constrain the set of feasible bargaining outcomes.[12] Second, the possibility of coalition formation implies that the highest-ability worker should have a larger impact on the team output than the lowest-ability worker because other workers are typically better off by forming a coalition with higher-ability workers. As the dispersion in ability increases, either the highest-ability or the lowest-ability team member might threat to opt out. If it is the former, the rest of the workers will accept a higher team norm (i.e. faster work pace) in order to retain her up to the point where the participation constraint binds for another worker. On the contrary, if it is the latter, the other members may simply let him leave and accept a new worker as long as this replacement is costless.

The bargaining story also offers a number of other implications. If replacement of a team member is not costly, bargaining over the team norm breaks down when dispersion in productivity among team members is too large, leading to turnover in teams that should narrow

[11] In order to develop a formal model that is best suited for our analysis, we would need to consider n-person coalitional bargaining in non-transferable utility games where workers can opt out during bargaining. This is beyond the scope of our paper.

[12] A proposed work pace may be too slow for the most-able worker or too fast for the least-able worker to accept.

dispersion. Also, disutility will be imposed on low-ability workers in the form of personal cost of efforts to keep up with high team norm.[13]

Although our discussion of the bargaining process is quite informal, it suggests some relationship between skill distribution among team members and team output and the possibility that the most able worker has the largest influence over the output norm. The actual relationship is an empirical question rather than a theoretical one.

Central to both free-riding and the effect of worker heterogeneity on productivity is whether or not workers join teams; however, the worker's decision to join a team has not been considered in the literature. Consider the participation incentives for high-ability (referring to technical skill) workers. Whether there is mutual learning or bargaining for team norm formation, the productivity level achieved by the team is limited by the productivity of the highest-ability worker on the team, and this worker will not join a team without an additional source of surplus from team production. Indeed, if there is little efficiency gain or non-pecuniary benefit from teamwork, high-ability workers will not participate even in the absence of free-riding because their incomes will be averaged out and almost surely be lower under team incentive pay. Due to this adverse selection problem, no one may want to join teams in equilibrium.

High-ability workers may join a team for two reasons. High-ability workers may join teams when team production offers productivity gains. As described above, teamwork benefiting from multi-skill abilities (e.g., technical and collaborative abilities) is a necessary condition for productivity gains, ceteris paribus. Moreover, those workers with high collaborative ability may sort themselves into teams (Farrell and Scotchmer 1988), which,

[13] If peer pressure is the mechanism to enforce team norm, pressure on low-ability workers will increase their

assuming the highest collaborative ability workers join teams first, suggests that teams formed earlier achieve higher productivity increases.

Alternatively, if socialization within teams turns a boring job into a more enjoyable one, workers may sacrifice income to join a team. This *differential* may be large for team members, especially when given the choice of participating in teams because workers who highly value socialization and cooperation are more likely to join teams, thus inducing better matching.[14] This compensating differential may be asymmetric between high and low-ability workers because it is more likely to be the high-ability workers who receive respect and joy from leading teams. In contrast, low-ability team members may experience a lower differential due to lower respect and lack of a leadership role. However, such compensating differentials yield no implication for the effect on productivity or heterogeneity per se. Nonetheless, workers participating as a result of compensating differentials or, for that matter, efficiency gains, may still be subject to free riding, mutual learning, and bargaining.

II. Production At Koret

Our empirical context for analyzing these behavioral responses is weekly productivity reports from a Koret Corporation garment manufacturing facility in Napa, California. The facility produces "women's lowers" including pants, skirts, shorts, etc. These garments are mid-priced clothes purchased and distributed by department stores. Along with many other firms in the garment industry, a major reason for the introduction of team production over the 1995 – 1997 period at Koret is the demand by retailers that apparel companies make just-in-time

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disutility as well. See Kandel and Lazear (1992).

[14] Enjoyment at work also may reduce the cost of effort or hard work. This is especially so when teams are empowered and their tasks involve substantial cognition and initiative. Psychologists have argued that increasing

deliveries. As noted by Berg et al. (1996), such demands required more flexible production systems, and pushed manufacturers like Koret to replace traditional individual production methods with more flexible teams. Because module production was expected to decrease costs through reductions in inventory, manufacturing space, supervisory and service functions, quality inspections, and rework, many apparel manufactures were willing to adopt a team system even if worker productivity fell.

Garment production at the plant is segmented into three stages. First, cloth is cut into pieces that conform to garment patterns. Finished garments may contain anywhere between 2 and 10 individual pieces including pockets, fronts, backs, waistbands, belt-loops, etc. Second, garments are constructed by sewing together pieces. Third, garments are finished by pressing, packaging, and placing them into a finished goods inventory where they await delivery to a storage warehouse or to customers. Our study focuses on the sewing operation.

Progressive bundling system production

Historically, the plant used a Taylorist progressive bundling system (PBS) (e.g., Dunlop and Weil (1996)) for production. In PBS production, sewing operations are broken down by management into a number of distinct and separate operations (usually totaling between 10 and 30) depending on the complexity of the garment. Management, in consultation with the union, assigns an expected sewing time or "standard" (in minutes) for each operation such that the amount of effort required to sew a standard minute is equivalent across tasks. The standard, which typically ranges between 0.5 and 2.0 minutes per operation, makes comparison of productivity across tasks and garments feasible and represents the central measure against which productivity is evaluated. Workers without any sewing background require little training

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variety and significance of tasks as well as enhancing social interaction inherent to the job raises intrinsic (approximately 2 weeks of on-the-job training). Sewing stations with one worker sitting at each station are evenly spaced in a grid on the shop floor and one sewing operation is assigned to each station. Two floor supervisors assign sewing tasks and deliver batches of material (stored on movable carts that hold between 30 and 50 garments or pieces of cloth) to sewing stations. Workers take garments from an input cart, execute their single sewing operation and re-stack the garments on an output cart. These carts hold the work-in-process (WIP) and remove any possibility of production externalities.[15]

Seamstresses are paid based on individual piece rates according to the standard set for the operation they undertake. In addition to the piece rate standard, workers also receive an hourly wage, or variance pay, when work is interrupted. Variances include the lack of work, machine breakage, job transfer, extra handling other than specified in the prescribed method, rework for which the seamstress is not responsible, making samples, and jury duty.[16]

Quality inspections during sewing occur two times: when the garment is half completed and again when it is fully completed. Supervisors record the seamstress' name for each batch sewn to track the source of such problems. Quality is evaluated by randomly selecting six out of the 30 to 50 garments in a bundle. Quality problems include non-uniform stitching, crooked

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motivation (See Staw (1980), for example).

[15] One exception to this independence is that workers may compete against each other to gain the favor of their supervisor so that they receive sewing tasks when production is slack. The supervisor acknowledged that an estimated 25% of the workers behave strategically to insure a steady supply of work during slow production periods (the supervisor called these interactions "greedy problems").

[16] During these interruptions, the union contract specifies that workers are paid either the minimum wage or an average wage, which is calculated for each worker based on their take home wage over the preceding 13 weeks. For the first two variances, workers receive a minimum wage for the first half-hour and average wage thereafter. Job transfers receive minimum or average wages depending on the situation. Extra handling, rework, and sample making are paid with an average wage. Jury duty is paid at the minimum wage less jury pay. Variance wages, on average, are approximately 10 to 11% of total garment standard (for a total of 111% when total garment standard is included). Also, supervision and management accounts for approximately 5% of total garment standard (for a total of 116%).

stitching, etc. Reworking garments due to one's poor quality is a variance that is unpaid—workers must correct their own quality problems without pay.

During the transition from PBS to module production, the plant manager used PBS production for garment orders with long lead times and large production volumes such as those before a selling season begins, in which quantities of greater than 50,000 units are common. Production time from receipt of order is approximately 5 weeks with materials in the sewing operation for approximately 2 weeks. Cumulative sewing time per garment is between 5 and 20 minutes depending on garment style. At any time, the sewing operation may have 10,000 garments in WIP.

Module Production

In the winter of 1994 the plant manager began experimenting with the use of flexible work teams known in the garment industry as module production. The general manager handpicked the first team. The manager began to rely on module production in earnest by setting up eight teams in 1995. However, instead of hand picking teams, he asked for volunteers. After joining a team, seamstresses could return to PBS production if they preferred it or if other team-members voted a worker off the team. This option was available until mid-1996 when the manager decided to convert the entire plant to module production. When initially interviewed in the fall 1995, the manager had no plans to convert the entire plant to module production. Table 1 summarizes the dates when individual teams were initiated between 1995 and 1997.

In module production at Koret each team typically is comprised of six or seven team-members[17] who work in a U-shaped work space approximately 12' x 24'. Contiguously located

[17]The manager stated that he experimented with the number of workers on a team. He believed that 10 workers were too many for the team to effectively make joint decisions and less than five was too few because cooperation broke down.

around the partitioned workspace are 10 to 12 sewing machines mounted on wheels so that the ordering of machines is easily changed.[18] Unlike seamstresses in floor production, module team-members sew standing up. Instead of storing WIP on carts, WIP is held on small dowels jutting out between each workstation. The dowel acts as a kanban[19] where team-members take pieces from the right and place sewn pieces into the left kanban. By rule, kanbans may hold no more than three to five garments, depending on the length of sewing operations (long operation times have smaller queues while short production times have larger queues). The use of a kanban introduces a production externality among workers as each worker's productivity depends on adjacent workers' output. The kanbans and close proximity of workers and machines reportedly facilitate team-members quickly identifying bottleneck operations and changes in worker productivity. Also, workers are cross-trained on all sewing machines and receive training on the use of the kanban production rule.

Modules are compensated with a group piece rate—the team receives a piece rate for the entire garment as opposed to a piece rate for each operation. The team's net receipts are divided equally. Group piece rates for modules have two additional differences from individual piece rates. First, each worker on the floor must unbundle and bundle the stack of garments when it arrives and leaves the workstation. Bundling and unbundling time accounts on average for five percent of the standard time for sewing an entire garment and is included in the PBS standard. With the module's kanban system, bundling and unbundling is not needed between operations—only when raw material bundles first arrive and finished goods bundles finally leave the work area. Thus, the standard for an entire garment is five percentage points lower for modules

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[18] A variety of different sewing machines, which are specialized for different types of operations, exist.

because of the elimination of intermediate unbundling and bundling steps, which means that teams should be able to increase garment production by 5%, ceteris paribus. However, worker productivity of PBS and module production is measured in comparison to standard minutes, not garments, which means that worker productivity measures for each are directly comparable. Second, whereas floor workers receive variance wages averaging approximately 10 to 12% of standard, module team-members receive no such variance wages. Instead, team-members receive piece-rate wages approximately 11% above the module-adjusted standard, which provides a small increase in incentive intensity. Quality, which the plant manager stated was at least as good and perhaps better than quality provided by PBS production, is monitored upon completion of the garment using same inspection method found in PBS production.

Initially, module production was used in response to three trigger events: small order quantities or need to replenish inventories, special short-term deliveries for customers, or small volumes. The characteristics of these orders is that they have very short lead times and small volumes ranging between 100 to 10,000 garments with an average of approximately 2,000 garments. The manager asserted that an important advantage of module production is that it can sew a batch of 300 garments within eight hours whereas conventional production would in the best scenario require at least two days of sewing and the efforts of up to two-dozen workers to sew the same number of garments. The plant manager also stated that just-in-time stocking by retailers had been a trend that had increased the need for small production runs with little forewarning.

[19] Kanban is a Japanese production concept whereby a queue between workstations is kept low by rule. In the limit where only one item is allowed in the queue, the upstream worker is not to perform her task and place WIP in the queue until it is empty.

While modules essentially use the same labor, capital, and material inputs as PBS production, modules differ in that the team is empowered to make an array of production decisions. Workers from one team described some of these decisions as well as the advantage and disadvantages of module production. Workers reported that they could produce faster with higher quality in modules. They claimed they learned all production tasks, had more information about production tasks, and were able to shift tasks, share tasks, and "figure our easier ways to sew" garments. They stated that they found working in a team to be more interesting and fun, they enjoyed the friendships they developed in the team, and they preferred standing to sitting because it avoided backaches. They reportedly pushed each other to work hard, which often involved joking around. They also stated that other team members quickly caught quality problems, which allowed the team to quickly identify and correct the source of quality problems. Team members claimed that the biggest difficulty of module production is that workers hold a "variety of attitudes", which can lead to "communication problems and misunderstandings". The manager added that workers were more aggressive than management at disciplining team-members.

III. The Koret Data

This paper utilizes a novel data set constructed from the personnel records of employees at Koret over the time period covering January 1, 1995 until December 31, 1997. The data consists of weekly information on worker productivity, pay, hours worked, and team membership for all individuals employed at Koret over this period. In addition, the birth date of each worker also was obtained, although further data on education, training, and so forth was not available to us. The productivity variable is measured as efficiency relative to the standard described above, with values greater than 100 indicating performance above the standard level.

Figure 1 plots median weekly productivity at the plant from the first week of 1995 (week 0) to the last week in 1997 (week 156). In addition, the fraction of plant workers engaged in team production is also presented. The figure shows that median productivity at Koret increases after the bulk of Koret workers are working in teams after week 70. However, the plot also shows substantial cyclical variation in productivity, which is accounted for by the inclusion of month and year dummies in the subsequent regression analysis. Table 1 presents summary statistics for the person-week data, both overall and by team membership status.[20] Consistent with Figure 1, columns (2) and (3) indicate that productivity was actually higher under team production, rather than lower as would be predicted if free-riding concerns were dominant. This higher productivity also translates into higher earnings when in teams, although team members also worked more hours.[21]

Table 2 reports average weekly worker productivity for individuals prior to joining the team and team productivity after joining the team for each of the teams formed at Koret over this period.[22] Productivity increases in 14 of the 23 teams for which we have valid pre- and post-team data. Moreover, teams formed in 1995 are the most likely to show a productivity increase, while teams formed in August 1996 and later (when team participation was less voluntary)

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[20] When workers are in teams, individuals are assigned the team productivity level. Because this is a standardized measure, it is comparable across the PBS and team production regimes.

[21] The distribution of weekly earnings at Koret shown in Table 2 appears to be roughly comparable to the pay of similar workers in the local labor market during this period. For example, using data from the outgoing rotation groups in the Current Population Survey for the San Francisco Bay area and neighboring environs, the median earnings of female immigrant workers with 12 years of education or less was $277 per week, with the lower and upper quartiles being $200 and $372, respectively. Similarly, the earnings of Hispanic women with a high school degree or less were $200, $278, and $400 at the 25th, 50th, and 75th percentiles, respectively. Thus, Koret does not appear to be a particularly highly paying employer in the local labor market.

[22] Team membership sometimes changed over the course of the sample period. In most cases, this represented vacations taken at various dates by individual team members. However, all teams experienced at least one major change in composition. The pre-team average individual productivity value in column (3) is constructed by weighting individuals by the length of time they spent on the team.

experience declines. It may be the case that workers with greater collaborative skills joined the early teams.[23]

Of course, the relationship between teams and productivity observed in Tables 1 and 2 might also reflect cyclical factors or other characteristics. We now explore the team productivity relationship in more detail.

IV. Empirical Analysis

In this section, we investigate the three related sets of issues raised earlier. First, did the use of teams lead to higher productivity, contrary to what might be predicted by simple models with free riding? The second issue relates to the types of workers that joined teams at Koret. The problem of free riding suggests that there may be adverse selection into teams. High-ability workers will not join teams because they are likely to face a reduction in pay. Alternatively, one of the main motivations behind the introduction of teams is that they utilize collaborative skills, not utilized in PBS production, which expand production possibilities. Also, workers may want to join teams despite a loss in pay in order to experience the non-pecuniary benefits of working together and making work less repetitive and more fun. Finally, little is known about the impact of team composition on team productivity. The discussion in Section I suggests that high-ability team members may have greater bargaining power that allows them to enforce a high-productivity team norm. In addition, mutual learning may cause low-ability teammates to be more productive. We now address each of these issues in turn.

[23] Table 2 shows that Team 21, which consisted primarily of new hires with no Koret experience, was highly productive. We suspect that this team was "hand-picked" by management, since it consisted of young workers in their early twenties from a range of ethnic backgrounds (as judged by the workers' names). Because no pre-team productivity data is available, Team 21 is excluded from the team regressions reported in Table 7 below.

What is the Impact of Teams on Productivity at Koret?

A particular advantage of the Koret data is that we are able to observe individual productivity prior to team membership for many workers. Consequently, unlike other studies of teams that rely on firm-level data that is subject to selection and contamination bias, we can use panel data of individuals to assess the impact of teams on productivity. To begin, let y_{it} be the natural logarithm of the productivity of worker *i* in week *t* at Koret. A worker's weekly productivity is modeled as

$$(1) \qquad y_{it} = X_{it}\beta + \alpha TEAM_{it} + \varepsilon_{it},$$

where the indicator variable $TEAM_{it}$ equals 1 if the worker *i* is a member of a team in week *t*, and zero otherwise. The covariate vector X_{it} consists of the age of individual *i* in week *t* and its square, as well as a constant. In addition, output at Koret exhibited considerable cyclical variation. To account for this factor, we obtained monthly data on U.S. women's retail apparel sales over the period from the Bureau of Economic Analysis. We include period *t* retail sales as well as sales up to 6 months in the future as regressors in the X_{it} vector, since such future sales may translate into current period demand for Koret output. Because the retail sales variable is seasonally adjusted, month dummies are also incorporated into X_{it} to account for cyclical factors.

The first column of Panel A in Table 3 presents the estimate of the impact of teams on productivity when equation (1) is estimated via ordinary least squares using the person-week data. Contrary to the predictions of moral hazard models that emphasize the importance of free-riding, the estimate implies that the use of teams at Koret led to a productivity increase of approximately 18%, on average, after accounting for a worker's age and other cyclical factors.[24]

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[24] Because all members of a team are assigned the team productivity level, there may concerns about heteroscedasticity in the regression results presented in Table 3. While robust standard errors that account for clustering by worker and team are reported in the table, we also re-estimated the OLS and OLS fixed effect models

Because outliers may influence this estimate, column (2) provides an estimate of the conditional median impact of teams on output obtained using quantile regression methods. The median estimate is close to that obtained by OLS, indicating that teams increase productivity by roughly 21%.

The estimates in Panel A potentially reflect two factors. First, for any particular individual, joining a team may lead to increased productivity. Second, high-ability workers may systematically choose to join teams. In order to distinguish between these competing explanations, suppose that the disturbance term ε_{it} in equation (1) may be specified as

$$(2) \qquad \varepsilon_{it} = \theta_i + \eta_{it},$$

where θ_i represents the unobserved characteristics that influence the productivity of worker *i* under both individual and team production, such as technical ability. Estimation of equation (1), incorporating specification (2) for the disturbance term produces estimates of the impact of teams on output identified by the "within" effect of teams on productivity for each worker.

Column (3) of Panel A in Table 3 presents the fixed effects estimates of the mean impact of teams on output. On average, a particular worker's productivity increases roughly 14% after joining a team. Comparison of columns (1) and (3) thus implies that of the 18% increase in productivity associated with teams at Koret, approximately one-fifth reflects the systematic selection of high-ability workers under the PBS system into teams, with the remaining amount reflecting a team effect. A similar pattern is observed for the median regression estimates. The median estimate of the impact of teams on productivity falls from 21% to 12% after worker fixed

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allowing the variance to be a multiplicative function of team status. The estimates from these multiplicative heteroscedasticity models were virtually identical to those reported in Table 3. For example, the *TEAM* coefficient from the specification corresponding to that in Panel A, column (1) was 0.174, while the *TEAM* coefficient from the OLS Fixed Effects model analogous to that in column (3) was 0.154. Results from the multiplicative heteroscedasticity specification for each model in Table 3 are available from the authors upon request.

effects are introduced. Overall, the finding in Panel A of Table 3 that productivity increased after the implementation of teams is consistent with the predictions of not only the utilization of collaborative skills but also the bargaining and mutual learning models, which appear to more than offset any possible free-riding.

The estimates in Panel A treat the teams formed at Koret over the 1995 – 1997 period as homogeneous in their impact on productivity. However, one might expect that early teams at Koret were more productive since workers with higher collaborative skills might be the first to choose to participate on teams. In addition, bargaining power for high-ability team members of the early teams was likely to be higher since threats to leave the team and move back to individual piecework were more credible. On the other hand, workers on teams formed after mid-1996 had virtually no non-team options within Koret. In order to avoid working on a team, they would have been forced to leave the firm.

Panel B of Table 3 presents the coefficient estimates of the team dummies for those teams formed in 1995, 1996, and 1997, denoted *TEAM95*, *TEAM96*, and *TEAM97*, respectively (team 1 was formed in 1994 and was omitted). Both the OLS and fixed effects estimates indicate substantial heterogeneity across teams in their impact on output. For example, column (3) shows that workers on teams formed in 1995 had approximately double the impact on productivity compared to those formed in 1996, after accounting for worker fixed effects. Moreover, the last set of teams created at Koret in 1997 had a negative effect, although the coefficient is not statistically significant.

One interpretation of these results is that they reflect team tenure effects, since the observations for teams formed in 1997 are concentrated on the early period immediately after team formation. To account for growth in team productivity, Panel C presents estimates for teams formed in each of the three years, where team tenure is categorized by the first 10 weeks the team is together, the 2nd ten weeks, and 21 weeks or more.[25] The results indicate that the findings of Panel B do not simply reflect tenure effects. Most notably, productivity of the teams was highest for those formed in 1995, and was markedly lower for both those created in 1996 and 1997. In addition, the 1996 teams showed a growth in productivity, as the team grew more experienced after week 20. By contrast, the three teams formed in 1997, a year in which team members were required to join teams to remain at Koret, experienced a decline in productivity even after week 20, although this finding is not statistically significant. Overall, the estimates in Table 3 suggest that the introduction of teams led to higher productivity for teams formed in the first year, and that the productivity impact declined as more workers in the firm engaged in modular production. These findings are consistent with the view that workers with higher levels of collaborative skills that were productive in a team setting tended to participate in teams first.

Who Joins a Team?

The results in Table 3 suggest that self-selection occurred in team formation at Koret, although it appears that more-productive workers under the PBS system, rather than less-productive workers, were the first to join teams. We now examine this issue more closely. As noted above, standard incentive models suggest that low-ability workers should want to join teams, while one might expect turnover at Koret to fall if teams expand production possibilities or provide a more stimulating work environment and workers thus receive greater non-pecuniary benefits under the modular system. We first investigate the type of worker that joins a team, and then assess the impact of teams on turnover at Koret.

[25] Other breakdowns of team tenure were used, such as five-week intervals and polynomials, and gave similar results. The 10-week intervals are utilized for ease of interpretation.

To investigate the question of self-selection into teams at Koret, we estimate a "pre-program" regression for the cross-section of the 151 non-team workers employed at the firm in the first week (week 0) of January 1995. This regression takes the form:

$$y_{i0} = X_{i0}\beta + \gamma FTEAM_{i0} + \varepsilon_{i0}, \qquad (3)$$

where y_{i0} is the ln(productivity) of worker i in the first week of January 1995 (week 0), and the indicator variable $FTEAM_{i0}$ equals 1 if worker i joins a team by mid-1996, and zero if she does not. The excluded category is thus individuals leaving the firm before joining a team, or those individuals forced to join a team after mid-1996 when virtually all workers became team members. Approximately 60% of the 151 workers joined a team by mid-1996, with many (41%) joining by the end of 1995. Because future team membership cannot affect current productivity, the coefficient γ measures the selection into teams.

Panel A of Table 4 indicates that workers who joined teams in the future were approximately 15%-16% more productive in non-team work in January 1995, although the difference is not significant in the median regression model. In Panel B, the *FTEAM* variable is decomposed into 2 dummy variables, one indicating whether the worker first joined a team in 1995 (*FTEAM95*), the second indicating whether the worker first joined a team during the period from January to May, 1996 (*FTEAM96*). The estimates show that the early teams attracted relatively high-productivity workers. In contrast, little selection on this observable measure of ability was observed for teams that formed later. These findings provide little support for the view that relatively low-productivity workers would be sorted into teams due to adverse selection problem discussed earlier. Just the opposite occurs. In fact, it appears that either technical ability is at least somewhat positively correlated with collaborative skills or teams may offer non-pecuniary benefits that are disproportionately large for high-ability workers, since these individuals were the first to join a team. In addition, it may be the case that the disutility imposed by team norm on low-productivity workers was large enough to discourage many of them from joining teams at the beginning.[26]

One of the major puzzles of the Koret data is that high-productivity workers join teams despite the fact that they take earnings losses in doing so. Figures 2A and 2B plot the percentage difference in post-team versus pre-team pay for individuals working under both systems against their pre-team median hourly and weekly earnings, respectively.[27] While it is the case that most workers experienced a pay increase after joining a team, since overall productivity increased, some Koret employees actually experienced a decline in hourly pay, particularly those who were high earners under the PBS production regime.[28] Regressions of the log of hourly pay on team membership (controlling for demographic and cyclical factors) presented in Panel A of Table 5 show that while average pay increased after the introduction of teams at Koret, workers at the top end of the pay distribution actually experienced an 8% reduction in hourly pay under teams.[29] The results for weekly pay, shown in Panel B, are very similar. In this case, workers at the top end see virtually no change in pay, due to the fact that they are working more hours. Both the figures and the pay regressions suggest that non-pecuniary benefits of team membership, such as more control over the work environment and less repetition, appear to be

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[26] A similar adverse selection issue is discussed in Landers et al. (1996), which analyzes law firms where the partnership structure could attract associates with a propensity to work short hours. They argue that legal partners screen out such associates by establishing stringent work norms through the use of associates' record of billable hours in promotion decisions. In our setting of a garment factory, social interactions in teams alone seem to have solved adverse selection.

[27] The horizontal axis of Figure 2A reports the percentage change in median hourly pay for 125 workers employed under both the PBS and team regimes. Similarly, the horizontal axis of Figure 2B reports the percentage change in median weekly pay for 95 workers employed under both the PBS and team regimes. The figures exclude workers who received substantial variance pay or whose hours worked deviated substantially from the mean.

[28] Koret did not give bonuses or rewards to high productivity workers who were "punished" by the team payment scheme.

[29] Earnings information was missing for 433 of the 20,626 person-weeks of data.

important for many workers.[30] While the 20% or more decline in hourly or weekly pay for some individuals shown in Figures 2A and 2B may seem surprising, studies of self-employed workers also show that many individuals are willing to accept 35% or more decline in earnings in exchange for the opportunity to "be their own boss" (Hamilton (2000)). Of course, it may be the case that these high-ability workers only participated in a team for a few periods, and then quit the firm when they learned that their pay was unlikely to exceed its pre-team level.

To investigate this hypothesis, we analyzed the impact of teams on the turnover behavior at Koret. We first constructed job spells for each of the 288 workers employed by Koret at some point over the 1995 – 1997 period. Note that some workers left the firm and were subsequently rehired. To investigate the impact of teams on turnover, we use the data on 402 job spells to estimate a Cox proportional hazard model for the duration of an employment spell at Koret. The job exit hazard is a function of age at the beginning of the spell and its square, as well as a time-varying covariate indicating the individual's team membership status.[31] Column (1) of Table 6 shows that exit hazards were significantly lower after workers joined teams at Koret, indicating that turnover declined after the introduction of teams.

It may not be surprising that turnover was lower for team members, since most of these individuals earned higher pay under this regime. However, one might expect that in the absence of non-pecuniary benefits of teamwork, the most highly paid workers under the individual incentive regime should be the most likely to leave Koret after the introduction of teams, since

[30] It may be argued that the outside wage for high performing workers is even less than what they received under team production, implying a smaller role for non-pecuniary factors. However, Table 4 shows that highly productive (and hence highly paid) PBS workers tended to be the first to join teams, rather than the last if non-pecuniary factors were not important. In addition, footnote 21 shows that the pay distribution at Koret was similar to that available outside the firm.

[31] The hazard model accounts for the left-censoring of employment spells of individuals working at Koret as of the first week of the sample period.

Figures 2A and 2B showed that many of these workers actually experienced a reduction in their pay. To investigate this hypothesis using a consistent sample of individuals with pre-team pay data, we analyze the turnover behavior of the 151 individuals working at Koret as of the first week of January 1995. The exit hazard is modeled as a function of age (as of 1/1/1995) and its square; earnings for the first week in January 1995 (PAY_0); and the time-varying team membership variable (*TEAM*). Column (2) of Table 6 shows that the exit hazard declines when workers join teams, and highly paid employees in the first week of January 1995 are also significantly less likely to leave Koret over the next 3 years. Column (3) includes an interaction between initial pay and team status, and shows that more highly paid individual workers are no more likely to exit Koret once they join teams than lower paid workers. The most highly paid workers in January 1995 might be the most likely to leave after joining a team. Therefore, we constructed indicator variables for the quintile of the PAY_0 distribution (PAY_0 *Q1* indicates the lowest quintile, and PAY_0 *Q5* indicates the highest). Column (4) shows that workers in the top 20% of the pay distribution in January 1995 were no more likely to leave Koret after joining a team than individuals in the bottom 20%. Overall, the results of this section indicate that high-ability workers tended to join teams first, despite a loss in earnings in some cases. These workers were no more likely to subsequently leave the firm after joining a team than lesser-paid individuals. It appears that teams provide non-pecuniary benefits to workers at Koret, and aid in reducing turnover.

How Does Team Composition Affect Team Productivity?

The final step of our empirical analysis investigates how team composition affects team productivity. While it seems straightforward that teams with high-ability members, on average, will be more productive, should teams be homogeneous or will greater heterogeneity in member technical ability lead to higher output? Recall that the bargaining model sketched out in Section I implies that more technically able workers may be able to impose a higher team norm output level, especially when there are non-team jobs available at the plant. Similarly, the mutual learning model suggests that heterogeneity might be preferred if more-able workers can teach their less-able teammates to be more productive.

In order to describe the ability composition of teams, we first constructed the average level of productivity for each individual under the PBS system, prior to their joining a team. The average ability of the team is then measured by the mean of these individual productivity levels.[32] The heterogeneity in ability on the team is measured by the ratio of the maximum to the minimum average individual productivity levels of the team members.[33] Figure 3 presents box plots representing the maximum and minimum individual productivity of team members, as well as plots of the median weekly productivity of each team.[34] The figure shows that the spread in the individual productivity levels of team members varies markedly from team to team. Team productivity exceeds the productivity level of the highest-ability team member in only 3 of the 23 teams pictured. Recall that team output may exceed the individual productivity level of every team member if the team is able to expand production possibilities. Figure 3 thus suggests that while collaborative skills may be a factor in expanding such possibilities, it cannot be

[32] In a few cases, teams had members who had not worked at Koret under the individual production scheme, so that we were unable to construct an ability measure for these individuals. Average team productivity is then calculated using the remaining team members with non-missing individual data. A dummy variable (*NEWHIRE*) is included in the regression to indicate that at least one team member had not previously worked at Koret.

[33] We also estimated the model using the standard deviation of average individual productivity levels of team members to measure the heterogeneity in the ability of the team members. The results were virtually identical to those presented in Table 7, and are available upon request.

[34] We calculate median team productivity in Figure 3 after removing the first 20 weeks that the team is in operation, so that the value of team productivity is not contaminated by potential learning-by-doing effects. Team 25 operated for fewer than 20 weeks by the end of the sample period, so it is not included in the figure. Team 21 consisted primarily of new hires that had not worked at Koret before, so it is also excluded.

distinguished from other explanations for the rise in productivity following the introduction of teams except for these three teams.

To examine the impact of team composition on team productivity, let y_{jt} be the natural logarithm of the productivity of team *j* in week *t* at Koret. A team's weekly productivity is modeled as

$$(4) \qquad y_{jt} = M_{jt}\pi + X_{jt}\delta + \varepsilon_{jt},$$

where the vector M_{jt} consists of measures of the productivity of team *j*'s members in week *t*, such as the average individual productivity level and the spread in individual abilities. X_{jt} includes variables thought in the literature to affect team productivity, such as team size (*SIZE*), the length of time the team has been in operation (*TENURE*) and its square, and whether the team includes a new hire with no previous Koret experience (*NEWHIRE*). To account for possible selection effects, indicator variables for the year of team formation are also included (*TEAM96*, *TEAM97*), as are variables to account for cyclical factors.[35]

The first three columns of Table 7 present regression estimates of equation (4) in which M_{jt} includes the mean individual productivity of the members of the team, and the ratio of the maximum to the minimum individual ability on the team. The results exhibit four notable features. First, increases in team size are not associated with decreases in productivity, which indicates that free-riding is not problematic in this setting. Second, as seen in Table 3, teams formed in 1996 and 1997 were less productive even after accounting for the observed productivity of their members, perhaps due to the sorting of workers with high collaborative skills onto the early teams. Third, teams with more productive members under the PBS system,

[35] Month dummies and monthly women's retail apparel sales are included to account for cyclical factors. Team 1 was excluded because of missing data on productivity and team membership after the first 10 weeks of 1994.

on average, have significantly higher levels of productivity. This result holds in both the OLS (column (1)) and median regression (column (2)) models. More-able workers make teams more productive. Finally, the estimates show that more heterogeneous teams are more productive, holding average ability constant, since the coefficient on the ratio of the maximum to the minimum individual productivity of team members is positive and significant. Column (3) shows that these results are significant even after accounting for unobserved fixed team effects, where the coefficients are identified by within-team changes in team composition. When forming a team, it appears to be better to have a mix of high-ability and low-ability workers, rather than a set of workers with identical technical abilities. This finding is consistent with both the bargaining and learning explanations outlined in Section I. It may be that high-ability workers are able to enforce a higher team norm by exerting their bargaining leverage. On the other hand, the results may reflect mutual learning, in which more-able workers are able to teach their less-able teammates to be more productive.[36]

A further issue relates to the importance of high-ability versus low-ability workers on the team. Suppose that the firm is attempting to improve team productivity by replacing one team member with a more productive individual. From columns (1)- (3), such an increase in average ability should lead to an increase in team output. Consider two alternative replacement schemes. In the first, the most-able team member is replaced by an even higher-ability individual, while in the second, the least-able team member is replaced by a more-able

[36] It may be argued that the less productive workers joining the early teams had exceptionally great collaborative skills, relative to the other workers joining early teams. Consequently, the significant impact of team heterogeneity may reflect the high level of collaborative skill for these early teams. While some of this effect should be captured by the year of team formation indicators, we further investigated this hypothesis by allowing the impact of team heterogeneity to vary by year of team formation. We found no significant difference in the estimated effect of the ratio of maximum to minimum productivity on team performance between teams formed in 1995 and 1996, suggesting that the team heterogeneity effect is more likely to reflect mutual learning or bargaining.

individual. Is team productivity higher if the team's most-able or least-able member is replaced by someone better?

The estimates in columns (4)-(6) of Table 7 suggest that an increase in the productivity of the most-able team member has a significantly larger impact on team productivity of than an equivalent improvement in the ability of the least-able member (although the estimates in the fixed team effect model (column (6)) are not statistically significant). High-ability workers appear to improve team productivity more than low-ability workers do. This finding is again consistent with both the bargaining and mutual learning models. High-ability workers may have more bargaining power to increase team output than low-ability workers, and may also able to teach more productive techniques.

V. Discussion and Conclusion

Our empirical analysis can be summarized by four key findings. First, the adoption of teams at Koret improved worker productivity by 14% on average, even after accounting for the self-selection of high-productivity workers under the PBS production system onto teams. Second, this productivity improvement was greatest for the teams that formed earliest and diminished as more workers in the firm engaged in modular production. Third, high-ability workers not only tended to join teams first, despite a loss in earnings in some cases, but also were no more likely to subsequently leave the firm after joining a team than low-ability workers. Finally, the estimates show that more heterogeneous teams are more productive, holding average ability constant. Moreover, high-ability workers appear to improve team productivity more than low-ability workers do.

Our results beg the question as to why the adoption of group piece-rate incentives achieved higher productivity than individual piece-rate incentives. Our results indicate that free-riding does not appear to be the dominant behavioral response at Koret. The lack of a strong free-riding effect may not be entirely surprising given the ease of peer monitoring within teams at Koret. However, while mutual monitoring may explain why productivity did not fall after the introduction of teams, it cannot explain why productivity increased significantly.

Our results are consistent with the view that workers may have both technical and collaborative skills (such as communication and leadership skills and flexibility), the latter of which were not utilized under PBS production. The participation of high-ability workers on early teams, the larger productivity improvement of early teams, the fact that productivity of three teams exceeded the productivity of their highest ability workers, and high-ability workers were no more likely to leave the teams or firm than low-ability workers, indicate that team production may have expanded production possibilities by utilizing collaborative skills.

We cannot escape the conclusion that workers received some non-pecuniary benefit by participating on teams: some high-ability workers joined teams despite an absolute decrease in pay. Teams offer more varied and less repetitive work, and also reduced variation in weekly pay. It could also be the case that high-ability workers may acquire a higher social status in teams because of their stronger bargaining power or receive appreciation for remaining and helping other workers in teams. Moreover, if additional decision authority given to workers increases worker satisfaction, then more-able workers may want to join teams first because these individuals are likely to take the initiative in making team decisions.

Our results also are consistent with the predictions of bargaining and mutual learning models for teams. More heterogeneous teams are more productive, and “stars” are influential in raising team productivity. It thus appears that teams benefit from a high-ability worker because it leads to a higher productivity social norm attained from a bargaining outcome, or because superior skills get transmitted to the members of the team through mutual learning. These two models may be complementary to our view that collaborative skills play an important role in team production because social skills presumably facilitate mutual learning and prevent bargaining breakdown by facilitating communication.

An alternative explanation for the rise in productivity at Koret after the introduction of teams is the increase in incentive intensity. Teams were paid an 11% higher piece rate, although variance pay (essentially a salary constituting roughly 11% of a PBS worker's earnings) was eliminated. Given the strong mutual monitoring that mitigated free-riding, productivity may have increased after the introduction of teams due to this higher piece rate. However, it is unclear how an increase in incentive intensity can explain why some high-ability workers took a pay cut to be on teams, why more heterogeneous teams are more productive, and why teams that formed early experience greater productivity gains. Thus, non-pecuniary benefits and bargaining or mutual learning remain important factors in explaining team productivity at Koret even if we credit team productivity gains to the minor increase in incentive intensity.

A complementary explanation for the rise in productivity is that teams are effective when a firm adopts a set of complementary practices including employment security, flexible job assignments, skills training, and communication procedures. For instance, several studies (e.g., Boning et al. (1997), Ichniowski et al. (1997), Macduffie (1995), Womack et al. (1990)) indicate that productivity improvements come about only when a set of high-performance employment practices is adopted together. In the case of Koret, an important institutional feature may be the fact that the plant was unionized and operating with a three-year union contract. Union representation at Koret may have provided an effective safeguard against management ratcheting the standard as well as to safeguard the option of team workers to return PBS production. Thus, group piece rates may not have delivered the same productivity improvements if the plant was non-union. This argument is consistent with Black and Lynch's (1997) empirical findings from a representative sample of U.S. business that unionized establishments that adopted industrial relations practices that promote joint decision-making coupled with incentive-based compensation have higher productivity than other similar nonunion plants. Those unionized businesses that maintained more traditional labor-management relations had lower productivity.

Overall, our arguments suggest that it may be feasible for a firm to reduce turnover and increase production by introducing team production, even if some workers earn lower pay after joining the team. Moreover, our analysis suggests the team production is a complex behavioral phenomenon that presents a challenge to theoreticians because it is likely to involve multiple mechanisms that go beyond free-riding and that these mechanisms may interact.

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TABLE 1
SUMMARY STATISTICS, OVERALL AND BY TEAM STATUS

Variable		Overall (1)	Not inTeam (2)	Team Member (3)
Productivity	25%	80.12	71.55	87.58
	50%	99.33	86.80	105.45
	75%	118.30	108.50	120.38
Weekly Earnings	25%	$197.52	$159.64	$226.66
	50%	$274.02	$221.77	$301.03
	75%	$350.26	$291.51	$369.06
Hours/Week	25%	28.52	24.00	30.01
	50%	34.40	32.00	35.72
	75%	38.80	38.33	38.86
Age	25%	30.0	30.9	30.1
	50%	37.0	39.7	35.9
	75%	45.4	48.0	44.3
N		20,626	6,688	13,938

TABLE 2
DATES OF TEAM FORMATION AND AVERAGE WEEKLY PRODUCTIVITY BEFORE AND AFTER TEAM FORMATION

Team	Date of Team Formation	Average Weekly Productivity	
		Individuals Prior to Joining Team[1]	Team (for Weeks 21+)[2]
1	Mar. 12, 1994	97.8	114.3
2	Jan. 7, 1995	82.9	122.6
3	Jan. 28, 1995	79.4	97.6
4	Jan. 28, 1995	94.0	106.0
5	Jan. 28, 1995	117.8	118.9
6	Jan. 28, 1995	89.4	88.3
7	Apr. 29, 1995	89.6	107.8
8	Oct. 7, 1995	122.6	115.6
9	Oct. 28, 1995	127.4	131.3
10	Apr. 13, 1996	85.6	83.6
11	Mar. 30, 1996	100.4	111.8
12	Apr. 13, 1996	87.3	109.3
13	Apr. 13, 1996	94.6	106.1
14	Apr. 13, 1996	85.6	91.2
15	May 18, 1996	78.3	76.8
16	June 22, 1996	81.1	82.6
17	July 20, 1996	81.7	122.9
18	Apr. 13, 1996	92.6	95.5
19	Apr. 13, 1996	86.1	79.7
20	Aug. 10, 1996	127.5	114.4
21	Dec. 7, 1996	-[3]	139.1
22	Jan. 18, 1997	94.0	80.0
23	Feb. 1, 1997	89.2	70.9
24	Mar. 15, 1997	92.1	61.2
25	Sep. 6, 1997	76.9	-

[1] Entries in column (3) are calculated by averaging the individual person-week productivity values of workers who subsequently join the particular team (individuals are weighted by the length of time they spent on the team).
[2] Team averages in column (4) calculated after excluding the first 20 weeks the team is in operation.
[3] Team 21 consisted of almost all new hires and so pre-team productivity data is not available.

TABLE 3
RELATIONSHIP BETWEEN TEAMS AND PRODUCTIVITY
Dependent Variable is ln($Productivity_{it}$)

Variable	No Individual Dummies		Fixed Effects	
	OLS	Median	OLS	Median
	(1)	(2)	(3)	(4)
Panel A: All Teams Grouped Together				
TEAM	0.178	0.211	0.136	0.116
	(0.053)	(0.044)	(0.035)	(0.032)
Panel B: Teams Grouped by Year of Formation				
TEAM95	0.221	0.234	0.177	0.169
	(0.052)	(0.048)	(0.034)	(0.038)
TEAM96	0.060	0.092	0.088	0.072
	(0.070)	(0.061)	(0.044)	(0.038)
TEAM97	-0.090	-0.094	-0.072	-0.082
	(0.120)	(0.186)	(0.065)	(0.068)
Panel C: Team Effects by Year of Formation and Team Tenure				
TEAM95				
Weeks 1-10	0.394	0.221	0.310	0.110
	(0.183)	(0.175)	(0.161)	(0.095)
Weeks 11-20	0.331	0.286	0.241	0.167
	(0.071)	(0.055)	(0.074)	(0.055)
Weeks 21+	0.201	0.237	0.183	0.204
	(0.050)	(0.043)	(0.046)	(0.039)
TEAM96				
Weeks 1-10	-0.087	-0.073	-0.046	-0.081
	(0.118)	(0.118)	(0.081)	(0.060)
Weeks 11-20	-0.019	0.057	-0.023	0.039
	(0.084)	(0.074)	(0.065)	(0.040)
Weeks 21+	0.079	0.118	0.150	0.131
	(0.063)	(0.059)	(0.048)	(0.047)
TEAM97				
Weeks 1-10	-0.365	-0.235	-0.277	-0.180
	(0.092)	(0.169)	(0.102)	(0.144)
Weeks 11-20	0.064	0.128	0.101	0.161
	(0.086)	(0.357)	(0.121)	(0.190)
Weeks 21+	-0.034	-0.165	0.002	-0.043
	(0.166)	(0.270)	(0.075)	(0.102)

Note: N = 20,627 person-week observations. Standard errors in parentheses. Standard errors for OLS regressions account for intra-person and intra-team correlation. Standard errors for median regressions are block bootstrapped using 500 replications. Each regression also includes a constant, age of the worker and its square, dummies for each month, and cyclical variables measuring women's retail garment sales.

TABLE 4
THE IMPACT OF FUTURE TEAM PARTICIPATION ON JANUARY 1995 INDIVIDUAL PRODUCTIVITY
Dependent Variable is ln(Productivity$_{i0}$)

Variable	OLS (1)	Median (2)
Panel A: All Future Teams Pooled		
FTEAM	0.156	0.145
(Joins Team in Future)	(0.070)	(0.129)
Panel B: Future Teams Formed in 1995 and 1996		
FTEAM95	0.206	0.154
(Joins Team in 1995)	(0.078)	(0.131)
FTEAM96	0.061	-0.015
(Joins Team in 1996)	(0.093)	(0.186)

Note: N = 151 observations. Standard errors in parentheses. Robust standard errors for OLS. Standard errors for the median regressions are bootstrapped using 500 replications. All regressions include a constant and age and its square.

TABLE 5
THE IMPACT OF TEAMS ON HOURLY AND WEEKLY PAY

Variable	OLS	Quantile				
		.05	.25	.50	.75	.95
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Dependent Variable is ln(Hourly Pay)						
TEAM	0.158	0.101	0.233	0.222	0.148	-0.083
	(0.035)	(0.044)	(0.038)	(0.045)	(0.046)	(0.039)
Panel B: Dependent Variable is ln(Weekly Pay)						
TEAM	0.260	0.285	0.348	0.312	0.240	0.026
	(0.039)	(0.076)	(0.042)	(0.041)	(0.039)	(0.063)

Note: N = 20,193 observations. Standard errors in parentheses. Robust standard errors for OLS regressions. Standard errors for OLS regressions account for intra-person and intra-team correlation. Standard errors for median regressions are block bootstrapped using 500 replications. Each regression also includes a constant, age of the worker and its square, dummies for each month, and cyclical variables measuring women's retail garment sales.

TABLE 6
COX PROPORTIONAL HAZARD ESTIMATES OF THE PROBABILITY OF LEAVING KORET

Variable	**All Employment Spells at Koret**	**Workers Employed at Koret on January 1, 1995 (first spell only)**		
		Specification		
	(1)	(2)	(3)	(4)
TEAM	-2.221	-2.700	-2.974	-2.835
	(0.183)	(0.419)	(0.644)	(0.586)
PAY_0		-0.009	-0.009	
		(0.003)	(0.003)	
$TEAM*PAY_0$			0.003	
			(0.006)	
PAY_0 *Q2*				-0.609
				(0.375)
PAY_0 *Q3*				-0.703
				(0.368)
PAY_0 *Q4*				-0.329
				(0.316)
PAY_0 *Q5*				-1.151
				(0.437)
$TEAM*PAY_0$ *Q2*				0.501
				(0.720)
$TEAM*PAY_0$ *Q3*				0.139
				(0.861)
$TEAM*PAY_0$ *Q4*				0.200
				(0.681)
$TEAM*PAY_0$ *Q5*				-0.443
				(1.154)
Log-likelihood	-884.34	-398.81	-398.68	-397.55
N	288 workers, 402 employment spells	151 workers, 151 employment spells		

Note: Standard errors in parentheses. All models include age (at the beginning of the employment spell) and its square. Separate baseline hazards estimated for left-censored observations in column (1).

TABLE 7
EFFECT OF TEAM COMPOSITION ON TEAM PRODUCTIVITY
Dependent Variable is ln(Productivity$_{jt}$) For Team in Each Week

	Model 1 Team Heterogeneity Measured by Average Productivity and Ratio of Max/Min Productivity			***Model 2*** Team Heterogeneity Measured by Max and Min Productivity		
Variable	OLS (1)	Median (2)	Fixed Effects (3)	OLS (4)	Median (5)	Fixed Effects (6)
Average Productivity	0.006 (0.0016)	0.005 (0.0014)	0.004 (0.001)			
Ratio of Max/Min Productivity	0.050 (0.023)	0.049 (0.024)	0.028 (0.014)			
Maximum Productivity				0.003 (0.001)	0.003 (0.0008)	0.0003 (0.0008)
Minimum Productivity				0.0006 (0.0019)	-0.0005 (0.002)	0.0002 (0.0009)
TENURE	-0.0002 (0.0022)	0.0009 (0.0019)	-0.001 (0.001)	0.00003 (0.002)	0.0008 (0.002)	-0.001 (0.001)
TENURE^2	-0.00006 (0.00015)	-0.00009 (0.00014)	-0.00005 (0.0001)	-0.00003 (0.00015)	-0.00007 (0.00015)	-0.00001 (0.0001)
SIZE	-0.033 (0.020)	-0.026 (0.018)	-0.017 (0.014)	-0.025 (0.021)	-0.017 (0.018)	-0.006 (0.015)
NEWHIRE	-0.013 (0.052)	0.004 (0.045)	0.015 (0.038)	-0.003 (0.051)	0.024 (0.042)	0.009 (0.038)
TEAM96	-0.097 (0.049)	-0.106 (0.056)		-0.105 (0.046)	-0.077 (0.053)	
TEAM97	-0.316 (0.129)	-0.293 (0.206)		-0.294 (0.141)	-0.285 (0.239)	

Note: N = 2027 observations. Standard errors in parentheses. OLS standard errors account for intra-team correlation. Robust standard errors for OLS and Fixed Effect regressions. Standard errors for median regressions are block bootstrapped with 500 replications. Each regression also includes a constant, dummies for each month, and cyclical variables measuring women's retail garment sales.

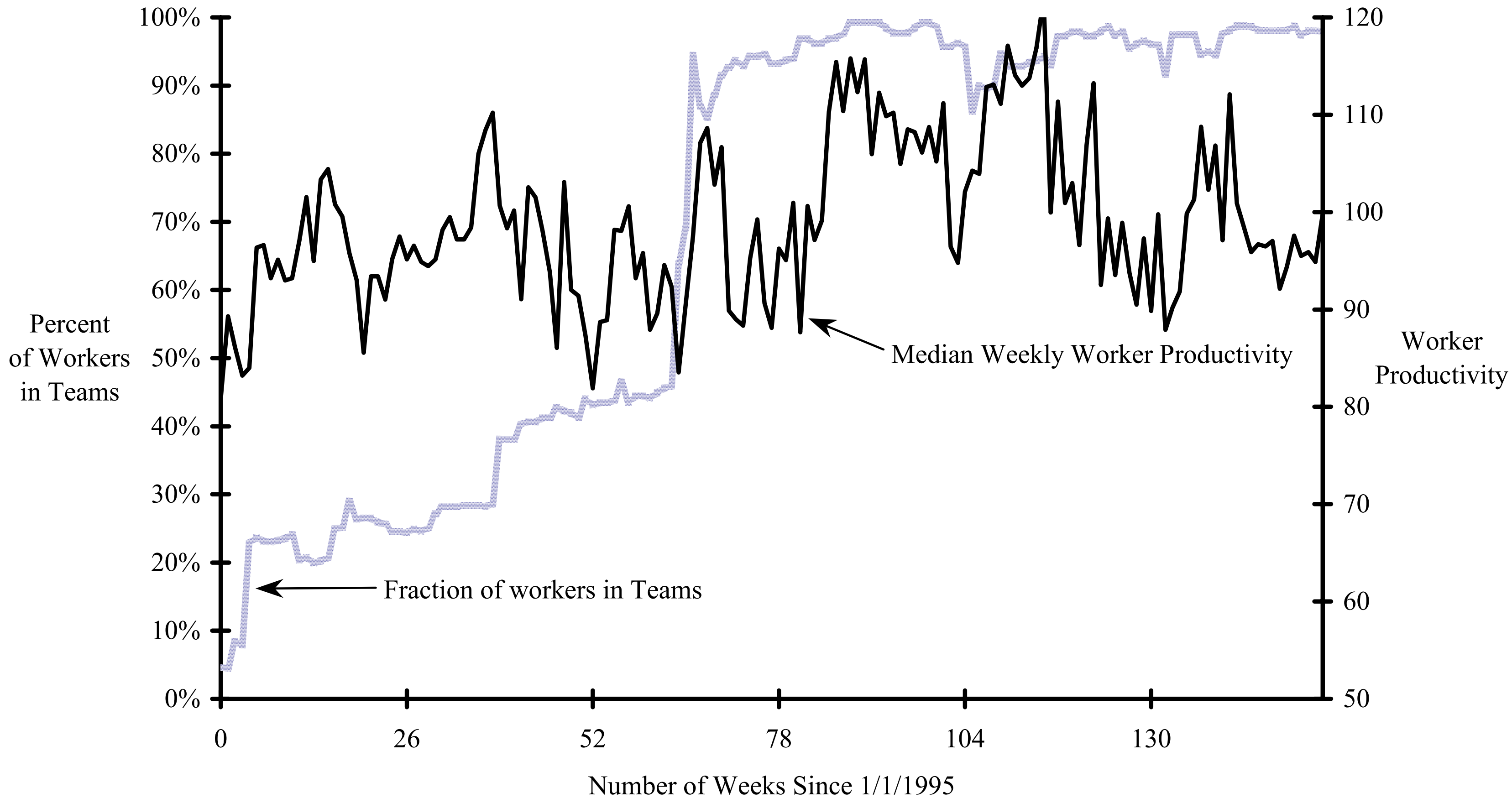

FIGURE 1: MEDIAN WORKER PRODUCTIVITY AND TEAM PARTICIPATION

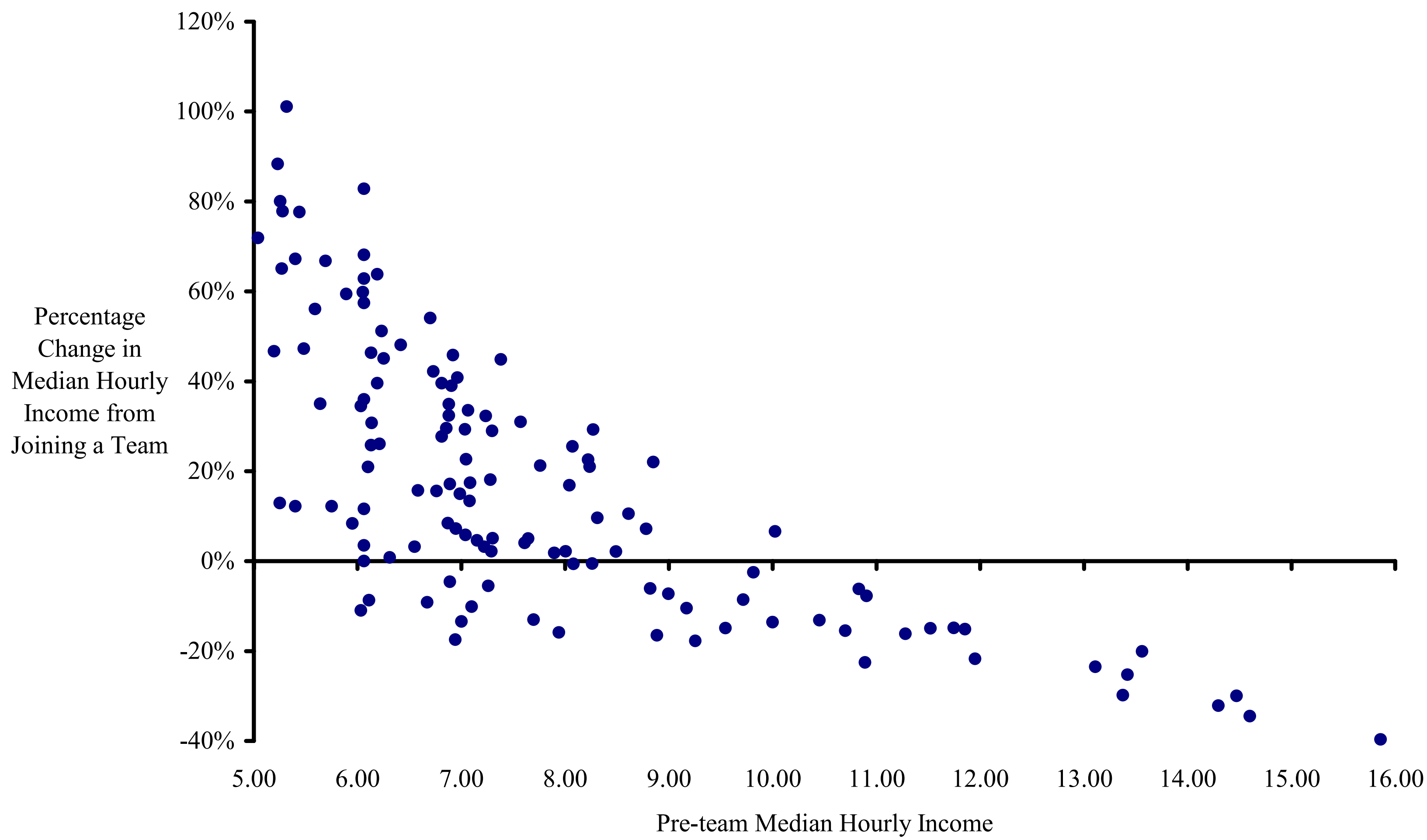

FIGURE 2A: PRE-TEAM AND POST-TEAM MEDIAN HOURLY INCOME

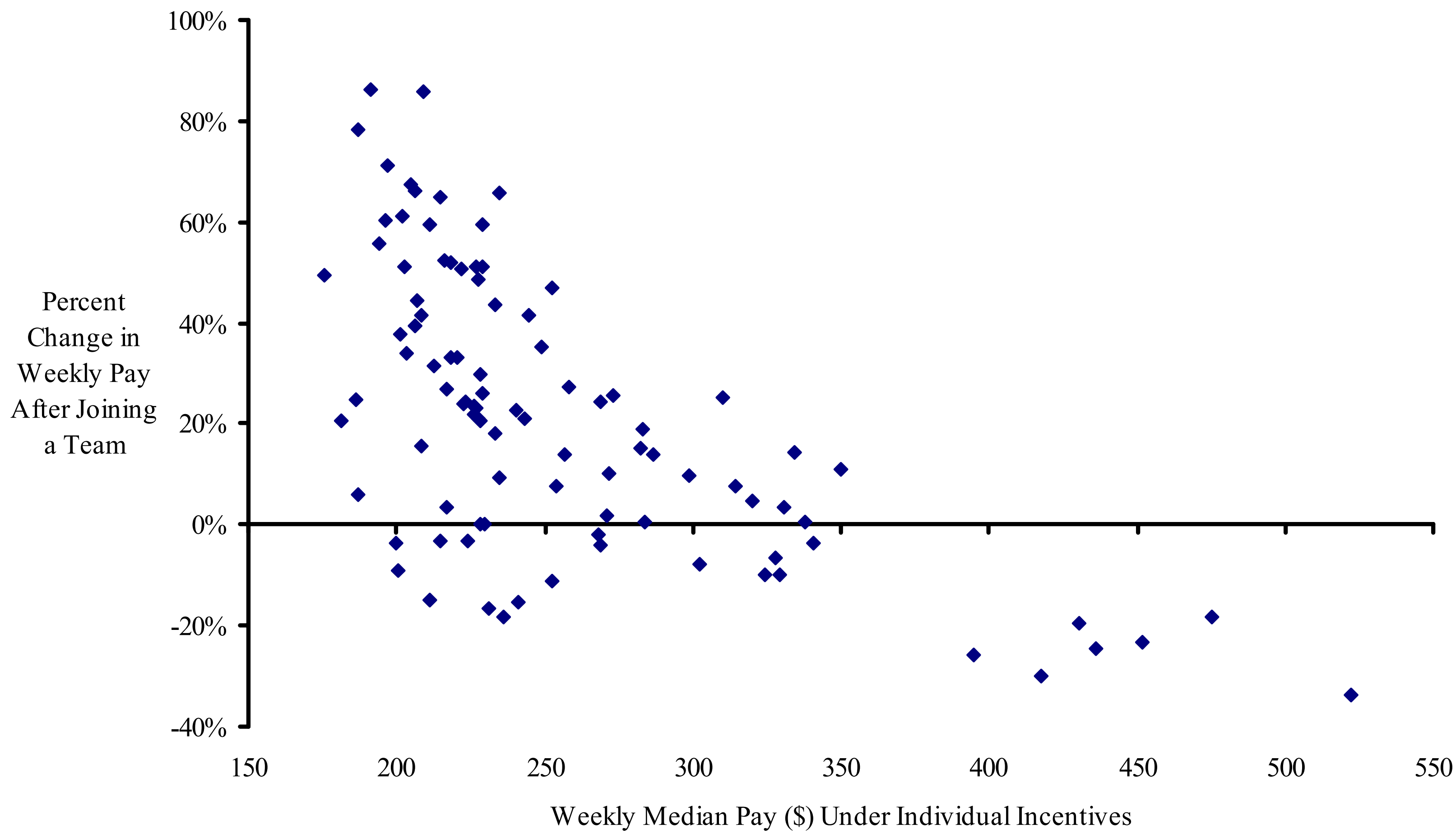

FIGURE 2B: PRE-TEAM AND POST-TEAM WEEKLY MEDIAN INCOME

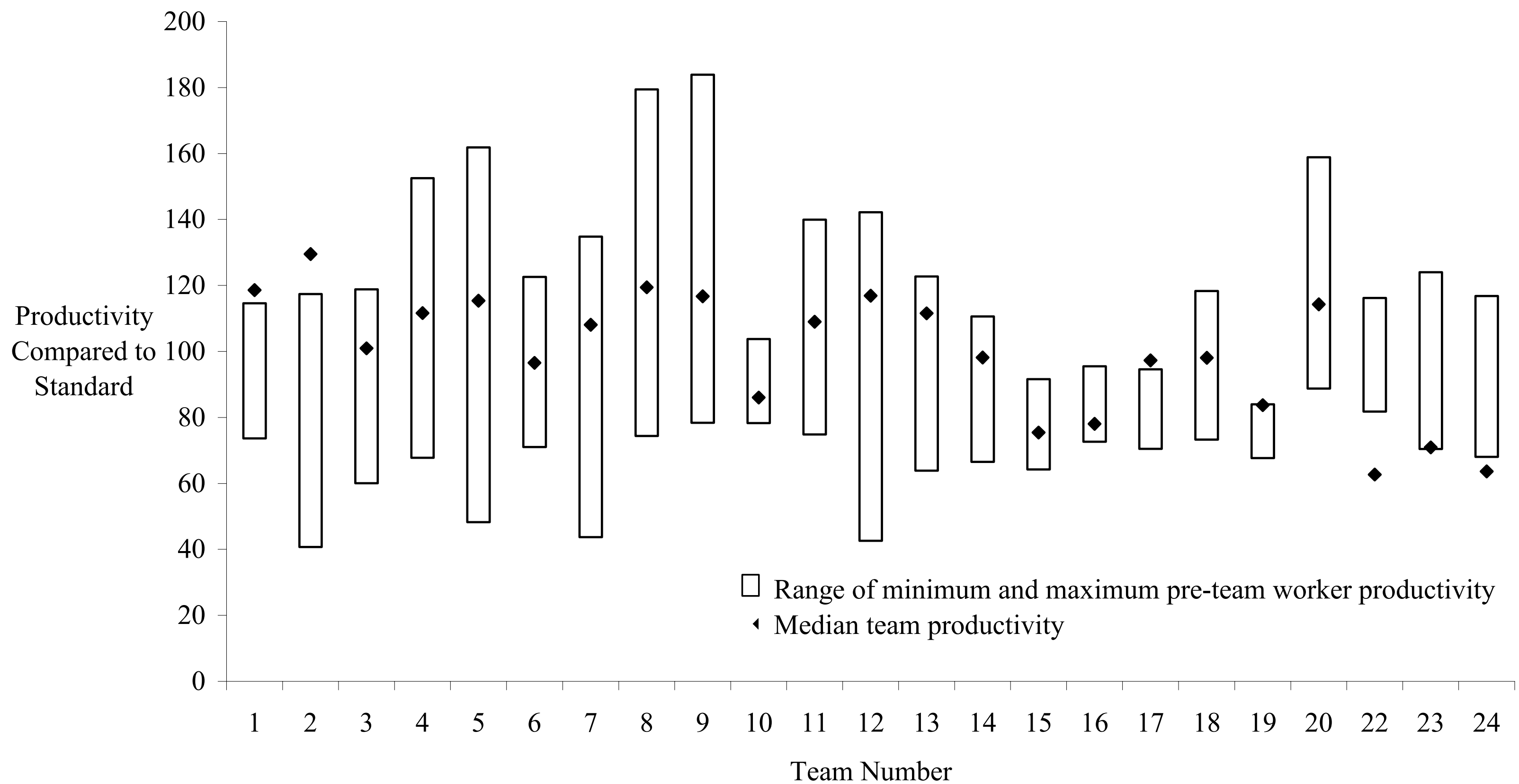

FIGURE 3: MINIMUM AND MAXIMUM PRE-TEAM WORKER PRODUCTIVITY AND MEDIAN TEAM PRODUCTIVITY