INCENTIVES FOR MANAGERS AND INEQUALITY AMONG WORKERS: EVIDENCE FROM A FIRM-LEVEL EXPERIMENT*

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We present evidence from a firm level experiment in which we engineered an exogenous change in managerial compensation from fixed wages to performance pay based on the average productivity of lower-tier workers. Theory suggests that managerial incentives affect both the mean and dispersion of workers' productivity through two channels. First, managers respond to incentives by targeting their efforts towards more able workers, implying that both the mean and the dispersion increase. Second, managers select out the least able workers, implying that the mean increases but the dispersion may decrease. In our field experiment we find that the introduction of managerial performance pay raises both the mean and dispersion of worker productivity. Analysis of individual level productivity data shows that managers target their effort towards high ability workers, and the least able workers are less likely to be selected into employment. These results highlight the interplay between the provision of managerial incentives and earnings inequality among lower-tier workers.

I. Introduction

The last two decades have seen a surge in the popularity of performance pay for individuals in executive and managerial positions, from CEOs down to middle and lower management [Hall and Liebman 1998; Hall and Murphy 2003; Oyer and Schaefer 2004]. The literature, however, does not provide much evidence on how managerial performance pay affects firms' productivity and the performance of individual workers in lower tiers of the firms' hierarchy. We present evidence from a firm level experiment explicitly designed to shed light on these issues. In the experiment we engineered an exogenous change in manage-

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rial incentives by augmenting managers' fixed wages with a performance bonus based on the average productivity of workers managed. Importantly, bottom-tier workers were rewarded according to the same compensation scheme throughout.

In our context, as in most firms, managers can affect average workers productivity through two channels—(i) they can take actions that affect the productivity of existing workers, and (ii) they can affect the identity of the workers selected into employment. A simple theoretical framework indicates that when workers are of heterogeneous ability and managers' and workers' efforts are complements the introduction of managerial performance pay makes managers target their effort towards the most able workers. We label this a "targeting effect" of managerial incentives. In addition, the introduction of managerial performance pay makes managers select the most able workers into employment. We label this a "selection effect" of managerial incentives.

Such targeting and selection effects influence both the mean and the dispersion of workers' productivity. Mean productivity unambiguously rises as managers target the most able workers and fire the least able. The effect on the dispersion, however, is ambiguous. On the one hand, targeting the most able workers exacerbates the natural differences in ability and leads to an increase in dispersion. On the other hand, if only more able and, hence, more similar workers are selected into employment in the first place, the dispersion of productivity may fall, depending on the underlying distribution of ability across workers.

Our research design combined with data from personnel records on the daily productivity of individual workers allows us to provide evidence on how the provision of incentives to managers affects manager's behavior and therefore filters through to the performance of individual workers at lower tiers of the firm hierarchy. We identify the effect of managerial performance pay on average worker productivity, on the dispersion of workers' productivity, and use individual productivity data to separate the targeting and selection effects.

The firm we study is a leading UK producer of soft fruit. Managerial staff belongs to two classes. The first class consists of a single general manager, the second comprises ten field managers. Throughout we refer to the general manager as the chief operating officer (COO), to distinguish him from the field managers. The bottom tier of the firm hierarchy consists of workers.

The task of the bottom tier workers is to pick fruit. This is a physically strenuous task, for which workers are of heterogenous ability. Managers are responsible for field logistics, most importantly to assign workers to rows of fruit within the field and to monitor workers. In this context, managerial effort can be targeted to individual workers and is complementary to worker's effort. The COO's task is to decide which workers are selected to pick fruit each day and which are assigned to nonpicking tasks. The COO also decides the allocation of workers and managers to fields. Managers and workers do not decide where they work or with whom they work.

The design of the experiment is as follows. We divided the peak picking season into two periods of two months each. In the first period the COO and managers were paid a fixed wage. In the second period, we added a daily performance bonus to the same level of fixed wages. The performance bonus is an increasing function of the *average* productivity of workers in the field on that day, conditional on average productivity being above an exogenously set threshold.

The data has three key features that allow us to identify the consequences of managerial performance bonus on the mean and dispersion of productivity among bottom tier workers and the heterogeneous effects across individual workers. First, the change in managerial incentives is orthogonal to other determinants of the firm's productivity—we had full control over the timing of the change, the structure of managerial compensation, and the information provided to managers. Second, we observe the *same* workers and managers under both managerial incentive schemes and therefore control for time invariant sources of heterogeneity across workers, such as their ability, and across managers, such as their management style.[1] Third, we have daily information on the pool of workers available to pick fruit on that day which allows us to precisely identify the effect of managerial incentives on the selection of workers. We observe the entire pool of workers because individuals are hired seasonally from Eastern Europe, and they live on the farm for the duration of their stay. Importantly, there is typically an excess supply of bottom-tier

1. Our empirical strategy is informed by the evidence that individual "styles" of managers affect firm performance over and above firm level characteristics themselves [Bertrand and Schoar 2003; Malmendier and Tate 2005].

workers, and work is offered on a causal basis with no daily guarantee of employment.

Our key findings are as follows. First, the introduction of managerial performance pay increases both the average productivity and the dispersion of productivity among lower-tier workers. The average productivity increases by 21 percent, and the coefficient of variation increases by 38 percent.

Second, the increase in the mean and dispersion of productivity is due to both targeting and selection effects. The analysis of individual productivity data reveals that the most able workers experience a significant increase in productivity while the productivity of other workers is not affected or even decreases. This suggests that the targeting effect is at play—after the introduction of performance pay, managers target their effort towards more able workers.

The individual data also provides evidence of a selection effect. More able workers, namely those who had the highest productivity when managers were paid fixed wages, are more likely to be selected into the workforce when managers are paid performance bonuses. Least able workers are employed less often, and workers at the bottom of the productivity distribution are fixed.

Third, the selection and targeting effect reinforce each other, as workers who experience the highest increase in productivity are also more likely to be selected into employment. The introduction of managerial performance pay thus exacerbates earnings inequality due to underlying differences in ability both because the most able workers experience a larger increase in productivity and because they are selected into employment more often.

Finally, we evaluate the relative importance of the targeting and selection effects through a series of thought experiments. We find that at least half of the 21 percent increase in average productivity is driven by the selection of more productive workers. In contrast, we find that the change in dispersion is nearly entirely due to managers targeting the most able workers after the introduction of performance pay. Namely, the dispersion of productivity would have increased by almost the same amount had the selection of workers remained unchanged. The reason is that the distribution of ability across workers is such that even when the least able workers are fired, the marginal worker selected to pick is still of relatively low ability. Hence, there remains considerable heterogeneity in productivity among selected workers.

We contribute to the empirical literature on the effects of incentive pay on performance. Our analysis complements recent evidence on the effects of incentives to bottom-tier workers on their own or aggregate firm performance [Jones and Kato 1995; Lazear 2000; Paarsch and Shearer 2000] and on the effect of incentive pay for CEOs and managers on aggregate firm performance [Groves et al. 1994; Chevalier and Ellison 1997; Oyer 1998].

Our paper combines both themes as we analyze the effect of *managerial* incentives on the productivity of *individual workers* in lower tiers of the firm's hierarchy. Using individual level personnel data at various layers of the firm's hierarchy, we open the black box of behavior within the firm and explore the efficiency and distributional consequences of the introduction of managerial incentives. Our findings draw attention to the interplay between the provision of managerial incentives and earnings inequality among workers. On the methodological front, our experimental research design allows us to address a key empirical challenge in identifying the causal effects of incentives on firm or individual performance, namely that observed incentive contracts might be endogenous to firm's performance [Prendergast 1999; Chiappori and Salanie 2003].

The paper is organized as follows. Section II describes our context, develops a theoretical framework to analyze the effects of managerial performance pay, and discusses how our experiment is designed to identify such effects. Section III describes the data and descriptive evidence. Section IV presents evidence on the effect of managerial incentives on the average and dispersion of workers' productivity. Section V uses worker level data to identify the heterogenous effects across workers. Section VI presents evidence on the selection effects of managerial incentives. Section VII concludes.

II. Context, Theory, and the Experiment

II.A. Context

The firm we study is a leading UK producer of soft fruit. Managerial staff belongs to two classes. The first class consists of a single general manager, the second comprises ten field managers.

Throughout we refer to the general manager as the chief operating officer (COO), to distinguish him from the field managers. The bottom tier of the firm hierarchy consists of workers.

The main task of the bottom-tier workers is to pick fruit. On average, workers pick on two different fields per day. Within a field-day, each worker is allocated their own row of fruit to pick. A worker's productivity depends on field conditions, on her effort, and on the managerial effort targeted towards her. The amount of fruit to be picked and, hence, the number of workers on a field varies both across fields on any given day because fields vary in their size, and within a field over time because plants reach maturity at different times. There are no complementarities among workers in picking—each worker's productivity is independent of the efforts of other bottom-tier workers. The only choice variable of workers is how much effort to exert into picking. Workers do not choose how many hours to work—all workers are present on the field-day for the number of hours it takes to pick all the available fruit.

Workers are organized and supervised by managers, with each manager being responsible for around twenty workers. Managers on the same field focus on their assigned group of workers and work independently of each other. Managers are responsible for field logistics. In particular, they are responsible for allocating workers to rows at the start of the day and for reallocating workers to new rows once they have finished picking the row they were originally assigned to. If several workers finish at the same time, the manager has to decide whom to reallocate first. Workers place the fruit they have picked into crates. Managers have to ensure that full crates of fruit are removed from the rows and that new empty crates are provided to workers. If several workers simultaneously fill their crates, the manager chooses whom to help first. Managers themselves never pick fruit.

The key choice variable of each manager is how to allocate her effort among her different workers. Managerial effort is complementary to worker's effort, namely, for a given effort level of the worker, her productivity is higher the more effort the manager targets towards her. For example, by assigning her to more plentiful rows and removing her full crates quickly, her productivity increases.

The effect of managerial effort on worker productivity can be substantial. Assuming that workers pick at a constant speed, if the manager slacks for five minutes every hour and a worker is left to wait for a new crate for the same time, his productivity would be 5/60 = 8 percent lower. The effort costs to the manager are considerable because the workers she is responsible for are dispersed over a large area. The median field size in our sample is three hectares. Given that on the median field-day there are three managers, each manager has to cover an area of one hectare. To make sure she is aware of which workers need to be reallocated to new rows and which need crates to be replaced, the manager needs to continuously walk around the field.

Workers and managers are hired seasonally from Eastern Europe and live on the farm.[2] Their work permit allows them to work on other UK farms subject to the approval of the permit agency. Their outside option to employment at the farm is therefore to return home or to move to another farm during the season. Individuals are typically not observed moving from picking tasks to managerial tasks or vice versa. Finally, work is offered on a causal basis with no daily guarantee of employment. In practice, managers manage each day, and workers are typically engaged in picking tasks every other day. On other days workers are asked to perform nonpicking tasks such as planting or weeding, or may be left unemployed for the day. Therefore on any given day, there is an excess supply of workers available for picking.

The COO is a permanent employee of the farm. His main task is to decide which of the workers present on the farm are selected to pick fruit each day, assigned to nonpicking tasks, or left unemployed for the day. If two fields are operated simultaneously, the COO allocates workers and managers to fields. Managers and workers do not choose which field to work on, nor whom they work with. The fruit is planted some years in advance, so the sequence in which fields are picked over time is determined at the start of the season and is not decided by the COO.

Workers are paid piece rates. The piece rate is the same for all workers on a given field-day and is set to minimize the firm's wage bill each field-day subject to a minimum wage constraint.[3]

2. In order to be recruited, individuals must be full-time university students and must return to the same university in the fall. Workers are not typically hired from the local labor market because of the seasonality of the work. Very few workers are hired for two consecutive seasons.

3. This is consistent with profit maximization. Given a competitive market for soft fruit and that the total quantity of fruit available is fixed some years in advance when fruit is actually planted, the firm faces little uncertainty over its total revenue. In contrast, given workers are paid piece rates, the firm's total wage bill is uncertain.

The piece rate is set so the *average* worker obtains an hourly wage of $\underline{w}$, where $\underline{w}$ is above the legally prescribed minimum wage, is chosen by the owner of the firm at the beginning of the season, and does not change over the season.

In practice, the COO has some discretion to make small adjustments to the piece rate across field-days, as field conditions vary. Let β_{ft} be the piece rate on field f and day t. This is set according to the following rule:

$$\beta_{ft} = \frac{\underline{w}}{E(y_{ft})}, \tag{1}$$

where $E(y_{ft})$ is the expected productivity of the average worker on the field-day.[4] Hence, the piece rate is lower whenever productivity is expected to be higher.[5]

The focus of our experiment is the compensation schemes of managers and the COO. Halfway through the peak picking season we exogenously change the compensation scheme by adding a field-day performance bonus to the existing level of managers' wages. The purpose of the experiment is twofold. First, we aim to identify the causal effect of managerial incentives on the mean and dispersion of worker's productivity. Second, we aim to decompose these aggregate effects into those that are attributable to the differential targeting of managerial effort across workers and those that are attributable to the differential selection of workers into picking by the COO.

4. At the start of the day the COO inspects each field to be picked. He then forms an expectation of worker productivity that field-day and sets the piece rate so that a worker with average productivity expects to obtain an hourly equivalent of $\bar{w}$. This piece rate is announced to workers before they start picking, and cannot be revised *ex post.* If a worker's productivity is so low that they earn an hourly equivalent less than the legally prescribed minimum wage, they are paid a one-off supplement to ensure they reach the minimum wage. When they first arrive on the farm, workers are informed that they will be sent home if they consistently need to be paid this supplement. We observe less than 1 percent of worker–field-day observations where workers are paid the supplement.

5. This raises concerns of a ratchet effect, whereby workers deliberately underperform to keep the piece rate high. In Bandiera et al. [2005] we provide evidence that in this setting, workers are unable to collude in this way. This is partly driven by the uncertainty they have over where they will work in the future, with whom they will work, and their inability to monitor workers in other fields. Moreover, given the stochastic nature of agricultural production, it is difficult for workers to disentangle changes in the piece rate due to changing conditions and those due to management learning about workers' true ability [Ickes and Samuelson 1987]. Such ratchet concerns have been documented in firms where productivity shocks are less common such as shoemaking [Freeman and Kleiner 2005] and bricklaying [Roy 1952].

II.B. Theoretical Framework

We develop a stylized model of the firm to analyze the effect of the introduction of managerial performance pay on the equilibrium mean and dispersion of workers' productivity. The model is tailored to fit our context and experimental design. The firm's hierarchy has three layers—a COO, managers, and workers. For parsimony and without loss of generality, we assume there is one manager and three workers. Since in our context there is an excess supply of workers available for picking tasks, we assume production requires only two workers and one manager in any given field. The division of tasks is as follows—workers pick fruit, the manager organizes logistics for each worker, and the COO decides which of the workers pick fruit and which are left unemployed.

The output of worker i is given by $y_i = (1 + km_i)e_i$, where e_i is her effort, m_i is the managerial effort targeted towards her, and $k > 0$ is a measure of the strength of the complementarity between the manager's and worker's efforts.[6] The productivity of worker i, measured as the kilograms of fruit picked per hour, is defined as y_i/h, where h is the number of hours worked on the field. This is the same for all workers in the field, and so we make the simplifying assumption that $h = 1$. This implies that in our framework output and productivity coincide.

The timing of actions is as follows. In the first stage, the COO chooses which two out of the three workers are selected into picking tasks. In the second stage, the manager and workers simultaneously choose their efforts. We determine the effects on the mean and dispersion of workers' productivity of changing the manager and COO's compensation from fixed wages to performance pay related to workers' average productivity. In what follows we present the key results and the intuition behind them. We refer the reader to the working paper version for details of the derivation and all proofs.[7]

Workers. Workers are paid piece rates, where the piece rate is β per kilogram fruit picked and is taken as given by workers. The total pay of worker i is therefore βy_i. Worker i has a disutility of effort of $\frac{1}{2}\theta_i e_i^2$, where θ_i captures the heterogeneity across

6. There may also be a pure public good component to managerial effort which affects all workers. The key comparisons between the managerial incentive schemes remain qualitatively unchanged in that case.

7. This is available at http://econ.lse.ac.uk/staff/bandiera/research.htm.

workers and is interpreted as the inverse of the worker's innate ability. The utility of a worker is assumed to be linear and additively separable between pay, βy_i, and effort, $-\frac{1}{2}\theta_i e_i^2$. Workers choose their effort, taking as given the managerial effort targeted towards them. Worker i's optimal effort is thus equal to $e_i^* = \beta(1 + km_i)/\theta_i$.

The Manager. The manager's compensation schedule is $w + b\bar{Y}$, where w is a fixed wage and $\bar{Y} = \frac{1}{2}(y_i + y_j)$ is the average productivity of the two workers i and j. The parameter b captures the strength of managerial incentives, namely the variable component of managerial pay which is linearly related to the average productivity of workers. We assume the manager's effort choice can either be 0 (low) or 1 (high). The manager chooses high or low effort, and how to allocate her effort between workers i and j. Effort entails disutility cm, where $m = m_i + m_j$, for the manager.

The manager chooses her effort taking as given the effort choices of the workers. The manager's maximization problem is

$$\max_{m_i, m_j} w + \frac{1}{2} b[(1 + km_i)e_i + (1 + km_j)e_j] - cm, \tag{2}$$

where $m \in \{0,1\}$. Note that the benefit of choosing high effort is linearly increasing in b and the disutility of high effort is constant. Thus, if incentives are sufficiently strong (b is high), the manager exerts high effort. In addition, since the manager's pay is a linear combination of the output produced by the two workers, when the ability differential between the two workers is sufficiently large the manager maximizes her payoff by targeting the high ability worker.[8]

It follows that changing the manager's compensation scheme from fixed wages ($b = 0$) to sufficiently high powered performance pay increases average worker productivity both because managerial effort enters the production function directly and because the worker's best response is nondecreasing in managerial effort.

In addition, managerial incentive pay increases the disper-

8. Workers' effort depends on their ability and the managerial effort targeted towards them. If the difference in ability is sufficiently large, the more able worker always exerts more effort, regardless of the level of managerial effort. Therefore, if workers are sufficiently heterogeneous, the unique equilibrium outcome is where the manager targets the most able worker. In a more general setting with a production function that is concave in manager and worker efforts, the same result holds as long as the strength of the complementarity between manager and worker efforts is not decreasing in the worker's effort.

sion of productivity because the manager targets the more able worker to maximize the marginal return to her effort. This increases the more able worker's productivity while leaving the productivity of the other worker unchanged. Thus, when the manager is given performance pay, the differences in productivity between workers that arise naturally because workers are of heterogeneous ability, are exacerbated by the differential targeting of managerial effort across workers.

The COO. The COO's compensation schedule is $W + B\bar{Y}$, where W is a fixed wage and $\bar{Y}$ is the average workers' productivity. The parameter B captures the strength of incentives, namely the variable component of COO pay, which is linearly related to the average productivity of workers.

The COO selects two of the three available workers into employment. We label workers as 1, 2, 3 and assume $\theta_1 < \theta_2 < \theta_3$, so worker 1 is the most able and worker 3 the least able. We make the simplifying assumption that the COO does not know the workers' ability *ex ante,* but can exert one unit of effort to learn each worker's ability. In our context, the COO may learn workers' ability by analyzing personnel files on workers' performance for example. We denote the COO's effort choice as $s \in \{0,1\}$ and his total effort cost as Cs. Hence, if the COO chooses to learn each worker's ability, he is able to creamskim the two most able workers into employment. Otherwise he chooses each possible pair of workers with equal probability.

To focus on the effect of the COO's incentives, we assume the manager is paid a fixed wage and thus chooses the low-effort level. The COO then chooses s, taking into account that the manager's and the workers' effort to maximize $W + BE(\bar{Y}(s)) - Cs$, where $E(\bar{Y}(s))$ is expected average productivity of the selected workers and depends on the COO's effort choice.

When incentives are sufficiently strong so B is large enough, the benefit of exerting high effort is larger than the cost C, and the COO exerts high effort. This increases average productivity because the COO finds out the identity of the weakest worker and drops him from the workforce. Note that the selection effect identified here is different from the sorting effect of incentive pay identified by Lazear [2000, 2005]. Here the introduction of managerial incentives affects the *demand* for lower-tier workers. Lazear [2000, 2005] makes the related point that incentive pay affects the *supply* of workers, namely when workers or managers are offered incentive pay, they self-select into jobs where they expect their compensation to be higher.

The effect on the dispersion of productivity depends on the distribution of ability among workers. Intuitively, when the COO incentives are high powered, the dispersion depends only on the difference in ability between workers 1 and 2, given that worker 3 is never selected. In contrast, when the COO is paid a fixed wage the dispersion depends on the pairwise differences between the three possible combination of workers, since all are selected with equal probability. The comparison of dispersion in the two cases then depends on the distribution of ability across workers. If the least able worker is sufficiently less able than the other two, creamskimming by the COO results in a pairing of the most similar workers and thus reduces dispersion.

The Combined Effect of COO's and Manager's Performance Pay. In our experiment we changed the compensation scheme of both the manager and the COO by adding a performance bonus to their existing fixed wage. Namely in the first part of the experiment $b = B = 0$; in the second part $B > 0$, and $b > 0$.

The effects on the mean and dispersion of productivity thus depend on the balance of effects stemming from changes in behavior of the manager and the COO. The effect on average productivity is unambiguously positive: the COO increases productivity by selecting more able workers, and the manager increases productivity by exerting more effort and targeting the more able workers.

The effect on the dispersion of productivity depends on the net effect of targeting by the manager, which is non-negative, and the effect of the selection by the COO, which is ambiguous. As the manager targets the most able worker, dispersion increases. If selection by the COO reduces dispersion, the net effect depends on the balance between the two factors. The positive targeting effect prevails when the complementarity between the manager and worker's effort is sufficiently strong. We later present evidence from our setting on which of the targeting and selection effects prevails overall, the relative importance of each, and the heterogeneous effects across workers.

II.C. The Design of the Experiment

The design of our experiment is as follows. At the start of the 2003 season, workers were paid piece rates, and the COO and managers were paid a fixed wage. Midway through the 2003 season we exogenously changed the compensation schemes of the COO and managers, adding a performance bonus to their same level of fixed wages. The experiment left the structure of the compensation scheme of bottom-tier workers unchanged—they were paid piece rates throughout the season.

The COO and managers did not know that they were taking part in an experiment and that the data would be used for scientific research. As such, our experiment is a natural field experiment according to the taxonomy developed by Harrison and List [2004]. The COO and managers were aware that productivity data were recorded and kept by the owner and that the data would be analyzed to improve the firms' efficiency.

The bonus payment was awarded on field f and day t if the average productivity of the bottom-tier workers on the field-day, $\bar{Y}_{ft}$, exceeded an exogenously fixed threshold, Y^*.[9] Conditional on reaching the threshold, the total monetary value of the bonus payment available to the managers on field-day ft, $B(\bar{Y}_{ft})$ increases at an increasing rate in the average field-day productivity to reflect the increasing marginal cost of supplying managerial effort.[10] Each manager obtains an equal share of the bonus payment generated on the field-day. If there are M_{ft} managers present, then each obtains a payment of $(1/M_{ft})B(\bar{Y}_{ft})$. In practice, each manager shares the bonus payment with at most three other managers on the field-day, implying her effort has a large effect on the probability she obtains the bonus.

Each manager's bonus payment depends only on the fields that she has worked on that day. In contrast, the COO effectively works on every field each day. The daily bonus payment that

9. To avoid multitasking concerns [Holmstrom and Milgrom 1991], the performance bonus was not awarded if the *quality* of fruit picking declined. Quality is measured in two ways. First is simply the quantity of damaged fruit. Second, fruit has to be classified as either suitable for market or supermarket. This classification is largely based on the size of each fruit. If the percentage of damaged or misclassified fruit rose by more than 2% of a pre-established norm, then the performance bonus was not awarded that field-day.

10. The bonus payment schedule is piecewise linear:

$$B(\bar{Y}_{ft}) = \begin{cases} 0 & \text{if } Y^* > \bar{Y}_{ft} \\ a_1 + b_1\bar{Y}_{ft} & \text{if } Y^* + c_1 > \bar{Y}_{ft} \geq Y^* \\ a_2 + b_2\bar{Y}_{ft} & \text{if } Y^* + c_2 > \bar{Y}_{ft} \geq Y^* + c_1 \\ a_3 + b_3\bar{Y}_{ft} & \text{if } \bar{Y}_{ft} > Y^* + c_2 \end{cases},$$

where the parameters a_i,b_i, and c_i are set such that $B(\bar{Y}_{ft})$ is a continuous and convex function. The actual values of a_i,b_i,c_i, and Y^* cannot be provided because of confidentiality reasons.

accrues to the COO for any given field is 1.5 times that which accrues to a manager on the field. The COO's daily bonus payment is the sum of these payments across all fields operated that day and is therefore equal to $1.5\ \Sigma_f\ (1/M_{ft})B(\bar{Y}_{ft})$.

The fraction of field-days on which the bonus was earned varies from 20 to 50 percent across managers. The *ex post* monetary value of the performance bonus to managers is substantial. Averaged across all field-days actually worked under the bonus, managerial hourly earnings increased by 7 percent. Conditional on obtaining the bonus, managerial hourly earnings increased by 25 percent. The true expected hourly earnings increase to managers because the performance bonus scheme is likely to lie between these bounds.[11]

Our experimental design allows us to address two key concerns. First, in our context managers live and work on the farm, and, therefore, each manager is aware of the compensation scheme offered to other managers. This raises the possibility of contamination effects if different managers were contemporaneously paid according to different compensation schemes. For example, those managers paid fixed wages throughout may become de-motivated, leading us to overestimate the causal effect of managerial performance pay on workers' productivity. To prevent such contamination effects arising, we offer all managers the same pay scheme at any given point in time.

Second, in our context there are a small number of managers and their behavior is analyzed only for one season. Hence, unobservable heterogeneity among managers is a more important determinant of productivity than unobservable time varying factors. Our design allows us to compare the same manager under the two schemes and we are thus able to control for time invariant sources of unobserved heterogeneity across managers such as their management style or motivational skills.

11. Given that managers are from Eastern Europe, their base pay is 20 percent higher than the UK minimum wage. Given that most individuals save earnings to spend later in their home country, these increases in hourly earnings translate into large increases in real income. As of January 2003, gross monthly earnings at the UK minimum wage (€1105) are five times as high as at the minimum wage in Poland (€201), where 40 percent of managers come from, and almost 20 times higher than in Bulgaria (€56), where 29 percent of managers come from.

III. Data and Descriptive Evidence

III.A. The Data

We exploit the firm's personnel records, which contain information on each worker's productivity for each field-day they pick fruit. Productivity is defined as kilograms of fruit picked per hour and is electronically recorded with little measurement error. Personnel records also allow us to identify all the workers and managers present each field-day.

Throughout, we analyze data on the main fruit type grown on the farm and focus on the main site on the farm during the peak picking season from May 1st until August 31st. To compare the effects of managerial incentives on the same pool of workers, we restrict the sample to workers that were available for work at least three weeks either side of the change in managerial incentives. To compare the effects of managerial incentives within the same set of fields, we restrict the sample to fields that were operated for at least one week either side of the change in managerial incentives. The final sample contains 247 field-days and 9897 worker–field-day observations. This covers 13 fields, one COO, 10 managers, 197 workers, and 95 days. As part of our experimental design, the change in managerial incentives occurs midway through the peak season so that there are 44 days in the pre-bonus period and 51 days in the post-bonus period.

III.B. Data Description

The top panel of Figure I shows the time series for worker productivity, averaged over all workers each day, for the 2003 picking season. Average productivity was somewhat declining in the pre-bonus period, rose after the introduction of performance bonuses, and remained at this higher level throughout the remainder of the season.

Identification of any causal effect of the change in managerial incentives on productivity is confounded if there is any natural time trend in productivity. To begin to address such concerns, the lower panel of Figure I shows the comparable time series for the 2004 season, when managers and the COO were paid the same level of fixed wages throughout and no performance bonus

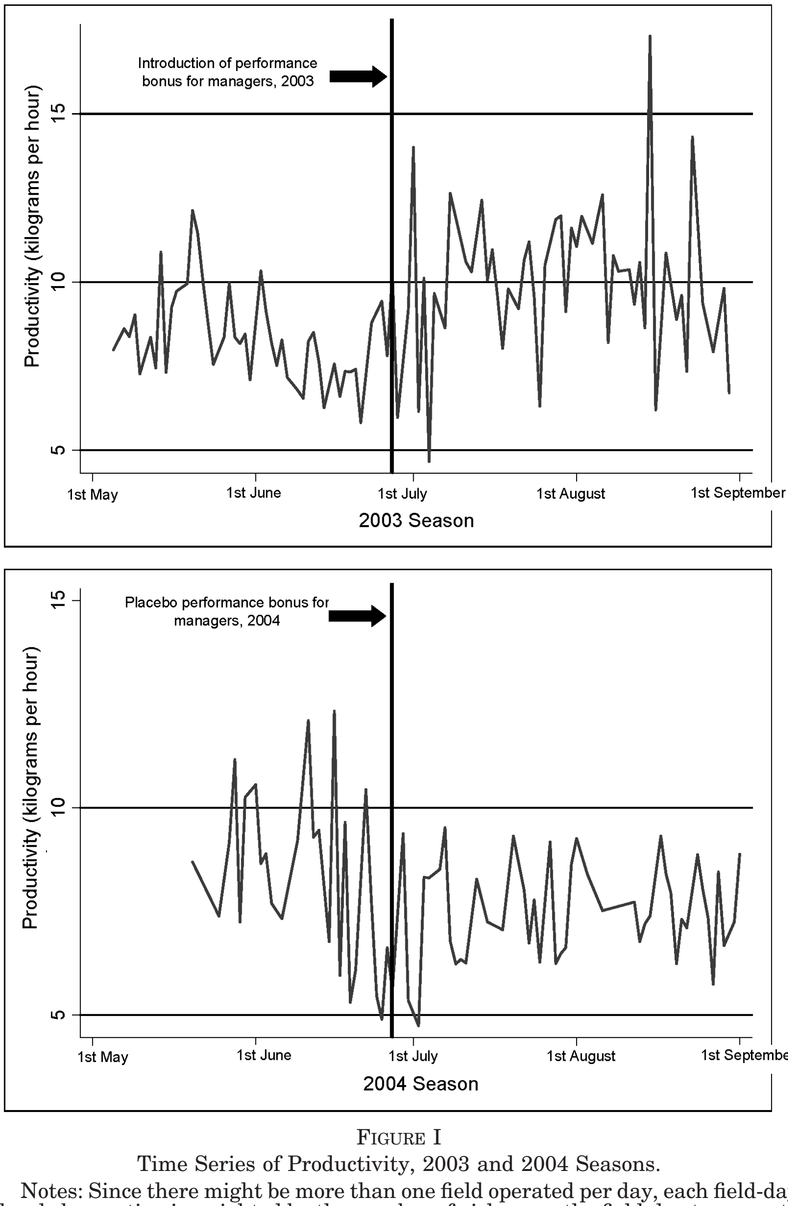

FIGURE I

Time Series of Productivity, 2003 and 2004 Seasons.

Notes: Since there might be more than one field operated per day, each field-day level observation is weighted by the number of pickers on the field-day to compute the average productivity for the day.

scheme was in place.[12] In 2004 aggregate productivity again declines in the first half of the season and then remains at the same level throughout the second half of the season.[13]

Table I provides descriptive evidence on worker level productivity in 2003 and 2004. Column (1) shows that, on average, workers' productivity in the first half of 2003 when managers are paid fixed wages is 8.37 kg/hour. The corresponding figure for 2004 is similar. Column (2) shows that in the second half of the 2003 season when managers are paid performance bonuses, productivity significantly rises by 25 percent to 10.4 kg/hour. In contrast, in the second half of the 2004 season worker productivity remains almost unchanged.[14]

As discussed in Section II, any causal effect of the change in managerial incentives on worker productivity in 2003 can potentially be ascribed to two mechanisms—a targeting effect and a selection effect. To begin to provide descriptive evidence on these mechanisms, we first note that in the second half of the 2003 season when managers are paid performance bonuses, only 130 out of the 197 workers continue to pick. The remaining 67 workers are "fired" from picking and either allocated to nonpicking tasks or left unemployed for some days. In contrast, at the corresponding time of the season in 2004 no workers are fired. All workers who pick in the first half of the season continue to do so in the second half of the season.

Columns (3) and (4) divide workers in the 2003 season into two groups: those who continue to pick after the introduction of managerial performance pay and those who are fired. We note that when managers are paid fixed wages the fired workers are less productive than the selected workers. This suggests management

12. We were only able to present our findings on the causal effect of the performance bonus to the farm management shortly before the beginning of the 2004 season. Because of technical constraints, they could not adjust their personnel practices to incorporate performance bonus calculations for 2004. However, given the success of the scheme in raising the firm's profits, a performance bonus scheme was introduced in 2005.

13. Both time series in Figure I average the productivity of workers in different fields. Hence, these aggregate series are in part driven by changes in the composition of fields over time. This composition effect explains the downward trend in productivity in the first half of both seasons—the most productive fields are picked early in the season. Our empirical analysis controls for levels differences in productivity across fields by including field fixed effects throughout.

14. Farm management also provided us information on what they had expected productivity to be on a subset of fields each week of the 2003 season. These expectations were formed before the start of the 2003 season, and before they were aware of the design of the field experiment. Productivity was projected to be 9.06 kg/hour in the pre-bonus period and 8.99 kg/hour in the post-bonus period.

TABLE I
DESCRIPTIVES OF WORKER PRODUCTIVITY BY MANAGERIAL INCENTIVE SCHEME

	Fixed wages	Performance bonus	Fixed wages		Performance bonus
	(May 1st–June 26th)	(June 27th–August 31st)	(May 1st–June 26th)		(June 27th–August 31st)
	(1)	(2)	(3)	(4)	(5)
Managerial Incentive Scheme, 2003 Season	All workers	All workers	Selected workers	Fired workers	Selected workers
Worker's productivity (kg/hr)					
Mean	8.37	10.4	8.52	7.69	10.4
Sd, overall	4.29	5.99	4.45	3.44	5.99
Sd, between	2.43	3.35	2.49	2.11	3.35
Sd, within	3.48	4.64	3.58	2.98	4.64
Number of workers	197	130	130	67	130
Managerial Incentive Scheme, 2004 Season	All workers	All workers			
Worker's productivity (kg/hr)					
Mean	7.86	7.85			
Sd, overall	5.24	3.51			
Sd, between	3.08	2.20			
Sd, within	4.21	2.87			
Number of workers	136	136			

Notes: These figures are based on all workers that are available for work three weeks either side of the change in managerial incentive schemes. Selected workers are defined to be those that pick at least one field-day under both managerial incentive schemes. Fired workers are only selected to pick when managers are paid fixed wages. (All observations are at the worker–field-day level.)

can identify the most productive workers, and it is these individuals that are selected to pick when managerial performance bonuses are introduced. Finally, comparing columns (3) and (5) we see that among the selected workers, productivity increases by 22 percent from 8.52 kg/hour to 10.4 kg/hour when managerial performance bonuses are introduced. This suggests the increase in overall productivity shown in columns (1) and (2) is not only driven by the selection of better workers but also because the managerial effort towards those selected workers changes when performance bonuses are introduced.

To shed light on whether managers target their effort differentially across selected workers, Table I then provides evidence on the between and within worker variation in productivity. In 2003, the variation in productivity both between and within workers significantly increases when performance bonuses are introduced.

In contrast, the variation in productivity declines over time in 2004. The variation between workers declines presumably because differences in picking experience become less relevant for differences in productivity later in the season. The variation in productivity within a worker might also decline because the productivity of a worker with more experience is less sensitive to daily shocks in field conditions.

To illustrate the effect of managerial incentives on the distribution of worker's productivity, Figure IIa shows the kernel density estimate of worker productivity by managerial incentive scheme. This is calculated for those workers who are selected to pick under both managerial incentive schemes and is therefore purged of any selection effect. The figure shows both the mean and dispersion of workers' productivity are higher when their managers are paid performance bonuses.

To highlight the effect of managerial incentives on the productivity of each worker, Figure IIb plots each worker's average productivity when managers are paid fixed wages against average productivity when managers are paid performance bonuses. Each observation is weighted by the number of times the worker is selected to pick under the performance bonus and a larger bubble identifies a worker who is selected more often.

Figure IIb shows that the effect across workers is heterogeneous and that those workers who experience an increase in their productivity are those workers who pick more frequently under the performance bonus.

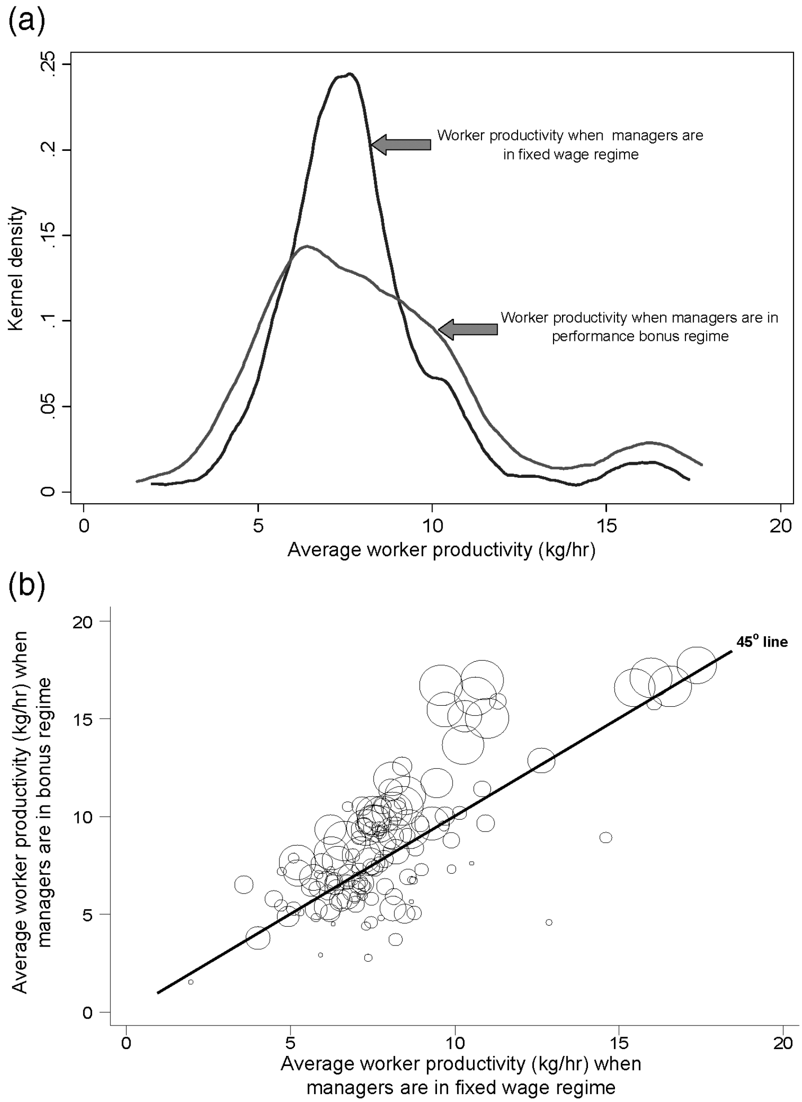

FIGURE II

(a) Kernel Density Estimates of Worker Productivity by Managerial Incentive Scheme (b) Scatter Plot of Worker Productivity by Managerial Incentive Scheme

Notes: Both figures use data on workers that are selected to pick fruit at least once under each managerial compensation schemes. The density estimates in Figure 2a are calculated using an Epanechnikov kernel. In Figure 2b, each observation is weighted by the number of field-days the worker picks under the managerial bonus scheme. A larger circle indicates that the worker picks on more field-days under the managerial performance bonus regime.

TABLE II
DESCRIPTIVES BY MANAGERIAL INCENTIVE SCHEME

	Managerial Incentive Scheme	
	Fixed wages	Performance bonus
Worker productivity (kg/hr)	8.37	10.4
	(0.240)	(0.486)
Kilograms picked per field-day	30.2	30.4
	(0.873)	(1.54)
Hours worked per field-day	3.70	3.03
	(0.169)	(0.157)
Hourly earnings from picking (£/hr)	4.81	4.53
	(0.133)	(0.199)
Piece rate per kilogram picked (£/kg)	0.617	0.476
	(0.030)	(0.016)
Number of workers on field-day	79.3	56.4
	(4.02)	(2.02)
Number of managers on field-day	5.27	3.28
	(0.231)	(0.075)
Worker-manager ratio	21.3	19.2
	(2.06)	(0.622)

Notes: Worker productivity, kilos picked per field-day, and hourly earnings are all calculated at the worker–field-day level. The standard errors on these worker–field-day level variables are clustered at the worker level. Hours worked per field-day, the piece rate per kilogram picked, the number of managers on the field-day, the number of workers on the field-day, and the worker–manager ratio, are all calculated at the field-day level.

Values given are means, standard errors in parentheses.

Table II provides further descriptives by managerial incentive scheme. The first panel shows that the increase in worker productivity is driven by workers picking the same quantity of fruit each field-day but in less time. This is as expected given that fruit is planted some years in advance, so the total quantity of fruit available is exogenous to the current incentive scheme.

The table also shows that worker's hourly earnings are left almost unchanged throughout the season. Empirically we therefore provide an estimate of the effect of managerial incentives on worker productivity holding constant workers' income. As productivity rises by 22 percent, then in order to minimize the wage bill subject to the same minimum wage constraint, the piece rate has to fall. Table II indeed confirms that the piece rate unconditionally falls by 23 percent. In the working paper version of this study we present evidence that the magnitude of this fall is explained by the introduction of performance bonuses. Following the introduction of the bonus, the COO, over nine days, revises his expectation of worker productivity and sets a lower piece rate thereafter. This provides evidence that the COO does not attempt to game the bonus scheme by increasing the piece rate above the level that minimizes the wage bill to increase workers' productivity and, hence, his expected bonus payment. This is as expected, given that the wage bill is easily observable by the owner of the firm.

It is important to stress that the increase in worker productivity is *not* due to an increase in the piece rate, as piece rates are actually lower after the introduction of the bonus. In the absence of large income effects, we therefore expect workers to exert less effort in the second half of the season, all else equal [Paarsch and Shearer 1999; Lazear 2000].

The final panel of Table II provides information on the number of workers and managers per field-day, and the ratio of the two. The number of workers declines by 29 percent after the introduction of performance incentives. As each worker's productivity has risen and the quantity of fruit available to pick is unchanged, fewer workers are needed to perform the same task. The number of managers on the field-day declines in proportion to the number of workers so the ratio of the two is unchanged. Therefore each manager's span of control remains at close to 20 workers, so that managers have to allocate their effort across the same number of workers within a field-day throughout the season.

IV. Aggregate Effects on Workers' Performance

IV.A. Average Productivity

To begin with, we investigate the effect of the change in managerial incentives on average field-day productivity, as this is the measure on which performance bonus payments are based. We estimate the following panel data specification:

$$y_{ft} = \lambda_f + \gamma B_t + \eta Z_{ft} + \sum_{s \in M_{ft}} \mu_s S_{sft} + \varepsilon_{ft}, \tag{3}$$

where y_{ft} is the log of average productivity of workers on field f on day t, B_t is a dummy equal to one after the performance bonus is introduced, and zero otherwise. The λ_f are field fixed effects which capture permanent differences in the level of productivity across fields. The Z_{ft} are time-varying field characteristics measured in logs. These include the average picking experience of workers and the field's life cycle, defined as the nth day the field is picked divided by the total number of days the field is picked over the season. This captures the natural within-field trend in productivity as fields deplete over time. We also include a time trend to capture learning by farm management and aggregate trends in productivity.[15] S_{sft} is a dummy equal to one if manager s works on field f on day t, and zero otherwise, and M_{ft} is the set of managers that work on the field-day. We allow the error terms ε_{ft} to follow an AR(1) process, and given that the dependent variable is a mean, all observations are weighted by the number of workers on the field-day.[16]

The parameter of interest is the coefficient on the performance bonus dummy, γ. This captures in reduced form the effect of the change in managerial incentives on average worker productivity at the field-day level. More precisely, this measures a combination of two effects—(i) the change in managerial effort targeted towards selected workers and (ii) the effect of the COO selecting different workers into the workforce. We expect both effects to work in the same direction of increasing average productivity on the field-day.

The first two columns of Table III report OLS estimates of (3). Column (1) only controls for the bonus dummy. Productivity is significantly higher after performance bonuses are introduced. Column (2) shows this result is robust to conditioning on field fixed effects, workers' picking experience, the field life cycle, and a time trend.[17] The signs of the coefficients on these controls make intuitive sense. There are positive returns to picking experience, and productivity naturally declines later in a field's life cycle. There is no aggregate trend in productivity at the farm level, which is consistent with the farm's practice to stagger fields to ensure a constant yield throughout the peak season.

15. As fields are operated on at different parts of the season and not all workers pick each day, the effects of the field life cycle and workers' picking experience can be separately identified from the effect of the time trend.

16. Therefore $\varepsilon_{ft} = \rho\varepsilon_{ft-1} + u_{ft}$, where u_{ft} is a classical disturbance term. We control for autocorrelation by estimating a Prais-Winsten regression. This estimator is consistent and performs well in short time series and trended data relative to other estimators [Doran and Griffiths 1983].

17. To the extent that the COO selects more experienced workers after the introduction of the bonus, this effect is captured by the experience variable rather than the bonus dummy. In practice, by the time performance bonuses have been introduced, the marginal return to experience is low for most workers. Thus, the estimated effect of the bonus is quantitatively similar regardless of whether we control for average workers' experience.

TABLE III

THE EFFECT OF THE MANAGERIAL INCENTIVES ON AVERAGE WORKER PRODUCTIVITY, FIELD-DAY LEVEL (Dependent Variable = Log of average productivity (kilogram picked per hour on field-day))

	(1) OLS	(2) Controls	(3) Field specific AR(1)	(4) Manager fixed effects	(5) Shorter window	(6) Tenure
Managerial performance bonus dummy	.225***	.203***	.196***	.194***	.195***	.190**
	(.044)	(.074)	(.069)	(.082)	(.095)	(.082)
Field life cycle		−1.35***	−1.42***	−1.31***	−1.38**	−1.29***
		(.167)	(.194)	(.177)	(.251)	(.174)
Average picking experience of workers		.284***	.276***	.313***	.352***	.335***
		(.050)	(.065)	(.062)	(.094)	(.093)
Time trend		−.003	−.002	−.001	−.002	−.003
		(.002)	(.002)	(.002)	(.007)	(.006)
Tenure under performance bonus scheme						.002
						(.005)
Field fixed effects	No	Yes	Yes	Yes	Yes	Yes
Manager fixed effects	No	No	No	Yes	Yes	Yes
R-squared	.0986	.3873	.8264	.8746	.8829	.8759
Number of field-day observations	247	247	247	247	171	247

Notes: *** denotes significance at 1 percent, ** at 5 percent, and * at 10 percent. All continuous variables are in logarithms. OLS regression estimates are reported in columns (1) and (2). Robust standard errors are calculated. In the remaining columns AR(1) regression estimates are reported. Panel corrected standard errors are calculated using a Prais-Winsten regression. This allows the error terms to be field specific heteroskedastic, and contemporaneously correlated across fields. The autocorrelation process is assumed to be specific to each field. Each field-day observation is weighted by the log of the number of workers present. The managerial performance bonus dummy = 1 when the managerial performance bonus scheme is in place, and 0 otherwise. The field life cycle is defined as the nth day the field is picked divided by the total number of days the field is picked over the season. Tenure under the performance bonus scheme is defined as the number of field-days the performance bonus has been in place for. The specification in column (5) restricts the sample to days up to and including the first 9 days in the post bonus period. These are the dates over which the piece rate has not adjusted to the higher productivity of workers.

The estimates indicate that average productivity increases by 21 percent after the bonus is introduced. In comparison, a one standard deviation increase in a field's life cycle decreases productivity by 22 percent, and a one standard deviation increase in the average picking experience of workers increases productivity by 18 percent. This suggests the introduction of performance bonuses has an economically as well as statistically significant effect on average productivity.

Column (3) shows that the coefficients are very similar when the same specification is estimated allowing for field-specific AR(1) error terms. The specification in column (4) controls for manager fixed effects. These can be separately identified from the field fixed effects because a given manager does not always work on the same field and capture all time invariant sources of heterogeneity across managers. We find that the magnitude and significance of the previous controls remain similar to those in column (3). Moreover, the manager fixed effects are jointly significant at the 1 percent significance level suggesting that, as expected, the middle-tier of managers have significant effects on workers' productivity.

A possible concern is that the increase in average productivity is due solely to workers changing their behavior rather than managers reacting to the change in incentives. For example this may be the case if workers have an income target and work harder because, following the introduction of the performance bonus, the piece rate falls. To address this concern we exploit the fact that for the first nine days in the post-bonus period, which corresponds to twenty-nine field-days, the piece rate was not significantly different from that under the fixed wage regime. If our findings were due to income targeting, we should find no effect of the introduction of the bonus for the first nine days when the piece rate remains at its pre-bonus level. In contrast, column (5) shows that when keeping the piece rate constant, the effect of the performance bonus on average productivity is still positive, significant, and of similar magnitude to the estimated effect in the whole sample.[18]

The final specification explores whether the baseline results are robust to controlling for the number of days the bonus has been

18. Given workers cannot choose the hours they pick for, they do not face a standard trade-off between leisure and income and so income targeting is unlikely to explain their behavior. Other analyses of income targeting in different settings reach mixed conclusions. Camerer et al. [1997] find that New York cab drivers work fewer hours when the observed daily wage is higher and interpret this as evidence in favor of income targeting. However, Farber [2005] presents evidence against income targeting by cab drivers.

in place for, or equivalently, allowing the bonus dummy to be interacted with the time trend. The result in column (6) shows the time trend does not vary over the two halves of the season. This indicates the effect of the bonus is long lasting, namely the bonus dummy is not just picking up a short run change in behavior.[19]

IV.B. The Dispersion of Productivity

We now analyze the effect of the introduction of managerial performance bonuses on the dispersion of workers' productivity within a field-day. We estimate

$$cv_{ft} = \lambda_f + \gamma B_t + \eta Z_{ft} + \sum_{s \in M_{ft}} \mu_s S_{sft} + u_{ift}, \tag{4}$$

where cv_{ft} is the log of the coefficient of variation of productivity of workers on field f on day t. To account for the fact that workers accumulate experience at different rates, we control for the log of the coefficient of variation of worker's picking experience on the field-day. Similarly, the variation in fruit available between rows within a field may increase over time so we control for the log of the field life cycle. Table IV presents estimates of (4) following a similar set of specifications as in Table III.

The parameter of interest is the coefficient on the performance bonus dummy, γ. The baseline result is that the introduction of performance bonuses increased the dispersion of productivity on the field-day by 38 percent other things equal (column (4)).[20] We note that in column (4) the manager fixed effects are jointly significant at the 1 percent significance level suggesting that, as expected, the middle tier of managers have significant effects on the dispersion of productivity.

These results have important implications for the inequality

19. We also performed a series of further robustness checks. First, the baseline results in column (4) are also robust to alternative functional forms such as allowing the controls to enter in levels rather than logs, and allowing for a nonlinear effect of the field life cycle. Second, the baseline results are robust to controlling for other time varying variables such as meteorological conditions and the average experience of managers on the field-day. Third, the results are robust to controlling for changes in the composition of nonpicking tasks over time by restricting the sample to workers who are exclusively assigned to picking tasks on a given day.

20. This result is robust to (i) controlling for the coefficient of variation of experience of managers on the field-day; (ii) controlling for other time varying variables such as meteorological conditions; (iii) alternative functional forms that allow the controls to enter in levels and allow for a nonlinear effect of the field life cycle; (iv) restricting the sample to workers who are exclusively assigned to picking tasks on a given day.

TABLE IV
THE EFFECT OF THE MANAGERIAL INCENTIVES ON THE DISPERSION OF WORKERS' PRODUCTIVITY, FIELD-DAY LEVEL (Dependent Variable = Log of the coefficient of variation of productivity (kilogram picked per hour on field-day). Standard errors allow for field specific AR(1))

	(1) OLS	(2) Controls	(3) Field specific AR(1)	(4) Manager fixed effects	(5) Tenure
Managerial performance bonus dummy	.084***	.177***	.191***	.317***	.314***
	(.031)	(.060)	(.058)	(.063)	(.065)
Field life cycle		.024	.040	.208	.228
		(.150)	(.135)	(.137)	(.145)
CV of picking experience of workers		−.029	−.016	−.082	−.077
		(.081)	(.079)	(.072)	(.073)
Time trend		−.002	−.002	−.001	−.002
		(.001)	(.002)	(.002)	(.003)
Tenure under performance bonus scheme					.001
					(.003)
Field fixed effects	No	Yes	Yes	Yes	Yes
Manager fixed effects	No	No	No	Yes	Yes
R-squared	.0279	.0731	.5364	.5780	.5812
Number of field-day observations	247	247	247	247	247

Notes: *** denotes significance at 1 percent, ** at 5 percent, and * at 10 percent. All continuous variables are in logarithms. OLS regression estimates are reported in columns (1) and (2). Robust standard errors are calculated. In the remaining columns, AR(1) regression estimates are reported. Panel corrected standard errors are calculated using a Prais-Winsten regression. This allows the error terms to be field specific heteroskedastic and contemporaneously correlated across fields. The autocorrelation process is assumed to be specific to each field. Each field-day observation is weighted by the log of the number of workers present. The managerial performance bonus dummy = 1 when the managerial performance bonus scheme is in place, and 0 otherwise. The field life cycle is defined as the nth day the field is picked divided by the total number of days the field is picked over the season. Tenure under the performance bonus scheme is defined as the number of field-days the performance bonus has been in place for.

of earnings among workers. In particular, the earnings inequality among workers significantly increases moving from a regime in which their managers are paid fixed wages to when their managers are paid performance bonuses. The daily earnings inequality across workers—as measured by the interquartile range of daily earnings—increases after the introduction of managerial performance bonuses.

IV.C. A Counterfactual

The experimental design is such that the change in managerial incentives occurs simultaneously for all managers in all fields. Hence, identification of a causal effect of this change on productivity arises from a comparison within a field over time. The estimated effect is then biased upward to the extent that it captures factors that cause productivity to rise through the season regardless of the change in incentive schemes and that are not captured by the observable time varying controls such as the farm level trend, workers' experience, or the field life cycle. We address this concern by exploiting data from the same farm in 2004 when managers were paid the same level of fixed wages throughout.

This counterfactual allows us to identify the causal effect of managerial incentives on the mean and dispersion of productivity under the assumption that productivity would have been the same in 2003 and 2004, had managerial incentives remained unchanged in 2003. We define a placebo bonus dummy for the 2004 season. This is equal to one after June 27th 2004, that is the date when performance bonuses were introduced in 2003, and zero otherwise.

We then stack the data and estimate the effect of the bonus as a difference-in-difference between the two seasons. These difference-in-difference estimates indicate that—(i) the placebo bonus dummy for the 2004 season has no effect on average productivity; (ii) the dispersion of productivity in 2004 is actually lower in the second half of the season.

These results add weight to a causal interpretation of the effect of managerial performance bonuses on workers' productivity. If the performance bonus dummy were spuriously capturing other time varying factors, the effect of the placebo bonus dummy should be similar in the 2004 season.

V. Targeting Effects

We now use individual level data to break down the aggregate effects of managerial performance bonuses into those arising through two separate channels—(i) a targeting effect that stems from managers having incentives to allocate their effort across workers differently; (ii) a selection effect that stems from the COO selecting different workers into employment. In this section we provide evidence on the targeting effect. Section VI investigates the selection effect.

The targeting effect is identified from a comparison of the same worker's productivity under both managerial incentive schemes. We therefore restrict attention to those workers that pick when managers are paid a fixed wage and continue to be selected to pick under the managerial performance regime. We first estimate a quantile regression to identify the heterogeneous effects of managerial performance bonuses across workers. We then estimate a fixed effects regression to identify the effects of performance bonuses on the same worker and to shed light on which observable worker characteristics explain the increase between worker variation in productivity under managerial performance bonuses.

V.A. Quantile Regression Estimates

Theory suggests managers have greater incentives to target their effort towards high ability workers when they are paid performance bonuses tied to the average productivity of the workers they manage, than when they are paid a fixed wage. Hence the effect of managerial performance bonuses on worker's productivity will differ at different points of the distribution of workers' productivity conditional on observables. We use quantile regression to estimate the following conditional distribution of the log of productivity of worker i on field f on day t, y_{ift}, at each quantile $\theta \in [0,1]$:

$$(5)\quad \text{Quant}_{\theta}(y_{ift}|\cdot) = \gamma_{\theta}\, B_t + \phi_{\theta f}\lambda_f + \delta_{\theta}\, X_{ift} + \eta_{\theta}\, Z_{ft} + \sum_{s \in M_{ft}} \mu_{\theta s} S_{sft},$$

where B_t is a dummy equal to one after the performance bonus is introduced, and zero otherwise; λ_f is a dummy equal to one for field f, and zero otherwise; X_{ift} is the log of worker i's picking experience; and Z_{ft} includes the log of the field life cycle and a farm level time trend, and S_{sft} is a fixed effect for manager s. The error terms are clustered by field-day because workers on the same field-day face similar field conditions and, hence, are likely to be subject to common productivity shocks. Bootstrapped standard errors based on 1,000 replications are calculated throughout.

The parameter of interest, γ_{θ}, measures the effect of the managerial performance bonus at the θth conditional quantile of log worker productivity. Figure IIIa graphs estimates of γ_{θ} and the associated 95 percent confidence interval at each quantile. This shows the heterogeneous effects of the performance bonus on worker productivity—the effect is negative at the lowest conditional quantiles and positive and significant for those above the

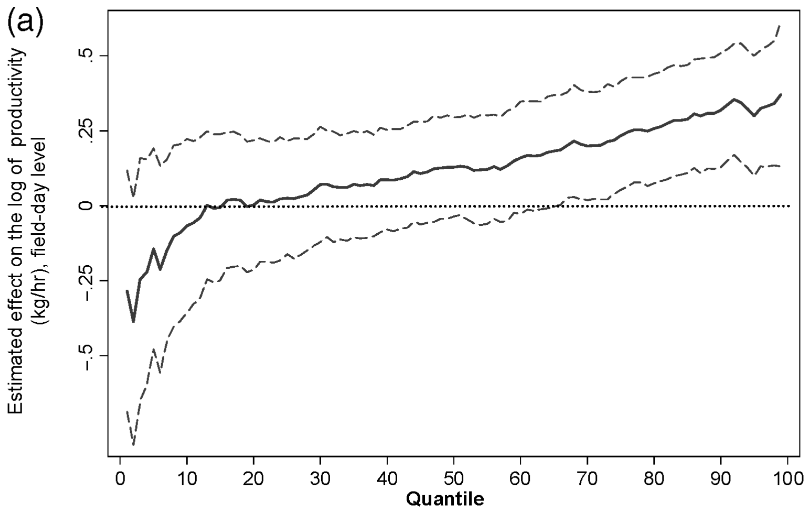

FIGURE III

(a) Quantile Regression Estimates (b) Workers' Fixed Effects

Notes: Figure 3a graphs the estimated effect of the managerial performance bonus dummy on the log of worker productivity at each quantile of the conditional distribution of the log of worker productivity and the associated 95 percent confidence interval. Bootstrapped standard errors that are clustered by field-day are estimated based on 1,000 replications. Figure 3b is based on a worker–field-day fixed effects regression. It plots the exponent of the workers fixed effect when managers are in the fixed wage regime against the exponent of their fixed effect when managers are in the performance bonus regime. Each observation is weighted by the number of field-days the worker picks under the managerial bonus scheme. A larger circle indicates that the worker picks on more field-days under the managerial performance bonus regime.

60th conditional quantile. In line with the descriptive evidence on the unconditional distribution of workers' productivity in Figure IIa, the QR estimates suggest the conditional distribution of productivity becomes more dispersed under managerial performance bonuses.

One possible concern with this interpretation is that the conditional distribution of productivity may naturally become more dispersed over time. For instance, this may be because some pickers quickly move up the learning curve and others become bored. The evidence from the control season in 2004, however, suggests the opposite. The descriptive evidence in Table I shows that in 2004 the dispersion of worker productivity is lower in the second half of the season. In addition, estimating the quantile regression specification (5) in this control season, we find the effect of the placebo bonus dummy to be positive and significant for all quantiles below the 40th, zero for intermediate quantiles, and negative and significant for the very highest quantiles. This finding implies that in the absence of a change in managerial incentives, the conditional distribution of productivity naturally becomes less dispersed over time.

V.B. Fixed Effect Estimates

While the QR results provide evidence of the heterogenous effects of managerial performance bonuses on worker productivity, they do not pin down whether a given worker's productivity is systematically higher or lower when their manager is paid a performance bonus relative to when she is paid a fixed wage. To provide such evidence on the effects of managerial incentives on the productivity of the *same* worker, we present fixed effects estimates. We first estimate the following worker–field-day specification for the 130 selected workers that pick under both managerial incentive schemes:

$$y_{ift} = \sum_{i=1}^{130} (\rho_i + \phi_i B_t) D_i + \lambda_f + \delta X_{ift} + \eta Z_{ft} + \sum_{s \in M_{ft}} \mu_s S_{sft} + u_{ift}, \tag{6}$$

where y_{ift} is the log of productivity of worker i on field f on day t, D_i is a dummy equal to one for worker i, and zero otherwise, and the other variables are as previously defined. We estimate (6) using OLS, where disturbance terms are clustered by field-day because workers on the same field-day are likely to face common productivity shocks.[21]

$\hat{\rho}_i$ is an estimate of worker i's expected productivity when her managers are paid a fixed wage, and $(\hat{\rho}_i + \hat{\phi}_i)$ is her expected productivity when her managers are paid performance bonuses. To rescale these estimates in terms of kilograms per hour, Figure IIIb then plots the exponent of $\hat{\rho}_i$ against the exponent of $(\hat{\rho}_i + \hat{\phi}_i)$ for each selected worker. Each worker's observation is weighted by the number of field-days that she is selected to pick under the performance bonus scheme. The figure thus provides evidence on the effect on the same worker of the change in a managerial incentive scheme, conditional on observable determinants of productivity.

Figure IIIb reiterates the message of the earlier descriptive evidence on unconditional worker productivity by managerial incentive scheme (Figure IIb). In particular we see that conditional on observable determinants of worker productivity: (i) there are heterogeneous effects of managerial incentives across workers—some workers have systematically higher productivity with the change in managerial incentives while others have systematically lower productivity; (ii) the more productive workers under the fixed wage regime always have higher productivity under the performance bonus scheme; (iii) those workers that experience an increase in their productivity are selected to pick most frequently under the performance bonus.[22]

VI. Selection Effects

VI.A. Evidence

Theory predicts that changing the COO's compensation scheme from fixed wages to sufficiently high powered performance pay will make him change his selection strategy in favor of the most able workers as this increases average productivity. The descriptive evidence in Table I and the estimated effects on the

21. Clustering at the worker or worker–managerial incentive scheme level yields considerably smaller standard errors. The fixed effects alone explain around 38 percent of the variation in productivity, suggesting there is considerable heterogeneity in the underlying ability of workers.

22. Using $\hat{\rho}_i$ as a measure of a worker's ability, we find that groups of workers on the field-day were equally heterogeneous before and after the change in managerial incentives. Hence, there is no evidence the COO sorts workers differently by ability into fields post-bonus. This is as expected given the considerable variation in the quantity of fruit available across rows within a field.

productivity of individual workers in Figure IIIb are both indicative of selection effects as they highlight that some workers are fired while more productive workers are selected to pick more often after the change in managerial pay. This section presents evidence on the selection mechanism and sheds light on the relative importance of the selection and targeting effects of managerial incentives on the rise in average productivity.

To analyze the selection choices of the COO, we now consider the sample of all workers that are available to pick fruit. This is the relevant pool of workers over which the COO makes his selection decision. Each day the COO selects which workers pick fruit, which workers perform other tasks such as weeding or planting, and which workers are unemployed for the day. As the introduction of the managerial bonus scheme increases workers' productivity, fewer workers are needed to pick the same quantity of fruit. Indeed as shown earlier in Tables I and II, sixty-seven workers are fired from picking tasks and the average number of workers on a field-day is 29 percent lower after the introduction of managerial incentives. For the average worker, the probability of being assigned to a picking task on any given day falls from 44 to 25 percent.

Figure IV shows the distribution of the number of field-days workers are selected to pick fruit by managerial incentive scheme, conditional on being chosen at least once under both schemes. The histograms highlight that even among those workers that still pick at least once under performance bonuses, there is a wide dispersion in the number of field-days workers are selected to pick fruit post-bonus. We divide selected workers into two groups—we define selected-in workers as those in the top quartile of the distribution of number of field-days picked post-bonus. On average, workers in this group pick on 100 field-days after the introduction of the bonus. Selected-out workers are defined to be those workers in the bottom three quartiles of the distribution of number of field-days picked post-bonus. The average worker in this category picks on eighteen field-days post bonus. Moreover, a further 67 out of the 197 workers in our sample are fired, namely they are *never* selected to pick after the introduction of the bonus scheme.

Table V shows that, as expected, whether a worker falls in the selected-in, selected-out, or fired category is correlated to her productivity before the introduction of managerial incentives. Panel A shows there is a clear ranking in terms of productivity

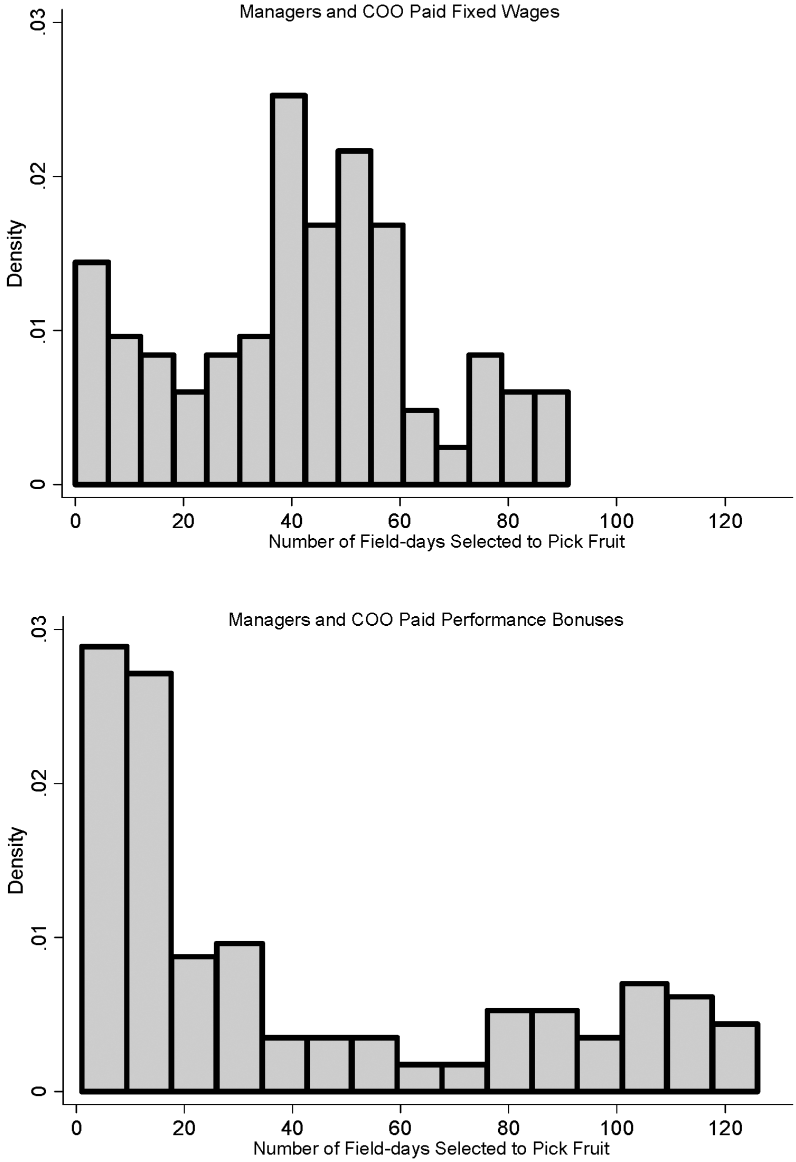

FIGURE IV

Distribution of Field-days Selected to Pick Fruit across Workers, by Managerial Incentive Scheme.

Notes: These histograms are drawn for those workers that are selected to pick fruit at least on one field-day under each managerial incentive scheme. Hence, they do not include "fired" workers that would otherwise be massed at zero on the lower histogram.

TABLE V
SELECTION INTO THE WORKFORCE

	Selected-in workers	Selected-out workers	Fixed workers
A: Productivity[a]			
Fixed wages	9.03	7.45	6.79
	(3.03)	(2.09)	(2.15)
Performance bonus	11.11	7.35	
	(3.66)	(2.50)	
B: Unemployment rate[b]			
Fixed wages	.037	.089	.187
	(.052)	(.122)	(.186)
Performance bonus	.059	.146	.340
	(.060)	(.180)	(.372)

Notes: These figures are based on the sample of all 197 workers available to pick fruit. Selected-in workers are defined to be those that are in the top quartile of the distribution of number of field-days picked post-bonus. This corresponds to 77 or more field-day observations on which the worker picks post-bonus. Selected-out workers are defined to be those workers in the bottom three quartiles of the distribution of number of field-days picked post-bonus. Fired workers are those who never pick after the introduction of the performance bonus. There are 67 fired workers. The unemployment rate for a worker is the share of days in which the worker is present on the farm but is not assigned to any task.

a. Average productivity of workers (kg/hr) by worker type and managerial incentive scheme. Standard deviation in parentheses.

b. Average unemployment rate of workers by worker type and managerial incentive scheme. Standard deviation in parentheses.

across different groups of workers—those who were most productive when managers were paid fixed wages are selected to pick more frequently when managers are paid performance bonuses. Workers with intermediate productivity levels are only selected to pick occasionally post-bonus, and those workers with the lowest productivity pre-bonus are fired from picking tasks altogether.

Panel B of Table V shows unemployment rates by worker type and managerial incentive scheme. Under fixed wages, there is a clear ranking of unemployment rates across the three types of worker. When performance bonuses are introduced, unemployment rates rise for all workers, but the increase is higher for workers who are fired and those who are selected out, indicating that these workers are not simply reallocated to other nonpicking tasks. In contrast, no workers are fired in the 2004 picking season. This is as expected given there is no rise in productivity over the two halves of the season in 2004.

An important consequence of these changes in the selection of workers into work and unemployment is that the differential rise in unemployment increases the earnings inequality across workers over the season. This selection effect exacerbates the increase in earnings inequality documented earlier that arises because the effects of managerial incentives on individual worker productivity are very heterogeneous to begin with.

In our working paper we shed light on the effect of managerial performance pay on the selection of workers into employment while controlling for farm level variables that affect the probability of being hired independently of the incentive scheme in place. Importantly, we are able to disentangle the effect of managerial performance pay from changes in the supply and demand of labor. The findings indicate that, other things equal, the average worker is less likely to be selected into picking and more likely to be left unemployed following the introduction of the managerial bonus scheme.

Section V showed that, conditional on being selected to pick, the productivity of some workers raises while the productivity of others falls after the introduction of the managerial bonus scheme. Next, we analyze whether these two effects reinforce each other, namely whether workers who experience the largest increase in productivity are also more likely to be selected into picking.

To do so we use a linear probability model and estimate the following specification:

$$(7) \qquad p_{it} = \sum_{i=1}^{130} (\psi_i + \omega_i B_t) D_i + \delta X_t^D + \eta X_t^S + u_{it},$$

where p_{it}, X_t^D, and X_t^S are as defined before, and D_i is a dummy equal to one for worker i, and zero otherwise.[23] $\hat{\psi}_i$ is an estimate of worker i's probability to be selected to pick when her managers are paid a fixed wage, and $(\hat{\psi}_i + \hat{\omega}_i)$ is her probability to be selected when her managers are paid performance bonuses.

Figure Va then plots $\hat{\omega}_i$—the change in probability of worker i to be selected into picking with the introduction of performance bonuses for managers against $\hat{\phi}_i$ from the fixed effects regression of worker's productivity (6)—worker i's change in log productivity when performance bonuses are introduced. The line of best fit slopes upward, indicating that workers who experience the largest increase in productivity also have the greatest increase in the

23. The mean of the dependent variable is close to one half, and so the LPM does not predict any probabilities outside the [0,1] interval.

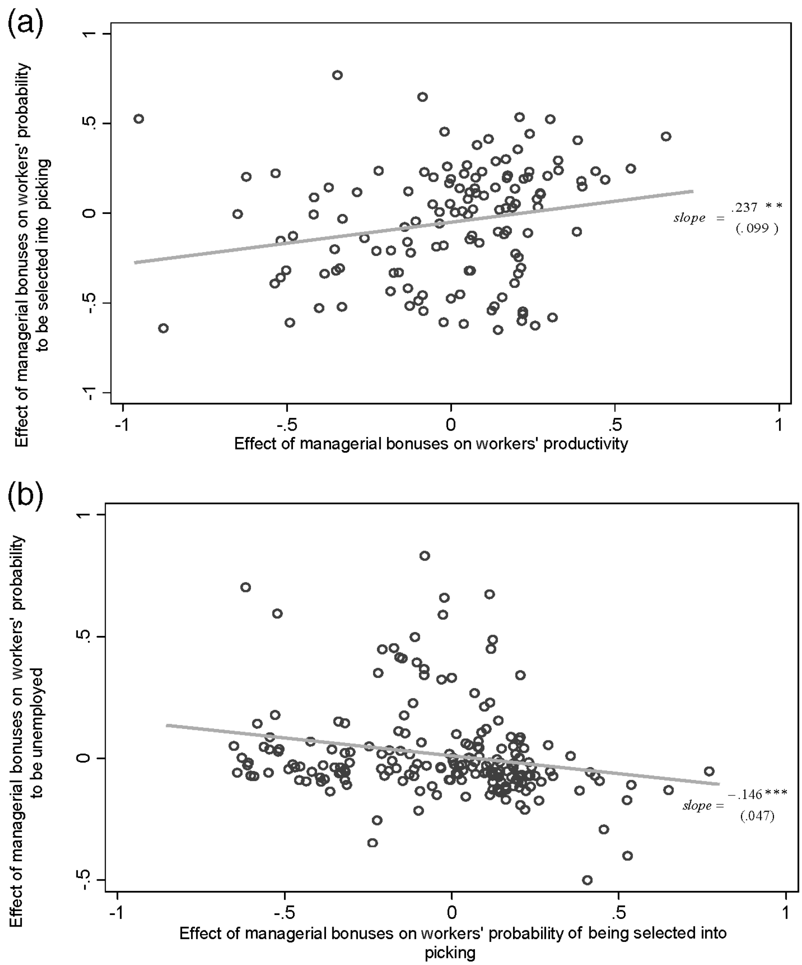

FIGURE V

(a) Selection and Productivity (b) Unemployment and Selection

Notes: To estimate the effect of the performance bonus on individual worker productivity, we regress log productivity on worker's picking experience, the field life cycle, a time trend and workers' fixed effects interacted with the bonus dummy. The effect of managerial bonuses on workers' productivity for any given worker is computed as the difference between the worker's fixed effect when managers are paid bonuses and the worker's fixed effect when managers are paid fixed wages. To estimate the effect of the performance bonus on the probability of being selected to pick fruit, we first define a selection dummy which is equal to one on days in which the worker is selected to pick, and zero otherwise. We then regress this selection dummy on labor supply, labor demand and workers' fixed effects interacted with the bonus dummy. The effect of managerial bonuses on workers' probability of being selected for any given worker is computed as the difference between the worker's fixed effect when managers are paid bonuses and the worker's fixed effect when managers are paid fixed wages.

likelihood to be selected into employment, conditional on all other determinants of productivity and selection.

To assess whether workers who are less likely to be selected into picking are reallocated to other tasks or left unemployed, Figure Vb presents evidence on the relationship between the change in the probability of being unemployment and the change in the probability of being selected into picking. We estimate a linear probability model analogous to (7) where p_{it} is redefined to be equal to one if worker i is unemployed on day t and zero if worker i is assigned to a nonpicking task. Figure Vb plots the change in the probability of worker i being unemployed against the change in the probability of worker i being selected into picking, moving from fixed wages to managerial performance bonuses. The relationship is negative, suggesting workers who are less likely to be selected to pick after the introduction of the bonus scheme are also more likely to be left unemployed.

VI.B. The Relative Importance of the Targeting and Selection Effects

In our setting, the introduction of managerial performance pay increases productivity both because the productivity of the most able workers increases and because the most able workers contribute to the average more often. These two effects reinforce each other, as the workers who experience the highest rise in productivity are also more likely to be selected in.

To understand the relative importance of the selection and targeting effects on average productivity, we conduct two thought experiments. In each case we compute the increase in productivity had the selection process remained unchanged over the season. Namely, the increase in productivity had each worker been chosen with the same probability after the bonus as she was before the bonus. In both cases we assume the productivity of selected-in and selected-out workers would be the same as actually observed, as given in Table V.

For the first thought experiment we assume the productivity of fired workers would have remained *unchanged* after the introduction of the bonus scheme. Under this assumption, average productivity would have increased by 7.5 percent in the post-bonus period.

For the second thought experiment we assume the productivity of all fired workers would have increased in the same proportion as the average of the selected-in workers. Under this assumption, average productivity would have increased by 11.1 percent in the post-bonus period.

Given the unconditional increase in productivity is 25 percent, these thought experiments suggest that the observed increase in productivity is driven at least as much by the selection of more productive workers—that is, largely attributable to the behavior of the COO, as it is driven by increases in the productivity of the same workers—something that is largely attributable to the behavior of managers. This is consistent with a "magnification effect" [Rosen 1982], so that the actions of individuals higher up in the firm hierarchy have a greater impact on firm performance than do the actions of individuals at lower tiers of the hierarchy.[24]

We perform similar thought experiments to assess the relative importance of targeting and selection effects in explaining the observed change in the dispersion of workers' productivity. These reveal that the change in dispersion is nearly entirely due to the fact that managers target the most able workers after the introduction of performance pay. In other words, the coefficient of variation would have increased by the same amount had the selection remained unchanged. The reason is that, as shown in Table V, the productivity of the marginal worker who is still employed after the bonus is more similar to the fired workers than to the most able workers. Namely, the distribution of ability across workers is such that even when the least able workers are fired, the marginal worker selected to pick is still of relatively low ability and so there remains considerable heterogeneity in productivity across selected workers.

VI.C. Potentially Reinforcing Mechanisms

We have so far emphasized that the change in managerial incentives affects worker productivity through both a targeting and selection effect and provided evidence on the relative importance of both. In our setting there are, however, two additional mechanisms through which the effects on productivity may be reinforced.

The first possibility is that some of the rise in productivity can be attributed to the fact that tighter selection creates a rat

24. The theoretical literature has traditionally focused on determining the optimal number of layers in a hierarchy, the span of control at each layer, and the distribution of wages within the firm [Williamson 1967; Calvo and Wellisz 1979; Qian 1994]. We have taken the first two factors as given throughout—workers are always managed in the firm we study, and as detailed in Section III, managers' span of control remains constant throughout the season.

race or rank order tournament among workers [Akerlof 1976; Lazear and Rosen 1981]. Indeed, by exerting effort workers not only increase their earnings today because they are paid a piece rate, but also increase the probability of being retained for future employment. In our setting, however, the most able workers experience an increase in productivity whereas the least able do not. This pattern would be consistent with a rat race only if it were too costly for the low ability workers to engage in the rat race so that only the high ability workers would be motivated by it. This seems unlikely in light of the fact that the marginal worker selected into employment has low ability, which implies that the high ability workers are unlikely to be left unemployed. In general, any rat race effect would reinforce the large and heterogeneous effects that managerial effort has on workers. Disentangling the effects of managerial effort from those of a rat race would at least require more precise information on managerial actions on each field-day, such as the allocation of workers to rows, which is unavailable.

Peer effects are a second mechanism through which the increase in average productivity could be reinforced. We have shown that following the introduction of managerial performance pay, the lowest ability workers are fired and this may affect the productivity of the remaining selected workers. In particular, if workers work harder when they are surrounded by more productive colleagues, firing the least able workers might increase the productivity of the remaining workers. In our context, however, the fact that the most able workers experience the highest increase in productivity while the least able selected workers are not affected (Figure IIIa) suggests there would have to be a very particular pattern of peer effects for this hypothesis to explain the data. Namely, peer effects should be such that the individuals who are most dissimilar to the fired workers are affected the most while the individuals who are most similar are affected the least. In other words, the highest ability workers should be most affected by the removal of the least able workers while the lowest ability workers still selected in, should be unaffected by the removal of similarly low ability workers.

VII. Discussion

This paper presents evidence from a firm level experiment designed to identify the effects of managerial performance pay on the mean and the dispersion of productivity of lower tier workers. We find that the introduction of managerial performance pay raises both the mean and the dispersion of productivity. The analysis of individual productivity data from personnel records, shows that the results are due to two underlying changes in managerial behavior. There is a targeting effect so that managers allocate more of their effort towards high ability workers, and there is a selection effect so that the least able workers are employed less often and, in some cases, fired.

The purely exogenous variation in managerial incentives created by our natural field experiment in combination with detailed personnel records and a fixed pool of individuals in the workforce allows us to precisely identify the causal effect of high powered managerial incentives on the firm's productivity through both targeting and selection of lower tier workers. Precision, however, inevitably entails some loss of generality because the firm we study, as any other, has unique features that influence the effect of managerial incentives on productivity.

Two features of our firm are particularly relevant for the external validity of this study. First, the employment situation is rather special as the pool of managers and workers available for employment is fixed and observable, at least in the short run. In a more general setting, a number of other factors would need to be taken into account.

Notably, when new workers and managers can join the firm, we expect high powered managerial incentives to attract more able managers and COO to the firm [Lazear 2005]. In addition, if the COO can hire from a larger pool of workers, he might want to attract more productive workers when he is paid a performance bonus. To the extent that more productive workers have a higher outside option, however, the COO might need to increase workers' pay to attract them.

Overall, when the pool of managers and the pool of individuals available for employment is not fixed, the introduction of high powered managerial incentives might attract more productive workers and managers to the firm, thus reinforcing the productivity enhancing effect we find here. However, this might come at the cost of a higher wage bill.

Second, in our setting workers operate independently of one another, and the manager can target their effort to individual workers. While this is true in many other settings, such as for salespeople, it is not the case in all settings. When workers operate in teams or, more generally, when managerial effort targeted to one worker has spillovers on others, the incentives for managers to target workers would differ, as would the effect of targeting on both the average and dispersion of productivity.

While our experimental research design is tailored to provide credible evidence on the effects of managerial incentives in this particular context, our results have broad implications for understanding behavior within firms more generally.[25]

Our findings shed some light on why firms provide performance related pay to managers in the first place. While such incentive schemes are obviously designed to increase unobservable managerial effort, our results also suggest another more subtle reason for their use. This stems from the general observation that firms are typically constrained to offer bottom-tier workers the *same* compensation scheme. This may be because of legal, technological, or informational constraints [Lazear 1989; Encinosa et al. 1997; Bewley 1999; Fehr et al. 2004].

To the extent that bottom-tier workers are of heterogeneous ability, however, offering the same compensation scheme to all of them will, in general, not be optimal for the firm. When managers' pay is linked to firm's performance, their interests become more aligned with those of the firm, and they have greater incentives to target their effort to specific workers in order to offset the inefficiency that arises because of the common compensation scheme. From the worker's point of view, it is then as if they face an individual specific incentive scheme.

This opens a broad empirical research agenda to examine whether firms are indeed more likely to offer managers perfor-

25. The analysis also has wider implications for environments outside of the workplace. For example, the provision of teacher incentives based on the average performance of students may have important consequences for the distribution of test scores among students, and the composition of students, and possibly teachers admitted into schools. Existing evidence indicates that school accountability programs, whereby schools are rewarded or sanctioned based on average test scores or on the pass rate, generate both selection and targeting effects, as weaker students are prevented to sit the test and teachers target resources to the marginal students at the expense of the others. For instance, Burgess et al. [2005] find that the introduction of school accountability based on test pass rates improved the performance of students in the middle of the ability distribution, at the expense of both high achieving and low achieving students. Similarly, Hanushek and Raymond [2004] and Reback [2006] provide evidence on the distributional consequences on student achievement under the *No Child Left Behind* policy. Finally, Jacob [2002] and Figlio and Getzer [2002] provide evidence on the selection effect. They show that the introduction of accountability schemes lead to an increase in grade retention and special educational placement in Chicago and Florida public schools, respectively.

mance pay in settings where lower tier workers are of heterogeneous ability, managers are able to target their effort towards specific workers, and workers are offered the same compensation scheme.

Our findings also highlight the interplay between the provision of managerial incentives and the earnings inequality among lower-tier workers. Such a linkage exists whenever managers can target their efforts towards some workers and away from others, and managers choose which individuals are selected into the workforce.

Understanding whether and how managerial incentives determine earnings inequality among workers is important for two reasons.

First, to the extent that managers do not internalize the effect of their actions on the long run performance of the firm, exacerbating inequality due to natural ability differences may be detrimental to the firms' long run performance. This is because increased perceptions of unfair treatment among workers might lead to less cooperation in the workplace [Baron and Pfeffer 1994; Bewley 1999; Lazear 1989]. Whether firms trade off the benefits of incentive pay with these types of long-run effects when designing compensation schemes deserves further research.

Second, the interplay between managerial incentives and earnings inequality among workers highlights a possible link between two important trends in labor markets over the past twenty years that have previously been unconnected in the economics literature—the rising use of managerial performance pay, and the rising earnings inequality among observationally similar workers.[26]

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26. Residual, or within-group wage inequality, is a sizable contributor of the growth in overall wage inequality in the United States. This has been argued to have increased throughout the 1970s and 1980s [Juhn et al. 1993], and into the 1990s [Acemoglu 2002, and Autor et al. 2005].

References

Acemoglu, Daron, "Technical Change, Inequality, and the Labor Market," *Journal of Economic Literature,* IX (2002), 7–72.

Akerlof, George A., "The Economics of Caste and the Rat Race and Other Woeful Tales," *Quarterly Journal of Economics,* XC (1976), 599–617.

Autor, David H., Lawrence F. Katz, and Melissa S. Kearney, Rising Wage Inequality: The Role of Composition and Prices, NBER Working Paper No. 11628, 2005.

Bandiera, Oriana, Iwan Barankay, and Imran Rasul, "Social Preferences and the Response to Incentives: Evidence From Personnel Data," *Quarterly Journal of Economics,* CXX (2005), 917–962.

Baron, James N., and Jeffrey Pfeffer, "The Social Psychology of Organizations and Inequality," *Social Psychology Quarterly*, LVII (1994), 190–209.

Bertrand, Marianne, and Antoinette Schoar, "Managing with Style: The Effect of Managers on Firm Policies," *Quarterly Journal of Economics,* CXVIII (2003), 1169–1208.

Bewley, Truman F., *Why Wages Don't Fall During a Recession* (Cambridge: Harvard University Press, 1999).

Burgess, Simon, Carol Propper, Helen Slater, and Deborah Wilson, "Who Wins and Who Loses from School Accountability? The Distribution of Educational Gain in English Secondary Schools," CMPO Working Paper Series 05/128, 2005.

Calvo, Guillermo A., and Stanislaw Wellisz, "Hierarchy, Ability, and Income Distribution," *Journal of Political Economy,* LXXXVIII (1979), 991–1010.

Camerer, Colin, Linda Babcock, George Loewenstein, and Richard Thaler, "Labor Supply of New York City Cabdrivers: One Day At A Time," *Quarterly Journal of Economics,* CXII (1997), 407–441.

Chevalier, Judith, and Glenn Ellison, "Risk Taking by Mutual Funds as a Response to Incentives," *Journal of Political Economy,* CV (1997), 1167–1200.

Chiappori, Pierre Andre, and Bernard Salanie, "Testing Contract Theory: A Survey of Some Recent Work," in *Advances in Economics and Econometrics Theory and Applications: Eighth World Congress, Volume 1,* Mathias Dewatripont, Lars P. Hansen, and Stephen J. Turnovsky, eds. (Cambridge: Cambridge University Press, 2003).

Doran, Howard E., and William E. Griffiths, "On the Relative Efficiency of Estimators Which Include the Initial Observations in the Estimation of Seemingly Unrelated Regressions with First-Order Autoregressive Disturbances," *Journal of Econometrics,* XXIII (1983), 165–191.

Encinosa, William E. III, Martin Gaynor, and James B. Rebitzer, "The Sociology of Groups and the Economics of Incentives: Theory and Evidence on Compensation Systems," NBER Working Paper 5953 (1997).

Farber, Henry S., "Is Tomorrow Another Day? The Labor Supply of New York City Cab Drivers," *Journal of Political Economy,* CXVI (2005), 46–82.

Fehr, Ernst, Alexander Klein, and Klaus M. Schmidt, "Contracts, Fairness, and Incentives," CESinfo Working Paper 1215 (2004).

Figlio, David N., and Lawrence S. Getzler, "Accountability, Ability and Disability: Gaming the System," NBER Working Paper 9307 (2002).

Freeman, Richard B., and Morris M. Kleiner, "The Last American Shoe Manufacturers: Decreasing Productivity and Increasing Profits in the Shift from Piece Rates to Continuous Flow Production," *Industrial Relations,* XLIV (2005), 307–330.

Groves, Theodore, Yongmiao Hong, John McMillan, and Barry Naughton, "Autonomy and Incentives in Chinese State Enterprises," *Quarterly Journal of Economics,* CIX (1994), 183–209.

Hall, Brian J., and Jeffrey B. Liebman, "Are CEOs Really Paid Like Bureaucrats?," *Quarterly Journal of Economics,* CXIII (1998), 653–691.

Hall, Brian J., and Kevin J. Murphy, "The Trouble with Stock Options," *Journal of Economic Perspectives,* XVII (2003), 49–70.

Hanushek, Eric A., and Margaret E. Raymond, "The Effect of School Accountability Systems on The Level and Distribution of Student Achievement," *Journal of the European Economic Association,* II (2004), 406–445.

Harrison, Glenn W., and John A. List, "Field Experiments," *Journal of Economic Literature,* CLII (2004), 1009–1055.
Holmstrom, Bengt, and Paul Milgrom, "Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design," *Journal of Law, Economics and Organization,* VII (1991), 24–52.
Ickes, Barry W., and Larry Samuelson, "Job Transfers and Incentives in Complex Organizations: Thwarting the Ratchet Effect," *Rand Journal of Economics,* XVIII (1987), 275–286.
Jacob, Brian A., "Accountability, Incentives and Behavior: The Impact of High-Stakes Testing in the Chicago Public Schools," NBER Working Paper 8968 (2002).
Jones, Derek C., and Takao Kato, "The Productivity Effects of Employee Stock-Ownership Plans and Bonuses: Evidence from Japanese Panel Data," *American Economic Review,* LXXXV (1995), 391–414.
Juhn, Chinhui, Kevin M. Murphy, and Brooks Pierce, "Wage Inequality and the Rise in Returns to Skill," *Journal of Political Economy,* CI (1993), 410–442.
Lazear, Edward P., "Pay Equality and Industrial Politics," *Journal of Political Economy,* LXLVII (1989), 561–580.
——, "Performance Pay and Productivity," *American Economic Review,* LC (2000), 1346–1361.
——, "Output-Based Pay: Incentives or Sorting?," *Research in Labor Economics,* XXIII (2005), 1–25.
Lazear, Edward P., and Sherwin Rosen, "Rank Order Tournaments as Optimum Labor Contracts," *Journal of Political Economy,* IXC (1981), 841–864.
Malmendier, Ulrike, and Geoffrey Tate, "CEO Overconfidence and Corporate Investment," *Journal of Finance,* LX 6 (2005), 2661–2700.
Oyer, Paul, "Fiscal Year Ends and Nonlinear Incentive Contracts: The Effect on Business Seasonality," *Quarterly Journal of Economics,* CXIII (1998), 149–185.
Oyer, Paul, and Scott Schaefer, "Why Do Some Firms Give Stock Options to All Employees? An Empirical Examination of Alternative Theories," *Journal of Financial Economics,* LXXVI (2004), 99–133.
Paarsch, Harry J., and Bruce S. Shearer, "The Response of Worker Effort to Piece Rates: Evidence from the British Columbia Tree-Planting Industry," *Journal of Human Resources,* XXXIV 4 (1999), 643–667.
——, "Piece Rates, Fixed Wages, and Incentive Effects: Statistical Evidence from Payroll Records," *International Economic Review,* XLI (2000), 59–92.
Prendergast, Canice, "The Provision of Incentives in Firms," *Journal of Economic Literature,* XXXVII (1999), 7–63.
Qian, Yingyi, "Incentives and Loss of Control in an Optimal Hierarchy," *Review of Economic Studies,* LXI (1994), 527–544.
Reback, Randall, *Teaching to the Rating: School Accountability and the Distribution of Student Achievement,* mimeograph, Columbia University (2006).
Rosen, Sherwin, "Authority, Control, and the Distribution of Earnings," *Bell Journal of Economics,* XIII (1982), 311–323.
Roy, Donald, "Quota Restriction and Goldbricking in a Machine Shop," *American Journal of Sociology,* LVII (1952), 427–442.
Williamson, Oliver E., "Hierarchical Control and Optimum Firm Size," *Journal of Political Economy,* LXXV (1967), 123–138.