Relative and Absolute Incentives: Evidence on Worker Productivity*

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Abstract

Using personnel data, we compare worker productivity under a relative incentive scheme -where pay is based on individual productivity relative to the average productivity of the group- to productivity under piece rates.

We find that productivity is at least 50% higher under piece rates. Further analysis shows this is due to workers partially internalizing the negative externality their effort imposes on others under the relative incentive scheme. Workers internalize this externality to a greater extent when they work with fewer co-workers, and a greater share of their co-workers are their close friends. The relationship among workers has no affect on productivity under piece rates.

Keywords: absolute incentives, relative incentives, social preferences.

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1 Introduction

Relative incentive schemes - where an individual's reward depends on her performance relative to others' - are ubiquitous in society. In the classroom, students are graded on a curve; on the sports field, sportsmen and women are rewarded relative to their competitors; and in business, managers compete for promotion.

In this paper we use personnel data to compare the effect of relative and absolute incentive schemes on workers' productivity. Workers in our sample are fruit pickers on a leading UK farm. Workers' individual productivity - defined as kilograms of fruit picked per hour - is recorded daily over the entire picking season. We first observe workers under a relative incentive scheme where pay depends on individual productivity relative to the average productivity among all co-workers. The same workers are then observed under an absolute incentive scheme - piece rates - where pay depends only on individual productivity.[1]

We provide two sets of results in this paper. First, we identify the causal effect of the change in incentive schemes on workers' productivity. Second, we provide evidence on how individuals behave in a situation where individual and social optima do not coincide - namely under a relative incentive scheme where each worker's effort imposes a negative externality on co-workers by lowering their relative performance.[2] To this purpose, we exploit data on each worker's social network which allows us to assess whether workers' behavior depends on the *identity* of co-workers who suffer from the externality.

Three features of the data help identify the causal effect on worker productivity of the change in incentive schemes. First, we use information on the daily productivity of the *same* workers before and after the introduction of the piece rates. Time invariant sources of unobservable individual heterogeneity such as worker ability and intrinsic motivation are therefore controlled for.[3]

[1] This is the first empirical comparison of absolute and relative incentive schemes in the workplace. Knoeber and Thurman (1994) analyze the effects of two different relative incentive schemes on chicken ranchers. The theory of rank order tournaments - a type of relative incentive - has been tested in experimental data (Bull *et al* (1987)) and in sports tournaments (Ehrenberg and Bognanno (1990), Becker and Huselid (1992)). Lazear (2000) and Paarsch and Shearer (1996) show that incentives matter *per se* - both find sizeable gains in worker productivity when moving from fixed pay to piece rates. Similarly, Laffont and Matoussi (1995) find worker productivity to be 50% higher in farms operated under high powered (fixed rent) contracts compared to those operated under low powered (sharecropping) contracts. Finally, Foster and Rosenzweig (1994) show that effort, proxied by the depletion of BMI net of calorie intake, is 22% higher for rural laborers paid by piece rates compared to those paid hourly wages.

[2] As made precise in section 2, under relative incentives individual worker's effort increases average productivity thus reducing other co-workers' pay, all else equal. In contrast, under piece rates, worker's effort does not affect other co-workers' pay.

[3] This is in contrast to studies that use cross-sectional or time-series variation across firms to measure incentive effects. If workers are not randomly allocated across firms, unobserved worker heterogeneity biases such estimates of the effect of incentives on productivity.

Second, the total stock of workers on the farm remains constant over the season. Hence there is no endogenous sorting of new workers into the sample. Furthermore, as we compare the productivity of the same worker before and after the change in regime, there is no endogenous attrition of workers out of the sample. This is important given existing evidence suggesting the quantitative effects on productivity of the endogenous sorting of workers in response to a change in incentives, are at least as strong as those arising from the incentives directly.[4]

Third, the change in incentive scheme was unannounced to workers beforehand. Moreover, no other farm practices changed with the change in incentives. Tasks, technology and management were the same under both incentives schemes.

Our main results are as follows. The change in incentive schemes had a significant and permanent impact on productivity; for the average worker productivity increased by at least 50%. The result is robust to controlling for a host of time varying factors at the worker, field, and farm level.

The productivity gains accrued to management and were not shared with workers. In particular, workers' pay and hours remained constant under both incentive schemes, while productivity increased, indicating that the change in incentive schemes made the average worker worse off.[5] We also provide evidence that the increase in productivity did not come at the expense of a lower quality of fruit picking.

Next, we investigate whether workers choose their effort to maximize their individual utility under both incentive schemes, namely whether they ignore the negative externality their effort imposes on their co-workers under relative incentives. In a stylized model of effort choices under the two incentive schemes, the Nash equilibrium indeed entails lower effort under relative incentives vis-à-vis piece rates.

Estimation of the first order conditions for worker's effort choice however reveals that the observed change in productivity is too large to be consistent with individual utility maximization. In that model, effort is lower under relative incentives because higher effort leads to higher average productivity and hence lower pay. For the group sizes observed in the data this effect is too small to account for the observed change in productivity.[6]

Further analysis indicates that workers' behavior under relative incentives is not consistent

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[4] Lazear (2000) uses worker level data to analyze the effect on installers of auto windshields of moving from fixed wage contracts to piece rates. He finds an increase in productivity of 44% six months after the change in incentives. Half of this is attributed to the endogenous turnover of workers.

[5] As discussed later, the estimated increase in productivity of 50% is therefore a lower bound on the pure effect of the change in incentives, holding worker utility constant.

[6] When workers are homogeneous the magnitude of this effect is of order $\frac{1}{N}$, where N is the number of co-workers. The average group size in our sample is 40. Evidence of the "$\frac{1}{N}$ problem", whereby individuals appear to overestimate their impact on others has also been found in the literature on team incentives (Hamilton *et al* (2003)), employee stock option plans (Jones and Kato (1995)), firm wide performance bonuses (Knez and Simester (2001), and experimental public goods games (Fehr and Gachter (2000)).

with the group optimum either. Namely, effort levels are too high to be consistent with workers *fully* internalizing the negative externality their effort imposes on others. We then posit workers to have *social preferences*, namely they place some weight on the benefits accruing to their co-workers. We find that the observed change in productivity is consistent with the average worker placing around twice the weight on their own private benefits, as on the benefits accruing to all others.

Finally, we ask whether the extent to which workers internalize the externality depends on their relationship with other members of the group. Using data on each worker's social network, we find that under relative incentives workers indeed choose lower effort when the share of personal friends in the group is larger and that this effect is stronger in smaller groups.

In contrast, we find that productivity under piece rates is *not* affected by the relationships among co-workers. This helps rule out the hypotheses that productivity is lower when friends are present because workers socialize with their friends, because of a norm of not working hard in the presence of friends, or because workers self select to work alongside their friends when they do not intend to work hard.

The contributions of this paper are twofold. First, we provide evidence on the effect of relative, compared to absolute, incentive schemes on worker productivity. The personnel data is rich enough to allow us to circumvent a number of econometric concerns that generally plague empirical studies of the effect of incentives on productivity.

Second, we shed light on *why* workers behave differently under the two schemes. In doing so, we integrate the recent work on social preferences - that has largely been motivated by experimental evidence - with the literature on the provision of incentives.[7]

These findings provide useful information for further developments of incentive theory and more generally, for the understanding of individual behavior in common resource management and other situations in which individual and social optima do not coincide.

To be clear, throughout we take the incentive schemes as given. The focus of this paper is the response of workers to a change in incentives. In the conclusion, we return to the issue of whether the observed incentive schemes are indeed optimally designed.

The paper is organized into 7 sections. Section 2 sets out stylized models of worker's effort choices under the two incentive schemes. Section 3 describes the data. Section 4 presents estimates of the causal effect of the change in incentives on productivity. Section 5 brings alternative models of workers' behavior to the data. Section 6 analyzes the effect of social networks on productivity under the two incentive schemes. Section 7 concludes. The appendix contains proofs and additional regression results.

[7] Prendergast (1999) reviews the incentives literature. Fehr *et al* (1999) and Fehr and Fischbacher (2002) review the literature on social preferences.

2 Theoretical Framework

To establish the null hypothesis of the effect of the change in incentives on worker productivity we present stylized models of workers' effort choices under relative incentives and piece rates.

Consider a group of N workers. Each worker i exerts $e_i \geq 0$ units of effort which determines his productivity. For simplicity we assume that effort is observable. Workers are heterogeneous and the disutility to worker i is $\frac{\theta_i e_i^2}{2}$, where θ_i is interpreted as the inverse of the workers innate ability. Assume workers can be ordered such that $\theta_1 < \theta_2 < ... < \theta_N$, where $\theta_i > 0$ for all i.

Under a relative incentive scheme, each worker's remuneration depends on how she performs relative to her peers. Workers' utility from the remuneration takes the form $\phi\left(\frac{e_i}{\overline{e}}\right)$ for all i, where $\overline{e} = \frac{1}{N}\sum_i e_i$ is the average effort of all N workers, and $\phi(.)$ is a differentiable concave function, with $\lim_{e\rightarrow 0} \phi'(e) = \infty$.[8]

Under piece rates, each worker's remuneration depends on her effort alone which is paid at rate β per unit. Under piece rates worker i's utility from pay is then $\phi(\beta e_i)$.

We analyze the Nash equilibrium when workers simultaneously choose their effort.[9]

Under relative incentives, the Nash equilibrium effort for worker i solves;

$$\max_{e_i} \phi\left(\frac{e_i}{\frac{1}{N}e_i + \frac{1}{N}\sum_{j\neq i} e_j}\right) - \frac{\theta_i e_i^2}{2} \tag{1}$$

The key characteristic of a relative incentive scheme is that as each worker i exerts effort, her benefits increase while those of co-workers decrease so that $\frac{\partial \phi\left(\frac{e_i}{\overline{e}}\right)}{\partial e_i} > 0$ and $\frac{\partial \phi\left(\frac{e_j}{\overline{e}}\right)}{\partial e_i} < 0$.

The logic behind this is straightforward. By exerting effort, each worker increases the average level of effort, thus reducing the relative performance of others. In short, by exerting effort under relative incentives, each worker imposes a *negative externality* on co-workers. The nature of effort choices among workers is therefore similar to that in a tragedy of the commons type of game.

Under piece rates, worker's benefits depends only on her *own* effort and the piece rate, β.

[8] This relative incentive scheme is *not* a rank order tournament. Worker benefits are based on their cardinal and not their ordinal ranking. It is however similar to a "linear relative performance evaluation" (LRPE) scheme as studied in Knoeber and Thurman (1994). Under a LRPE worker's compensation is;

$$\max_{e_i} \alpha + \mu(e_i - \overline{e}) - \frac{\theta_i e_i^2}{2}$$

where α and μ are taken as given by workers.

[9] By analyzing workers' choice in a static framework we implicitly rule out the analysis of dynamic incentives within each scheme. In particular, workers might want to underperform to make sure that the management does not lower the pay rate in future periods. We discuss some of the empirical implications of this *ratchet effect* in section four.

The equilibrium effort level under piece rates solves;

$$\max_{e_i} \phi(\beta e_i) - \frac{\theta_i e_i^2}{2} \tag{2}$$

To compare efforts under the two schemes, evaluate the first order conditions of problems (1) and (2) at $\beta = \frac{1}{\bar{e}}$ so that for a *given* average effort level, the marginal benefit of effort is the same under both incentive schemes.

Proposition 1: *In the Nash equilibrium each worker exerts less effort under relative incentives than under piece rates. The variance of effort is also lower under relative incentives.*

Under relative incentives, the first order condition for effort is;

$$\phi'\left(\frac{e_i}{\bar{e}}\right)\frac{1}{\left(\sum_i e_i\right)}\left(1-\frac{e_i}{\left(\sum_i e_i\right)}\right) = \frac{1}{N}\theta_i e_i \tag{3}$$

The first order condition for effort under piece rates is;

$$\phi'\left(\frac{e_i}{\bar{e}}\right)\frac{1}{\left(\sum_i e_i\right)} = \frac{1}{N}\theta_i e_i \tag{4}$$

The marginal benefit of effort is lower under relative incentives by a factor $\left(1-\frac{e_i}{\left(\sum_i e_i\right)}\right) \leq 1$. This is due to the fact that under relative incentives an increase in effort increases the average effort and hence decreases the remuneration of worker i. Stylized effort schedules under both incentive schemes are shown in figure A below;

Insert figure A about here

The difference in effort is greatest for the *most* able workers - namely those with the lowest θ. Workers that suffer a high disutility from effort exert more similar levels of effort under the two schemes.

A key point is that the difference in effort across the schemes depends on group size. As group size increases the marginal impact of effort on average effort is trivial so that $\left(1-\frac{e_i}{\left(\sum_i e_i\right)}\right)$ tends to 1 and the difference in effort between the two schemes tends to zero.[10]

[10] This is seen most clearly in the case of homogeneous workers. Then the Nash equilibrium effort level under relative incentives is $e_i^* = e^R = \sqrt{\left(1-\frac{1}{N}\right)\phi'(1)}$ and $e_i^* = e^P = \sqrt{\phi'(1)}$ under piece rates, as detailed in the appendix. The ratio of effort under the two systems is thus $\sqrt{\left(1-\frac{1}{N}\right)}$. If workers are heterogeneous the ratio depends on group size and worker's ability.

As discussed in more detail later, the group sizes observed in our data are large. Under the relative incentive scheme the average effort is calculated over about 40 co-workers. For conceivable distributions of underlying ability, we would not therefore expect large changes in Nash equilibrium efforts moving from relative incentives to piece rates, if this framework accurately captures the effort choice problem of workers under the two incentive schemes.

3 Context and Data Description

3.1 Context

We analyze data from a leading UK soft fruit farm for the 2002 season. We use personnel records in combination with information on workers' characteristics from questionnaires we administered to the workers directly. Workers in the sample are hired seasonally to pick fruit across a number of fields within the farm.

We observe workers being paid first according to a relative and then according to an absolute incentive scheme. In both cases workers face a compensation schedule of the form;

$$\text{compensation} = \beta K_i$$

where K_i is the total kilograms of fruit picked by worker i in the day.[11] Throughout we define individual productivity y_i as the number of kilograms of fruit K_i picked per hour.

Under the relative scheme, the picking rate β is *endogenously* determined by the average productivity of all workers in the field-day. In particular β is set equal to;

$$\beta = \frac{\overline{w} + c}{\overline{y}} \tag{5}$$

where $\overline{w}$ is the minimum wage, c is a constant set by the management at the beginning of the season, and $\overline{y}$ is the average hourly productivity of all workers on the field-day. As higher effort leads to higher productivity, an increase in worker i's effort imposes a negative externality on her co-workers by increasing the average productivity on the field-day thus reducing the picking rate β.

In line with the relative scheme analyzed in section 2, worker i 's compensation depends on her productivity relative to the average productivity of her co-workers. In particular, given that

[11] To comply with minimum wage laws, workers' compensation is supplemented whenever βK_i falls below the pro-rata minimum wage. In practice the farm management makes clear that any worker who needs to have their compensation increased to the minimum wage level repeatedly would be fired. Indeed, we observe less than 1% of all worker-field-day observations involving pay increases to meet the minimum wage requirements. Of these, 46% occurred under relative incentives, 54% occurred under piece rates.

$K_i = y_i * h$, where h is the number of hours worked in a day, worker i 's pay can be written as $\frac{y_i}{\overline{y}} h(\overline{w} + c)$.

At the start of each field-day, the field supervisor announces an *ex ante* picking rate based on her expectations of worker productivity. This picking rate can then be revised at the end of each field-day to ensure the average worker earns the pre-established hourly wage, $\overline{w} + c$.

Under piece rates, the picking rate is set *ex ante*, again based on the supervisor's expectation of productivity that field-day. This picking rate cannot be revised. The key difference between the two systems is that under the relative incentives, workers' effort affects the rate at which they are paid, whereas under piece rates it does not.[12]

We analyze productivity data on one type of fruit only and focus on the season's peak time - between mid May and the end of August. Data on workers' productivity is recorded electronically. Each worker is assigned a unique bar code, which is used to track the quantity of fruit they pick on each field and day in which they work. This ensures little or no measurement error in recorded productivity.

The sample is restricted to those workers who worked at least 10 field-days under each incentive scheme. Our working sample contains 10215 worker-field-day level observations, covering 142 workers, 22 fields and 108 days in total.

The incentive scheme changed midway through the season. Relative incentives were in place for the first 54 days, piece rates were in place for the remaining 54.[13] The change was announced on the same day it was first implemented and it was therefore unexpected by the workers. No other organizational change took place during the season, as reported by farm management and as documented in the next section.

From interviews with the management, we know that the relative incentive scheme was adopted for two reasons. First, the relative scheme allows to difference out common shocks, such as those deriving from weather and field conditions, that are a key determinant of productivity in this setting. Second, the relative scheme gives the management more control over the total wage bill. Eventually, the management decided to move to piece rates because they felt

[12] Workers face more uncertainty over the picking rate under relative incentives because although a rate is announced *ex ante*, this can be revised *ex post* to reflect the productivity of the average worker. Under piece rates, the *ex ante* picking rate cannot be revised. In this context, however, uncertainty is unlikely to have a large impact on effort choices. First, since the workers play the same game daily they have sufficient information to form expectations on the "typical" adjustments of the picking rate under the relative system. Second, the data under piece rates indicates that, other things equal, supervisors get the $ex - ante$ rate right. The announced rate under piece rates is generally identical to the rate that would obtain if the relative formula were used.

[13] No picking takes place on Sundays. The panel is unbalanced in that we do not observe each worker picking every day. This is of concern if there is endogenous attrition of either fields or workers over time. We ameliorate the latter of these concerns by restricting the sample to workers who worked at least 10 field-days under each scheme. To address the first concern, we later exploit only variation in productivity within the same field over time.

productivity could have been higher. Assessing whether the move to piece rates had the desired effect is the task of the next section.

Finally, workers in the sample are hired on a casual basis, namely work is offered daily with no guarantee of further employment. All workers are hired from Eastern and Central Europe and live on the farm for the duration of their stay.[14] Workers are issued with a farm-specific work permit for a maximum of six months, implying they cannot be legally employed elsewhere in the UK. Their outside option is therefore to return to their home countries. The vast majority of workers in the sample report their main reason to seek temporary employment in the UK is financial, which is hardly surprising in light of the fact that, even at the minimum wage, the value of their earnings is remarkably high in real terms.[15]

3.2 Descriptive Analysis

Worker Productivity

Table 1 gives unconditional worker productivity, by incentive scheme. Productivity rose significantly from an average of 5.01kg/hr in the first half of the picking season under relative incentives, to 7.98kg/hr in the second half of the season under piece rates. This corresponds to an unconditional increase in productivity of 59%.

To minimize spurious variation in productivity due to other factors changing between the two halves of the season, the remaining rows of table 1 report productivity data for different subsamples. We first restrict the sample to workers whose only task was picking on a given day. This eliminates variation in productivity arising from differences across time in non-picking tasks done by field-day. This would be of concern if, for instance, at the start of the season workers exert relatively more effort into non-picking tasks such as planting. On field-days in which workers are only picking, the rise in productivity is quantitatively similar to the sample as a whole.[16]

The third row restricts the sample to ten days either side of the change in incentive scheme. This minimizes the variation in productivity arising from varying field conditions, field composition, management practices, and workers endogenously leaving after the change in incentive scheme. For instance, suppose low yield fields were less likely to be picked over time. This attrition of fields would cause productivity to rise over the season. Over this shorter time frame,

[14] In order to qualify, individuals must be full-time students, studying in Eastern and Central Europe, and having at least one year before graduation. Workers must - (i) return to the same university in the autumn; (ii) be able to speak English; (iii) have not worked in the UK before; (iv) be aged between 19 and 25.

[15] Working eight hours at the minimum wage rate implies a daily income of 32 GBP, i.e. about 55 USD or 14300 USD per year (based on a five-day week)..PPP adjusted GDP per capita is 3816 USD in the poorest of the sample countries (Ukraine) and 11243 USD in the richest (Slovakia).

[16] The number of fields worked per day by each worker also remained constant over the season.

there remains a significant rise in productivity moving from one incentive scheme to the other.

The final row restricts the sample to workers picking on the two main fields that operated for the most amount of time under both incentive schemes. Since fields are contiguous and planted with the same variety of fruit, this eliminates the variation in productivity arising from differences across fields. Productivity rises significantly in these fields.

Productivity is computed as kilograms picked per hour. Further analysis reveals that the increase in productivity was entirely due to workers picking more fruit over the same time period, rather than working shorter hours. Workers picked on average 23.2 more kilograms per day under piece rates (significant at the 1% level) while hours worked did not significantly change across incentive schemes, remaining constant at just over 8 hours per day.

Figures 1 and 2 show disaggregated productivity data across time and across workers under the two schemes. Figure 1 shows the mean of worker productivity over time in the two fields that were operated for the most days under each incentive scheme. Together these fields contribute one third of the total worker-field-day observations. Under relative incentives, there is no discernible trend in productivity. With the introduction of piece rates, productivity rose and remained at this higher level until the end of the season.

Figure 2 shows kernel density estimates of productivity by each incentive scheme. The productivity of each of the 142 workers in the sample is averaged within each incentive scheme in this figure. In line with table 1, the mean and variance of productivity both rise moving from relative incentives to piece rates.

Aggregate Farm Level Data

Figure 3 shows the cumulative distributions of arrivals and departures of workers over the season. The change in incentive scheme did not coincide with a wave of new arrivals, nor did it hasten the departure of workers. Indeed, very few workers left before or just after the change in incentive schemes.

Figures 4a to 4c show total kilograms picked, total man-hours worked, and the total number of pickers over the season at the level of the farm. Each series is measured as a percentage deviation from its mean.

Kilograms picked per day shows no discernible trend under either incentive scheme.[17] Total man-hours spent picking are higher under relative incentives and figure 4c shows this is due entirely to more workers picking rather than each worker picking for longer hours. Under piece rates, the total kilograms picked in aggregate remains at the same level as under relative incentives. The total man-hours spent picking however falls as fewer workers are required to pick each

[17] Given the farm faces a relatively constant product demand and labor supply through the season, there is a deliberate timing of planting of fields to ensure that not all fruit ripens simultaneously. This helps smooth out variations in productivity over time.

day.

Figures 4a to 4c together indicate that while total kilograms picked and the time spent picking per field-day remained constant throughout the season, the total number of workers that were required to pick fell after the introduction of the piece rate. Some workers were therefore reallocated to alternative tasks, and this is one source of gains that accrued to management arising from the change in incentive scheme.

Group size, namely the number of workers working on the same field at the same time, remained constant throughout the season. Average group size was 41.1 under relative incentives and 38.1 under piece rates, the difference being not statistically different from zero. Since on average there are over 40 workers picking together under the relative incentive scheme, the difference in productivity across schemes should be orders of magnitude smaller than those reported in table 1 if - (i) workers chose their effort according to the Nash equilibrium set out in section 2; (ii) there is no natural increase in productivity over the season.

Picking Rate and Daily Pay

Figure 5a shows the picking rate paid per kilogram over time, as a percentage deviation from its mean. Under relative incentives the picking rate rises gradually as productivity declines. This is as expected given the picking rate is set according to (5) under the relative incentive scheme.

With the introduction of piece rates there is a one-off fall in the picking rate. The difference in average picking rates between the two halves of the season is .105, significant at the 1% level. We can therefore rule out that the observed rise in productivity is a consequence of higher returns to the marginal unit of effort under piece rates. To the contrary, the marginal return to effort is lower under piece rates, indicating that our estimates provide a lower bound of the effect of the change in incentives in productivity.[18]

Figure 5b then shows the daily pay from picking over the season, as a percentage deviation from its mean. Given that productivity and picking rates are inversely related to each other, it is no surprise that workers' pay remained relatively constant over time. The difference in average daily pay between relative incentives and piece rate is indeed not significantly different from zero. Average daily pay fell for the least productive workers and rose for the most productive. Overall, the average worker became worse off under piece rates - their productivity rose, while total compensation remained the same.

Given that these gains in productivity accrued largely to the farm management and not to pickers, suggests picking rates were set optimally from the management's point of view. In other

[18] We maintain the standard assumption in the incentive literature that the utility maximizing level of effort is increasing in the piece rate. Two reasons make strong income effects very unlikely in this context. First, workers had no choice over the number of hours worked, implying they could not revise their labor supply choice on the extensive margin. Second, workers on the farm had the opportunity to earn very high wages (in real terms) for a limited amount of time.

words, there is little evidence of learning over the season by management on how much workers would be able to pick each field-day.

4 Evidence on Workers' Productivity

4.1 Empirical Method

We assume the underlying production technology is Cobb Douglas, and estimate the productivity of worker i on field f on day t, y_{ift}, using the following panel data regression, where all continuous variables are in logarithms;

$$y_{ift} = \alpha_i + \beta_f + \gamma P_t + \delta X_{ift} + \eta Z_{ft} + u_{ift} \tag{6}$$

Worker fixed effects, α_i, capture time invariant worker level determinants of productivity such as workers innate ability and intrinsic motivation. Field fixed effects, β_f, capture time invariant field level determinants of productivity such as soil quality and fruit variety.

P_t is a dummy equal to one after the piece rate is introduced, and zero otherwise. As the piece rate is introduced simultaneously across all fields it is not possible to control for day fixed effects. Instead we control for time varying factors at both the individual and field level, in X_{ift} and Z_{ft} respectively.

The disturbance term, u_{ift}, captures unobservable determinants of productivity at the worker-field-day level. Worker observations within the same field-day are unlikely to be independent since workers face similar field conditions. We account for this by clustering standard errors at the field-day level in all productivity regressions.

The parameter of interest throughout is γ. In the next section after presenting the baseline estimates of (6), we address a number of concerns that may lead to γ being inconsistently estimated. These arise from - (i) omitted time varying factors at the worker, field, or farm level, that cause productivity to rise over the picking season, biasing $\widehat{\gamma}$ upwards; (ii) the endogenous attrition of low yield fields over time. This type of survivor bias also biases $\widehat{\gamma}$ upwards; (iii) potentially endogenous responses of workers before or after the change in incentive scheme; (iv) a potential endogenous timing of the change in incentives as management respond to lower than anticipated productivity in the first half of the season, biasing $\widehat{\gamma}$ upwards.

4.2 Results

Table 2 presents the baseline estimates of the causal effect of the change in incentive scheme on worker productivity. Column 1 regresses worker productivity on a dummy for the introduction of the piece rate, clustering standard errors by field-day. Productivity significantly rises by 53% when moving from relative incentives to piece rates.[19]

Column 2 controls for worker fixed effects, so that only variation within a worker over time is exploited, while column 3 also adds field fixed effects, so only variation within a worker picking on the same field over time is exploited. The coefficient of interest remains significant and of similar magnitude.

The last column controls for other time varying determinants of productivity at the level of the farm, field, and individual.

First, we include a linear time trend to capture farm level changes over time. For example, if management become better informed about the quality of fields and workers, the allocation of resources over time improves and this leads to productivity gains.

Second, the yield within each field may vary over the season. To capture such field level changes over time, we include a measure of each field's life cycle - the number of days that the field has been operated on at any moment in time, divided by the total number of days that the field is operated over the season.

Finally, workers may be more productive in the second half of the season when they have acquired more picking experience. We therefore control for each worker's picking experience - the number of field-days the worker has been picking.[20]

Column 4 controls for these time varying factors at the level of the farm, field, and worker. There is no trend in productivity over time at the level of the farm, all else equal. Within each field, productivity declines as the field is picked later in its cycle. There are positive returns to picking experience as expected.[21] A one standard deviation increase in the field life cycle reduces productivity by 20%, while a one standard deviation increase in picking experience increases productivity by 7%. In contrast, the introduction of piece rates causes productivity to significantly increase by 58%.

Omitted Factors

Table 3 controls for other time varying factors. First, any improvement in meteorological conditions in the second of the season would cause productivity to rise even in the absence of

[19] We experimented with a number of alternative specifications for calculating standard errors. First we allowed observations to be clustered at the worker level to account for idiosyncratic worker characteristics that lead to worker productivity over different days being correlated. Doing so caused standard errors to fall relative to those in column 1. Second, we also ignored time variation altogether and collapsed the data into a single observation for each worker under each incentive scheme. Doing so, we continued to find that productivity increases significantly, at the 1% level after the change in incentive scheme. This and other results not reported for reasons of space are available upon request.

[20] Management informed us that it takes a worker between 6 and 10 days before they are able to pick at their optimal speed. For the first 3 or 4 days of picking, workers are paid an hourly wage. This initial period of learning is not in our sample.

[21] Defining work experience as the cumulative hours spent picking also led to similar results as those reported.

piece rates. Column 1 controls for daily meteorological conditions - the maximum and minimum temperatures, and hours of sunshine. Doing so, the effect of piece rates on productivity remains largely as before.[22]

The actual farm management remained the same over the picking season. However there remains a concern that management practices may have changed with the change in incentive scheme. The earlier descriptive analysis showed that some practices, such as the length of the working day or number of workers in each field, did not change over the season. Another relevant practice is the allocation of supervisors to fields. If the allocation of supervisor talent altered with the incentive scheme, part of the observed rise in productivity may be due to this.

The personnel data allows us to identify the supervisor(s) present on each field-day. Column 2 controls for supervisor fixed effects so that the effect of the change in incentives is identified from variation in productivity of the same worker, on the same field, working under the same supervisor, over the two incentive schemes. We continue to find the introduction of piece rates led to a significant increase in productivity, controlling for the allocation of supervisor talent.

Finally, the ratio of supervisors to workers may have risen over the season. If so, workers would be more able to shirk when the relative incentive scheme was in place, again biasing $\widehat{\gamma}$ upwards. Column 3 shows the earlier results to be robust to controlling for the ratio of supervisors to workers.

Alternative Comparison Groups

As the change in incentive scheme occurs at the same time in all fields, identification of the effect of incentives on productivity arises from a comparison over time of the same worker under the two schemes. Table 4 considers the effect of incentives on productivity for subsamples in which the variation in productivity is less likely to be due to other time varying factors. These subsamples correspond to those for which the unconditional differences in productivity were reported in table 1.

We first restrict the sample to workers that have *only* been picking each day. This reduces the variation in productivity arising from differences in non-picking tasks done in the first and second half of the season. On field-days in which workers are only picking, we find productivity significantly rises after the introduction of piece rates.

In column 2, we restrict the sample to ten days either side of the change in incentive scheme. Over this shorter time frame, productivity still rises by 39%. As before, the coefficient is significant at the 1% level.

Column 3 restricts the sample to workers picking on the two main fields that operated for the most amount of time under both incentive schemes. This reduces the variation in productivity

[22] Controlling for lagged weather conditions and/or rainfall led to similar results.

arising from differences across fields. Again, productivity significantly rises in these two fields.

Robustness Checks

The final set of robustness checks are in table 5. In the first two columns we simulate the introduction of piece rates in fields and for workers that did not actually experience the change in incentive schemes. We proceed as follows.

First note that in the two main fields operated for the most days under both incentive schemes, the change in incentive scheme occurred 25% of the way through each field's life cycle. If productivity jumps naturally 25% of the way through a field's life cycle, the effect of piece rates would be overestimated. To check for this we construct a fake piece rate for each field, that is set equal to one after a field has passed 25% of its life cycle and zero otherwise. We then take the sample of fields that have only operated under *either* relative incentives or piece rates and see if productivity jumps at this stage of the field life cycle. The result in column 1 shows no evidence of a natural jump in productivity on fields after they have passed 25% of their life cycle.

Column 2 exploits the same idea but at the worker level. In the baseline sample, worker's had been picking for an average of 19 days before the incentive scheme changed. If workers typically exhibit a change in productivity after this time, we would incorrectly attribute this to the introduction of piece rates. To check for this, we exploit information on workers who arrived *after* the introduction of piece rates. We create a fake piece rate for each such worker set equal to one after that worker has been picking for 19 days. The result in column 2 shows no evidence of a natural jump in worker productivity after this time.

The second set of robustness checks relate to potentially endogenous behavioral responses by workers and management to the change in incentives.

An identifying assumption underlying (6) is that workers do not anticipate the change in incentive scheme. To check this, column 3 introduces a dummy equal to one in the week prior to the change in incentives. This dummy is not significant, while the coefficient on the piece rate remains significant and of similar magnitude to the baseline specification in column 4 of table 2.

Another concern is that the exact date at which the incentive scheme was changed may have been an endogenous response by management to lower than expected productivity in the first half of the season. To assess the quantitative importance of this, we drop the last 10 days of picking under relative incentives from the sample. The result in column 4 shows that the estimated rise in productivity is greater than in the baseline specification. This is not consistent with management changing the incentive scheme when productivity was at its lowest point. Indeed the previous result in column 3 showed productivity was not falling in the week prior to the move to piece rates.

The descriptive analysis in section 3 highlighted that workers become worse off under piece rates - they pick more kilograms per hour than under the relative incentive scheme, and on average receive the same total daily compensation. It is thus plausible that after the introduction of piece rates, workers had incentives to under perform. By doing so they may have hoped to convince the management that the relative incentive scheme was not responsible for lower productivity in the first half of the season.

To check for this, we drop the first ten days of picking under piece rates from the sample. The result in column 5 shows that the productivity increase is indeed higher if this initial period is omitted. This is consistent both with workers deliberately under performing in the hope of re-installing relative incentives, or with workers responding with a lag because of learning.

A related issue is that workers may under perform also under piece rates if they believe that working hard will result in lower piece rates in the future. One testable implication is that this type of ratchet effect should be weaker the shorter the time horizon of the worker. Column 6 checks for this by controlling for a dummy whether the worker is in her last week of work - the time at which this ratchet effect is of least concern to the worker. We find no differential effect on productivity at this time.[23]

Finally, column 7 analyses how the behavioral response of workers to the introduction of piece rates changes with time. We use the number of days piece rates have been in place as a measure of tenure under piece rates, and introduce an interaction between this and the piece rate dummy.[24] The result shows the interaction between tenure and piece rates to be significant and positive. However, the magnitude of this effect is equal and opposite to the coefficient on the time trend in this specification.[25] Hence productivity was actually declining under the relative incentives, all else equal, and there is no significant trend in productivity under piece rates.[26]

Section 8.3 in the appendix reports further results on the effect of the change in incentives over time.

One final concern is that the increase in productivity came at the expense of the *quality* of fruit picked. Pickers are expected to classify fruit as either class one - suitable as supermarket produce, or class two - suitable as market produce. Theories of multi–tasking suggest that if

[23] This type of concern of employees was documented in Roy's (1952) study of industrial workers. He provides evidence that workers set informal quotas in response to ratchet concerns.

[24] There is no variation across workers in tenure so defined. We also experimented with an alternative definition of tenure based on the number of days *each* worker had been picking under piece rates. The results proved to be very similar with both measures.

[25] In this specification, the coefficient on the time trend is -.024 with standard error of .005.

[26] This is in contrast to the results in Paarsch and Shearer (1996). They find that for tree planters in British Columbia, although individual productivity significantly increases moving from fixed wages to piece rates, it subsequently declines over time. They attribute this to planters becoming tired. The downward trend in productivity under relative incentives is however consistent with recent experimental evidence in public goods games in which contributions are found to increase if players are able to communicate and sanction one another. See Masclet *et al* (2003) for a recent contribution.

workers are given incentives for only one task - picking, they devote less effort to the unrewarding task - the correct classification of fruit *quality* (Holmstrom and Milgrom (1991), Baker (1992)). This is especially pertinent in this context because misclassifications of fruit *cannot* be traced back to individuals workers. To check for this we analyze whether the misclassification of fruit worsened after the introduction of piece rates. Results, reported in section 8.4 of the appendix, show this was not the case.

Summary

Taken together, the results show that moving from a relative incentive scheme to piece rates significantly increased worker productivity by at least 50%. The quantitative and qualitative significance of the result is robust to alternative specifications that reduce other potential sources of variation in productivity over time. These include those arising at the level of the farm, across fields, and within workers over time.[27]

Furthermore, as workers' pay remained constant under both incentive schemes, while productivity increased, this estimated increase in productivity is a lower bound on the pure effect of the change in incentives, holding worker utility constant. In what follows we analyze whether workers' behavior is consistent with individual utility maximization under the two schemes.

5 Workers' Behavior: Individualistic or Cooperative?

If workers are of heterogeneous ability and each chooses effort to maximize their own net benefit, standard theory predicts that the mean and variance of effort across workers rise moving from relative incentives to piece rates, as summarized in proposition 1. In this section we analyze whether workers choose their equilibrium effort levels in accordance with this framework or whether, in contrast, they internalize the externality their effort imposes on other workers under the relative scheme.

To this purpose we derive the first order conditions of the workers' utility maximization problem under these alternative behavioral assumptions and then check whether these can be reconciled with the observed change in productivity. To do so, we use the first order conditions of their maximization problem to compute an estimate of the cost parameter, θ_i, under each incentive scheme and each behavioral assumption. Since the workers' cost (ability) parameters

[27] We also examined which individual characteristics explain the difference in productivity between the incentive schemes. We found no affect of self-reported mathematical ability on productivity, suggesting that confusion over how the relative incentive scheme operated is unlikely to explain the rise in productivity. Workers that came to work specifically as part of their university course, had significantly higher productivity under relative incentives. This may reflect that these workers had relatively more to lose from being caught shirking. Finally, workers that reported themselves to being "popular", had larger increases in productivity moving to piece rates. This hints at the possibility that relationships among workers may play a role in workplace behavior - the subject of the remainder of the paper. These results are available upon request.

are innate, we ought to find the *same* implied distributions of costs across workers under both incentive schemes if the underlying behavioral assumption is correct.

To proceed, in section 5.1 we first recover an estimate of workers' effort from the productivity data, namely we separate out all other factors that affect productivity in any field-day. Section 5.2 shows that, not surprisingly, the observed change in productivity is too large to be consistent with workers maximizing their individual rewards net of disutility costs. Section 5.3 shows that workers do not cooperate fully either - in other words they do not behave as if maximizing the sum of individual utilities. In section 5.4 we posit that workers have social preferences and recover the weight workers place on the net benefits of all others which is consistent with the observed change in productivity.

5.1 Workers' Effort

We assume that workers' effort e translates into productivity y through a Cobb Douglas production function. This specification ensures that the same effort can lead to two different levels of productivity depending on other inputs into production, such as field conditions. To estimate worker effort, we first run the productivity regression (6) by *each* incentive scheme, controlling for the same determinants of productivity as in the baseline specification of column 4 in table 2. An estimate of worker i's effort in field f on day t under scheme s is each worker's estimated fixed effect added to the residual from this regression;

$$\widehat{e}^s_{ift} = \widehat{\alpha}^s_i + \widehat{u}^s_{ift} \tag{7}$$

The first term captures the workers average effort over time under incentive scheme s. The second term captures how much of the worker's productivity cannot be explained by observables - field fixed effects, a time trend, field life cycle, and the worker's picking experience. This residual is interpreted as the workers deviation from her average effort level under each incentive scheme. This method thus provides an estimate of each workers effort on *every* field-day on which they pick.

Figure 6a shows the kernel density estimate of the distribution of worker's effort across field-days. Consistent with the actual distribution of productivity by incentive scheme in figure 3, the mean and variance of effort both rise significantly moving from relative incentives to piece rates.

Figure 6b plots each workers mean effort under piece rates against that under relative incentives. Few workers lie below the 45^0 line - nearly all put in more effort under piece rates than under relative incentives. The correlation between estimated efforts across incentive schemes is .4648. Hence there is little evidence of churning of workers - those who put in the most effort under relative incentives continue to exert the most effort under piece rates and *vice versa.*[28]

Figures 7a and 7b split the estimated effort (7) into each of its components - the residual, $\widehat{u}_{ift}^{s}$, and the worker fixed effect, $\widehat{\alpha}_{i}^{s}$. Figure 7a shows the exponent of the residuals. Under the two schemes these are centred around zero. Workers do not systematically exert more or less effort than would be predicted by the baseline regression specification.

Figure 7b shows the distribution of worker fixed effects - a measure of the average effort the worker puts in under each incentive scheme. It is clear that these fixed effects, and not the residuals, drive the difference in the distributions of effort in figure 6a.

5.2 Individualistic Behavior

Suppose workers choose effort to maximize their own net benefit, ignoring the negative externality their effort imposes on co-workers. Using the framework developed in section 2, noting that productivity is observable, and that effort and productivity are related through a Cobb Douglas production function, the first order conditions for effort under relative incentives and piece rates are as follows;

$$\phi'\left(\frac{y_i}{\overline{y}}\right)\frac{\partial y_i}{\partial e_i}\left(\frac{\sum_{j\neq i} y_j}{\left(\sum_i y_i\right)^2}\right)=\frac{1}{N}\theta_i e_i \tag{3'}$$

$$\phi'\left(\beta y_i\right)\beta\frac{\partial y_i}{\partial e_i}=\theta_i e_i \tag{4'}$$

For a given benefit function, $\phi(.)$, estimated effort, e_i, and picking rate, β, each of these can be solved for each worker's θ_i. If workers choose their effort levels to maximize their own net benefits under each incentive scheme, the implied distribution of the cost parameter should be the *same across incentive schemes.*

We assume the benefit function is of the following CRRA type;

$$\phi(y)=\rho y^{\frac{1}{\rho}} \text{ for } \rho\geq 1 \tag{8}$$

The effort levels estimated above are substituted into the first order conditions (3′) and (4′), which are then solved for the workers cost parameter. The data identifies the group of workers for each field-day. This allows us to construct a measure of the average effort level in the field-day, which enters the first order condition under relative incentives. To estimate the first order condition under piece rates (4′), we exploit information on the field-day specific picking rate, β.[29]

[28] An alternative way to state this is that each workers relative ranking of effort remains unchanged moving from one incentive scheme to the other.

[29] These data are recorded using the same technology that records worker productivity each field-day. Hence we are able to match each worker-field-day observation with a corresponding picking rate under piece rates.

Having obtained an estimate of θ_i on each field-day the worker picks, we take the median of each worker's estimated θ_i as a unique estimate of θ_i, under each incentive scheme. Intuitively, if workers choose their effort levels according to ($3'$) and ($4'$), the implied distribution of costs across workers should then be the *same* under both incentive schemes.

Figure 8a shows the kernel density estimate of the distribution of workers' cost of effort under each incentive scheme. The distribution of cost parameters under relative incentives lies almost entirely to the *right* of the distribution under piece rates. It is clear that the same distribution of costs cannot be fitted to both incentive schemes.[30]

An interpretation of this is that given the observed change in productivity over time, the distribution of cost parameters under the two incentives schemes would have to be as shown in figure 8a. In other words, to generate the significant increase in productivity after piece rates are introduced, workers must face significantly *higher* costs of exerting effort under relative incentives than piece rates, if indeed workers' effort choices are determined by the first order conditions ($3'$) and ($4'$).

Since worker cost is an innate parameter, the implied distributions of costs ought to have been the same under both incentive schemes if workers effort choices were actually determined by these first order conditions. As this hypothesis is resoundingly rejected by the data, we explore alternative hypotheses of how workers may be choosing their effort levels.[31]

5.3 Cooperative Behavior

Suppose workers choose their effort levels cooperatively, namely to maximize the utility of the entire group. This behavioral assumption might be appropriate if the conditions of the folk theorem apply. If the gain from choosing efforts cooperatively is large enough and workers play trigger strategies, no worker has an incentive to deviate and induce punishment. Punishment may be relatively easy in this setting both because deviations can be easily observed given workers work side-by-side, and because workers interact along a number of social dimensions, giving them

[30] Similar results obtain if the mean of each worker's estimated cost parameter is used instead. The advantage of this method is that we impose no distributional assumptions on θ. Alternatively, ($3'$) and ($4'$) can be estimated using maximum likelihood for a given distribution of θ.

[31] Suppose workers' strategies have two components - how much effort to exert and the variability of effort. For example, if workers experiment with different picking techniques they will have a higher variance of productivity over time. Under relative incentives, there may be an incentive for low ability workers to experiment more. This is because with a minimum wage guarantee always in place, a high variance strategy has little cost if the outcome is bad, and will increase pay when the outcome moves the worker closer to, or above, the average. High ability workers have no such incentives to choose high variance strategies. To check for this, we calculated the correlation between worker's variance of productivity and their estimated cost parameter under piece rates for $\rho = 2$. This correlation was .0837. Hence low ability workers have slightly more variable productivity under relative incentives, but this correlation is not significantly different from zero.

access to a number of punishment mechanisms.[32]

If workers choose effort levels cooperatively, the first order condition for worker i under the relative scheme is;[33]

$$\frac{\partial y_i}{\partial e_i}\frac{1}{\left(\sum_i y_i\right)^2}\left[\phi'\left(\frac{y_i}{\overline{y}}\right)\sum_{j\neq i} y_j - \sum_{j\neq i}\phi'\left(\frac{y_j}{\overline{y}}\right)y_j\right] = \frac{1}{N}\theta_i e_i \tag{9}$$

Under piece rates, the effort level chosen by worker i does not affect the utility of other workers in the group. Hence the first order condition is the same as in the individualistic case, (4′).

Following the same methodology as above, we derive the implied distribution of the cost parameter under each incentive scheme, now assuming that effort levels are chosen according to (9) and (4′).

Figure 8b shows the implied distributions of the cost parameter θ_i, by incentive scheme. The distribution of θ_i under piece rates is, by definition, unchanged to that derived in the previous section. However, the distribution of costs under relative incentives now lies almost entirely to the *left* of the distribution under piece rates.

If workers chose their effort levels cooperatively, then the disutility of effort under relative incentives would have to be significantly *lower* under relative incentives to fit the observed productivity data. This is because productivity is actually too high under relative incentives if workers are choosing their effort levels cooperatively. Indeed, figure 8b shows that a significant fraction of workers have to have a near zero cost of effort for the observed data under relative incentives to be consistent with workers choosing the cooperative effort levels.

Figures 8a and 8b together reveal an interesting pattern. The assumption of individualistic behavior can only be reconciled with the observed change in productivity if workers have *higher* costs of effort under relative incentives vis-à-vis piece rates. The assumption of cooperative behavior can only be reconciled with observed productivity if workers have *lower* costs under relative incentives vis-à-vis piece rates. This suggests workers internalize the negative externality to some extent. The next subsection explores this idea in more detail.

5.4 Social Preferences

The salient distinction between the two incentive schemes is the presence of a negative externality under relative incentives. The negative externality arises because as a given worker increases her

[32] Workers live together on the farm for the picking season. Many workers also study with their co-workers in their home country, or are already friends before arriving at the farm.

[33] Note that if workers were of homogeneous ability the Pareto optimum would require all to extert the minimum feasible level of effort.

effort, she worsens the relative performance, and hence the benefits, accruing to co-workers. The fact that neither the individualistic nor the fully cooperative model fit the data suggests workers may internalize this negative externality to some extent.

To explore this further we follow the recent experimental economics literature and posit each worker to have *social preferences*. For worker i these are;

$$u_i(e_1, .., e_N) = \phi\left(\frac{y_i}{\overline{y}}\right) + \pi_i \sum_{j \neq i} \phi(\frac{y_j}{\overline{y}}) - \frac{\theta_i e_i^2}{2} \tag{10}$$

Workers are thus heterogeneous in two dimensions - their disutility of effort (θ_i), and the "social weight" they attach to the benefits of all others (π_i).

These social preferences can be thought of as a reduced form representation of behavior consistent with reciprocity or altruism (Fehr and Schmidt (1999)), or the evolutionary equilibrium of a repeated Prisoner's Dilemma game in which workers learn which strategies to play (Levine and Pesendorfer (2002), Sethi and Somanathan (1999)).

With social preferences, the first order condition for worker i's effort choice under relative incentives is;

$$\frac{\partial y_i}{\partial e_i} \frac{1}{\left(\sum_i y_i\right)^2} \left[\phi'\left(\frac{y_i}{\overline{y}}\right) \sum_{j \neq i} y_j - \pi_i \sum_{j \neq i} \phi'\left(\frac{y_j}{\overline{y}}\right) y_j\right] = \frac{1}{N} \theta_i e_i \tag{11}$$

There is a wedge between the first order conditions ($3'$) and (11). This wedge is the extent to which the negative externality imposed on others is taken account of by worker i.

Under piece rates, in contrast, the first order condition for effort is the same as when workers are assumed to be individualistically motivated. The reasoning is straightforward - under piece rates no externalities arise from each workers effort and so even if individuals place positive weight on the benefits of others, this does not affect their own optimal choice of effort.

Defining social preferences this way allows us to capture two special cases. If $\pi_i = 0$ for all workers, the first order conditions coincide with those under individualistic behavior ($3'$). If $\pi_i = 1$ for all workers, the first order conditions coincide with those under cooperative behavior (9).

In order to derive the distribution of social weights that fit the productivity data, we assume the true cost of effort of each worker is that derived under piece rates.[34] Given $\widehat{\theta}_i$, we solve (11) for the implied social weight of each worker under the relative incentive scheme. To be clear, this is the implied distribution of social weights that is consistent with the change in productivity across the two incentive schemes, assuming the true cost parameter of each worker is that derived

[34] Under this assumption we can test whether groups became more or less heterogeneous with the move to piece rate. We find that groups were equally heterogeneous, in terms of ability, before and after the change in incentives.

under piece rates.

The resulting distribution of social weights is shown in figure 9. The implied distribution of social weights is robust to this choice of the parameter ρ in the benefit function (8).

For $\rho = 2$, the average worker places a social weight of .65 on the benefits of all others in the same field-day. Less than 3% of workers have an implied social weight greater than one, and less than 2% of workers have an implied social weight of less than zero.[35]

In summary, under relative incentives workers behave as if they internalize the externality they impose on others to some extent. The average worker places just under twice the weight on their own private benefits, as on the benefits accruing to all others. As the estimated social weight each worker places on others varies by field-day, the next section explores how observable factors on the field-day explain the workers' behavior under relative incentives over time.

6 Incentives, Social Networks and Workers' Productivity

A natural candidate to explain the extent to which workers internalize the negative externality their effort imposes on others is the *relationship* among workers in any given field-day. To this purpose we use information on the number of self-reported friends that each worker works alongside with on a given field-day.[36] Each worker was asked to name up to five people they were friends with on the farm. We would expect workers to internalize the externality *more* and hence to be *less* productive when the externality hurts their friends rather than other workers.

To investigate this issue, Table 6 presents estimates of the productivity regression (6) under relative incentives, where we now additionally control for group composition at the field-day level, as well as the baseline determinants of worker productivity as in column 4 of table 2. Note that we identify the effect of group composition on productivity by comparing the productivity of the *same worker* working within different groups on different days when relative incentives are in place.

Column 1a controls for the share of co-workers in the same field that are friends of worker i. Having more friends present significantly reduces productivity under relative incentives. The estimated coefficient implies that if worker i moved from a group with no friends to a group where 10% of co-workers were her friends, her productivity would fall by 17%.

[35] A negative social weight can be interpreted as the worker being "spiteful" towards others (Levine and Pesendorfer (2002)).

[36] Levine and Pesendorfer (2002) show that in an evolutionary equilibrium of a repeated Prisoner's Dilemma game in which workers learn which strategies to play, players behave as if they have social preferences. Moreover, the weight each player places on the benefits of another player depends on the relation between players. They argue that, "individuals will behave more altruistically when they can identify with the beneficiary of their altruism".

Column 1b controls for the share of workers in the same field that are friends of worker i, as well as for the total number of workers in the field-day, and an interaction between this and the share of workers that are friends of i. We see that - (i) having more friends present significantly reduces productivity under relative incentives; (ii) this effect is smaller the greater the number of workers in the same field. The latter is consistent with the fact that the externality imposed by i on her friends is smaller when the overall group size is larger.[37]

The results in columns 1a and 1b have some obvious alternative interpretations - when workers work alongside their friends, they exert less effort and become less productive because they talk and socialize with their friends. Or, alternatively, they may choose to work with their friends when they feel less prone to work hard.

To shed light on these hypotheses we use the following intuition. Any relationship between the composition of co-workers and productivity that is *unrelated* to the incentive scheme in place, such as socializing with friends, will be present when *either* relative incentives or piece rates are in place. If however the relationship between the composition of co-workers and productivity is related to the incentive scheme in place, this relation should only arise under relative incentives.

Columns 2a and 2b then report the same productivity regressions as 1a and 1b when piece rates are in place. In both cases the share of co-workers that are friends of i has *no* affect on productivity under piece rates.

In summary, the data does not allow us to tell whether workers internalize the externality because they are altruistic towards their friends, or because of the threat of punishment and retaliation by their friends. However, since workers' productivity is not affected by the presence of friends under piece rates, we can rule out other potential explanations. The evidence does support the hypotheses that productivity is lower when friends are present because workers socialize with their friends, because of a norm of not working hard in the presence of friends, or because workers self select to work alongside their friends when they do not intend to work hard.

Robustness Checks

The finding that the share of friends is a significant negative determinant of productivity under relative incentives only, may still be spurious for the following reason. If workers are more likely to chat with friends, and not work, when they first arrive, the effect of friends on

[37]The share of friends on the field can also be used to explain the worker's derived daily social weight, π_{ift}. In line with the productivity results, we find that workers place a greater weight on the benefits of co-workers when a greater share of co-workers are their friends. The magnitude of the coefficient implies that if worker i went from having *no* friends working alongside her, to having *only* her friends working alongside her, her social weight would rise by .454. We also find evidence that this effect is larger in smaller groups.and that workers' social weights significantly increase as the relative incentive scheme has been in place longer, controlling for their own work experience. A possible explanation is that later arrivals learn from workers with more experience about the negative externality under the relative incentive scheme. The data do not allow us to explore this possibility further.

productivity will only be picked up under the relative incentives scheme, as that was in place for the first half of the season. Indeed, any factor unrelated to incentives but that causes individuals to treat friends differently over the season will be spuriously attributed to the change in incentive scheme.

In order to check this, in column 1 of table 7 we examine if under piece rates, the effect of having more friends on the field is different for those that arrived later and so *only* worked under piece rates, compared to those who were also present under the relative incentive scheme. We see that for both types of worker, there is no effect of the composition of workers in field-day on productivity under piece rates.

In column 2 we allow the effect of group composition to vary by the number of co-workers in the field. There is still no affect of group composition under piece rates, for both types of worker.

Taken together, the results suggest that individuals take account of the externality their effort imposes on their friends when they work under relative incentives. This result is not driven by the nature of interaction between workers and their friends changing over time. The results in tables 6 and 7 also hold for other definitions of friends - such as those individuals the worker lives with. These results are available from the authors on request.[38]

7 Conclusions

Using personnel data, we present evidence on workers' productivity under two incentive schemes - relative incentives and piece rates. We find the introduction of piece rates led to a significant and permanent rise in productivity of at least 50%.

We show the rise in productivity is too large to be consistent with a model where workers choose effort to maximize their individual net benefits and too small to be consistent with a model were workers choose effort levels cooperatively to maximize the group's rewards.The evidence suggests that instead workers behave as if they internalize the externality they impose on fellow workers under relative incentives to some extent. In addition, workers appear to internalize the externality more when a greater share of their co-workers are their close friends.

The contributions of the paper are twofold - first, we present evidence on the role of incentives on worker productivity across two common types of incentive scheme. Second, we shed light on why productivity differs over the two schemes. In doing so, we integrate recent insights from the

[38]If workers can devote effort to helping others, they have less incentives to do so under more high powered incentive schemes (Lazear (1989)). This idea has found empirical support in Drago and Garvey (1998). To check whether this explains why friends do not determine productivity under piece rates, we asked workers from whom they mainly learned to pick (we did not try to illicit workers own evaluations of how much help they offered to others). For workers in our baseline sample that worked at least 10 field-days under both incentive schemes, 47% said they learned from practice, 26% from workers around them, 19% from supervisors, and 8% from their friends. The corresponding figures for those who only worked under piece rates were 43%, 22%, 24% and 4%.

literature on social preferences - that has largely been motivated by experimental evidence - with the literature on the provision of incentives. To our knowledge, we provide the first real world evidence on the interplay between social preferences and behavioral responses to incentives.[39]

Throughout we have taken the incentive schemes as given. Our focus has been the response of workers - agents - to a change in incentives. A separate issue is whether the observed incentive schemes are indeed optimally designed by the principal. The natural question is if the relative incentive scheme was detrimental to productivity, why was it ever adopted?

Incentive theory emphasizes that a principal may prefer relative to absolute performance evaluation when agents face common shocks. Such common shocks are important in the workplace environment analyzed here.[40]

The superiority of relative incentives however relies on the assumption that workers play Nash and maximize their individual rewards - namely they choose effort to maximize their payoff taking as given the effort chosen by others and ignoring the externality their effort imposes on others. Under these conditions the marginal benefit of effort under relative and absolute incentives are approximately equal for large group sizes.

This assumption on worker behavior is not supported in our data. Relative incentives led to lower productivity because, perhaps surprisingly, workers internalized the negative externality to some extent. In general, our analysis illustrates that understanding worker preferences is key for the optimal choice between alternative incentive schemes.[41]

Finally, the fact that workers' behavior depends on the *identity* of their co-workers suggests two questions for future research.

First is the identification of the causal effect of worker i's effort on worker j's effort. The identification of such social effects has been confounded by the "reflection problem" in much of the existing literature. In this work environment, the composition of co-workers changes on a daily basis. There are potentially exogenous sources of variation in group composition that would aid identification of social effects across workers. Such spillovers may also differ across social networks and incentive schemes.

Second is the analysis of how group composition determines the extent to which workers internalize the externality under relative incentives. The literature on common resource management

[39] Hart (2001) reviews some of the recent theoretical literature incorporating the role of norms into the theory of the firm. Rotemberg (1994) provides an analysis of the provision of incentives within firms when workers endogenously choose their level of altruism towards co-workers.

[40] See Lazear and Rosen (1981), Nalebuff and Stiglitz (1983) and Green and Stokey (1983). Relative performance evaluation may also be preferred to piece rates as it lows informational rents to high types (Bhaskar (2002)), and reduces incentives of workers to exert effort in influence activity (Milgrom(1988)).

[41] The relative incentive scheme can be thought of as a group incentive scheme where worker's pay increases in their own effort and decreases in the average effort of all workers. An implication of the results is that there ought to be further large productivity gains over piece rates if workers were rewarded positively for their own *and* the group's effort.

and group participation suggests that heterogeneity should play a major role. Our data allows us to explore the extent to which the distribution of ability or other individual traits such as nationality, within a group help or hinder cooperation under relative incentives. Such an analysis would yield insights both for the optimal choice of group composition, and on the determinants of cooperation in a real world situation where individual and social optima do not coincide.[42]

Such research would complement the findings in this paper. Together, they shed new light on and old idea - the interplay between social effects and the provision of incentives within firms.[43]

8 Appendix

8.1 Proof of Proposition 1

Denote by e_i^R and e_i^P the equilibrium level of efforts chosen by worker i under relative incentives and piece rates, respectively.

Under relative incentives, the first order condition for worker i's effort choice is;

$$\phi'\left(\frac{e_i^R}{\bar{e}^R}\right)\left(\frac{\sum_{j\neq i} e_j^R}{\left(\sum_i e_i^R\right)^2}\right) = \frac{1}{N}\theta_i e_i^R$$

This first order condition is violated if the worker exerted zero effort as $\phi'(0) > 0$. Hence $e_i > 0$ for all i. Consider any pair of workers (j,k) such that $\theta_j < \theta_k$. Dividing j's first order condition by k's;

$$\frac{\phi'\left(\frac{e_j^R}{\bar{e}^R}\right)}{\phi'\left(\frac{e_k^R}{\bar{e}^R}\right)}\frac{\sum_{i\neq j} e_i^R}{\sum_{i\neq k} e_i^R} = \frac{\theta_j e_j^R}{\theta_k e_k^R} \tag{A1}$$

Assume $e_j^R \leq e_k^R$. Then $\frac{\phi'\left(\frac{e_j^R}{\bar{e}^R}\right)}{\phi'\left(\frac{e_k^R}{\bar{e}^R}\right)} \geq 1$ and $\frac{\sum_{i\neq j} e_i^R}{\sum_{i\neq k} e_i^R} \geq 1$ so the left hand side in (A1) is greater than or equal to one. However $\frac{\theta_j e_j^R}{\theta_k e_k^R} < 1$ so the right hand side is less than one - a contradiction. Hence for any two pair of workers (j,k) such that $\theta_j < \theta_k$, $e_j^R > e_k^R$. This establishes that workers with a lower disutility of effort parameter exert more effort. Consider the highest cost worker, $i = N$.

[42] In recent work on incentives within teams, Hamilton *et al* (2002) find - (i) teams with a greater spread in ability, holding average ability constant, are more productive; (ii) high ability workers have a stronger impact on team productivity than low ability workers. These results are both consistent with high ability workers being able to impose a higher team norm level of output, because they have higher outside options to within team bargaining, or with high ability workers being able to teach low ability workers how to execute tasks better and more quickly.

[43] The idea that human relations affect workplace performance goes back to Mayo (1933), and Roethlisberger and Dickson (1939).

Under piece rates the first order condition for worker j when $\beta = \frac{1}{\bar{e}}$ is;

$$\phi'\left(\frac{e_j^P}{\bar{e}}\right)\frac{1}{\left(\sum_i e_i^P\right)} = \frac{1}{N}\theta_j e_j^P$$

If this worker exerts zero effort this first order condition is violated as $\phi'(0) > 0$. Hence $e_i > 0$ for all i. Consider any two pairs of workers (j,k) such that $\theta_j < \theta_k$. Dividing j's first order condition by k's;

$$\frac{\phi'\left(\frac{e_j^P}{\bar{e}}\right)}{\phi'\left(\frac{e_k^P}{\bar{e}}\right)} = \frac{\theta_j e_j^P}{\theta_k e_k^P} \tag{A2}$$

Assume $e_j^P \leq e_k^P$. Then $\frac{\phi'\left(\frac{e_j^P}{\bar{e}^P}\right)}{\phi'\left(\frac{e_k^P}{\bar{e}^P}\right)} \geq 1$ so that the left hand side in (A2) is greater than or equal to one. However $\frac{\theta_j e_j^P}{\theta_k e_k^P} < 1$ which is a contradiction. Hence for any two pair of workers (j,k) such that $\theta_j < \theta_k$, $e_j^P > e_k^P$. This establishes that lower cost workers put in more effort.

Note that the first order conditions for (j,k) under the two schemes, (A1) and (A2), differ by a term $\frac{\sum_{i\neq j} e^R}{\sum_{i\neq k} e^R} < 1$. Hence the ratio of efforts for any two types is greater under piece rates than relative incentives;

$$\frac{e_j^P}{e_k^P} > \frac{e_j^R}{e_k^R} \text{ for all pairs } (j,k) \text{ such that } \theta_j < \theta_k.$$

Setting $j = 1$, $k = N$, implies the range of efforts is higher under piece rates than relative incentives.

Given that;

$$\begin{aligned}
\bar{e}^P &= \frac{1}{N}\left(e_1^P + ... + e_N^P\right) \\
\frac{\bar{e}^P}{e_N^P} &= \frac{1}{N}\left(\frac{e_1^P}{e_N^P} + .. + \frac{e_{N-1}^P}{e_i^P} + 1\right) \\
&> \frac{1}{N}\left(\frac{e_1^R}{e_N^R} + .. + \frac{e_{N-1}^R}{e_N^R} + 1\right)
\end{aligned}$$

Which after multiplying through by e_N^R and rearranging implies;

$$\frac{\bar{e}^P}{\bar{e}^R} > \frac{e_N^P}{e_N^R} > 1$$

where the second inequality follows from the fact that at the same average level of effort, the marginal benefit to effort under relative incentives is smaller than that under piece rates by a factor of $\frac{\sum_{i \neq j} e^R}{\sum_{i \neq k} e^R} < 1$. Hence $e_i^P > e_i^R$ for all i so that average effort is higher under piece rates than relative incentives.

Given that the ratio of effort of any two consecutive types is greater under piece rates, it follows that the variance of effort is higher under piece rates than relative incentives.

Finally, note that because $\lim_{N \to \infty} \frac{\sum_{i \neq j} e^R}{\sum_{i \neq k} e^R} = 1$, effort under the two incentive schemes is the same when the group size becomes large.[44]■

8.2 Piece Rates and Productivity Over Time

Table A1 presents results related to the effect of incentives on productivity over time.

First, workers that have been picking for longer under relative incentives may be more entrenched into a particular set of work habits. If so we would expect a differential response across workers to the introduction of piece rates, depending on their work experience under relative incentives. In column 1 of table A1, we allow both the effects of piece rates and tenure to depend on how long each worker has been working under the relative incentive scheme. To this purpose we interact the piece rate and the tenure variables with the individual worker's experience under relative incentives in deviation from the mean.

The result shows that workers more used to picking under relative incentives have a significantly *larger* increase in their productivity once piece rates are introduced. The marginal effect of the piece rate varies from .55 for the workers with the least experience at the time of introduction to .72 for the workers with the most experience. At the average experience level under relative incentives, the marginal effect is .63. The trend in productivity under piece rates does not however differ depending on workers' total experience under relative incentives.

[44] With homogeneous workers the first order condition for worker i's effort choice is;

$$\phi' \left(\frac{e_i}{\frac{1}{N} e_i + \frac{N-1}{N} e^R} \right) \left(\frac{\frac{1}{N} e_i + \frac{N-1}{N} e^R - \frac{1}{N} e_i}{\left(\frac{1}{N} e_i + \frac{N-1}{N} e^R \right)^2} \right) - e_i = 0$$

For e^R to be a Nash equilibrium this must hold for all $e_i = e^R$;

$$\phi' \left(\frac{e^R}{e^R} \right) \left(\frac{\frac{N-1}{N} e^R}{\left(e^R\right)^2} \right) = e^R$$

so that $e^R = \sqrt{\left(1 - \frac{1}{N}\right) \phi'(1)}$.

Under piece rates the first order condition for worker i is;

$$\beta \phi' (\beta e_i) - e_i = 0$$

Evaluating the first order conditions of problems (1) and (2) at $\beta = \frac{1}{e}$ so that the marginal benefit of effort is the same under both incentive schemes then gives $e^P = \sqrt{\phi'(1)}$.■

The final two columns compare the workers in our sample - who worked at least 10 field-days under each incentive scheme, to other workers who did not. These other workers either only picked under relative incentives or piece rates, or arrived just prior to, or just after, the introduction of piece rates. We restrict the sample to the first four weeks any worker picks to compare these groups of workers at similar levels of work experience.

Column 2 identifies whether productivity under piece rates is different for workers who have experienced both incentive schemes for at least 10 field-days, compared to other workers. Reassuringly, the result suggests that this is not the case. Moreover using this larger sample of workers, the pattern of coefficients on the other controls remains similar to that in the baseline specification. In short, there is no evidence to suggest that workers observed at least 10 field-days under both schemes respond differently to incentives to workers that arrive at a different part of the season.

In column 3 we interact workers experience with whether the worker has experienced both incentive schemes for at least 10 field-days. It is again reassuring to see that the returns to experience do not differ between the two groups of workers. This supports the hypothesis that the speed of learning to pick does not vary over the season.

These results support the hypothesis that the sample of workers used for the main analysis do not differ from those who arrived earlier or later in the season.

8.3 Quality and Quantity

The evidence presented earlier suggested that the operation of the farm did not change along a number of important margins over the season - the stock of workers available, the length of the working day, and the allocation of supervisors. However one margin that may have been unintentionally affected by the change in incentives is the *quality* of picking.

Pickers are expected to classify fruit as either class one - suitable as supermarket produce, or class two - suitable as market produce. This classification takes place within the field by each worker as they pick. Each class of fruit is then placed into a separate punnet. After fruit has been picked it is transported to a cooled warehouse for packing. In the packhouse each punnet passes through a quality check. Whenever a class two fruit is detected in a class one punnet, it is removed - downgraded - and transferred to a class two punnet. By the time the fruit picked from a given field-day arrives in the farm packhouse for inspection, misclassifications of fruit *cannot* be traced back to individual workers.

The electronic system used to record individual productivity data is not the same as that which records misclassifications of fruit at the field-day level in the packhouse. It is thus not possible to match every field-day from the productivity and packhouse databases. However we are able to do this for a subsample of 67 field-days. In this sample, 30 field-days were operated under relative incentives, 37 were operated under piece rates.[45]

In table A2 we assess whether the trade-off between the quality and quantity of picking changed significantly with the change in incentive scheme. The measure of the quality of picking is the log of the ratio of the total fruit of class two that is misclassified as class one, to the total fruit picked classified as class two. On average under relative incentives, 15% of fruit is misclassified as class one. Under piece rates this falls to 12%, although this difference is not significant.

In column 1 we regress this measure of the quality of picking on a dummy for the introduction of the piece rate and field fixed effects. The incentive scheme in place has no affect on the quality of picking. Column 2 shows this to be the case when the tons of class two fruit picked is controlled for. In column 3 we additionally control for a time trend, its square. We find that the level of misclassification of fruit picked increases over time, but at a decreasing rate.

Finally, column 4 additionally controls for the field life cycle, and meteorological factors. Again the quality of picking does not respond to the change in incentives.

The productivity gains achieved under piece rates were not at the expense of a lower quality of picking. Combined with the fact that worker pay remained constant over the season, the change in incentives unambiguously led farm management to become better off.

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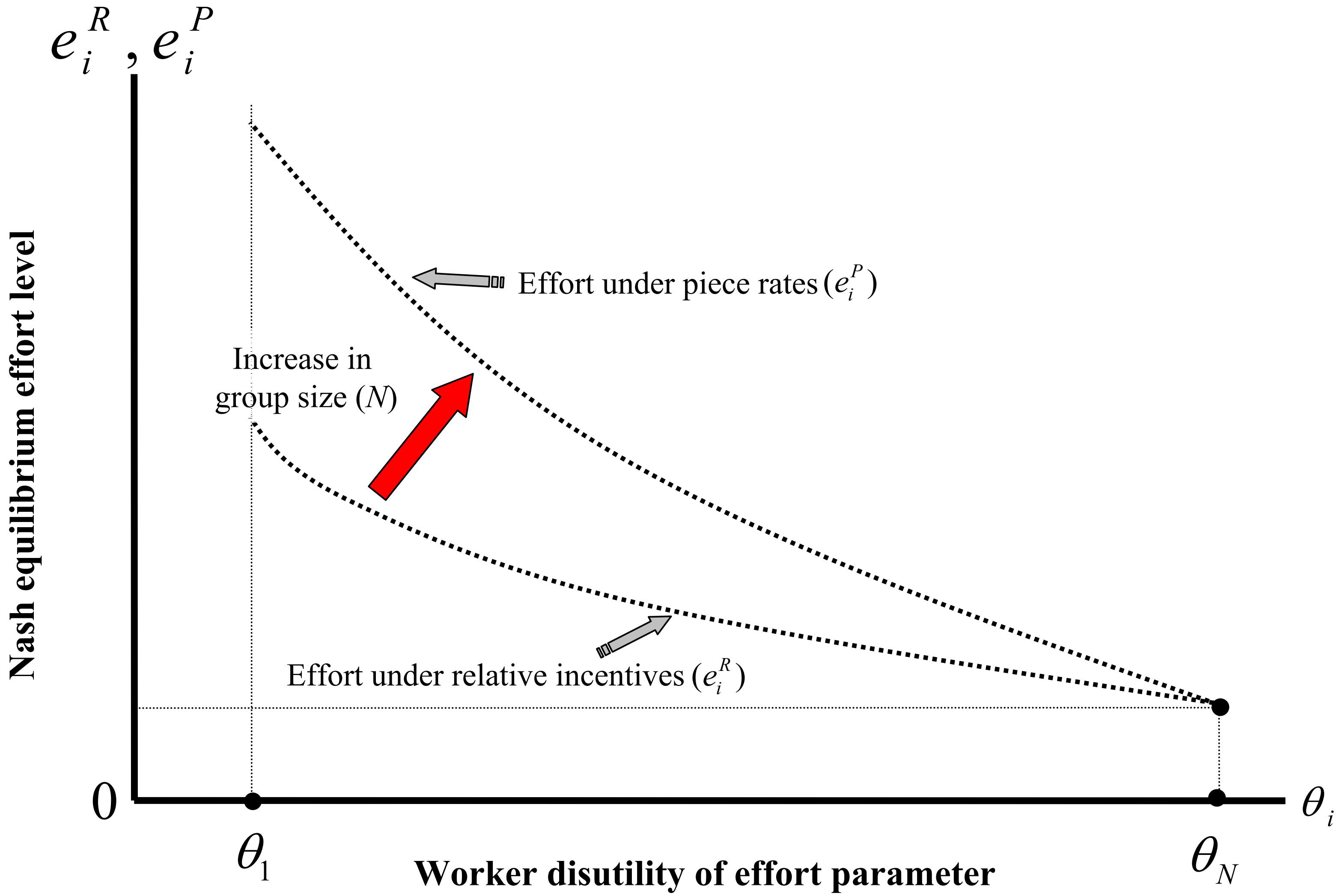


Figure A
The equilibrium effort schedules by incentive scheme

Figure 1: Productivity (kilogram/hour) Over the Season

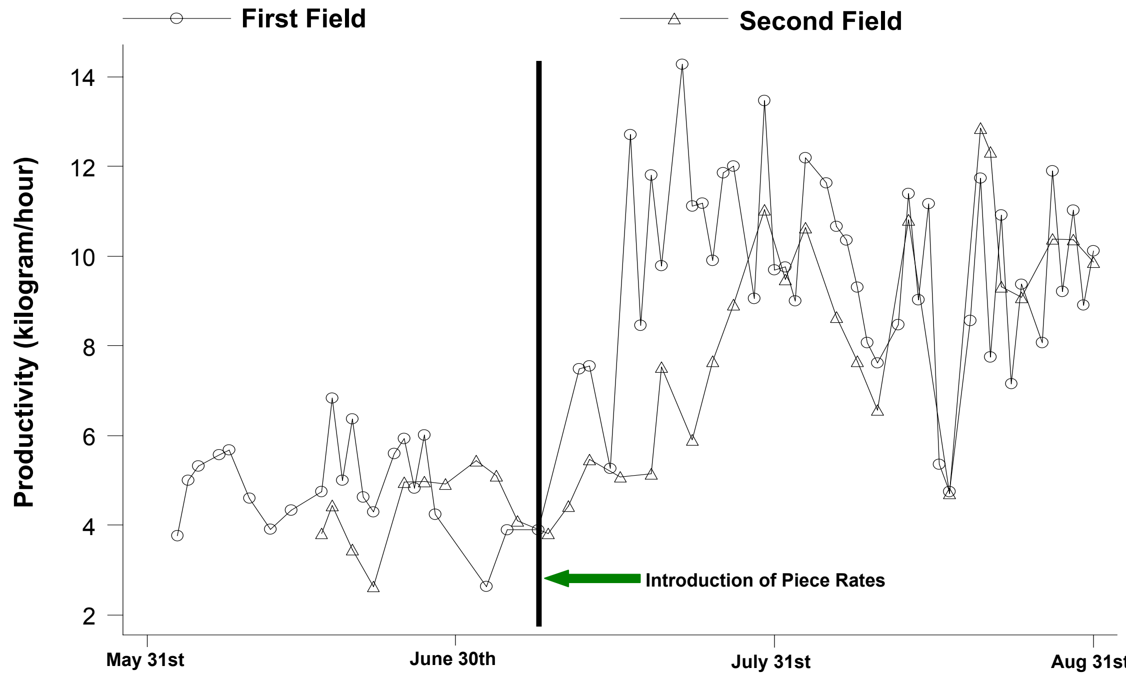
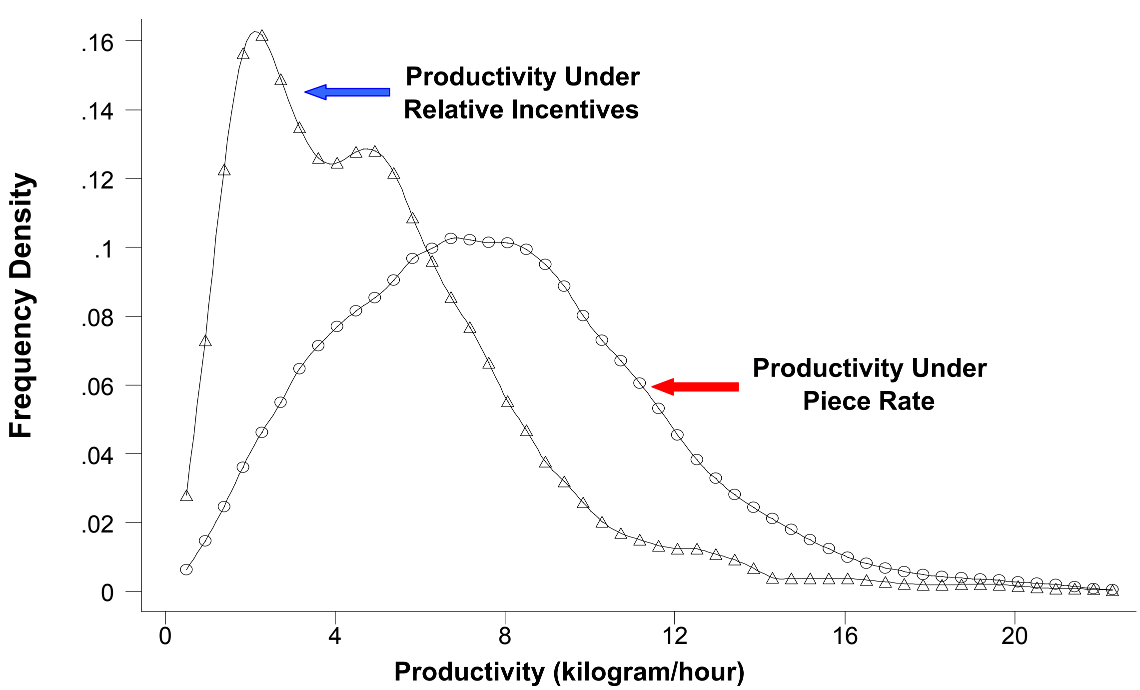
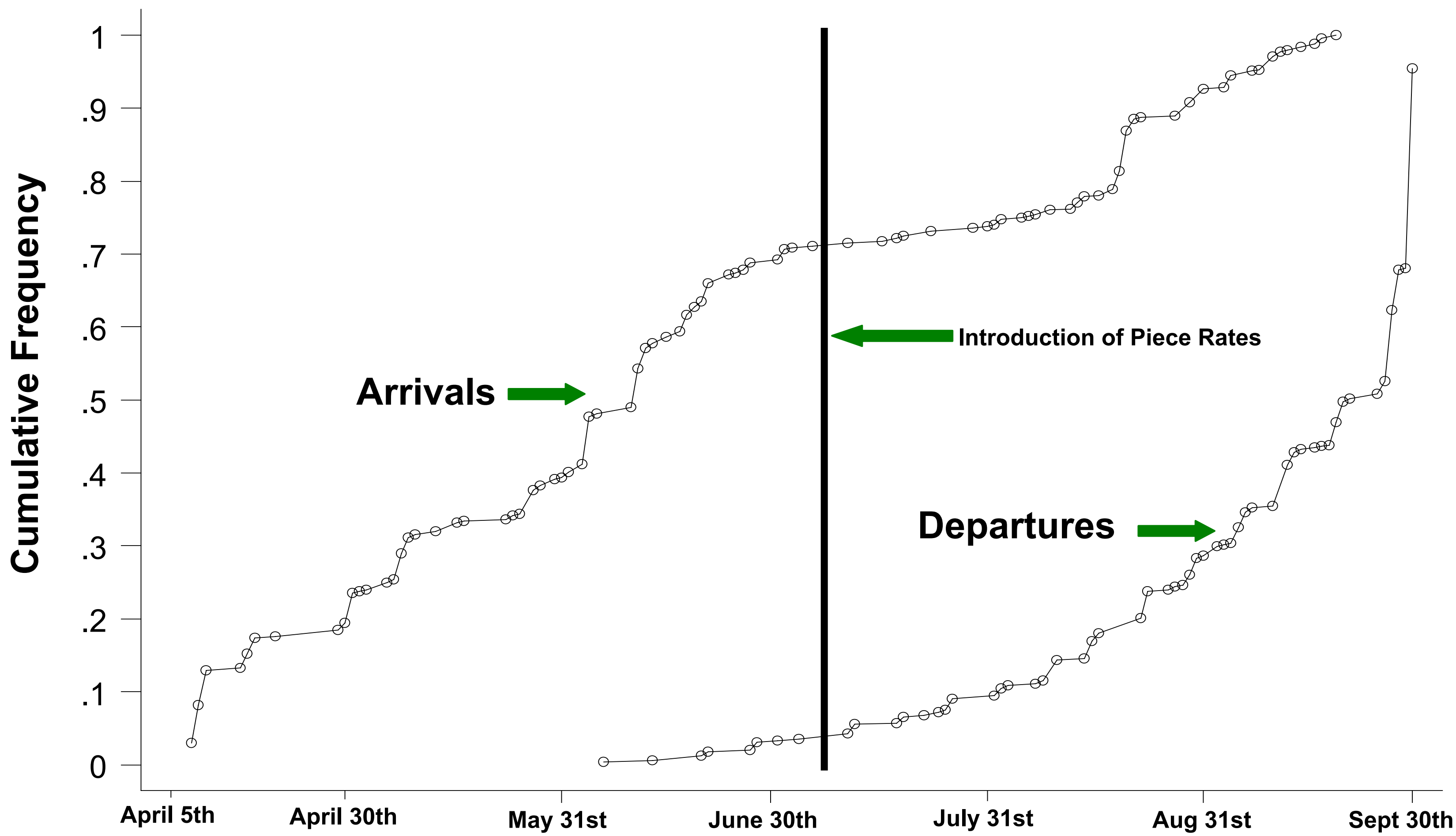


Figure 2: Distribution of Productivity (kg/hr) by Incentive Scheme



Notes: In figure 2, average productivity on the two main fields is shown for those workers that work at least 10 field-days under each incentive scheme. These fields are operated for the greatest number of days under each incentive scheme. Together they contribute one third of the total worker-field-day observations. The kernel density estimates in figure 3 are calculated using an Epanechnikov kernel.

Figure 3: Cumulative Distribution of Arrival and Departure of Workers



Notes: The sample for this figure includes all workers on the farm that are available for picking.

Figure 4a: Aggregate Kilos Picked Per Day Over the Season

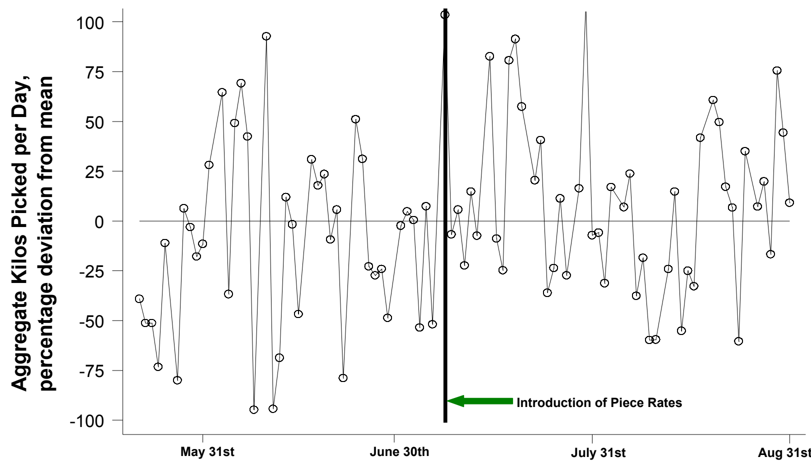


Figure 4b: Aggregate Hours Worked Per Day Over the Season

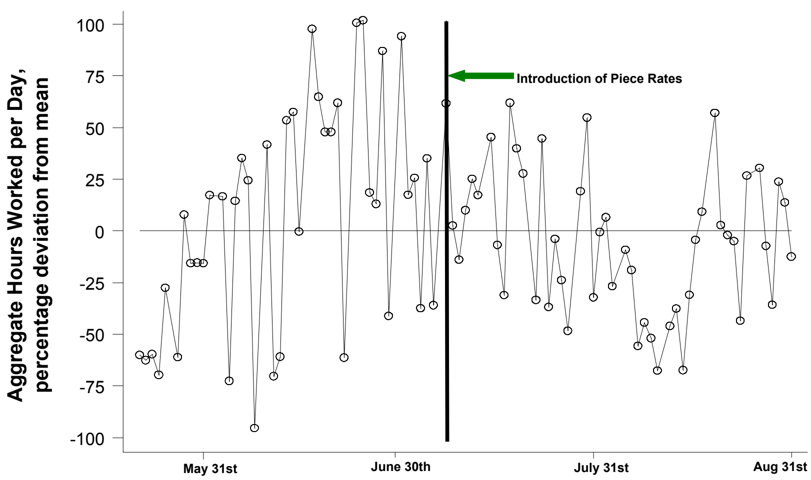
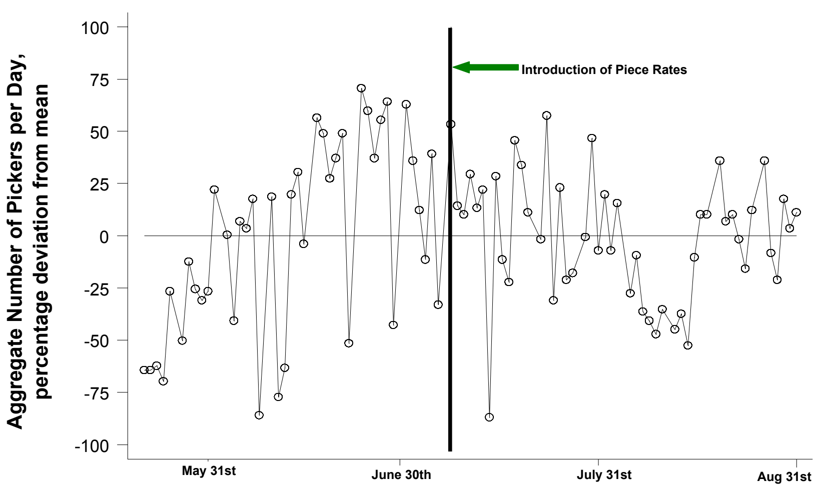


Figure 4c: Total Number of Pickers Over the Season



Notes: The sample in each series is based on all workers that are present on the farm at any given moment in time.

Figure 5a: Picking Rates Over the Season

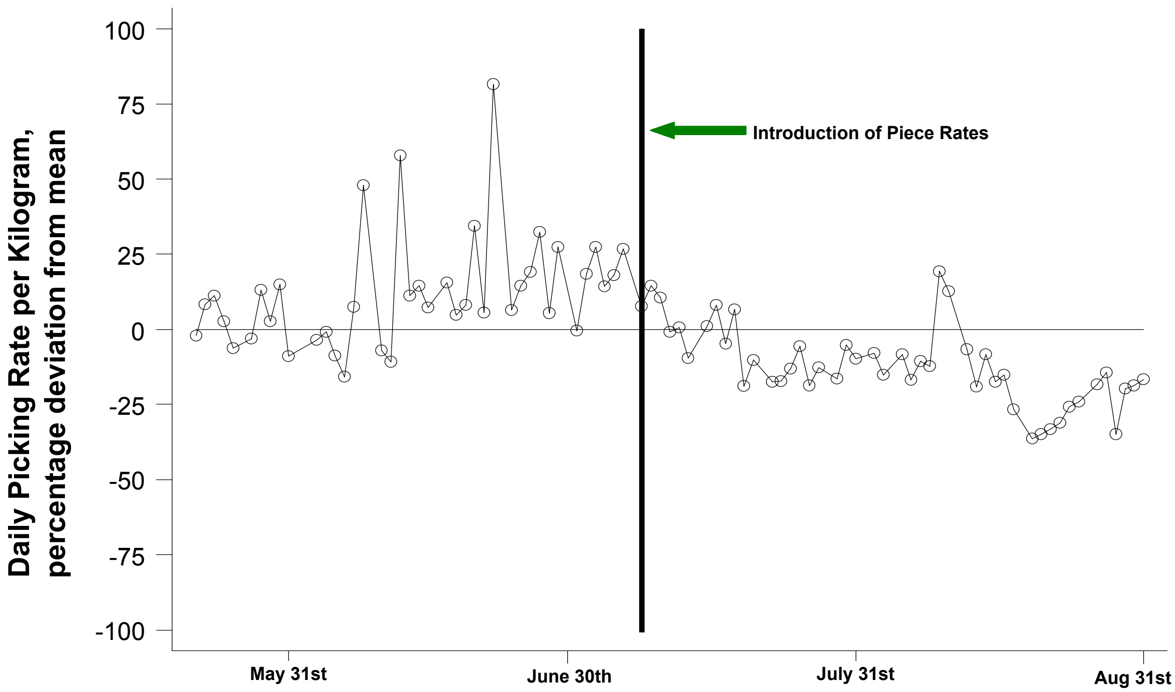
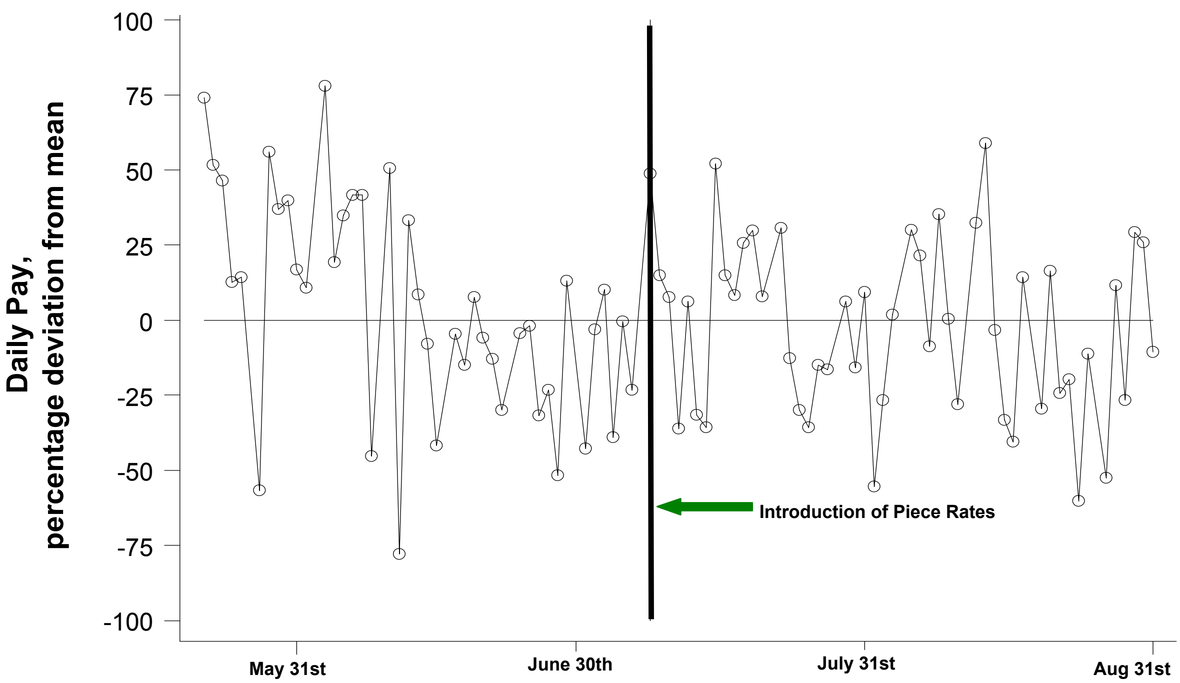


Figure 5b: Daily Pay Over the Season



Notes: Sample sizes are the same as those used for the productivity regressions. The series for the daily rate is an average over all fields operated on each day. This average is weighted by the number of man-hours on each field-day. The series for daily pay is averaged over all workers each day. This average is weighted by the hours worked per worker on each day.

Figure 6a: Kernel Density Estimates of Effort by Incentive Scheme

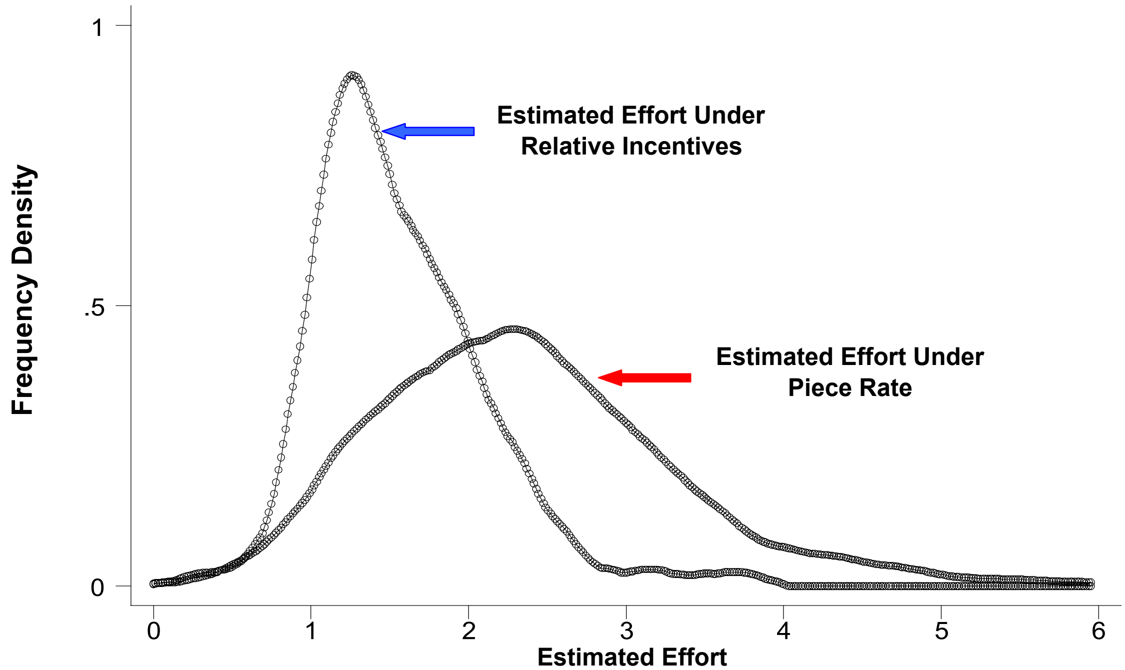
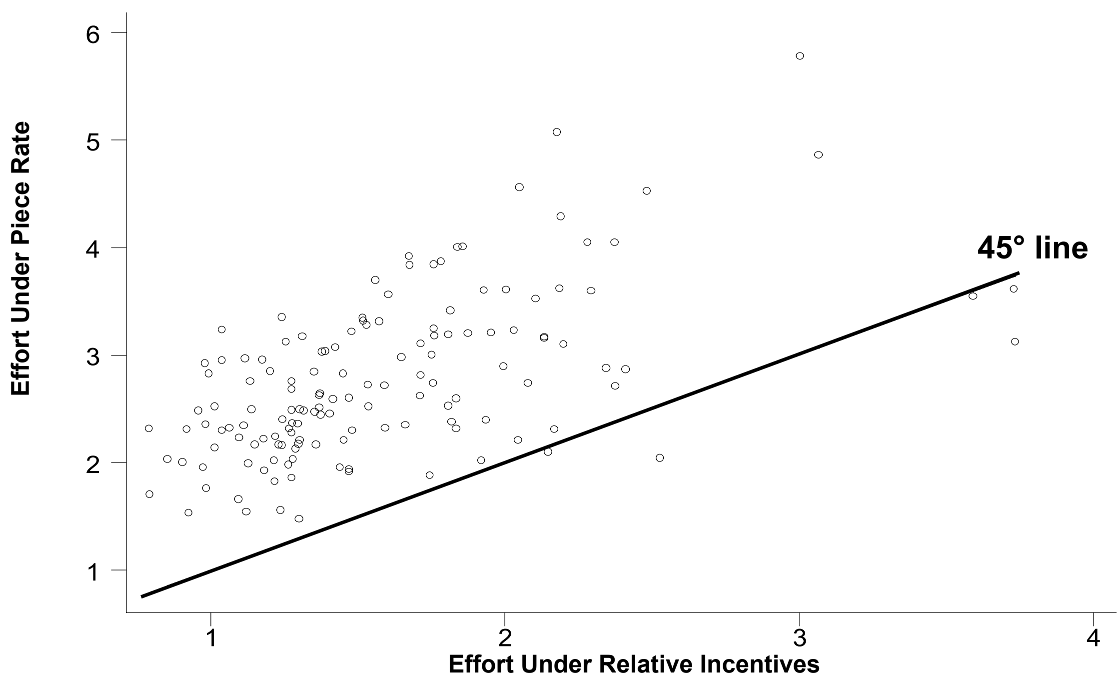


Figure 6b: Scatter Plot of Efforts in the Two Incentive Schemes



Notes: Kernel density estimates are calculated using an Epanechnikov kernel. The underlying benefit function used to estimate worker effort is assumed to be;

$$\varphi(y) = 2y^{\frac{1}{2}}$$

The total cost of effort is assumed to be quadratic in effort.

Figure 7a: Residuals by Incentive Scheme

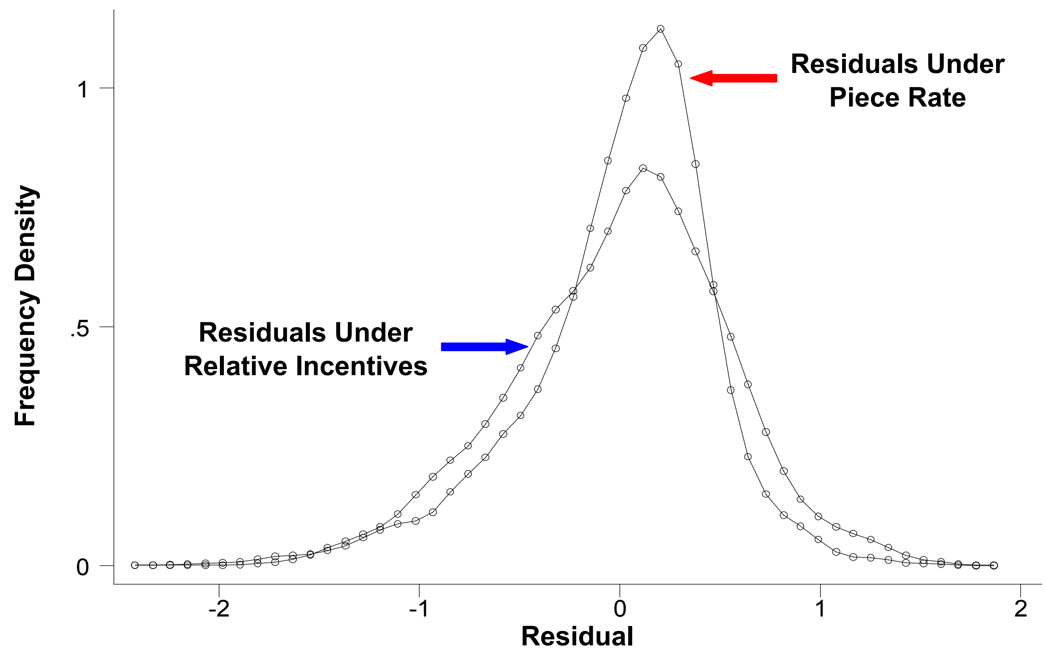
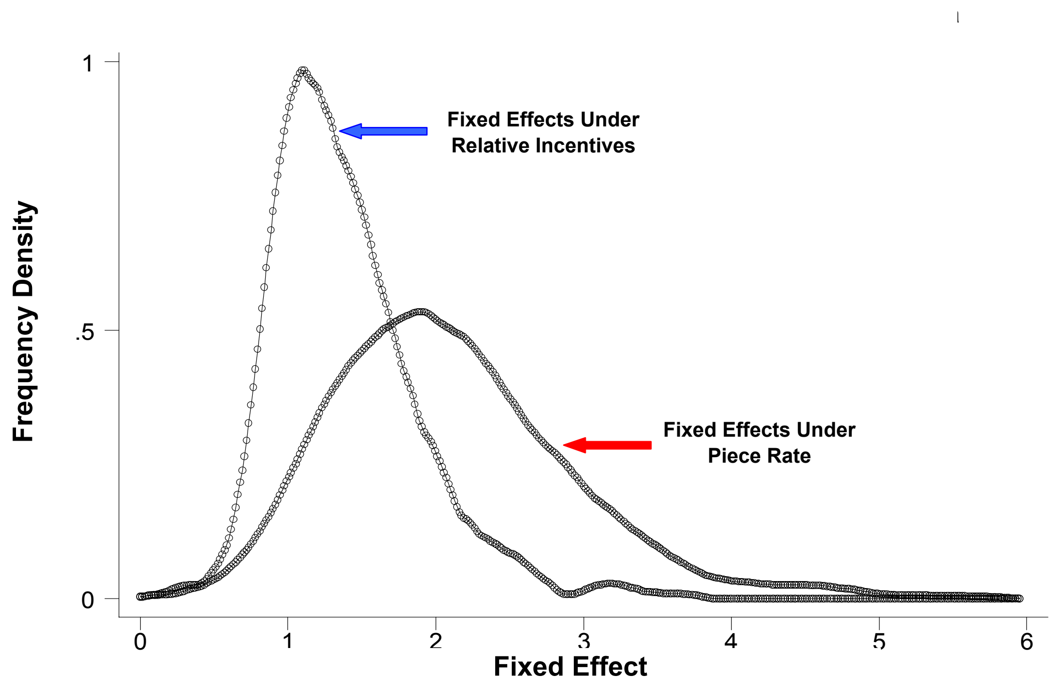


Figure 7b: Kernel Density Estimates of Fixed Effects by Incentive Scheme



Notes: Both figures are for the 142 workers in the productivity regressions. The residuals for each worker-field-day observation are derived from estimating the baseline productivity specification, in column 4 of table 3. The kernel density estimates are calculated using an Epanechnikov kernel. A Kolmogorov-Smirnov equality of distributions test rejects the null against a one-sided alternative that the fixed effects under relative incentives are lower than under the piece rate (p-value .000.).

Figure 8a: Kernel Density Estimates of Disutility of Effort Parameter, by Incentive Scheme Assuming Individualistic Behavior

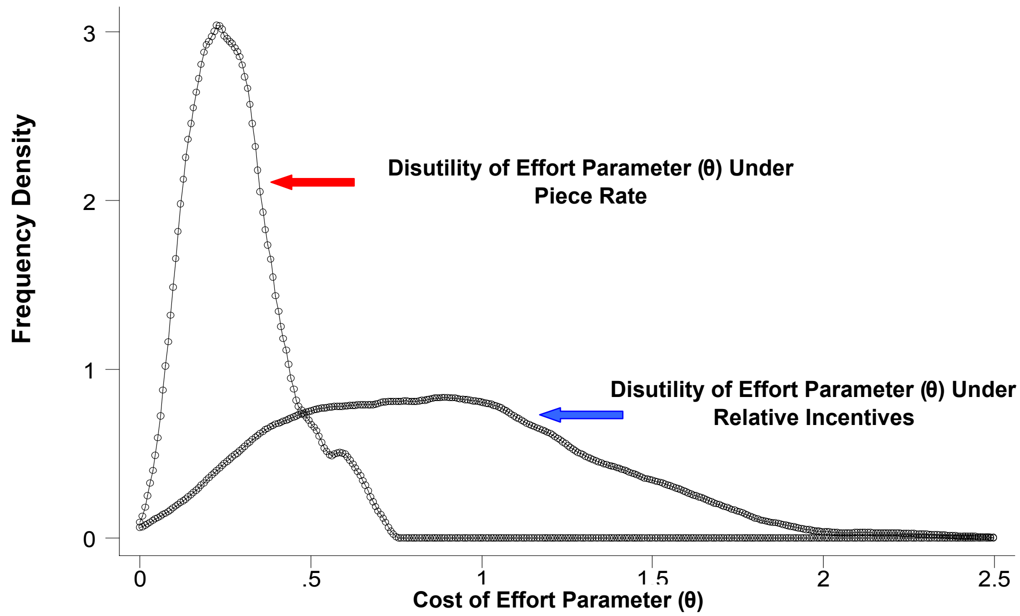
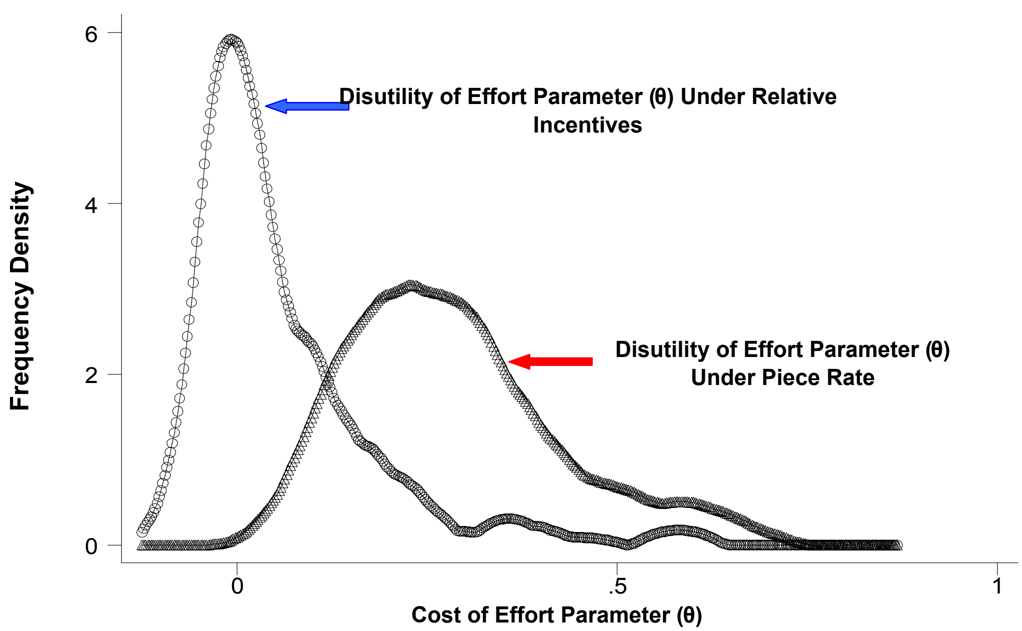


Figure 8b: Kernel Density Estimates of Disutility of Effort Parameter, by Incentive Scheme Assuming Cooperative Behavior

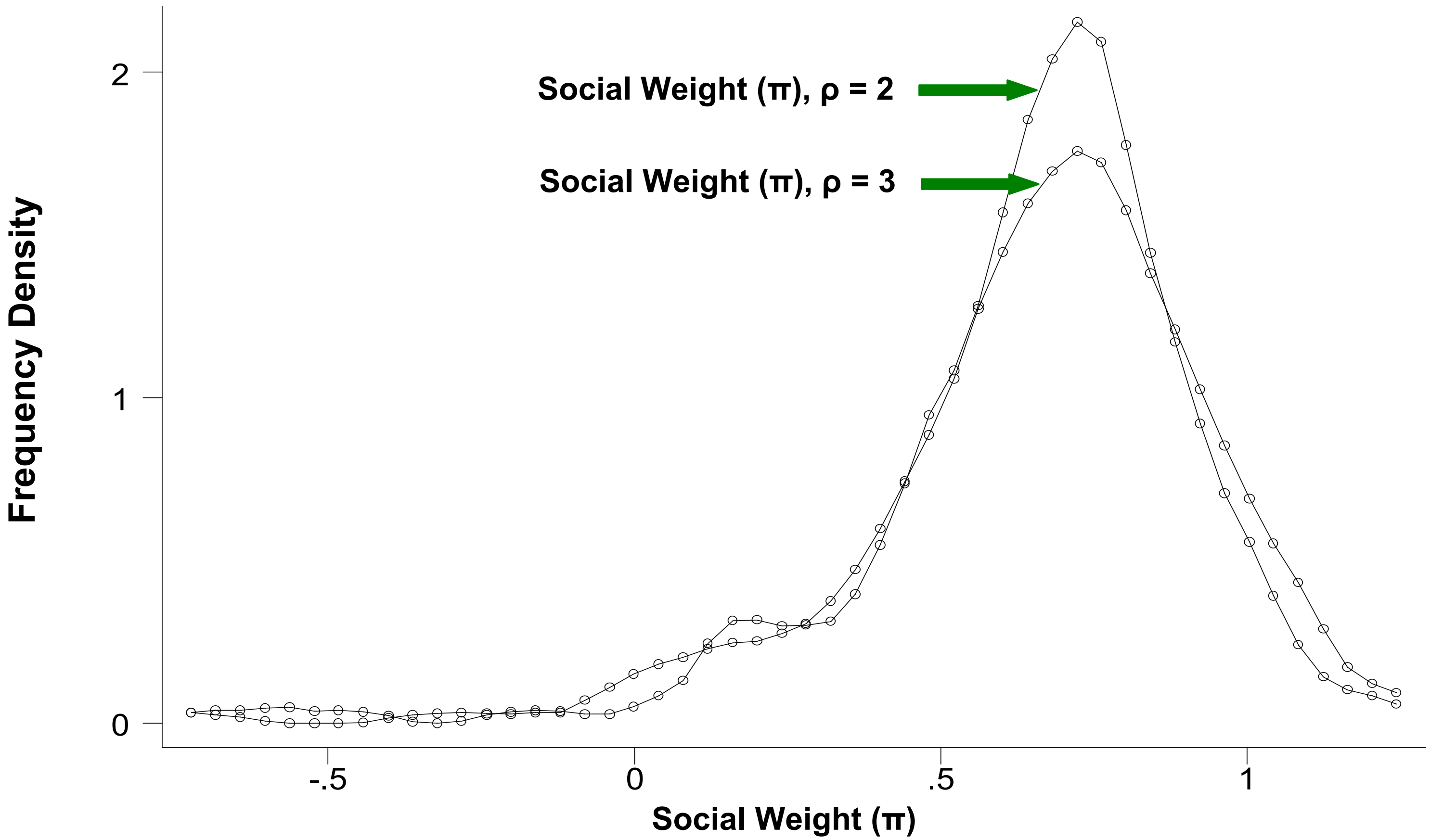


Notes: Kernel density estimates are calculated using an Epanechnikov kernel. The underlying benefit function is assumed to be;

$$\varphi(y) = 2y^{\frac{1}{2}}$$

The total cost of effort is assumed to be quadratic in effort. Under individualistic behavior we imply the worker chooses their effort to maximize their own net benefits. Under cooperative behavior we imply the worker chooses their effort level to maximize the sum of all workers utilities.

Figure 9: Kernel Density Estimates of Social Weight (π)



Notes: Kernel density estimates are calculated using an Epanechnikov kernel. The underlying benefit function is assumed to be;

$$\varphi(y) = 2y^{\frac{1}{2}}$$

The total cost of effort is assumed to be quadratic in effort.

Table 1: Unconditional Differences in Productivity, by Incentive Scheme

Mean, standard errors in parentheses, and confidence interval in brackets

	Productivity Under Relative Incentives	Productivity Under Piece Rates	Difference
Entire Sample	5.01 (.243) [4.53, 5.49]	7.98 (.208) [7.57, 8.39]	2.97***
Limit Sample to Workers that Have Only Been Picking	5.19 (.317) [4.57, 5.82]	8.12 (.234) [7.66, 8.58]	2.93***
Limit Sample to Ten Days Before and After Introduction of the Piece Rate	4.44 (.361) [3.72, 5.15]	7.21 (.377) [6.46, 7.95]	2.77***
Limit Sample to Two Main Fields	4.72 (.206) [4.32, 5.13]	9.10 (.312) [8.49, 9.72]	4.38***

Notes : *** denotes significance at 1%. Sample sizes are the same as those used for the productivity regressions. Standard errors and confidence intervals take account of the observations being clustered by field-day.

Table 2: The Effect of Piece Rates on Productivity

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

	(1) Unconditional	(2) Worker Heterogeneity	(3) Field Heterogeneity	(4) Controls
Piece rate	.530*** (.059)	.515*** (.056)	.460*** (.070)	.577*** (.098)
Time trend				.004 (.003)
Field life cycle				-1.16*** (.362)
Worker experience				.077*** (.031)
Worker fixed effects	No	Yes	Yes	Yes
Field fixed effects	No	No	Yes	Yes
Adjusted R-squared	.1607	.2925	.3407	.3640
Number of observations (worker-field-day)	10215	10215	10215	10215

Notes: *** denotes significance at 1%, ** at 5%, and * at 10%. Standard errors are clustered at the field-day level. All continuous variables are in logs. The sample is restricted to workers who have worked at least 10 days under both incentive schemes. There are 142 workers, 22 fields and 108 days in the sample.

Table 3: The Effect of Piece Rates on Productivity - Omitted Factors

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

	(1) Meteorology	(2) Supervisors	(3) Shirking
Piece rate	.554***	.524***	.523***
	(.096)	(.101)	(.101)
Time trend	.004	.005	.005
	(.003)	(.003)	(.003)
Field life cycle	-1.28***	-1.36***	-1.36***
	(.360)	(.372)	(.372)
Worker experience	.078***	.080***	.081***
	(.030)	(.029)	(.029)
Minimum temperature	.302**	.305**	.304**
	(.134)	(.138)	(.138)
Maximum temperature	.143	.177	.163
	(.254)	(.271)	(.271)
Hours of sunshine	-.024	-.026	-.026
	(.038)	(.041)	(.041)
Supervisor-worker ratio			.756
			(1.67)
Worker fixed effects	Yes	Yes	Yes
Field fixed effects	Yes	Yes	Yes
Supervisor fixed effects	No	Yes	Yes
Joint F-test (p-value)		(.0000)	(.0000)
Adjusted R-squared	.3745	.3948	.3950
Number of observations (worker-field-day)	10215	10215	10215

Notes: *** denotes significance at 1%, ** at 5%, and * at 10%. Robust standard errors are calculated throughout, allowing for standard errors to be clustered at the field-day level. All continuous variables are in logs. The sample is restricted to workers who have worked at least 10 days under both incentive schemes. Temperature variables correspond to a 0900-0900 time frame. Hours of sunshine are measured daily.

Table 4: Alternative Comparison Groups

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

	(1) Only Picking	(2) Twenty Days	(3) Main Fields
Piece rate	.644***	.387***	.610***
	(.113)	(.110)	(.070)
Worker fixed effects	Yes	Yes	Yes
Field fixed effects	Yes	Yes	Yes
Other Controls	Yes	No	No
Adjusted R-squared	.3704	.2922	.4032
Number of observations (worker-field-day)	7077	2969	3404

Notes: *** denotes significance at 1%, ** at 5%, and * at 10%. Robust standard errors are calculated throughout, allowing for clustering at the field-day level in all columns. All continuous variables are in logs. The sample is restricted to workers who have worked at least 10 days under both incentive schemes. The sample in column 1 is restricted to workers that have only been picking on that day. The sample in column 2 is restricted to 10 days either side of the change in incentive schemes. The sample in column 3 is restricted to the two main fields operated on over the season. Other controls include worker picking experience, field life cycle, and a linear time trend.

Table 5: Robustness Checks

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

	(1) Fake Piece Rate	(2) Fake Piece Rate	(3) Anticipation	(4) Drop Last 10 Days Under Relative Incentives	(5) Drop First 10 Days Under Piece Rate	(6) Last Week	(7) Tenure
Piece rate			.456***	.753***	.719***	.577***	.629***
			(.125)	(.138)	(.114)	(.098)	(.098)
Dummy equal to one for the week prior to the introduction of the piece rate			-.166				
			(.124)				
Fake piece rate based on field life cycle	.156						
	(.196)						
Fake piece rate based on number of days present on the farm		-.009					
		(.091)					
Dummy equal to one if it is the last week of picking for the worker						-.054	
						(.041)	
Tenure under piece rates							.027***
							(.005)
Worker fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Field fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	.4927	.5921	.3665	.3813	.4245	.3640	.3950
Number of observations (worker-field-day)	2863	879	10215	9340	8873	10215	10215

Notes: *** denotes significance at 1%, ** at 5%, and * at 10%. Robust standard errors are calculated throughout, allowing for clustering at the field-day level in all columns. All continuous variables are in logs. In columns 3 to 7 the sample is restricted to workers who have worked at least 10 days under both incentive schemes. The tenure variable controls for the number of days piece rates have been in place for. Other controls include worker picking experience, field life cycle, and a linear time trend.

Table 6: The Effect of Group Composition on Productivity by Incentive Scheme

Dependent Variable = Log of worker's productivity (kilogram picked per hour per field-day)

Robust standard errors reported in parentheses, allowing for clustering at field-day level

	(1a) Relative Incentives	(1b) Relative Incentives	(2a) Piece Rates	(2b) Piece Rates
Share of workers in the field that are friends	-1.68***	-5.52**	.072	1.17
	(.647)	(2.36)	(.493)	(1.60)
Share of workers in the field that are friends x number of workers in same field		1.60**		-.285
		(.684)		(.501)
Number of workers in same field x 10^{-2}		.182		.085
		(.117)		(.069)
Worker fixed effects	Yes	Yes	Yes	Yes
Field fixed effects	Yes	Yes	Yes	Yes
Other Controls	Yes	Yes	Yes	Yes
Adjusted R-squared	.3470	.3620	.3065	.3081
Number of observations (worker-field-day)	2860	2860	4400	4400

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 logs. The sample is restricted to workers who have worked at least 10 field-days under both incentive schemes. Other controls include worker experience, field life cycle, and a linear time trend.

Table 7: Robustness Checks on The Effects of Group Composition on Productivity by Incentive Scheme

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

	(1) Piece Rates	(2) Piece Rates
Share of workers in the field that are friends	.200	1.13
	(.495)	(1.57)
Share of workers in the field that are friends x number of workers in same field		-.227
		(.498)
Number of workers in same field x 10^{-2}		.073
		(.069)
Share of workers in the field that are friends x worked only under piece rates	-2.65	5.93
	(1.90)	(7.00)
Share of workers in the field that are friends x number of workers in same field x worked only under piece rates		-3.70
		(2.53)
Number of workers in same field x worked only under piece rates x 10^{-2}		.110
		(.230)
Worker fixed effects	Yes	Yes
Field fixed effects	Yes	Yes
Other Controls	Yes	Yes
Adjusted R-squared	.3619	.3636
Number of observations (worker-field-day)	4667	4667

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 logs. Other controls include worker experience, field life cycle, and a linear time trend. The sample also includes workers that have only picked under piece rates.

Table A1: Piece Rates and Productivity Over Time

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

	(1) Entrenchment	(2) History	(3) Learning
Piece rate	.630***	.485***	.546***
	(.098)	(.111)	(.102)
Tenure	.029***		
	(.005)		
Time trend	-.026***	-.012***	-.012***
	(.005)	(.004)	(.004)
Field life cycle	-.620*	-.429	-.432
	(.365)	(.372)	(.373)
Worker experience	.206***	.064**	.055*
	(.032)	(.028)	(.032)
Piece rate x [experience under relative scheme - mean experience under relative scheme]	.115***		
	(.052)		
Tenure x [experience under relative scheme - mean experience under relative scheme]x10^{-3}	-.140		
	(1.20)		
Piece rate x have worked 10 field-days under both incentive schemes		.079	
		(.058)	
Worker experience x have worked 10 field-days under both incentive schemes			.019
			(.024)
Worker fixed effects	Yes	Yes	Yes
Field fixed effects	Yes	Yes	Yes
Adjusted R-squared	.3956	.3117	.3115
Number of observations (worker-field-day)	10215	9349	9349

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 logs. Confidence intervals for the marginal effect of the piece rate and tenure are both calculated at the mean experience under the average system. The final two columns compare the workers in our sample - who worked at least 10 field-days under each incentive scheme, to workers who did not. These workers include those who worked only under relative incentives or piece rates, or arrived just prior to, or just after, the introduction of piece rates. We restrict the sample to include only the first four weeks of picking for each worker. The tenure variable controls for the number of days piece rates have been in place for.

Table A2: The Effect of Piece Rates on the Quality of Picking

Dependent Variable = Log of total fruit of class two misclassified as class one, at the packfield-day level
Robust standard errors reported in parentheses

	(1)	(2)	(3)	(4)
Piece rate	.330	.336	.434	.399
	(.257)	(.265)	(.322)	(.304)
Tons of class two fruit picked x 10^{-3}		-.794	-.401	-.249
		(.845)	(.780)	(.859)
Time trend			.067**	.060*
			(.032)	(.033)
Time trend squared x 10^{-3}			-.349**	-.330**
			(.146)	(.151)
Field life cycle				-.520
				(.666)
Minimum temperature				.059
				(.039)
Maximum temperature				.028
				(.043)
Hours of sunshine				-.009
				(.035)
Packfield fixed effects	Yes	Yes	Yes	Yes
R-squared	.0724	.0901	.1845	.2224
Number of observations (field-day)	67	67	67	67

Notes: *** denotes significance at 1%, ** at 5%, and * at 10%. Robust standard errors are calculated throughout. Data is based on the packhouse software system. It is assumed that all fruit arrives in the packhouse two days after it is picked. Variables are only available aggregated on field-day level where fields are further grouped according to fruit variety. This forms a packfield. The sample is restricted to those packfields that operated under both incentive schemes. All right hand side variables are lagged by two days to allow for a time lag between picking and packing. Temperature variables correspond to a 0900-0900 time frame. Hours of sunshine are measured daily.