Managerial Incentives in Hierarchies: Evidence From a Field Experiment*

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Abstract

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. The experiment allows us to measure the effects of managerial incentive pay on both aggregate firm performance and on the individual productivity of workers at lower tiers of the firm hierarchy. We find that the introduction of managerial incentives increased aggregate firm performance by 21%. The effects on the productivity of individual workers were, however, very heterogeneous. Productivity increased significantly for the most able workers, while it decreased for the least able workers. The experiment also reveals that the introduction of managerial incentives made the most able workers more likely to be retained in the workforce and that this selection effect accounts for at least half of the aggregate productivity gains. Finally, we discuss how some of the distributional consequences of the performance pay scheme – such as the increased earnings inequality within managers and workers – influence the long run sustainability of such managerial incentive schemes.

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1 Introduction

Firms are hierarchical organizations in which the incentives faced by agents at one tier of the hierarchy have important consequences for agents at other tiers. This paper presents evidence from a firm level field experiment designed to shed light on how managerial incentive pay affects the individual productivity and the selection of workers at lower tiers of the firm hierarchy.

In the experiment we engineered an exogenous change in managerial 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, piece rates, throughout.

We address three sets of questions. First, we provide evidence on whether the change in managerial incentives improves aggregate firm performance. Second, we analyze the effect of the change in managerial incentives on the productivity of each individual worker. We assess whether the effect differs across workers and identify the worker characteristics that explain the differences. Third, we analyze whether and how the introduction of managerial performance pay changes the composition of workers selected into the workforce.

Since managerial bonuses give managers a stake in raising average productivity, we expect average productivity to increase following the change in incentive scheme. However, the effect on the productivity of each individual worker is *a priori* ambiguous. The reason lies in the general observation that firms are often constrained to offer all bottom-tier workers the *same* compensation scheme. This is especially so if workers physically work alongside each other or perceive themselves to be performing similar tasks to co-workers.[1] 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.

Following the introduction of performance bonuses, managers' interests become more aligned with those of the firm and they have stronger incentives to target their effort to specific workers in order to offset the inefficiency that arises because all bottom-tier workers must be paid the same piece rate. If the piece rate is set too low for high ability workers, managers will have incentives to target their effort towards high ability workers. On the other hand, if the piece rate is set at a level such that high ability workers are performing at their full potential, managers might increase average productivity by raising the productivity of workers in the bottom tail.[2]

Identifying the effect of managerial performance pay on individual workers is important given

[1] We do not aim to explain why firms are unable to provide worker specific compensation schemes. However, in many cases this stems from technological or informational constraints, or broader notions of what is perceived to be fair (Lazear 1989, Encinosa *et al* 1997, Bewley 1999, Fehr *et al* 2004). We return to this issue in Section 6.

[2] In a knife-edge case workers may have preferences such that the optimal piece rate is independent of the ability of the worker. In general however, there will be some relationship between a worker's ability and the optimal piece rate the firm should set for her.

the potential distributional consequences within the group of bottom-tier workers. To the extent that managers target high ability workers, inequality within the lower level of the hierarchy will increase, and this can generate perceptions of unfair treatment which might ultimately reduce cooperation in the workplace (Baron and Pfeffer 1994, Bewley 1999, Lazear 1989).

Besides increasing the productivity of existing workers, managers may also respond to performance pay by changing the composition of workers selected into the workforce. As managers' interests become more aligned with those of the firm, they have incentives to select more able workers to increase average productivity. The selection effects of managerial incentives may further improve firm performance through the creation of a rat-race among bottom-tier workers (Akerlof 1976, Lazear and Rosen 1981). In other words, workers might want to increase their effort to increase the probability of being employed in the future.

The firm we study is a leading UK producer of soft fruit. Three tiers of the firms' hierarchy are of relevance to our study. The first tier consists of a single chief operating officer (COO), the second tier comprises managers, and the third tier is made up of workers.[3] The main task of the bottom-tier workers is to pick fruit. This is a physically strenuous task and one for which we expect workers to be of heterogenous ability. Fruit picking takes place on a number of different fields each day of the season.

Workers are assigned to a group of managers on each field-day. Managers are responsible for logistics, for instance to organize the transportation of fruit away from fields. Managers supervise workers and decide the allocation of workers to rows of fruit within the field. This is important because there is considerable variation in the amount of fruit in different rows within a field and so there are potentially large productivity gains to be had from matching good workers to good rows. Finally, there is little reassignment of individuals from manager to worker or *vice versa*, and only the bottom-tier workers pick fruit.

The COO selects which workers will pick fruit each day, assigns workers and managers to the different fields, and sets the piece rate for each field-day. The piece rate is the same for all workers on a given field-day, but varies across field-days as field conditions change.

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 hourly wage. In the second period, we added a daily performance bonus to the same fixed hourly wage. The performance bonus is an increasing function of the *average* productivity of workers on the field-day, conditional on productivity being above a set threshold.[4]

We exploit two data sources – the firm's personnel records, and survey data from a questionnaire

[3] We negotiated over the design of the field experiment with the CEO of the firm who is one tier above the COO.

[4] The change in managerial incentives was announced to the COO and managers a week in advance of the actual change. During this week, we spent time going through numerical examples with management to make sure they understood how the performance bonus would be calculated.

we administered to workers and managers. Personnel files contain panel data on each worker's daily productivity, which is recorded electronically with little or no measurement error. The survey data provides information on individuals' background characteristics, preferences, and attitudes.

The key features of the data that help identify the consequences of managerial performance pay are as follows. First, 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.[5] Second, 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 COO's selection of workers. We observe the entire pool of workers because individuals are hired seasonally from Eastern Europe, and they live and work on the farm. Moreover, work is offered on a casual basis with no daily guarantee of employment.

The empirical analysis proceeds in three stages. First we determine the overall effect of the change in managerial incentives on average field-day productivity. Second, we analyze the effect of the introduction of managerial incentives on the dispersion of productivity within the field-day and use individual level panel data to isolate the effect on the productivity of each individual worker. Third, we analyze whether and how the introduction of managerial incentives led the COO to change the selection of workers into employment.

The main results are as follows. As expected, the introduction of managerial performance pay significantly increases *average* field-day productivity by 21%. The magnitude of the effect is large relative to other observable determinants of productivity.

Second, we find the introduction of managerial performance pay significantly increases the dispersion of productivity across workers within a field-day – the coefficient of variation increases by 38%. The analysis of individual worker-field-day productivity reveals that the effects of managerial incentives on the productivity of individual workers are very heterogeneous – productivity significantly increases for some workers, and decreases for others. Moreover, the increased heterogeneity between workers is explained by factors such as their physical strength and underlying motivation. Namely those workers that can reasonably be expected to have the highest productivity, have the greatest change in productivity when their managers are paid performance bonuses.

Third, we find that the introduction of managerial performance pay affects the selection of workers by the COO. Workers who were the most productive when managers were paid fixed wages are significantly more likely to be selected into work after the introduction of the bonus. Workers with intermediate productivity are hired occasionally and workers with the lowest *ex-ante* productivity are fired. Moreover, we find that the increase in productivity is highest for workers

[5] 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 2004). This reinforces the importance of controlling for unobserved heterogeneity across managers.

that are selected to pick more frequently. Hence there is a clear interaction between the increase in the productivity of the same individuals and the selection of these individuals into the workforce. A series of thought experiments highlight the relative importance of these two effects. These suggest that the observed increase in productivity is driven at least as much by the selection of more productive workers, as it is driven by increases in the productivity of the same workers.

The selection effect is entirely due to the COO while the productivity effects are largely due to the managers. The findings are thus consistent with a 'magnification effect' (Rosen 1982), so 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.[6]

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 individual performance (Lazear 2000, Paarsch and Shearer 2000), on aggregate firm performance (Jones and Kato 1995), and on the effect of incentive pay for CEOs and managers on aggregate firm performance (Chevalier and Ellison 1997, Groves *et al* 1994, Oyer 1998). Our paper combines both themes as we analyze the effect of *managerial* incentives on the productivity of *individual workers*. Using individual level personnel data in combination with survey data, we open the black box of behavior within the firm, at various layers of the firm's hierarchy, and explore the efficiency and distributional consequences of managerial incentives. On the methodological front, our experimental research design allows us to address a key empirical challenge in identifying the effects of incentives on firm or individual performance, namely that incentive contracts are endogenously chosen (Prendergast 1999, Chiappori and Salanie 2003).

The remainder of the paper is organized as follows. Section 2 details the firm's operation, the design of the experiment, and describes the data. Section 3 presents evidence on the effect of managerial incentives on field-day level productivity. Section 4 uses the worker-field-day level data to identify the heterogenous effects on the productivity of workers of managerial performance pay. Section 5 details the changes in behavior of the COO to identify the selection effects of managerial incentives. Section 6 concludes with a discussion of some of the unintended consequences of managerial performance pay. Further robustness checks are presented in the Appendix.

[6] 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 1978, Qian 1994). We take the first two factors as given – workers are always managed in the firm we study, and as detailed in Section 2, managers' span of control remains constant throughout the season. Throughout the paper we provide evidence on the effect of managerial incentives on earnings inequality within layers of the firm.

2 Context and Data Description

2.1 Context

The firm we study is a leading UK producer of soft fruit.[7] Three tiers of the firm's hierarchy are relevant for our study. The first tier consists of a single chief operating officer (COO), the second tier comprises managers, and the third tier is made up of workers. Figure 1 presents a stylized representation of the firm's hierarchy, and the responsibilities at each layer.

The main task of the bottom-tier workers is to pick fruit. Fruit picking takes place on a number of different fields each day of the season. Each large box on Figure 1 represents a field-day. Within a field-day, each worker is allocated their own row of fruit to pick. There are no complementarities among workers in picking – each worker's productivity is determined solely by their own effort.

On any given field-day, workers are supervised by a group of managers. Managers can take a number of actions to affect the productivity of workers. Some of these actions, such as coordinating with other managers to prevent bottlenecks in production, and organizing the transportation of fruit from fields to packing, are likely to affect the productivity of all workers in a similar way. Other types of managerial actions are targeted towards specific workers. These include the allocation of workers to rows of fruit within the field, monitoring the inputs and outputs of workers, and reporting workers to the COO for shirking.

The COO decides which of the workers present on the farm are actually selected to pick fruit each day. As discussed in more detail below, he also decides the piece rate workers face for picking on each field-day. The piece rate is the same for all workers on a given field-day, but varies across field-days as field conditions change.

Table 1 shows the design of the experiment. At the start of the 2003 season, the COO and managers were paid a fixed hourly wage, which was the standard compensation scheme used in previous years. Midway through the 2003 season, the compensation schemes for the COO and managers were exogenously changed to the same level of fixed hourly wages plus a performance bonus. Managers and the COO would be awarded a bonus payment if the average productivity on field f and day t, $\overline{y}_{ft}$, exceeded an exogenously fixed threshold, y^*. Conditional on reaching the threshold, the monetary value of the bonus payment was increasing in average field-day productivity. This threshold was set in advance and remained constant over the season. Throughout the season, workers were paid piece rates.[8]

[7] The soft fruit industry in the UK is a competitive market on the supply side, with the majority of fruit being sold directly to supermarkets or market wholesalers.

[8] More specific details on the performance bonus are given later, when we exploit these features for the empirical analysis. At this stage it is important to emphasize that 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,

The 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%. Conditional on obtaining the bonus, managerial hourly earnings increased by 25%. The true expected hourly earnings increase to managers of the performance bonus scheme is likely to lie between these two bounds.[9] The fraction of field-days on which the bonus was earned varies from 20 to 50% across managers, highlighting the need to control for unobserved heterogeneity across managers.

Three further points are of note. First, given the production technology in soft fruit farming, managerial decisions have a direct impact on field-day level productivity, and hence on whether managers are awarded performance bonuses. Second, managers can potentially earn the performance bonus each and every field-day they work. We therefore observe the same manager on different field-days where the returns to managerial effort may vary, as for example, field conditions change.

Third, we observe the entire pool of workers available to pick fruit on each day. Workers and managers are hired seasonally from Eastern Europe, and live and work on the farm. Their work permit allows them to work in 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. Work is offered on a casual basis with no daily guarantee of employment. Finally, workers are typically not hired from the local labor market due to the seasonality of the work.[10]

2.2 The Data

We exploit two data sources – the firm's personnel records and survey data from a questionnaire we administered to workers and managers. Personnel records contain panel data on each worker's productivity on 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 the set of co-workers each individual picks with on every field-day, and to identify the managers also present on the field-day. The survey data contains information on individuals'

then the performance bonus was not awarded that field-day.

[9] Given that managers are from Eastern Europe, their base pay is 20% higher than the UK minimum wage, and 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 5 times as high as at the minimum wage in Poland (€201), where 40% of managers come from, and almost 20 times higher than in Bulgaria (€56), where 29% of managers come from. The nominal monetary value of the performance bonus to the COO is 1.5 times that to a single manager. Given that the COO's base pay is considerably higher than a manager's, then the increase in expected earnings for the COO is small.

[10] There are ten nationalities represented in the data, both genders are equally represented, and individuals are aged 20 to 25 years. In order to be recruited, individuals must be full-time university students, have at least one year before graduation, and must return to the same university in the Fall. Only a handful of workers are hired for two consecutive seasons.

characteristics, preferences, and attitudes, which is exploited at various stages of the analysis.

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.[11] Since different fields are operated at different times of the season, we restrict the sample to fields that were operated at least a week either side of the change in managerial incentives to compare the effects of managerial incentives within the same set of fields. Similarly, 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. 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 equally split between the pre and post-bonus periods.

2.3 Data Description

Figure 2 shows the time series for worker productivity, averaged over workers each day, for the 2003 picking season. This shows that 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.

A difficulty with attributing changes in productivity over the two halves of the season to the change in managerial incentives, is that there may just be a natural upward trend in productivity over time. To begin to address such concerns, Figure 2 also shows the comparable time series for the 2004 season, when managers and the COO were paid the same level of fixed hourly wages throughout and no bonus scheme was in place. 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.

Table 2 provides descriptive evidence on worker level productivity in 2003 and 2004. On average, worker productivity in the first half of 2003 when managers are paid fixed wages is 8.37 kg/hr. The corresponding figure for 2004 is very similar. In the second half of the 2003 season when managers are paid performance bonuses, productivity significantly rises by 25% to 10.4 kg/hr. In contrast, in the second half of the 2004 season worker productivity declines to 7.91 kg/hr.[12] [13]

[11] Fields are located on two sites on the farm, of which we only use the largest for the analysis as fruit in the smaller site began to ripen only after the introduction of the performance bonus scheme.

[12] 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 9.06kg/hr in the pre-bonus period and 8.99kg/hr in the post-bonus period.

[13] Table 2 at least suggests the introduction of managerial performance bonuses may be causally related to the increase in worker productivity. Hence an immediate issue is why this incentive scheme was not in place in 2004. We return to this in Section 6 after having presented evidence on all of the intended and unintended consequences

Importantly, Table 2 highlights that in 2003, the variation in productivity across workers significantly increases. In contrast in 2004, the variation in productivity declines over time. Figure 3 sheds more light on this issue and reveals a rich story behind the increase in average worker productivity in 2003. Figure 3a shows a kernel density estimate of worker productivity by managerial incentive scheme. In the cross section, both the mean and variance of worker productivity increase. Figure 3b plots each worker's average productivity when their managers are paid fixed wages, against her average productivity when her managers are paid performance bonuses. This shows the heterogeneous effects across workers – some workers have higher productivity with the change in managerial incentives, others have lower productivity.

Table 3 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.[14] Fruit is planted some years in advance so that the *aggregate* quantity of fruit to be picked is given. As the average worker becomes more productive with the introduction of performance bonuses for managers, fewer workers need to be selected to pick fruit each field-day.

The firm aims to minimize its wage bill subject to a minimum wage constraint.[15] One instrument the COO has to achieve this outcome is the piece rate. The COO sets the piece rate each field-day so that all workers obtain an hourly wage of at least $\underline{w} + c$, where $\underline{w}$ is the legally prescribed minimum wage, and c is a (small) constant term that does not change over the season.[16] In practical terms, this implies that the piece rate is lower whenever productivity is expected to be higher.[17]

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of the change in managerial incentives.

[14] 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. Given the near constant aggregate demand for fruit over the summer, the firm aims to have a near constant aggregate supply of fruit over the peak picking period.

[15] 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 wage bill is uncertain.

[16] 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 the workers with average productivity are expected to obtain an hourly equivalent of $\underline{w} + c$. 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 $\underline{w}$, they are paid a one-off supplement to ensure they reach the minimum wage level. When they first arrive on the farm, all workers are informed that they will be sent home if they consistently need to be paid this supplement. We observe less than 1% of worker-field-day observations where workers are paid the supplement.

[17] This raises concerns of a rachet effect, whereby workers initially deliberately under perform not to reveal their true ability to management. 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 shoe making (Freeman and Kleiner 2005) and bricklaying (Roy 1952).

Figure 4 shows that, as expected, the piece rate is inversely related to productivity. Table 3 confirms that the piece rate unconditionally falls by 23% when managers are paid performance bonuses. In the Appendix we present evidence that the magnitude of this fall is explained by the introduction of performance bonuses. Therefore the change in piece rates is consistent with the COO minimizing the wage bill subject to a minimum wage constraint throughout the season.

Given that piece rates and productivity move in opposite directions, worker's hourly earnings are left almost unchanged throughout the season. We therefore provide an estimate of the effect of managerial incentives on worker productivity holding constant workers' income.[18] Importantly, the increase in worker productivity is *not* due to an increase in the marginal return to worker effort, as piece rates are lower after the introduction of the bonus. In the absence of large income effects, we therefore expect workers to be exerting less effort in the second half of the season, all else equal (Lazear 2000, Paarsch and Shearer 1997).

The final panel of Table 3 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% after the introduction of performance incentives. As each workers 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 managers span of control remains at close to 20 workers, so each worker's likelihood to be monitored remains unchanged over the season.

3 Aggregate Effects

3.1 Average Field-day Productivity

The first stage of our empirical analysis investigates whether managers responded to the introduction of performance bonuses. We study the effect of the change in managerial incentives on average field-day productivity, as that is the measure on which bonus payments are based. We estimate the following panel data specification;

$$y_{ft} = \lambda_f + \gamma B_t + \eta Z_{ft} + \sum_{s \in M_{ft}} \sigma_s S_{sft} + \varepsilon_{ft} \quad (1)$$

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

[18] We cannot infer anything on the effects of managerial incentives on the utility of the average worker. This would require further assumptions to be made on the degree of complementarity between worker and manager's effort in the production function.

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.[19] 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 a field-specific 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.[20]

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: the effect on the productivity of the same workers and the effect on the selection of workers into the workforce.

The first two Columns of Table 4 report OLS estimates of (1). Column 1 only controls for the bonus dummy. Productivity significantly rises when 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.[21] 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, hence productivity was not naturally increasing in the second half of the season. This is consistent with the farm's practice to stagger fields to ensure a constant yield throughout the peak season.[22]

The implied magnitudes of these effects are also informative. Average productivity increases by 21% after the bonus is introduced. In contrast, a one standard deviation increase in a field's life cycle decreases productivity by 22%, and a one standard deviation increase in the average picking experience of workers increases productivity by 18%. This suggests the introduction of performance bonuses has an economically as well as statistically significant effect on average productivity.

[19] 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 farm level time trend.

[20] 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).

[21] 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.

[22] Further analysis, not reported for reasons of space, shows that the time trend does not differ over the two halves of the season. This indicates that the effect of the bonus is long-lasting, namely the bonus dummy is not just picking up a 'Hawthorne effect' – that individuals change behavior in response to *any* change in the work environment, and quickly revert back to their previous behavior. Moreover, this helps rule out that the bonus dummy is picking up workers and managers' career concerns that lead them to exert more effort later in the season, when their good performance may have greater influence over them being re-hired the following season.

Column 3 shows that the coefficients are very similar when the same specification is estimated allowing for field-specific AR(1) error terms. The final specification in Column 4 controls for a series of manager dummies. This is the most general way to capture all time invariant sources of heterogeneity across managers. This specification also addresses concerns that the bonus dummy merely picks up the better allocation of managerial talent over time by the COO. We find that the magnitude and significance of the previous controls remain similar to those in Column 3. Moreover, the manager dummies are jointly significant at the 1% significance level suggesting that, as expected, the middle-tier of managers do have significant effects on workers' productivity.

Since the change in incentives occurs at the same time for all managers in all fields, identification of the 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 farm level trend, workers' experience, or the field life cycle.

We address these concerns in Table A1 in the Appendix. First, we report a difference-in-difference specification between 2003 and a comparable sample from 2004 when managers were paid fixed wages throughout. The placebo bonus dummy for 2004 is not significantly different from zero, suggesting that there is no natural increase in productivity on June 27th.

Second, we control for the average experience of all managers present on the field-day to show that the bonus dummy does not pick up positive returns to managerial experience. Third, we control for changes in the composition of non-picking tasks over time by restricting the sample to workers who are exclusively assigned to picking tasks on a given day. Finally we show the magnitude and significance of the estimated effect of the bonus is robust to controlling for time varying factors such as meteorological variables, the worker-supervisor ratio, and the number of workers on the field-day.

3.2 The Strength of Managerial Incentives

To provide further evidence of a causal relationship between managerial incentives and workers' productivity, we exploit three features of the bonus scheme which are orthogonal to time and make the incentives faced by managers stronger on some days and weaker on others.[23] First, the nominal productivity threshold, y^*, is fixed at the start of the season and is the same across all fields. Given that fields deplete with time, the probability of exceeding the threshold on a field declines later in its life cycle. Managerial incentives are therefore weaker later in the field's life cycle, all else equal.[24]

[23] By 'strength of incentives' we mean that the marginal return to managerial effort is higher, all else equal.

[24] Conditional on passing the threshold, the bonus payment is increasing in average field-day productivity. This ensures that managers have incentives to increase productivity even after the threshold is reached.

Second, the allocation of the bonus payment *across* fields in a given day depends on the man-hours of supervision on the field-day, relative to the total man-hours of supervision on all fields that day. We refer to each manager's daily contribution to man-hours of supervision as the manager's 'bonus share'. Hence the size of the bonus payment received by the group of managers, and hence the strength of managerial incentives, on a field-day are *positively* related to average bonus shares of managers that field-day.

Third, conditional on the number of workers on the field-day, the size of the bonus to be shared among managers *within* a field is independent of the number of managers. Managerial incentives are therefore stronger when there are fewer managers present on the field-day since each gets a larger share of the bonus payment.

Table 5 presents these results on the effect of the performance bonus as the strength of managers' incentives vary along these dimensions. Column 1 shows that the marginal effect of the bonus is lower when a field is later in its life cycle. Figure 5 plots the implied marginal effect of the bonus scheme on log productivity, by the field life cycle. If the performance bonus were introduced in a field at the start of its life cycle, the estimates imply productivity would increase by close to 60%. By the end of the field life cycle, when the performance bonus is unlikely to be reached, the implied productivity is no different to that when managers are paid fixed wages.[25]

The remaining columns in Table 5 show that, consistent with the design of the performance bonus, the marginal effect of the bonus is greater when – (i) the share of total man-hours of supervision accruing to the field is greater; (ii) there are fewer managers for a given number of workers.[26] The final Column shows the results to be robust to simultaneously controlling for all three sources of variation in the strength of managerial incentives.

The results in Table 5 add weight to a causal interpretation of performance bonuses on average productivity. More precisely, if the bonus dummy were spuriously capturing other time varying factors we would not expect its effect to vary with the strength of managerial incentives. In addition, since the bonus shares and the number of managers on the field-day determine the strength of incentives for managers but not for the COO, the results imply that managers are driven at least in part by monetary incentives. In other words, greater monitoring of managers by the COO is unlikely to be the sole reason for their change of behavior.

[25] The fact that productivity is no lower than under fixed wages by the end of the field life cycle suggests there are no discouragement effects of performance bonuses. This result also suggests there is no intertemporal substitution of managerial effort over time, from field-days when the threshold level of productivity is unattainable to field-days when it is.

[26] In Column 3 there is *no* effect of having more than two managers present when managers are paid fixed wages, suggesting the interaction effect with the bonus dummy is not merely picking up that it is harder for managers to coordinate among each other when there are more of them.

4 Distributional Effects

4.1 The Dispersion of Productivity Within a Field-day

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

$$cv_{ft} = \lambda_f + \gamma B_t + \eta Z_{ft} + \sum_{s \in M_{ft}} \sigma_s S_{sft} + u_{ift} \quad (2)$$

where cv_{ft} is the log of the coefficient of variation of productivity of workers on field f on day t. The other controls are as previously defined. Table 6 presents estimates of (2) following a similar set of specifications as in Table 4.[27] The basic result is that the introduction of performance bonuses increased the dispersion of productivity on the field-day by 38% other things equal (Column 4).[28] In addition, we find that there is a natural downward time trend in the dispersion of worker productivity – workers become more similar to each other over time.[29]

In Appendix Table A2 we show these results are robust to the same set of checks performed on the effect of the bonus on average productivity in Table A1.

These findings have two important implications. First, after the introduction of the bonus scheme workers are *not* more likely to be sorted in different fields by ability.[30] Hence, given the constraint that workers must all be paid the same piece rate, there remains scope for managers to target their effort specific to each worker. The key reason for why workers are not sorted by ability is that there is variation in the amount of fruit in different rows within the same field so that high ability workers should optimally be distributed across different fields.

Second, when managers are paid performance bonuses, pay inequality among workers increases. Figure 6 shows how the daily pay inequality across workers – as measured by the interquartile range of daily pay – increases after the introduction of managerial performance bonuses.[31]

[27] To control for workers becoming more heterogenous to each other in their experience over time, we control for the mean and standard deviation 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 field life cycle.

[28] At first sight this magnitude seems implausibly large especially as the unconditional increase in the dispersion of productivity is only 7%. However, from Table 2 we see that in the 2004 season when managers were paid fixed wages throughout, the coefficient of variation among workers *declines* by 29% in the second half of the season.

[29] If we allow for the coefficient of the trend to differ pre and post-bonus we find that this convergence stops once performance bonuses are introduced. Namely, the coefficient on the interaction of the bonus dummy with the time trend is of equal magnitude and opposite sign to the coefficient on the time trend.

[30] This finding is confirmed in the next subsection using worker's individual fixed effects from the pre-bonus period as a measure of the worker's ability.

[31] Note also that there are some days when performance bonuses are in place where pay inequality is lower than when managers are paid fixed wages. This is due to the fact that, as discussed in Section 5, the most productive workers pick much more frequently post-bonus. On days in which few pickers are needed only the best workers are present, which lowers pay inequality among employed workers.

The dispersion of productivity may increase for a variety of reasons. If managerial effort affects all workers, we expect all workers' productivity to rise, but not necessarily by the same extent.[32] Alternatively, if managers reallocate their effort across workers, the productivity of targeted workers increases and the productivity of others workers would decrease. Similarly, if managers allocate workers more efficiently to rows within a field, the dispersion of productivity would again increase because some workers' productivity rise and other workers' productivity fall. To shed light on these issues we turn to an analysis of the individual level data.

4.2 Effects on Individual Productivity

To identify the effect of the managerial performance bonus on the productivity of individual workers, we estimate the following worker-field-day specification;

$$y_{ift} = \sum_{i=1}^{197}(\rho_i + \phi_i B_t)D_i + \lambda_f + \delta X_{ift} + \eta Z_{ft} + \sum_{s \in M_{ft}} \sigma_s S_{sft} + u_{ift} \tag{3}$$

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. X_{ift} is the worker's picking experience, Z_{ft} is the field life cycle, and both are measured in logs. The other variables are as defined previously. We estimate (3) using OLS, where disturbance terms are clustered by field-day because workers on the same field-day are likely to face common productivity shocks.[33]

The coefficient ρ_i is worker i' s fixed effect before the introduction of the performance bonus for managers. The coefficient ϕ_i measures the average effect of the performance bonus on the productivity of worker i. Given that piece rates for workers are adjusted to leave their overall earnings unchanged, this provides an estimate of the effects of managerial performance pay on individual worker productivity holding worker's income constant.

Figure 7 then shows the distribution of $\widehat{\phi}_i$'s in two ways. Panel A shows this distribution where each $\widehat{\phi}_i$ is equally weighted. We see the performance bonus for managers has a positive effect on some workers' productivity, and a negative effect on others. Panel B shows the distribution of $\widehat{\phi}_i$'s where each $\widehat{\phi}_i$ is weighted by the number of field-days that worker i picks once performance bonuses are in place. This distribution is shifted to the right relative to the unweighted distribution in Panel A. This implies that those workers who pick more frequently once the performance bonus is in place, are precisely those workers for whom the increase in productivity is the greatest. In other words there is an interaction between the productivity effect of managerial incentives on a

[32] This would occur if managerial effort was *solely* a public good. Plausible examples of such types of managerial effort include managers preventing bottlenecks or coordinating better with each other.

[33] Clustering at the worker or worker-managerial incentive scheme level yields considerably smaller standard errors.

given worker, and the likelihood the worker is selected into employment in the first place. We return to this issue in more detail in Section 5.[34]

4.3 Explaining the Heterogeneous Effects Across Workers

To shed light on which factors explain the heterogeneous productivity responses across workers to the change in the incentives of their managers, we estimate the following specification;

$$y_{ift} = \alpha_i + \lambda_f + \gamma_0 B_t + \gamma_1 (B_t * C_i) + \delta X_{ift} + \eta Z_{ft} + \sum_{s \in M_{ft}} \sigma_s S_{sft} + u_{ift} \tag{4}$$

where C_i is an observable (to managers and the econometrician) characteristic of worker i, and α_i is worker i's fixed effect. Column 1 in Table 7 reports the baseline individual level productivity regression, where no individual characteristic is interacted with the managerial performance bonus dummy. The point estimate of this dummy on worker productivity is positive, corresponds to a 5% productivity increase, but is not statistically different from zero. This relates to the information in Figure 7, that the effect of the bonus on individual workers' productivity is very heterogeneous, being positive for some workers and negative for others. In the remaining analysis of individual productivity we focus attention on identifying the workers for whom the marginal effect of the performance bonus to their managers is greatest.

The remaining Columns of Table 7 show that the effect of the bonus scheme is higher for workers who – (i) are men; (ii) report playing sports; (iii) report monetary earnings as one of the main reasons for coming to the farm; (iv) report preferring piece rates to fixed wages.[35] The first two of these factors may be reasonably assumed to be proxies of physical strength, and the last two may proxy workers underlying motivation and ability.

The estimates imply a worker with all these characteristics has 17% higher productivity under the performance bonus compared to himself pre-bonus. A worker with none of these characteristics has 10% lower productivity under the bonus compared to herself pre-bonus.

This result is consistent with the hypothesis that the piece rate is set below what is optimal for the high ability workers. This makes intuitive sense in this setting because – (i) the COO sets the piece rate so that *all* workers obtain an hourly wage of at least $\underline{w} + c$, where $\underline{w}$ is the minimum

[34] Using $\widehat{\rho}_i$ 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.

[35] The 'play sports' dummy is defined to be one if the worker reports playing sports at least once a month, and zero otherwise. The 'came for earnings' dummy is defined to be one if the worker reports one reason why they came to the farm is because the pay is good, and zero otherwise. Other options were 'to travel and meet new people', 'to learn English', and 'it is part of my university course'. The 'pay preference' dummy is defined to be one if the worker reports preferring a piece rate of £.50 a kilogram, to a fixed hourly wage of £4.85 and zero otherwise. Workers that report being 'indifferent' are classified as zero.

wage, and c is a (small) constant term; (ii) workers are of heterogenous ability.

Given that all workers face the same piece rate while managerial effort may be targeted to specific workers, when managers are paid performance bonuses their interests become more aligned with those of the firm, and they have greater incentives to target their effort towards high ability workers for whom the piece rate is too low. On the margin, managers therefore change their behavior towards each and every worker on the basis of their expectation of that worker's productivity. Hence the productivity of high ability workers increases when their managers' pay changes from fixed wages to performance bonuses, and the opposite is true for low productivity workers.

These heterogeneous effects are further magnified by the fall in the piece rate that follows from the rise in average productivity. In short, productivity falls for some workers because – (i) less managerial effort is targeted towards them so for example, they are allocated worse quality rows; (ii) the piece rate has fallen and they would prefer to exert less effort all else equal. In contrast, the productivity of others workers increases because managerial effort is targeted towards them and despite the fact that the piece rate has fallen.

In the Appendix we show further that – (i) the effects are even more heterogeneous across workers earlier in the field life cycle, namely when managerial incentives are stronger (Table A3); (ii) these results are not just picking up a health endowment effect such that workers who play sports, say, get tired at a slower rate than other workers (Table A4).

5 Selection Effects

5.1 Descriptive Evidence

Following the introduction of the performance bonus, managers succeeded in raising average productivity by increasing the productivity of the most able workers at the expense of workers in the bottom tail of the ability distribution. We now analyze whether the introduction of managerial incentives also affected the selection of workers into employment, and, if so, whether this reinforces or offsets the distributional consequences of our previous findings.

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. As shown earlier in Table 3, the number of workers allocated to pick on a field-day is on average 29% lower after the introduction of performance incentives. Table 8 provides further descriptive evidence on how the allocation of workers to tasks varies over the 2003 season. As a point of comparison, the Table also shows the corresponding figures for the 2004 season when managers were paid fixed wages throughout.

In the first half of the 2003 season, the average worker picks on 34 field-days. The corresponding figure for the 2004 season is 29. In the second half of the 2003 season when managers are paid performance bonuses, average productivity rises and hence less workers are required to pick – the average worker only picks on 29 field-days post-bonus. In contrast in 2004 where there is no rise in productivity over time, the average worker picks on 42 field-days in the second half of the season.

To shed more light on whether the potential selection effects in 2003 are heterogenous across workers, Figure 8 shows the distribution of the number of field-days workers are selected to pick fruit by managerial incentive scheme. For the average worker, after the change in managerial incentives the probability of being assigned to a picking task on any given day falls from 44% to 25%. The average number of field-days picked by a worker falls by 18% and the standard deviation of field-days picked across workers increases by 58%. This highlights that 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 therefore classify those workers that continue being selected to pick post-bonus into two groups. '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. '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. Moreover, a further 60 out of the 197 workers in our sample are 'fired', namely they do not perform *any* picking tasks after the introduction of the bonus scheme.

We present descriptive evidence on the selection criteria in Table 9. Panel A shows that in the pre-bonus period, selected-in workers pick on average 59 field-days, selected-out workers pick 36, and fired workers only pick 17 field-days. Therefore, workers who pick more frequently when managers are paid the performance bonus – selected-in workers – also pick more frequently *before* the introduction of the bonus. The difference between the two groups increases starkly after the introduction of the bonus. The average for selected-in workers rises to 100 field days while for selected-out workers the average falls to 18.

Panel B shows there is a clear ranking in terms of productivity 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.

In the previous Section we showed the coefficient of variation of productivity across workers increases after the introduction of the performance bonus. Here it is important to note that this occurs *despite* the fact that the least able workers are fired after the change in managerial incentives, which acts in the opposite direction– namely to reduce the variance in ability of hired workers.

Panel C of Table 9 shows unemployment rates by worker type and managerial incentive scheme. Unemployment rates rise for all categories of 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 non-picking tasks. In contrast, no workers are fired in the 2004 picking season.

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. 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.

5.2 Conditional Logit Estimates

We now shed light on the determinants of selection into the workforce controlling for farm level variables that affect the probability of being hired independently of the incentive scheme in place. We estimate the following conditional logit model, where observations are grouped by worker;

$$\Pr(p_{it} = 1) = \Lambda(B_t, X_t^D, X_t^S, X_{it}) \tag{5}$$

p_{it} equals one if worker i is selected by the COO to pick on day t on the main site, and is zero otherwise. X_t^D and X_t^S proxy the demand and supply of labor on day t. We measure the demand for labor using the total daily fruit yield on each site on the farm. As mentioned in Section 2.2, fields are located on two sites, of which we use the largest for the analysis as fruit in the smaller site begins to ripen only after the introduction of the performance bonus scheme. Since both sites compete for the same stock of workers, we control for yields in each site separately. We measure the supply of labor using the total number of workers present each day on any site on the farm.

All continuous variables are divided by their standard deviations so that one unit increase can be interpreted as an increase of one standard deviation. We report odds ratios throughout, and standard errors are calculated using the delta method.

Column 1 of Table 10 shows that others things equal, workers are significantly less likely to be selected into the workforce after the introduction of the performance bonus – the odds ratio post-bonus is 77% of the ratio pre-bonus. The other coefficients show that, as expected, workers are more likely to work on days in which the fields on the main site bear more fruit and on days in which they face less competition from other workers. The estimates imply that a one standard deviation increase in yield more than doubles the odds of being selected, whereas one standard deviation increase in the stock of available workers reduces the odds of working to less than a half.

Column 2 explores the idea that workers' previous performance affects the probability of being selected. We control for each worker's productivity on the last day she picked, in percentage deviation from the mean productivity on that day, to remove the effects of factors that determine the productivity of all workers and are beyond the worker's control.[36] The results suggest that a given worker has 17% higher odds of being selected into work when her productivity on the last day she picked, in deviation from mean, is one standard deviation higher.[37]

In Section 4.2 we showed the introduction of the bonus had a larger effect on men, on workers who play sports regularly, on workers who report coming to the farm for the monetary earnings, and on workers who report preferring piece rates over fixed wages. Column 3 shows workers are also more likely to be selected into work on two out of these four characteristics. In particular, being male increases the odds of being selected by 35%, and preferring piece rates more than doubles the odds. This again highlights the interplay between the effect of managerial incentives on the productivity of the same workers being managed, and the selection of different workers into employment.

Conditional on not being selected to pick on the main site on a given day, a worker can either be assigned to other tasks on the main site, to work on the other site, or be left unemployed for the day. Column 4 shows that the introduction of the bonus scheme significantly raises the probability of being unemployed. In particular, when the bonus scheme is in place the odds of being unemployed on any given day are between one quarter and one third higher. Reasonably, the probability of being unemployed is lower when yields are higher and when the stock of available workers is lower.

These results raise the possibility that some of the rise in productivity can be attributed to the fact that tighter selection creates a rat race or rank order tournament among workers (Akerlof 1976, Lazear and Rosen 1981).[38] 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. It is too costly for low ability workers, or those with a high value of leisure, to compete in such a rat race. They decrease their effort because with the rise in average productivity, the piece rate has fallen. In contrast, for high ability workers that are motivated by the rat race, they are effectively paid an efficiency wage which motivates them to exert more effort despite the fall in the piece rate. This explanation is consistent with the observed increased dispersion in productivity across workers (Table 6), and the increased productivity of high ability workers and the decreased productivity of low ability workers (Table 7) after the introduction of performance

[36] We first take the deviation of the worker's productivity from the field average productivity on each field she picked on the day she was last selected to pick, and then calculate a weighted average of this across all fields she worked on where the weights are based on the number of pickers on the field.

[37] We found that this deviation in mean productivity variable had no differential effect on the probability of being selected to pick fruit pre and post-bonus. This is most likely because there is less variation in productivity among the selected-in workers, who had the highest productivity to begin with (Table 9).

[38] This interpretation implies it is optimal for the firm to have unemployed workers present on the farm to motivate those workers that are selected into the workforce.

bonuses.

This rat race effect therefore reinforces 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, improved coordination and logistics and so forth, which is unavailable.

5.3 Understanding The Importance of Selection Effects

To summarize, the evidence indicates that the introduction of the performance bonus affects the composition of workers selected to pick by the COO. We find that workers who are most productive before the bonus, pick much more frequently post-bonus. In addition, the effect of the bonus on workers' productivity is stronger for workers who are selected to pick more frequently. Table 9 shows the average productivity of selected in workers increases unconditionally by 23%, whereas the average productivity of selected out workers is unchanged. Finally, the results reveal that men and workers who prefer piece rates to wages, both experience a strong increase in productivity after the bonus *and* are more likely to be selected in the workforce (Tables 7 and 10).

In our setting, the introduction of managerial performance pay increases productivity both because the productivity of individual workers increases and because the best 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.[39]

To understand the relative importance of the selection effects in raising productivity, versus the effect on the productivity of the same worker, 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 shown in Panel B of Table 9.[40]

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% in the post-bonus period.

[39] There are too few managers in the data to say anything meaningful on the possible selection by the COO of 'better' managers post-bonus. Although fewer managers are needed on each field-day under the performance bonus (Table 3), managers continue to work each day. They are typically reassigned to fields either on the smaller site, or onto fields in the main site that are only operated post-bonus.

[40] Implicitly we assume that there are no peer effects, namely the effect of the bonus would be the same regardless of the composition of the workforce, and that the effect of the bonus on each individual worker does not depend on how frequently they pick – namely that the best pickers would experience the same increase even if they were to pick less frequently post bonus.

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% in the post-bonus period.

Given the unconditional increase in productivity is 25%, 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.

6 Discussion

We have presented evidence from a firm level field experiment on the effects of tying the compensation of managers to the performance of the bottom-tier workers they manage. We find that introducing this type of managerial performance pay raises average productivity. The increase comes both from increases in the productivity of the most able of the existing workers, and from the selection of more productive workers into employment.

We also provide evidence on the distributional consequences of managerial incentive pay for workers in the bottom-tier of the hierarchy. The effects on the productivity of individual workers are very heterogeneous. Productivity increases for the physically fittest and most motivated workers and falls for the least able. This is reinforced by changes in the selection process because, following the introduction of managerial incentives, the most able workers are also more likely to be selected into employment.

The intuition why the productivity effects are heterogeneous across workers lies in the observation that the firm is constrained to offer all bottom-tier workers the *same* compensation scheme. To the extent that bottom-tier workers are of heterogeneous ability, however, offering the same piece rate to all of them is not optimal. Following the introduction of performance bonuses managers interests' become more aligned with those of the firm. They then have greater incentives to target their effort to specific workers, and change the composition of the workforce performing the same task. These behavioral changes offset the inefficiencies that arise because all bottom-tier workers must be paid the same piece rate.

The first order gain to the firm is the 21% increase in average productivity. This is likely to have translated into higher profits given the firm could adjust the size of its workforce once bonuses were in place – since the productivity of the average worker increased, fewer workers were required to pick the same quantity of fruit. As the employment contract does not oblige the firm to provide daily employment, this translated into many workers being underemployed. The reduction in the firms' wage bill from the overall fall in man-hours of labor required to pick all of the fruit on the farm is orders of magnitude larger than the monetary costs of paying the performance bonuses and administering the scheme. This raises the question of why the performance bonus scheme was not adopted for the 2004 season, given that it appears to have increased profits in 2003.[41] [42]

Anecdotal evidence indicates three potential sources of hidden costs of the managerial incentive scheme. First, the scheme caused a redistribution of earnings from workers left underemployed in the second half of the season, to selected-in workers. The morale of underemployed workers is likely to have fallen and this may be detrimental to the firm's performance along dimensions that are not captured by productivity.

Second, as documented in Sections 3 and 4, earnings inequality among workers increased significantly under performance bonuses. This occurs both because the effects of managerial effects on individual worker productivity are very heterogeneous, and this is exacerbated by the differential selection of workers into employment and unemployment post-bonus. Wage inequality among managers also increased because the fraction of field-days on which the bonus was earned varies from 20 to 50% across managers.

This increase in wage inequality could have increased perceptions of unfair treatment both among workers and managers, especially if individuals view others at the same layer of the hierarchy essentially performing the same task and under similar conditions as them (Baron and Pfeffer 1994, Bewley 1999). Such perceptions may ultimately reduce cooperation and increase sabotage activities in the workplace, which is obviously detrimental to the firm's performance (Lazear 1989).

Third, performance bonuses increase the incentives for managers and workers to engage in influence activities and other forms of rent seeking behavior (Milgrom 1988). Workers have incentives to lobby managers and the COO to ensure they are selected to pick, and managers have incentives to lobby the COO to ensure they are assigned the most productive workers or to work on fields early in their life cycle. If even a small fraction of senior management's time is spent dealing with such influence activities, this may be a significant hidden cost of managerial incentive pay.[43]

[41] Agency theory suggests that the provision of incentives may be tempered if agents are risk averse or there are multi-tasking concerns (Holmstrom and Milgrom 1990, Baker 1992). In our context neither factor seems a entirely plausible explanation, The savings on the workers' wage bill were substantially higher than any insurance compensation required for managers. Moreover, to alleviate multi-tasking concerns, the performance bonus was designed so that it would not be paid if the *quality* of fruit picked declined.

[42] Relatedly, Freeman and Kleiner (2005) document how the move away from piece rates to time pay in the shoe manufacturing sector in the US reduced worker productivity but increased firm profitability in the long run. This was due to cost savings in the form of lower workers' compensation insurance costs, smaller inventories, lower monitoring costs, lower hourly wages, and greater flexibility to introduced new shoe styles.

[43] Discussions with managers revealed that some of them deemed the scheme unfair as it rewarded people on the basis of factors such as the quality of managed workers, that were beyond their control.

These forms of hidden costs could of course be reduced by designing managerial incentive pay differently. For example, managerial pay could be negatively related to the dispersion of worker productivity as well as positively related to the average productivity. Regardless of the precise managerial incentive scheme in place, however, the possibility that firms trade-off the benefits of incentive pay with the types of hidden costs discussed above when designing compensation schemes for their employees deserves further investigation.[44]

Finally, our experiment highlights an important consideration for the study of firms – that the compensation schemes offered to workers at different tiers of the firm hierarchy interact with each other. In this paper we have discussed the implications of this for overall firm performance, and for the distribution of wages within each layer. Much more remains to be understood about the nature and consequences of other types of interaction between layers of the firm hierarchy.

7 Appendix

7.1 Robustness Checks: Field-day Level Analysis

Table A1 presents robustness checks on the effect of performance bonuses on average field-day level productivity from specification (1). Since the change in incentives occurs at the same time for all managers in all fields, the estimated effect ($\widehat{\gamma}$) will be biased upward if 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 aggregate time trend, workers' experience, or the field life cycle.

To address this issue, we collected personnel and survey data for the following season in 2004, during which managers were paid fixed wages throughout. We stack the data from the 2003 season and a comparable sample from the 2004 season to estimate the following specification;

$$y_{ft} = \lambda_f + \gamma_{03} B_t + \gamma_{04} PB_t + \eta Z_{ft} + \sum_{s \in M_{ft}} \sigma_s S_{sft} + \varepsilon_{ft} \tag{6}$$

where B_t is a dummy equal to one after the performance bonus is introduced on June 27th in 2003, and zero otherwise, and PB_t is a placebo bonus dummy equal to one after June 27th in 2004, and zero otherwise. All other variables are as defined in Section 3.1.

Column 1 of Table A1 shows the coefficient on the placebo bonus dummy for 2004 ($\widehat{\gamma}_{04}$) is small, negative and not significantly different from zero, suggesting there is no natural increase in productivity after June 27th.[45]

[44] The effects of these hidden costs on productivity are already accounted for in the analysis, so it seems reasonable that these costs affected performance in other parts of the farm. Fruit picking is only one activity performed on the farm.

[45] The set of fields operated on in 2003 are not identical to those from 2004. Similarly, the identity of managers is not the same across the two seasons. Qualitatively similar results are obtained if we allow each of the controls

Column 2 controls for the average experience of all managers present on the field-day to check whether the bonus dummy picks up positive returns to managerial experience. We find that this is not the case, namely the estimated effect of the bonus is unchanged.

In Column 3 we restrict the sample to workers who are exclusively assigned to picking tasks on a given day, to check whether the bonus dummy is capturing the effect of changes in the composition of non-picking tasks over time.[46] For instance, if workers were given a wider variety of tasks on post-bonus days they might be less bored or less tired and hence more productive. The result in Column 3 shows that this was not driving the previous findings. The estimated effect of the performance bonus dummy remains similar to the baseline specification in Table 4.

Finally we find that the magnitude and significance of the estimated effect of the bonus is robust to the inclusion of other time-varying controls such as meteorological conditions (Column 4), the worker-supervisor ratio, and the number of workers present on the field-day (Column 5).

Table A2 presents an analogous set of robustness checks for specification (2), on the estimated effect of performance bonuses on the dispersion of productivity at the field-day level. In line with the descriptives in Table 2, we find that dispersion was lower in the second half of the 2004 season, namely the placebo bonus dummy is negative and significant in 2004 (Column 1). In addition, Table A2 shows that the dispersion in worker productivity is not driven by dispersion in the experience of managers (Column 2), difference in tasks composition in the two halves of the season (Column 3), change in meteorological conditions (Column 4), or changes in the worker-manager ratio and number of workers on the field-day (Column 5).

7.2 Robustness Checks: Individual Level Analysis

The next set of robustness checks relate to the estimated effects of individual characteristics on worker productivity from specification (4). If the heterogeneous effects of managerial performance bonuses on the productivity of workers managed are truly reflective of managers changing their behavior towards workers, then we expect these effects to be greater earlier in the life cycle when managerial incentives are stronger. To explore this we estimate the following specification;

$$y_{ift} = \alpha_i + \lambda_f + \gamma_0 B_t + \gamma_1 (B_t * C_i) + \gamma_2 (B_t * C_i * Z_{ft}) + \gamma_3 (B_t * Z_{ft}) + \delta X_{ift} + \eta Z_{ft} + \sum_{s \in M_{ft}} \sigma_s S_{sft} + u_{ift} \quad (7)$$

where the variables are as defined in Section 4.1. Intuitively we expect that $\gamma_2 < 0$ so the effect of performance bonuses on a worker with characteristic C_i is greater earlier in the field life cycle (when Z_{ft} is smaller). The estimates of (7) are reported in Table A3. The pattern of coefficients shows that earlier in the field life cycle, there is greater heterogeneity in worker productivity for

in the specification to have a different coefficient in 2003 and 2004.

[46] Workers may also be asked to perform non-picking tasks such as weeding or planting.

men and for workers whose main reason to come to the farm was monetary earnings. The effect is also significantly stronger at the 11% level earlier in the life cycle for those who play sports.[47]

A separate concern is that the results in Table 7 may just be picking up a health endowment effect, namely that men and workers who play sports, say, get tired at a slower rate than other workers and hence are more productive in the second half of the season. To address this concern we control additionally for the interaction of the worker characteristic C_i with the worker's picking experience X_{ift}. Intuitively, if workers with characteristic C_i were to tire less quickly over time compared to other workers, this would be captured by the interaction between C_i and the continuous experience variable, rather than by the interaction between C_i and the bonus dummy. Table A4 then reports the estimates of the following specification;

$$y_{ift} = \alpha_i + \lambda_f + \gamma_0 B_t + \gamma_1 (B_t * C_i) + \gamma_2 (C_i * X_{ift}) + \delta X_{ift} + \eta Z_{ft} + \sum_{s \in M_{ft}} \sigma_s S_{sft} + u_{ift} \qquad (8)$$

We find no evidence that these heterogeneous effects vary with the picking experience of workers. For all four characteristics, the interaction term γ_2 is not significantly different from zero. Moreover the point estimates on the interaction terms are also close to zero so that this result is not driven by the interaction terms being imprecisely estimated.

7.3 Predicting the Piece Rate

As discussed in Section 2.3, the firm aims to minimize its wage bill subject to a minimum wage constraint. In particular, the COO should set the piece rate each field-day so that all workers obtain an hourly wage of at least $\underline{w} + c$, where $\underline{w}$ is the legally prescribed minimum wage, and c is a (small) constant term that does not change over the season. Hence in practical terms, the piece rate falls whenever productivity is higher.

In this subsection we explore whether this rule is followed throughout the season, or whether the COO sets the piece rate higher than is in the firms interests, thereby providing additional incentives to workers and increasing the likelihood he obtains the performance bonus. We estimate the following regression to understand the determinants of the piece rate;

$$\beta_{ft} = \lambda_f + \eta Z_{ft} + \mu R_t + \sum_{s \in M_{ft}} \sigma_s S_{sft} + \varepsilon_{ft} \qquad (9)$$

where β_{ft} is the piece rate on field-day ft, λ_f are field fixed effects, Z_{ft} are time varying characteristics of the workers and field, R_t are meteorological conditions, and S_{sft} is a dummy for whether

[47] Note that because in specification (7) we also include an interaction term between the performance bonus dummy and the field life cycle ($B_t * Z_{ft}$), the effect of the bonus dummy itself, $\widehat{\gamma}_0$, is positive and significant unlike in Table 7. This is because this effect of the bonus dummy is evaluated when the field is at the start of its life cycle, when managerial incentives are strongest.

manager s is present on field-day ft. The error terms are assumed to follow a field-specific AR(1) process.[48]

We first estimate (9) using the sample of pre-bonus field-days, and use this to predict the piece rate in the post-bonus period. Figure A1 shows this out-of-sample prediction, and Appendix Table A7 Column 1 shows the regression coefficients from (9). As expected, the piece rate is consistently over predicted in the post-bonus period when the prediction is derived from the field-days pre-bonus. Moreover, the result in Table A7 shows that factors that are positively correlated to productivity are negatively correlated to the piece rate. If we then additionally control for the performance bonus dummy in (9), Figure A1 shows the actual piece rate is predicted with little systematic error.[49] The information in both the level and the trend in these residuals suggests that the COO continues to set the piece rate using the same algorithm throughout the season. This is as expected given that – (i) the COO is a permanent employee of the firm; (ii) the wage bill is easily observable by the COO's own manager, the CEO of the firm.

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[48] Picking takes place inside tunnels. This ensures the quantity of fruit to be picked is insensitive to weather shocks. However workers effort may be sensitive to meteorological conditions, and if the COO recognizes this in setting the piece rate, these conditions should be included in (9).

[49] A Shapiro-Wilk test of the pre and post-bonus residuals does not reject the null hypotheses that these are both Normally distributed.

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Figure 1: A Stylized Representation of the Firm Hierarchy

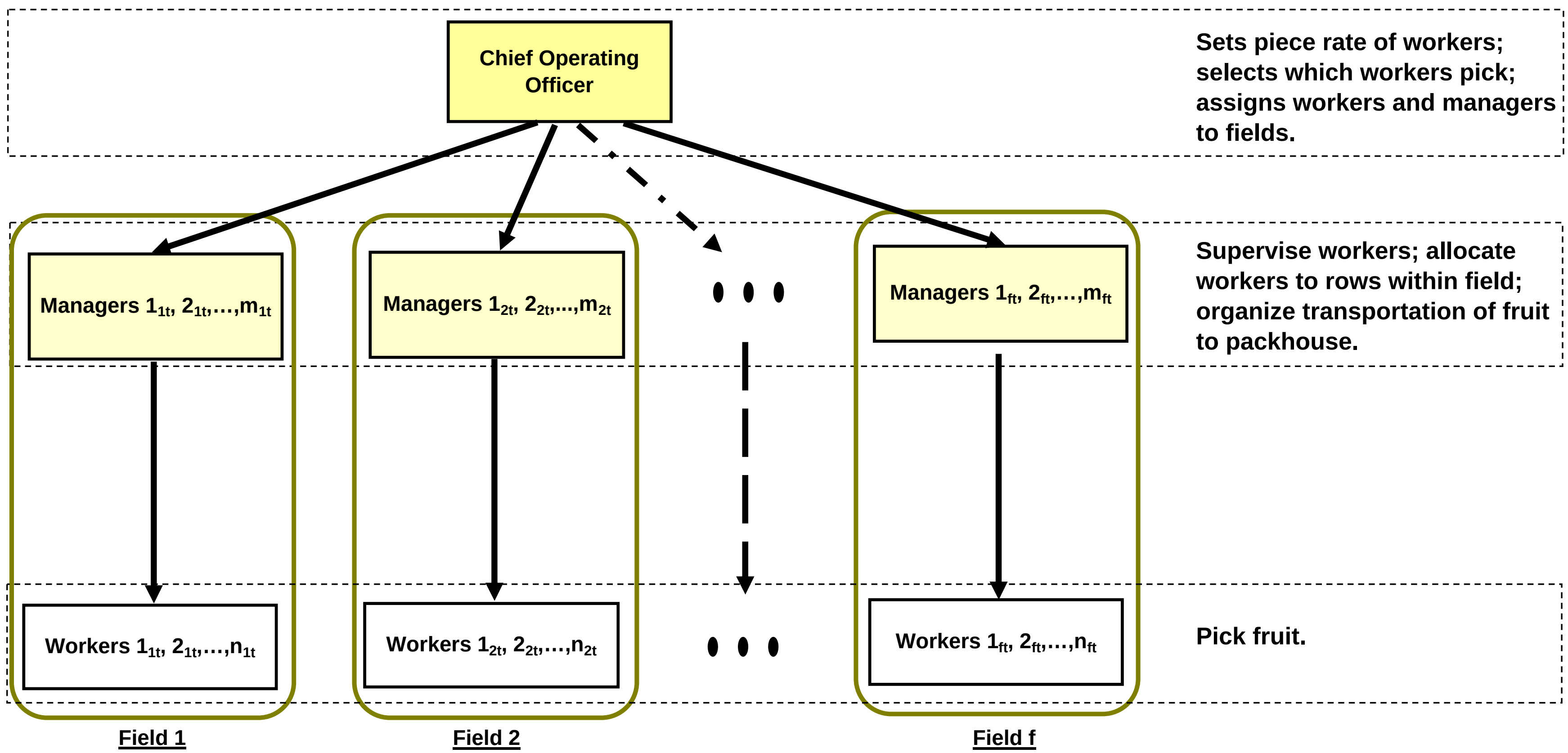
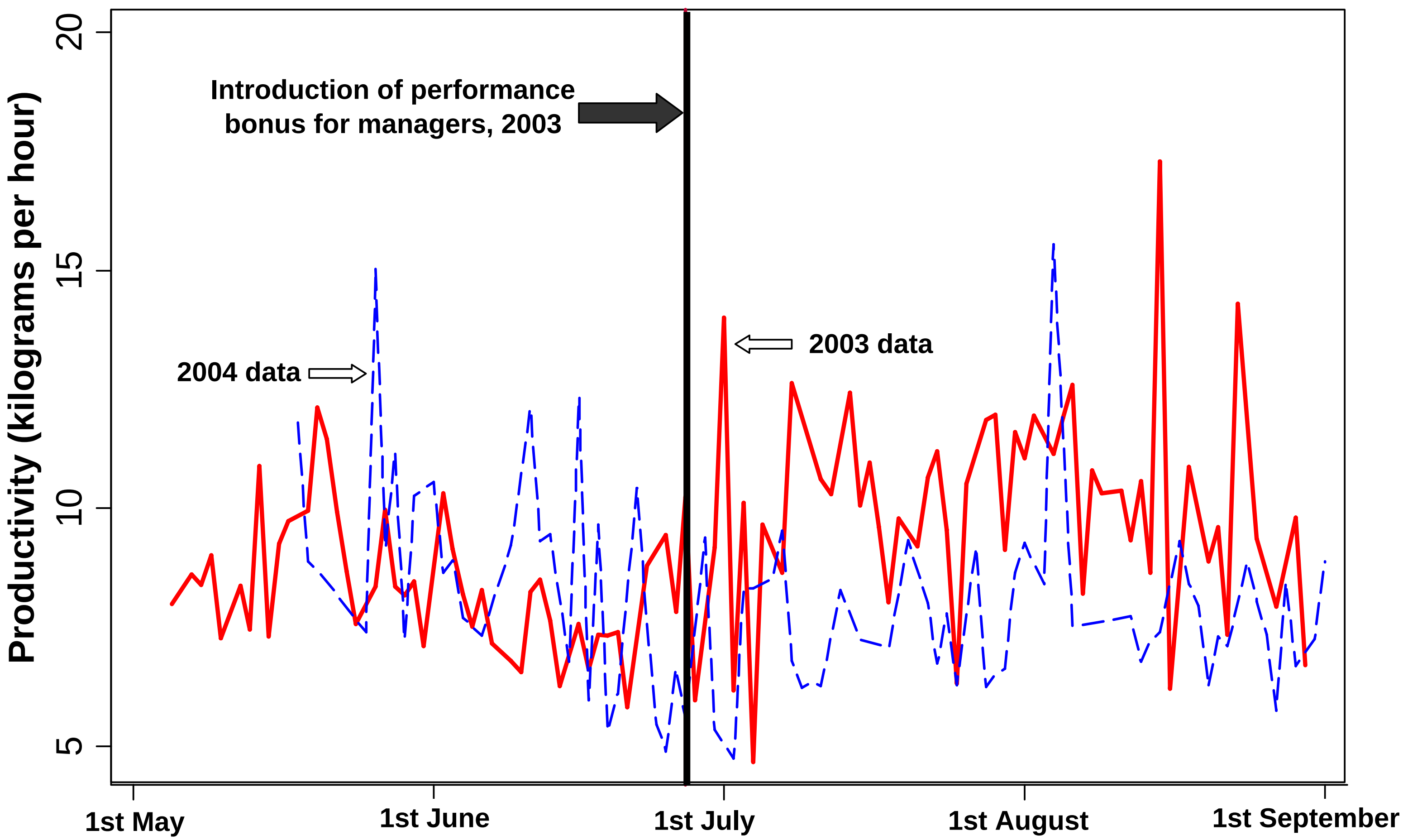


Figure 2: Time Series of Productivity, 2003 and 2004 Seasons



Notes: As more than one field is picked per day, each field-day level observation is first weighted by the number of pickers on the field-day before forming a day level average productivity.

Figure 3a: Kernel Density Estimates of Worker Productivity by Managerial Incentive Scheme

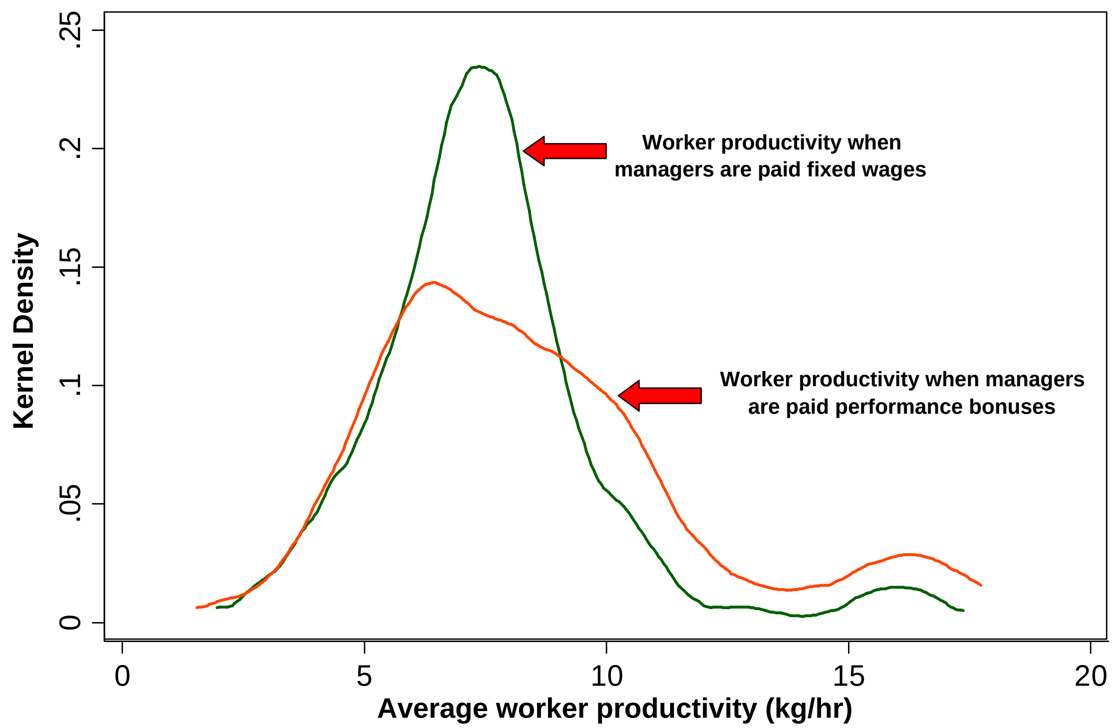
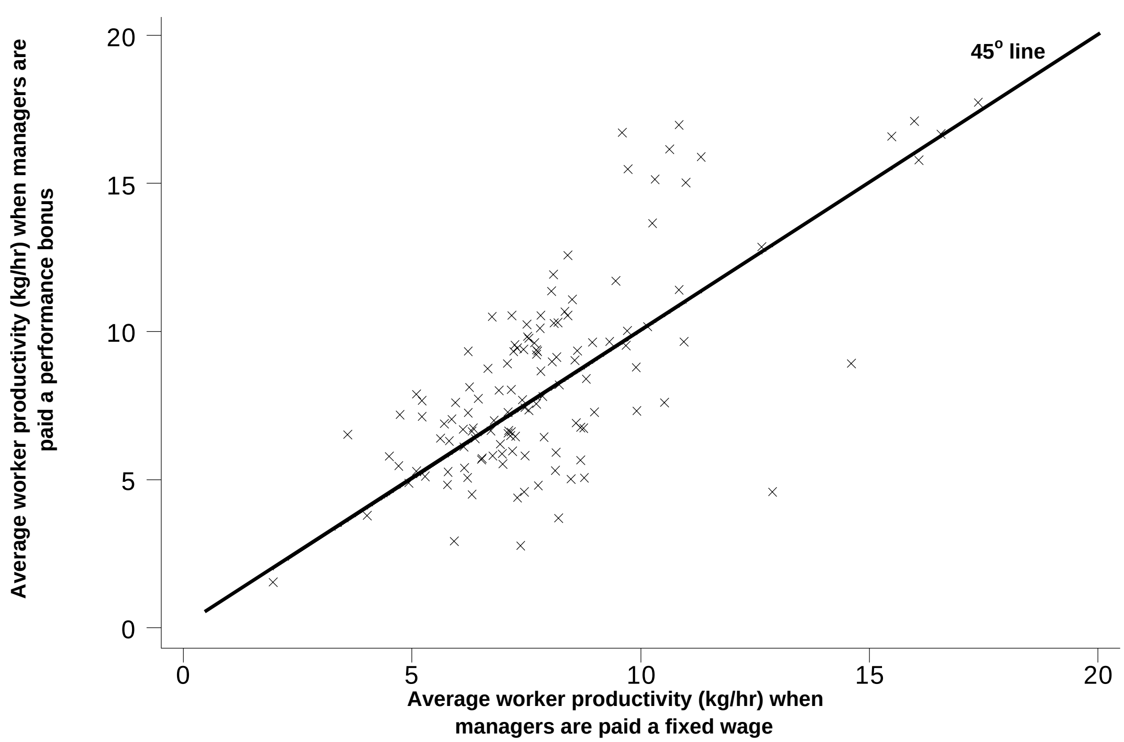


Figure 3b: Scatter Plot of Worker Productivity by Managerial Incentive Scheme



Notes: The density estimates in Figure 3a are calculated using an Epanechnikov kernel.

Figure 4: Time Series of Workers' Piece Rate

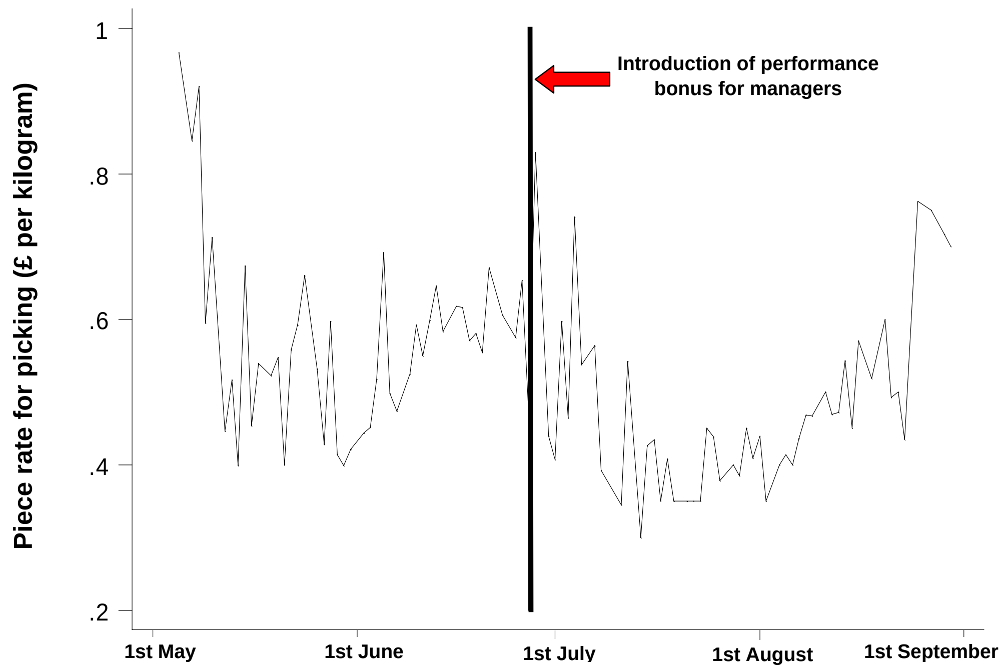
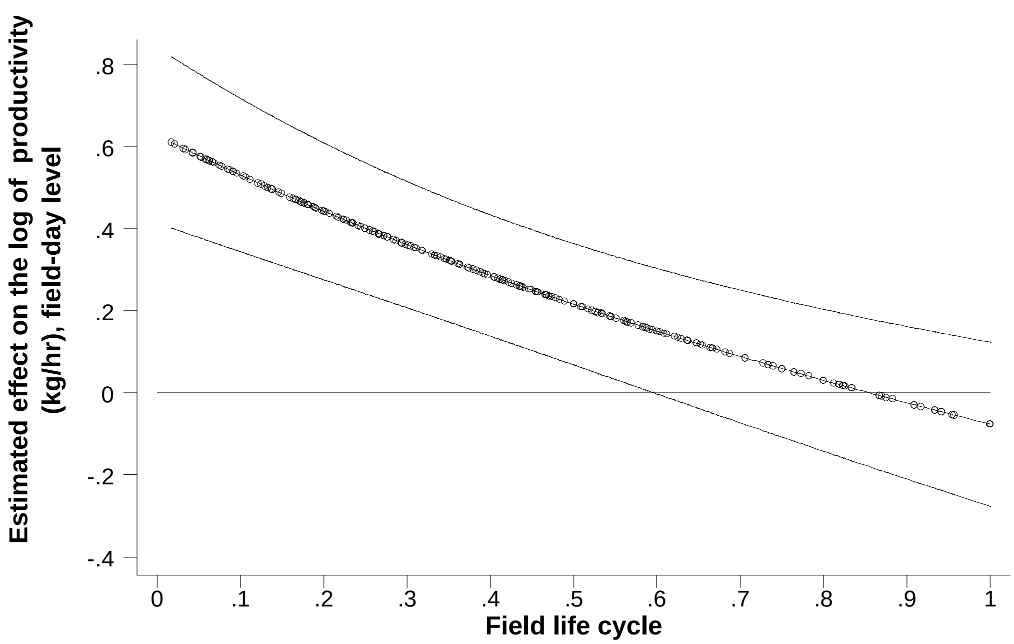
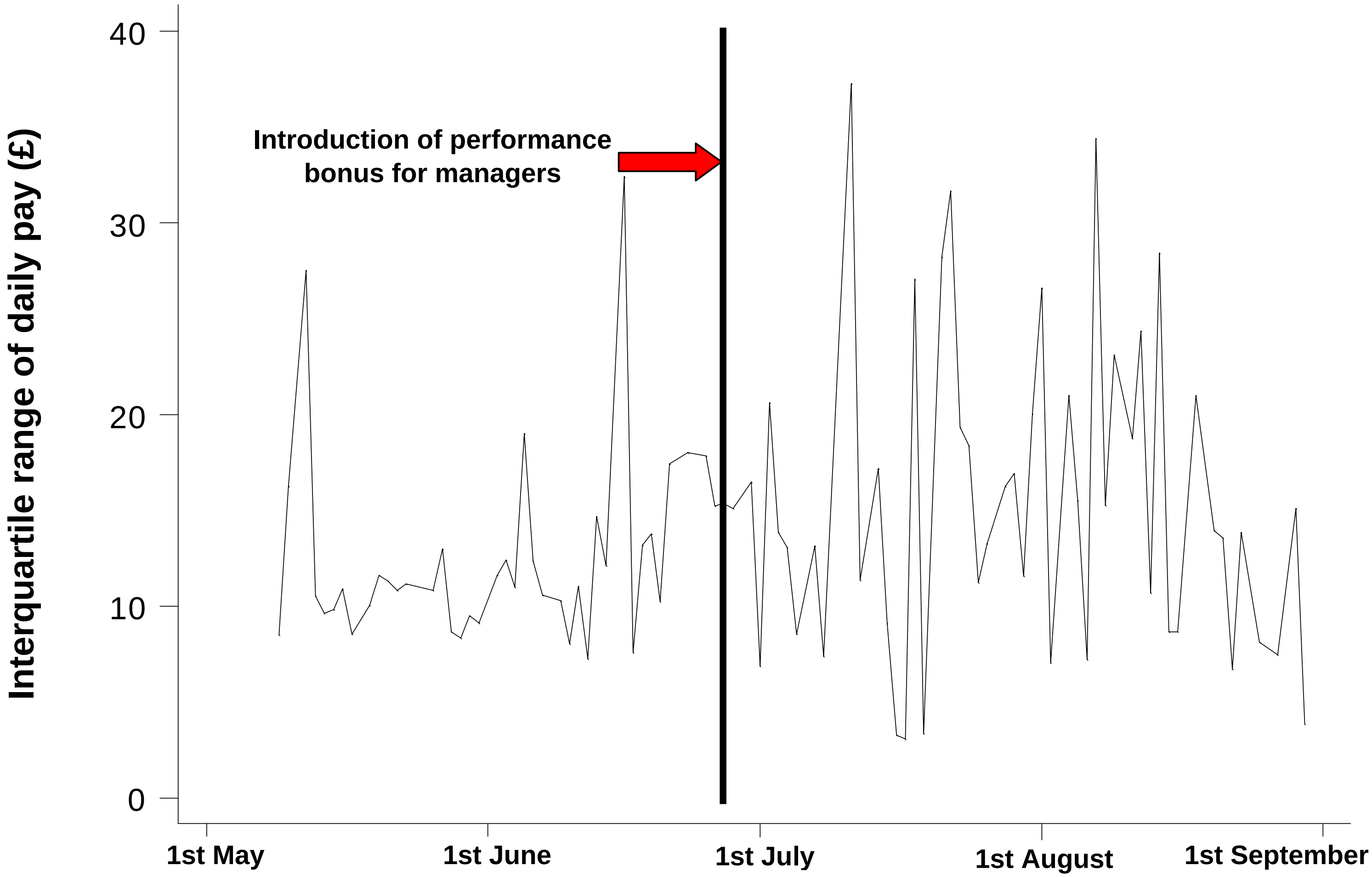


Figure 5: Estimated Effect of the Change in Managerial Incentives on Productivity, by Field Life Cycle



Notes: The piece rate is field-day specific. Hence for Figure 4, as more than one field is picked per day, each field-day level observation is weighted by the number of pickers on that field-day, before forming a day level average piece rate. Figure 5 graphs the estimated effect of the managerial performance bonus on average worker productivity, at different stages of the field life cycle. The figure also shows the 95% confidence interval. 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.

Figure 6: Pay Inequality Among Workers, by Managerial Incentive Scheme
Interquartile Range of Daily Pay



Notes: In Figure 6, the interquartile range are first calculated for each field-day. The daily average is computed by weighting each field-day by the total man-hours worked on it.

Figure 7a: Unweighted Distribution of the Estimated Effects of the Managerial Performance Bonus on the Productivity of Workers

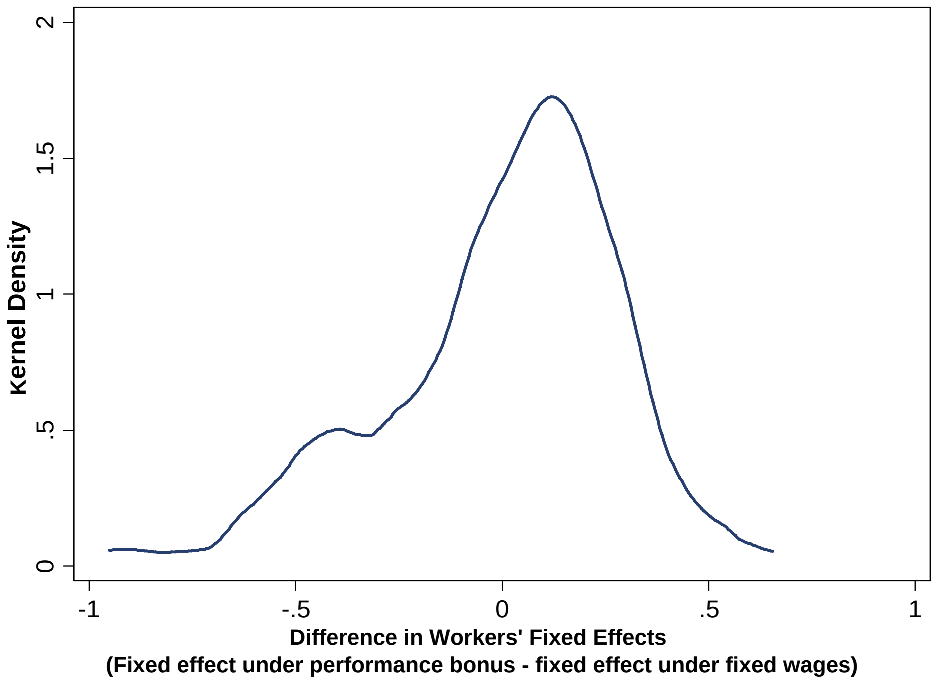
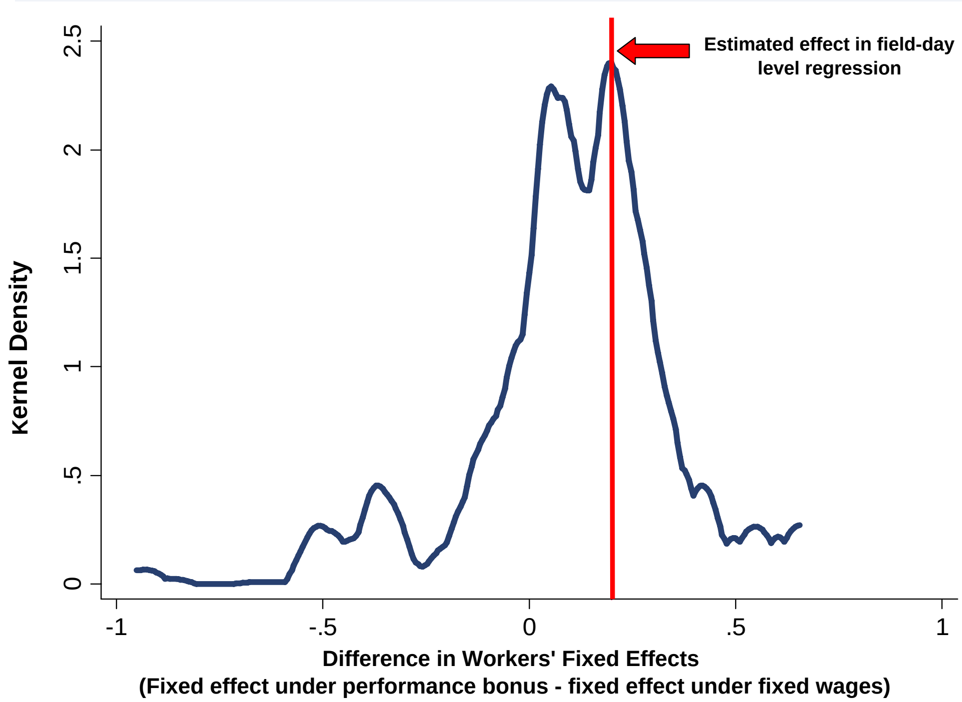
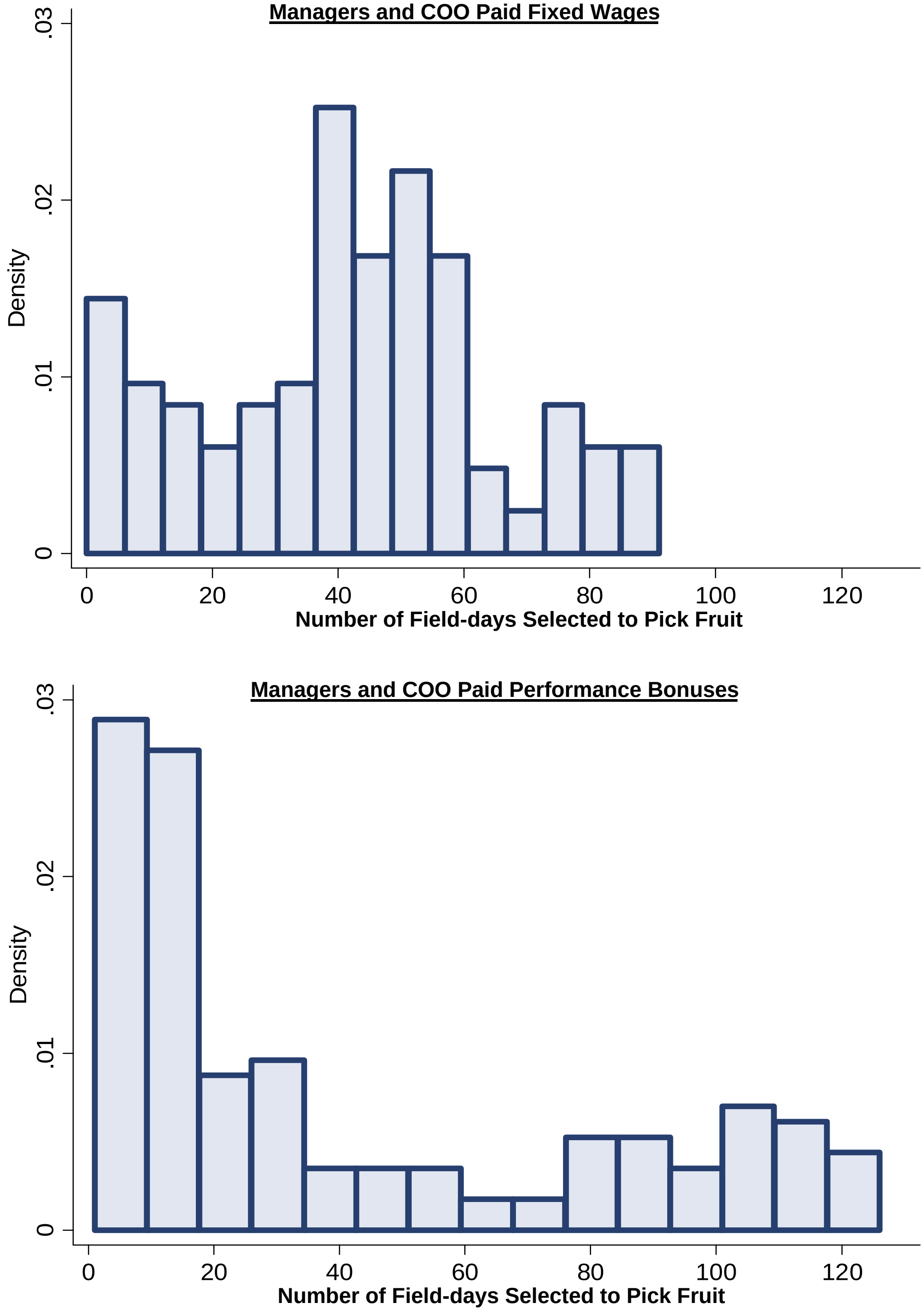


Figure 7b: Weighted Distribution of the Estimated Effects of the Managerial Performance Bonus on the Productivity of Workers



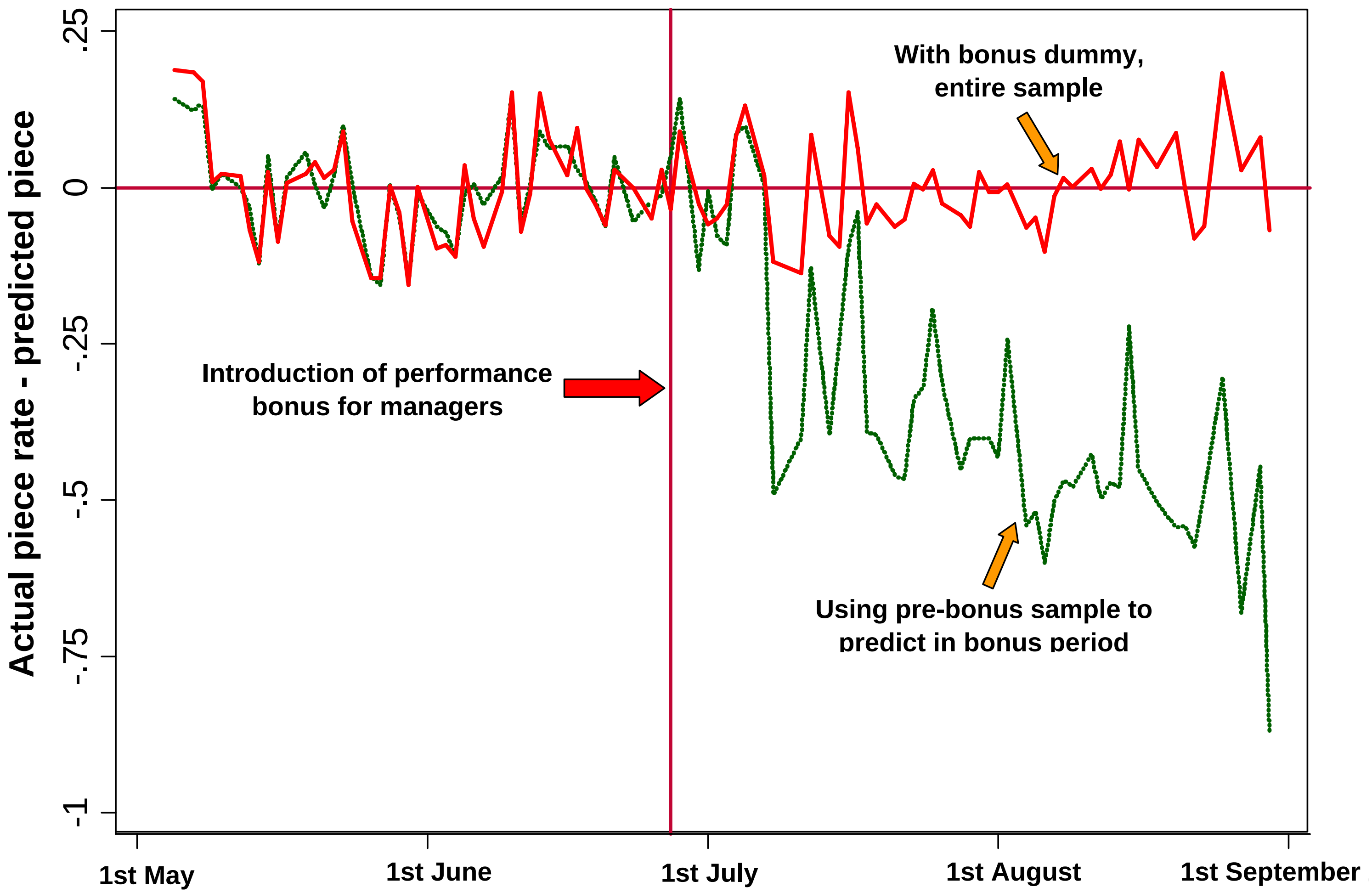
Notes: The density estimates are calculated using an Epanechnikov kernel. In Figure 7a each worker is weighted equally. Figure 7b weights each worker by the number of field-days he/she works after performance bonuses are introduced.

Figure 8: 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 be massed at zero on the lower histogram.

Figure A1: Predicting the Piece Rate for Workers



Notes: The dashed series labeled 'Without bonus dummy' is based on the specification in Column 1 of Table A5. This uses the data on the piece rate in the time period before managerial performance bonuses were introduced, to predict the piece rate in the post bonus period. The solid series is based on the specification in Column 2 of Table A5. This uses the data on the piece rate over all field-days in our working sample and is labeled 'With bonus dummy'.

Table 1: The Design of the Field Experiment

Tier	**Incentive Scheme in Place** **May 1st - June 26th**	**June 27th - August 31st**
1. Chief Operating Officer	**Fixed wages**	**Fixed wages plus performance bonus**
2. Managers	**Fixed wages**	**Fixed wages plus performance bonus**
3. Workers	**Piece rates**	**Piece rates**

The performance bonus is obtained by managers and the COO if the average productivity of workers on the field-day is greater than a fixed threshold. This threshold value is the same across all field-days and is set at the start of the season.

Table 2: Descriptives of Worker Productivity, by Managerial Incentive Scheme

All observations are at the worker-field-day level

	May 1st - June 26th	June 27th - August 31st
Managerial Incentive Scheme, 2003 Season:	**Fixed Wages**	**Performance Bonus**
Worker's productivity (kg/hr)		
Mean	8.37	10.4
Standard deviation	4.29	5.98
Managerial Incentive Scheme, 2004 Season:	**Fixed Wages**	**Fixed Wages**
Worker's productivity (kg/hr)		
Mean	8.32	7.91
Standard deviation	5.07	3.40

Notes: In the 2003 season, there are 197 workers in the sample. There are 6457 worker-field-day observations when managers are paid fixed wages. The average number of observations per worker under this regime is 33. There are 3440 worker-field-day observations when managers are paid the performance bonus. The average number of observations per worker under this regime is 26. In the 2004 season, there are 133 workers in the sample. There are 1686 worker-field-day observations in the period from May 1st to June 26th. The average number of observations per worker in this period is 13. There are 1539 worker-field-day observations in the period from June 27th to August 31st. The average number of observations per worker in this period is 16.

Table 3: Descriptives, by Managerial Incentive Scheme

Means, standard errors in parentheses, and 95% confidence intervals in brackets

	Managerial Incentive Scheme	
	Fixed Wages	Performance Bonus
Worker productivity (kg/hr)	8.37	10.4
	(.240)	(.486)
	[7.89, 8.84]	[9.47, 11.4]
Kilograms picked per field-day	30.2	30.4
	(.873)	(1.54)
	[28.4, 31.9]	[27.3, 33.4]
Hours worked per field-day	3.70	3.03
	(.169)	(.157)
	[3.36, 4.03]	[2.72, 3.34]
Piece rate per kilogram picked (£/kg)	.617	.476
	(.030)	(.016)
	[.557, .677]	[.445, .507]
Field-day pay from picking (£)	17.6	13.5
	(.499)	(.620)
	[16.6, 18.6]	[12.3, 14.7]
Hourly earnings from picking (£/hr)	4.81	4.53
	(.133)	(.199)
	[4.54, 5.07]	[4.41, 4.93]
Number of workers on field-day	79.3	56.4
	(4.02)	(2.02)
	[71.4, 87.2]	[52.4, 60.4]
Number of managers on field-day	5.27	3.28
	(.231)	(.075)
	[4.82, 5.73]	[3.13, 3.42]
Worker-manager ratio	21.3	19.2
	(2.06)	(.622)
	[17.2, 25.4]	[17.9, 20.4]

Notes: Worker productivity, kilos picked per field-day, field-day pay from picking, 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 worke 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.

Table 4: The Effect of the Managerial Performance Bonus Scheme on Average 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 Dummies
Managerial performance bonus dummy	.225***	.203***	.196***	.194***
	(.044)	(.074)	(.069)	(.082)
Field life cycle		-1.35***	-1.42***	-1.31***
		(.167)	(.194)	(.177)
Average picking experience of workers		.284***	.276***	.313***
		(.050)	(.065)	(.062)
Time trend		-.003	-.002	-.001
		(.002)	(.002)	(.002)
Field fixed effects	No	Yes	Yes	Yes
Manager dummies	No	No	No	Yes
R-squared	.0986	.3873	.8264	.8746
Number of field-day observations	247	247	247	247

Notes: *** denotes significance at 1%, ** at 5%, and * at 10%. 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.

Table 5: The Strength of Incentives Under the Managerial Performance Bonus Scheme, Field-Day Level

Dependent Variable = Log of average productivity (kilogram picked per hour on field-day)
Standard errors allow for field specific AR(1)

	(1) Field Life Cycle	(2) Managers' Bonus Share	(3) Number of Managers	(4) All Effects
Managerial performance bonus dummy	.627***	.362***	.308***	.939***
	(.109)	(.131)	(.100)	(.175)
Interaction of bonus dummy with -				
Field life cycle	-1.01***			-.918***
	(.214)			(.213)
Average of managers' bonus shares		.165*		.200**
		(.092)		(.086)
More than two managers present (Yes = 1)			-.237**	-.261***
			(.104)	(.096)
Field life cycle	-.895***			-.948***
	(.172)			(.175)
Average of managers' bonus shares		-.092		.085
		(.068)		(.060)
More that two managers present (Yes = 1)			.066	.077
			(.074)	(.067)
Field fixed effects	Yes	Yes	Yes	Yes
Manager dummies	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes
R-squared	.8535	.8857	.8881	.8890
Number of observations	247	247	247	247

Notes: *** denotes significance at 1%, ** at 5%, and * at 10%. All continuous variables are in logarithms. 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 "manager's bonus share" equals the manager's daily supervision hours, divided by the total daily hours of supervision by all managers. In Columns 2 and 4, we control for the average of these bonus shares across all managers present on the field-day. In Columns 3 and 4 we also control for the number of pickers on the field-day. Other controls include the average picking experience of workers on the field-day, the field life cycle, and a time trend.

Table 6: The Effect of the Managerial Performance Bonus Scheme on the Dispersion of 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 Dummies
Managerial performance bonus dummy	.084***	.198***	.266***	.325***
	(.031)	(.062)	(.060)	(.064)
Field life cycle		-.149	-.148	.082
		(.161)	(.139)	(.144)
Average picking experience of workers		.082	.107*	.061
		(.062)	(.059)	(.060)
SD of picking experience of workers		.118*	.099	.141**
		(.070)	(.064)	(.060)
Time trend		-.006***	-.007***	-.006***
		(.002)	(.002)	(.002)
Field fixed effects	No	Yes	Yes	Yes
Manager dummies	No	No	No	Yes
R-squared	.0279	.1356	.5555	.5962
Number of field-day observations	247	247	247	247

Notes: *** denotes significance at 1%, ** at 5%, and * at 10%. 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.

Table 7: Heterogeneous Effects of the Managerial Performance Bonus Scheme on Worker Productivity

Dependent Variable = Log of worker's productivity (kilogram picked per hour on the field-day)
Robust standard errors reported in parentheses, allowing for clustering at field-day level

	(1) Baseline	(2) Gender	(3) Play Sports	(4) Came For Earnings	(5) Pay Preference	(6) All
Managerial performance bonus dummy	.050	-.052	-.063	.003	.084	-.118
	(.068)	(.072)	(.084)	(.077)	(.073)	(.084)
Interaction of bonus dummy with -						
Male (yes = 1)		.160***				.075**
		(.038)				(.036)
Play sports (yes = 1)			.176***			.126***
			(.039)			(.030)
Came for earnings (yes = 1)				.105***		.070**
				(.036)		(.035)
Pay preference (prefer piece rates = 1)					.071***	.052**
					(.034)	(.037)
Worker and field fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Manager dummies	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	.4106	.4137	.3788	.3861	.3847	.3972
Number of observations	9897	9897	6409	6031	6188	5780

Notes: *** denotes significance at 1%, ** at 5%, and * at 10%. Robust standard errors are calculated throughout, allowing for clustering at the field-day level. All continuous variables are in logarithms. The managerial performance bonus dummy is one when mangers are paid according to the performance bonus, and zero otherwise. The "play sports" dummy is defined to be one if the worker reports playing sports at least once a month, and zero otherwise. The "came for earnings" dummy is defined to be one if the worker reports one reason why they came to the farm is because the pay is good, and zero otherwise. Other options were 'to travel and meet new people', 'to learn English', and 'it is part of my university course'. The "pay preference" dummy is defined to be one if the worker reports preferring a piece rate of £.50 a kilogram, to a fixed hourly wage of £4.85, and zero otherwise. Workers that report being 'indifferent' are classified as zero. The sample falls in Columns 3 to 6 because the survey questionnaire was not administered to all workers. Other controls include worker picking experience, field life cycle, and a time trend.

Table 8: The Allocation of Workers to Picking Tasks, by Managerial Incentive Scheme

Means, and standard deviations in parentheses

	May 1st - June 26th	June 27th - August 31st
Managerial Incentive Scheme, 2003 Season:	**Fixed Wages**	**Performance Bonus**
Number of field-days selected to pick	34.4 (24.0)	28.8 (38.6)
Managerial Incentive Scheme, 2004 Season:	**Fixed Wages**	**Fixed Wages**
Number of field-days selected to pick	29.2 (16.8)	42.3 (38.4)

Notes: For both seasons, these statistics are calculated for workers that were available for work three weeks either side of June 27th - the date on which managerial incentives were changed in 2003.

Table 9: Selection into the Workforce

A: Field-Days Picking

Average number of field-days selected to pick fruit by worker type and managerial incentive scheme
Standard deviation in parentheses

	Selected-In Workers	Selected-Out Workers	Fired Workers
Fixed Wages	58.6	35.7	16.9
	(15.6)	(21.9)	(16.2)
Performance Bonus	99.8	18	
	(16.1)	(15.8)	

B: Productivity

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

	Selected-In Workers	Selected-Out Workers	Fired Workers
Fixed Wages	9.03	7.45	6.79
	(3.03)	(2.09)	(2.15)
Performance Bonus	11.11	7.35	
	(3.66)	(2.50)	

C: Unemployment Rate

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

	Selected-In Workers	Selected-Out Workers	Fired Workers
Fixed Wages	.037	.089	.187
	(.052)	(.122)	(.186)
Performance Bonus	.059	.146	.340
	(.060)	(.180)	(.372)

Notes: 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. 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.

Table 10: Selection of Workers

Conditional logit estimates
Columns 1-4: Dependent Variable = 1 if worker *i* is chosen to pick on day *t* in main site, 0 otherwise
Columns 5-6: Dependent Variable = 1 if worker *i* is unemployed on day *t*, 0 otherwise
Odd ratios reported, standard errors in parentheses

	Probability of Being Selected to Pick			Probability of Being Unemployed
	(1) Baseline	(2) Productivity	(3) Individual Characteristics	(4)
Managerial performance bonus dummy	.771***	.783***	.800	1.23*
	(.067)	(.068)	(.172)	(.138)
Total yield in site 1	2.26***	2.24***	2.23***	.756***
	(.090)	(.089)	(.117)	(.034)
Total yield in site 2	.879***	.882***	.862***	.829***
	(.028)	(.029)	(.037)	(.029)
Number of workers available to pick fruit	.377***	.382***	.322***	1.15***
	(.017)	(.017)	(.019)	(.053)
Worker *i*'s previous deviation from mean productivity		1.17***	1.28***	
		(.038)	(.055)	
Interaction of bonus dummy with				
Male (yes = 1)			1.35**	
			(.210)	
Play sports (yes = 1)			1.23	
			(.199)	
Came for earnings (yes = 1)			.894	
			(.136)	
Pay preference (prefer piece rates = 1)			2.76***	
			(.636)	
Log-likelihood	-5208.29	-5197.01	-3035.78	-3934.14
Number of observations	15551	15551	9168	11284

Notes: *** denotes that the odd ratio is significantly different from one at 1%, ** at 5%, and * at 10% levels. Conditional logit estimates are reported where observations are grouped by worker. All continuous variables are divided by their standard deviations so that one unit increase can be interpreted as increase by one standard deviation. "Total yield" on the site is the total kilograms of the fruit picked on the site-day. The "number of workers available to pick fruit" is the total number of individuals that are on the farm that day and are available for fruit picking. "Worker i's previous deviation from mean productivity" is defined on the last day the worker was selected to pick. We first take the deviation of the worker's productivity from the field average productivity on each field he picked on the day he was last selected to pick, and then calculate a weighted average of this across all fields he worked on where the weights are based on the number of pickers on the field. The "play sports" dummy is defined to be one if the worker reports playing sports at least once a month, and zero otherwise. The "came for earnings" dummy is defined to be one if the worker reports one reason why they came to the farm is because the pay is good, and zero otherwise. Other options were 'to travel and meet new people', 'to learn English', and 'it is part of my university course'. The "pay preference" dummy is defined to be one if the worker reports preferring a piece rate of £.50 a kilogram, to a fixed hourly wage of £4.85. Workers that report being 'indifferent' are classified as zero. The sample falls in Columns 3 and 4 because the survey questionnaire was not administered to all workers. Worker i is defined to be unemployed on day t if she is present on the farm but is not assigned to any paid tasks.

Table A1: Robustness Checks on The Effect of the Managerial Performance Bonus Scheme on Average Productivity, Field-Day Level

Dependent Variable = Log of average productivity (kilogram picked per hour on field-day)

Standard errors allow for field specific AR(1)

	(1) Difference in Difference with 2004 Season	(2) Managers' Experience	(3) Only Picking	(4) Meteorological Variables	(5) Worker-Manager Ratio and Number of Workers
Managerial performance bonus dummy in 2003	.180**	.190**	.192**	.246***	.200***
	(.075)	(.083)	(.086)	(.082)	(.084)
Placebo managerial performance bonus dummy in 2004	-.023				
	(.097)				
Average experience of managers		-.008			
		(.062)			
Rainfall (mm)				-.050**	
				(.026)	
Minimum temperature (Celsius)				.052	
				(.059)	
Worker-manager ratio					-.137
					(.091)
Number of workers					.330***
					(.096)
Field fixed effects	Yes	Yes	Yes	Yes	Yes
Manager dummies	Yes	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes	Yes
R-squared	.9025	.8749	.8693	.8770	.9107
Number of observations	370	247	246	247	247

Notes: *** denotes significance at 1%, ** at 5%, and * at 10%. All continuous variables are in logarithms. 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 in 2003, and 0 otherwise. In Column 1, the placebo bonus dummy is equal to one after June 27th in 2004, and zero otherwise. In Column 3 the field-day averages are constructed only from workers that were engaged in picking tasks all day. In Column 4 the rainfall and minimum temperature measures correspond to a 0900-0900 time frame. Other controls include average picking experience of workers, field life cycle, and a time trend.

Table A2: Robustness Checks on The Effect of the Managerial Performance Bonus Scheme on the Dispersion of 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) Difference in Difference with 2004 Season	(2) Managers' Experience	(3) Only Picking	(4) Meteorological Variables	(5) Worker-Manager Ratio and Number of Workers
Managerial performance bonus dummy in 2003	.448***	.318***	.271***	.315***	.291***
	(.064)	(.067)	(.067)	(.066)	(.068)
Placebo managerial performance bonus dummy in 2004 season	-.359***				
	(.087)				
Average experience of managers		-.041			
		(.061)			
SD of experience of managers		-.009			
		(.028)			
Rainfall (mm)				.015	
				(.024)	
Minimum temperature (Celsius)				-.003	
				(.049)	
Worker-manager ratio					.081
					(.088)
Number of workers					.119
					(.088)
Field fixed effects	Yes	Yes	Yes	Yes	Yes
Manager dummies	Yes	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes	Yes
R-squared	.6807	.5956	.6190	.5964	.5855
Number of observations	370	247	246	247	247

Notes: *** denotes significance at 1%, ** at 5%, and * at 10%. All continuous variables are in logarithms. 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 in 2003, and 0 otherwise. In Column 1, the placebo bonus dummy is equal to one after June 27th in 2004, and zero otherwise. In Column 3 the field-day averages are constructed only from workers that were engaged in picking tasks all day. In Column 4 the rainfall and minimum temperature measures correspond to a 0900-0900 time frame. Other controls include average picking experience of workers, field life cycle, and a time trend.

Table A3: Individual Characteristics and the Strength of Managerial Incentives

Dependent Variable = Log of worker's productivity (kilogram picked per hour on the field-day)
Robust standard errors reported in parentheses, allowing for clustering at field-day level

	(1) Gender	(2) Play Sports	(3) Came For Earnings	(4) Pay Preference
Managerial performance bonus dummy	.355***	.397***	.453***	.609***
	(.125)	(.150)	(.139)	(.132)
Field life cycle x bonus dummy	-.999***	-1.11**	-1.08***	-1.29***
	(.259)	(.320)	(.310)	(.272)
Interaction of bonus dummy with -				
Male (yes = 1)	.245***			
	(.071)			
Play sports (yes = 1)		.268***		
		(.079)		
Came for earnings (yes = 1)			.240***	
			(.068)	
Pay preference (prefer piece rates = 1)				.075
				(.061)
Interaction of field life cycle x bonus dummy with -				
Male (yes = 1)	-.226*			
	(.139)			
Play sports (yes = 1)		-.257		
		(.178)		
Came for earnings (yes = 1)			-.356**	
			(.181)	
Pay preference (prefer piece rates = 1)				.008
				(.136)
Field life cycle	-.782***	-.707***	-.731***	-.707***
	(.163)	(.177)	(.176)	(.175)
Worker and field fixed effects	Yes	Yes	Yes	Yes
Manager dummies	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes
Adjusted R-squared	.4249	.3939	.4010	.3990
Number of observations	9897	6409	6031	6188

Notes: *** denotes significance at 1%, ** at 5%, and * at 10%. Robust standard errors are calculated throughout, allowing for clustering at the field-day level. All continuous variables are in logarithms. The "play sports" dummy is defined to be one if the worker reports playing sports at least once a month, and zero otherwise. The "came for earnings" dummy is defined to be one if the worker reports one reason why they came to the farm is because the pay is good, and zero otherwise. Other options were 'to travel and meet new people', 'to learn English', and 'it is part of my university course'. The "pay preference" dummy is defined to be one if the worker reports preferring a piece rate of £.50 a kilogram, to a fixed hourly wage of £4.85. Workers that report being 'indifferent' are classified as zero. The sample falls in Columns 2 to 4 because the survey questionnaire was not administered to all workers. Other controls include worker picking experience and a time trend.

Table A4: Robustness Check on Individual Heterogeneity Results

Dependent Variable = Log of worker's productivity (kilogram picked per hour on the field-day)
Robust standard errors reported in parentheses, allowing for clustering at field-day level

	(1) Gender	(2) Play Sports	(3) Came For Earnings	(4) Pay Preference
Managerial performance bonus dummy	-.034 (.073)	-.051 (.087)	.006 (.081)	.083 (.073)
Interaction of bonus dummy with -				
Male (yes = 1)	.133*** (.043)			
Play sports (yes = 1)		.160*** (.047)		
Came for earnings (yes = 1)			.100** (.049)	
Pay preference (prefer piece rates = 1)				.079 (.050)
Picking experience	.158*** (.021)	.149*** (.023)	.151*** (.021)	.165*** (.021)
Interaction of picking experience with -				
Male (yes = 1)	.019 (.014)			
Play sports (yes = 1)		.011 (.020)		
Came for earnings (yes = 1)			.003 (.016)	
Pay preference (prefer piece rates = 1)				-.005 (.028)
Worker and field fixed effects	Yes	Yes	Yes	Yes
Manager dummies	Yes	Yes	Yes	Yes
Adjusted R-squared	.4185	.3787	.3860	.3846
Number of observations	9897	6409	6031	6188

Notes: *** denotes significance at 1%, ** at 5%, and * at 10%. Robust standard errors are calculated throughout, allowing for clustering at the field-day level. All continuous variables are in logarithms. The "play sports" dummy is defined to be one if the worker reports playing sports at least once a month, and zero otherwise. The "came for earnings" dummy is defined to be one if the worker reports one reason why they came to the farm is because the pay is good, and zero otherwise. Other options were 'to travel and meet new people', 'to learn English', and 'it is part of my university course'. The "pay preference" dummy is defined to be one if the worker reports preferring a piece rate of £.50 a kilogram, to a fixed hourly wage of £4.85. Workers that report being 'indifferent' are classified as zero. The sample falls in Columns 2 to 4 because the survey questionnaire was not administered to all workers. Other controls include worker picking experience, field life cycle, and a time trend.

Table A5: Predicting the Piece Rate

Dependent Variable = Piece rate on field-day (£ per kilogram picked)
Standard errors allow for field specific AR(1)

	(1) Pre Bonus Period	(2) Entire Sample
Field life cycle	.376***	.508***
	(.129)	(.064)
Average picking experience of workers	.003	.001
	(.003)	(.001)
SD of picking experience of workers	-.007*	-.004*
	(.004)	(.002)
Time trend	-.003	-.003
	(.005)	(.002)
Rainfall (mm)	-.026***	-.005
	(.009)	(.004)
Minimum temperature (Celsius)	-.011**	-.006*
	(.006)	(.003)
Share of workers that are women	.350**	.262***
	(.152)	(.099)
Share of workers that play sports	-.636***	-.344**
	(.234)	(.151)
Share of workers that came for earnings	.077	.125
	(.222)	(.139)
Share of workers with a preference for piece rates	-.403	.154
	(.387)	(.227)
Number of supervisors	-.031	-.169
	(.063)	(.152)
Number of workers	-.0005	-.001***
	(.0004)	(.002)
Managerial performance bonus dummy		-.122***
		(.039)
Field fixed effects	Yes	Yes
Manager dummies	Yes	Yes
R-squared	.7731	.7953
Number of observations	140	245

Notes: *** denotes significance at 1%, ** at 5%, and * at 10%. All continuous variables are in logarithms. 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. The rainfall and minimum temperature measures correspond to a 0900-0900 time frame. The piece rate data is missing for two field-days operated in the period before managerial performance bonuses were introduced.