Relative and Absolute Incentives: Evidence on Worker Productivity*

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Abstract

We use personnel data to 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 an absolute incentive scheme - piece rates.

We find that for the average worker, productivity is at least 50% higher under piece rates. We show this is due to workers partially internalizing the negative externality their effort imposes on others under the relative incentive scheme and that workers internalize this externality to a greater extent when they work alongside their close friends. The results demonstrate the importance of understanding how workers behave in the presence of externalities when designing incentive schemes.

Keywords: absolute incentives, relative incentives, social preferences.

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1 Introduction

This paper uses personnel data to compare the effect of relative and absolute incentive schemes on workers' productivity. Relative schemes - where an individual's reward depends on her performance relative to others' in her peer group - are ubiquitous in society and the focus of an extensive theoretical literature. Their effect on productivity in the workplace, however, remains largely unknown.[1]

One key difference between relative and absolute incentive schemes is that under relative incentives, individual effort imposes a negative externality on co-workers by lowering their relative performance. Under piece rates, in contrast, individual reward depends only on individual performance and individual effort has no effect on others.

Understanding the extent to which workers internalize the externality is crucial for the optimal choice between relative and absolute incentive schemes. Theoretical comparisons of relative and absolute schemes generally rely on the assumption that workers ignore the externality. We investigate whether this assumption is borne out in the data, thus providing real world evidence on individual behaviour in a situation where the individual and social optima do not coincide.

We use personnel data from a leading UK farm that first used a relative incentive scheme for its workers, and then moved to piece rates. The workers' task is to pick fruit and their individual productivity is recorded daily. Under the relative incentive scheme, workers' pay depends on the ratio of individual productivity to average productivity among all co-workers in a field. Under the absolute incentive scheme - piece rates - individual pay only depends on individual productivity.

The difference in worker productivity under the two schemes then critically depends on the extent to which, if any, workers internalize the externality. This, in turn, might depend on the *relationship* between co-workers. To address this issue, we combine the personnel records with survey data that contains precise information on each worker's social network of friends on the farm.

Four features of the data help identify the causal effect of the change in incentive schemes and of group composition on worker productivity. First, we use information on the daily productivity

[1] This paper provides the first evidence on the 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. See Prendergast (1999) for a review of the empirical literature on incentives.

of the *same* workers before and after the introduction of the piece rates. Time invariant sources of unobservable individual heterogeneity are therefore controlled for.[2]

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 and no endogenous attrition of workers out of the sample.[3]

Third, the change in incentive scheme was unannounced to workers and other farm practices remained unchanged throughout the season. Tasks, technology and management were the same under both incentives schemes.

Finally, there are daily changes in the composition of co-workers each individual works with. This allows us to identify the effect of group composition on worker productivity from the comparison of the behavior of the *same* worker working alongside different co-workers.

We find the change in incentive schemes had a significant and permanent impact on productivity. For the average worker, productivity increased by at least 50% moving from the relative incentives to piece rates. The result is robust to controlling for a host of time varying factors at the worker, field, and farm level. Moreover, the increase in productivity did not come at the expense of a lower quality of fruit picking.

To shed light on the workers' maximization problem, we estimate the first order conditions for worker's effort choice under alternative behavioral assumptions. This exercise reveals that the observed change in productivity is too large to be consistent with the Nash equilibrium outcome where workers maximize their individual net benefit and ignore the externality they impose on others.[4] Workers' behavior under relative incentives is not consistent with the assumption that workers maximize the group's welfare either. Namely, effort levels are too high to be consistent with workers fully internalizing the negative externality their effort imposes on others.

When we posit workers to have *social preferences*, namely that they place some weight on the benefits accruing to their co-workers, we find that the observed change in productivity is

[2] 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.

[3] 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. 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.

[4] Under this assumption, the equilibrium levels of effort under relative incentives and piece rates differ only because each worker takes into account that higher effort increases average productivity and hence reduces own pay, other things equal. For the group sizes observed in the data this effect is too small to account for the observed change in productivity. With homogeneous workers, the magnitude of this effect is of order $\frac{1}{N}$, where N is the number of co-workers. Evidence of the "$\frac{1}{N}$ problem", whereby individuals appear to overestimate the impact of their actions on their pay 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)).

consistent with the average worker placing around twice the weight on their own private benefits, as on the benefits accruing to all others.[5]

Finally, our results indicate that the extent to which workers internalize the externality depends on their relationship with their group of co-workers. Under relative incentives workers choose lower effort when the share of their 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.

Overall our findings suggest that worker productivity is significantly different under the two schemes, that workers internalize the externality they impose on others under relative incentives, and they do so more when they work alongside friends.

Throughout we take the incentive schemes as given and focus on the response of workers to the change in incentives. In the conclusion, we reconcile our results with the assumption that the observed incentive schemes were optimally designed from the principal's point of view.

The paper is organized into 7 sections. Section 2 sets out stylized models of worker's effort choices under alternative behavioral assumptions. 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 the identity of co-workers on productivity under the two incentive schemes. Section 7 concludes. The appendix contains additional regression results.

2 Theoretical Framework

This section makes precise the workers' effort choice under relative incentives and under piece rates. The comparison of the first order conditions for effort yield predictions on the effect of the change in incentive schemes on worker productivity.

There are N workers. Each worker i exerts $e_i \geq 0$ units of effort which determines her productivity. Without loss of generality, we assume that effort equals productivity in what follows. Each worker's payoff is $\phi(.) - \frac{\theta_i e_i^2}{2}$, where $\phi(.)$ is the benefit derived from compensation (and depends on effort), and $\frac{\theta_i e_i^2}{2}$ is the cost of effort. We assume $\phi(.)$ is a differentiable concave function, with $\lim_{x \to 0} \phi'(x) = \infty$. The parameter θ_i is interpreted as the inverse of the workers innate ability, and we assume workers are heterogeneous along this dimension. Workers can be ordered such that $\theta_1 < \theta_2 < ... < \theta_N$, where $\theta_i > 0$ for all i.

Each incentive scheme then defines a particular relationship between effort and compensation.

[5] Fehr *et al* (1999) and Fehr and Fischbacher (2002) review the literature on social preferences. Our findings are in line with the large experimental literature on public good games where individual contributions are generally found to be halfway between the selfish Nash equilibrium (complete free riding) and the group optimum. See Ledyard (1995) for a review of this literature.

Piece Rates

Under piece rates, compensation depends only on individual effort, which is paid at rate β per unit of effort. Worker i chooses her effort under piece rates as follows;[6]

$$\max_{e_i} \phi\left(\beta e_i\right) - \frac{\theta_i e_i^2}{2} \tag{1}$$

The equilibrium effort level solves the first order condition;

$$\phi'\left(\beta e_i\right)\beta = \theta_i e_i \tag{2}$$

Relative Incentives

Under the relative incentive scheme observed in the data, each worker's remuneration depends on how she performs relative to her peers. More specifically, workers' benefit from compensation 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.[7] The relative scheme has the key characteristics that other things equal, an increase in worker's i effort - (i) increases her compensation; (ii) increases average effort and hence reduces the compensation of everybody else in the group.

Hence each workers effort imposes a negative externality on the entire group. The choice of effort under relative incentives then depends on whether and to what extent workers internalize the externality.

To this purpose, we assume workers have "social preferences", namely they take into account the effect of their effort on the benefits of the group of co-workers. Assuming that each worker puts an equal social weight, π_i, on the each of her fellow co-worker's benefits, the equilibrium effort for worker i solves;

$$\max_{e_i} \phi\left(\frac{e_i}{\overline{e}}\right) + \pi_i \sum_{j\neq i}\phi\left(\frac{e_j}{\overline{e}}\right) - \frac{\theta_i e_i^2}{2} \tag{3}$$

Social preferences are a reduced form representation of a number of models. They depict behavior consistent with reciprocity or altruism (Fehr and Schmidt (1999)), or the evolutionary

[6] We do not analyze workers' dynamic incentives to put in effort under each scheme. For example, workers might want to under perform to ensure the management does not lower the pay rate in future periods. We discuss some of the empirical implications of such ratchet effects in section four.

[7] 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;

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

where α and μ are taken as given by workers.

equilibrium of a repeated Prisoner's Dilemma game in which workers learn which strategies to play (Levine and Pesendorfer (2002), Sethi and Somanathan (1999)). We do not attempt to distinguish between models in which workers preferences display altruism towards others, and models in which workers behave *as if* they are altruistic because, for instance, they play trigger strategies.

Assuming worker i chooses her effort taking the effort of others as given, the Nash equilibrium effort for worker i solves;

$$\phi'\left(\frac{e_i}{\overline{e}}\right)\frac{1}{\overline{e}}\left(\frac{\sum_{j\neq i} e_j}{\left(\sum_i e_i\right)}\right) - \frac{\pi_i}{\overline{e}}\sum_{j\neq i}\phi'\left(\frac{e_j}{\overline{e}}\right)\frac{e_j}{\left(\sum_i e_i\right)} = \theta_i e_i \tag{4}$$

To compare effort choices under the relative scheme and under piece rates we evaluate the first order condition (2) at $\beta = \frac{1}{\overline{e}}$ so that for a given average effort level, the marginal benefit of effort is the same under both incentive schemes. The first order condition under piece rates then is;

$$\phi'\left(\frac{e_i}{\overline{e}}\right)\frac{1}{\overline{e}} = \theta_i e_i \tag{5}$$

The differences between the first order conditions (4) and (5) can be ascribed to two sources, both of which make effort levels under relative incentives *lower* than under piece rates.

First, and most importantly, is the externality worker i imposes on others by increasing average effort and reducing everybody's pay. The magnitude of this effect on effort depends on the extent to which workers internalize the externality, that is on the social weight π_i. This is captured in the $\frac{\pi_i}{\overline{e}}\sum_{j\neq i}\phi'\left(\frac{e_j}{\overline{e}}\right)\frac{e_j}{\left(\sum_i e_i\right)}$ term in (4).

In one extreme case, suppose workers place no social weight on the benefits of co-workers, $\pi_i = 0$. This is the standard case assumed in most of the literature on relative incentives. The first order condition under relative incentives (4) coincides with the first order condition of the Nash equilibrium with purely self-interested individuals;

$$\phi'\left(\frac{e_i}{\overline{e}}\right)\frac{1}{\overline{e}}\left(\frac{\sum_{j\neq i} e_j}{\left(\sum_i e_i\right)}\right) = \theta_i e_i \tag{6}$$

In this case, the difference between the relative scheme and piece rates only arises because of the second reason why (4) and (5) diverge - that by exerting more effort, each worker imposes an externality on herself $\frac{\sum_{j\neq i} e_j}{\left(\sum_i e_i\right)}$, which is negligible in large groups as $\lim_{N\to\infty}\left(\frac{\sum_{j\neq i} e_j}{\left(\sum_i e_i\right)}\right) = 1$.[8]

[8] 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. The ratio of effort

In the other extreme case, suppose workers place the same weight on the benefits of co-workers as on themselves so $\pi_i = 1$. The first order conditions under relative incentives (4) then coincides with the first order conditions of the Pareto optimum, that is when effort levels are chosen cooperatively to maximize the welfare of the group as a whole;

$$\phi'\left(\frac{e_i}{\bar{e}}\right)\frac{1}{\bar{e}}\left(\frac{\sum_{j\neq i} e_j}{\left(\sum_i e_i\right)}\right) - \frac{1}{\bar{e}}\sum_{j\neq i}\phi'\left(\frac{e_j}{\bar{e}}\right)\frac{e_j}{\left(\sum_i e_i\right)} = \theta_i e_i \tag{7}$$

In this case the difference in effort between the relative scheme and piece rates is maximized because workers fully internalize the externality their effort imposes on others under relative incentives.

In summary, this stylized model illustrates that the difference between productivity under relative incentives and productivity under piece rates depends on the extent to which workers internalize the externality they impose on others. In the remainder of the paper we first establish whether productivity is different under the two schemes and then derive implications for the workers' behavior in the presence of the externality under the relative incentive scheme.

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' social network of friends from questionnaires we administered to 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 incentive scheme, and then according to piece rates. 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.[9] Throughout we define individual productivity y_i as the number of kilograms of fruit picked per hour.

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, although it can be shown that $\lim_{N\to\infty} e^R = e^P$.

[9] 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.

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;

$$\beta = \frac{\overline{w} + c}{\overline{y}} \tag{8}$$

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. 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, $\overline{w} + c$.

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

Moreover, an increase in worker i's effort increases the average productivity on the field-day and thus imposes a negative externality on her co-workers by reducing the picking rate β in (8).

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.[10]

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.[11] The change was announced

[10] 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 many opportunities to learn the *ex post* adjustment of the picking rate under relative incentives. Second, the data under piece rates indicates that, other things equal, supervisors set the *ex ante* rate correctly. In other words, the announced *ex ante* rate under piece rates is generally identical to the rate that would obtain *ex post* if the relative formula were used instead.

[11] No picking takes place on Sundays. The panel is unbalanced in that we do not observe each worker picking

on the same day it was first implemented and it was unanticipated 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, it became clear that the relative incentive scheme was adopted because it differences out common shocks to productivity, such as those deriving from weather and field conditions, that are a key determinant of productivity in this setting. However, management decided to move to piece rates because they felt productivity was too low. 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.[12] 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 to be financial, which is hardly surprising in light of the fact that, even at the minimum wage, the value of their earnings is high in real terms.[13]

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, an unconditional increase in productivity of 59%.

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 a higher level until the end of the season.

every day. This is of concern if there is endogenous attrition of either fields or workers over time. The empirical analysis in section 4 takes these concerns into account.

[12] 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.

[13] Working eight hours at the minimum wage rate implies a daily income of around 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).

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. The mean and variance of productivity both rise moving from relative incentives to piece rates.

Productivity is computed as kilograms picked per hour. The second and third rows of table 1 reveal that the increase in productivity was entirely due to workers picking more fruit over the same time period, rather than working shorter hours. On average, workers picked 23.2 more kilograms per day under piece rates - a significant difference at the 1% level. Hours worked did not significantly change across incentive schemes, remaining constant at just over 8 hours per day.

The discussion in section 2 makes clear that the size of the group over which relative pay is computed is key for understanding workers' behavior under relative incentives. The fourth row of table 1 reports average group size, namely the number of people each worker worked with on a given field and day. We note that average group size remained constant throughout the season. Importantly, the fact that, on average, there are over 40 workers picking together under the relative incentive scheme indicates that - (i) by exerting effort, the worker reduces the relative performance of a large number of co-workers; (ii) the externality each worker imposes on herself is negligible.

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.[14] Total man-hours spent picking are higher under relative incentives. Figure 4c shows this is due entirely to more workers picking, rather than each worker picking for longer hours. The total man-hours spent picking however falls as fewer workers are required to pick each 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 piece rates. Some workers were therefore reallocated

[14] 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.

to alternative tasks, and this is one source of gains that accrued to management arising from the change in incentive scheme.

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 that under the relative incentive scheme, the picking rate is set endogenously according to (8).

With the introduction of piece rates there is a one-off fall in the picking rate. Table 1 shows that the difference in average picking rates between the two halves of the season is .105, significant at the 1% level. We 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 the estimates provide a lower bound of the effect of the change in incentives in productivity.[15]

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. Table 1 shows that the difference in average daily pay between relative incentives and piece rate is indeed not significantly different from zero. Overall, the average worker became worse off under piece rates - their productivity rose, while total compensation remained the same. However, the top third of workers did have significant increases in pay moving to pay rates (not reported), which is expected if workers are of heterogeneous picking ability.

Given that the 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 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

[15] 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 large income effects 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.

variables are in logarithms;

$$y_{ift} = \alpha_i + \beta_f + \gamma P_t + \delta X_{ift} + \eta Z_{ft} + u_{ift} \tag{9}$$

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 when piece rates are in place, and zero when relative incentives are in place. As piece rates are 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 (9), we address a number of concerns that may lead to γ being inconsistently estimated. These are of two types.

First, 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. The estimated effect of piece rates $\widehat{\gamma}$ is then biased upward to the extent that it captures the effect of factors that cause productivity to rise through the season regardless of the change in incentive schemes. This concern arises if there is attrition of low yield fields over time or changes in the composition of tasks workers perform in the two halves of the season.

Second, both the timing of the change in incentives, and the response of workers before or after the change may be endogenous. For instance, if the management shifted to piece rates when productivity under relative incentives was at its lowest, $\widehat{\gamma}$ is biased upwards. If on the other hand, workers initially under perform under piece rates in the hope of reinstating the relative incentive scheme, $\widehat{\gamma}$ is biased downwards.

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.[16]

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. Controlling for workers' heterogeneity improves the fit of the model considerably as workers fixed effects almost double the explained variation in productivity. In contrast, field heterogeneity appears much less important.

Column 4 controls for other time varying determinants of productivity at the level of the farm, field, and individual. We include a linear time trend to capture farm level changes over time, a measure of each field's life cycle to capture field level changes over time and a measure of workers' experience to capture natural changes in workers' productivity.

We measure the field's life cycle as 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. Picking experience is defined as the number of field-days the worker has been picking.[17]

There is no trend in productivity over time at the level of the farm, all else equal. This is consistent with the fact that different fields are operated at different times to ensure a constant stream of output throughout the season.[18] Within each field, however, productivity declines as the field is picked later in its cycle. Moreover, there are positive returns to picking experience as expected.[19]

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 comparison, the introduction of piece rates causes productivity to significantly increase by 58%.

Further analysis, not reported for reasons of space, show that this result is robust to controlling for a number of other time varying factors including contemporaneous and lagged weather conditions, the identity of field supervisors that monitor workers, and the ratio of supervisors to workers.

[16] 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.

[17] 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 dropped from the sample.

[18] The finding that productivity does not exhibit an increasing time trend also rules out the hypothesis that the management become better informed about the quality of fields and workers and hence improved the allocation of resources over time.

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

Concerns : Spurious Time Effects

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 of the same worker over time. The estimated effect of piece rates $\widehat{\gamma}$ is biased upward to the extent that it captures the effect of factors that cause productivity to rise through the season regardless of the change in incentive schemes.

The first three columns of table 3 estimate the effect of piece rates on subsamples in which the variation in productivity is less likely to be due to other time varying factors.

First, we eliminate the variation that can be ascribed to changes in task composition throughout the season. While workers are primarily hired to pick fruit, sometimes they can be assigned to other tasks such as planting or building tunnels to cover the fields. To reduce the variation in productivity arising from differences in non-picking tasks done in the first and second half of the season, we restrict the sample to workers that have *only* been picking each day. Column 1 shows that also in this restricted sample productivity significantly rises after the introduction of piece rates.

Second, we eliminate the variation that can be ascribed to changes in field composition throughout the season. For instance, if low yield fields are less likely to be picked later in the season, the attrition of fields causes productivity to rise in the second half of the season. Column 2 restricts the sample to the two largest fields, which are contiguous and planted with the same fruit variety. The magnitude and significance of the estimated effect of piece rates is unchanged.

To minimize the variation in productivity arising from any other time varying factors, column 3 restricts the sample to ten days either side of the change in incentive scheme. Over this shorter time frame, there remains a significant rise in productivity moving from relative incentives to piece rates.

Columns 4 and 5 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 4 shows no evidence of a natural jump in productivity on fields after they have passed 25% of their life cycle.

Column 5 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 5 shows no evidence of a natural jump in worker productivity after this time.

Concerns : Endogenous Responses

Table 4 deals with concerns that derive from the endogenous behavioral responses to the change in incentives.

An identifying assumption underlying (9) is that workers do not anticipate the change in incentive scheme. To check this, column 1 introduces a dummy equal to one in the week prior to the move to piece rates. 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 2 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 1 showed productivity was not falling in the week prior to the move to piece rates.

The descriptive analysis in section 3 highlighted that the average worker 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 3 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 in early periods will result in management setting lower piece rates in the future. One testable implication is that this type of ratchet concern is weaker the shorter the time horizon of the worker. Column 4 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.[20]

Finally, column 5 analyses how the behavioral response of workers to the introduction of piece rates changes with time. One concern is that the actual effect of the introduction of piece rates is short lived as workers eventually revert to their previous behavior.[21] 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.[22] 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.[23] Hence productivity was actually declining under the relative incentives, all else equal, and there is no significant trend in productivity under piece rates.[24]

Section 8.1 in the appendix reports further results on the effect of the change in incentives over time.

A 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 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 individual workers. To check for this we analyze whether the misclassification of fruit worsened after the introduction of piece rates. Results, reported in section 8.2 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

[20]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.

[21]This is known as the "Hawthorne" effect, after the Hawthorne Western Electric Plant in Illinois. Lazear (2000) find no evidence of this effect in his study of fixed wages versus piece rates. In contrast, Paarsch and Shearer (1996) find that for tree planters in British Columbia individual productivity significantly increases moving from fixed wages to piece rates but it subsequently declines over time.

[22]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.

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

[24]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.

fields, and within workers over time.[25]

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 discuss the implications of our findings on the workers' underlying maximization problem.

5 Evidence on Workers' Behavior

This section analyzes the evidence on worker productivity in light of the models discussed in section 2 to draw implications on workers' behavior. We analyze whether the observed change in productivity is consistent with the assumption that workers maximize their individual benefit without internalizing the externality they impose on others under the relative scheme or whether, in contrast, they internalize the externality and, if so, to what extent.

To this purpose, we use the first order conditions of the workers' maximization problem derived in section 2 to compute an estimate of the cost parameter, θ_i, under each incentive scheme and each behavioral assumption. Since the workers' cost (ability) parameters 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.

Throughout we assume the benefit function is of the following CRRA type;

$$\phi(y) = \rho y^{\frac{1}{\rho}} \text{ for } \rho \geq 1 \tag{10}$$

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. To do so we assume that workers' effort e translates into productivity y through a Cobb Douglas production function.[26]

We then substitute data for estimated effort, observed productivity and observed rates of pay (β) into the first order condition of the maximization problem under piece rates and into the first order condition of the maximization problem under relative incentives, for each alternative

[25] 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 reflects that these workers had relatively worse outside options as they had 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.

[26] 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

model of behavior. Having obtained an estimate of θ_i on each field-day the worker picks, $\widehat{\theta}_{ift}$, we take the median of these as a unique estimate of θ_i, under each incentive scheme.[27] We therefore derive three estimates of θ_i based on calibrating the first order conditions (2), (6), and (7) respectively - (i) under piece rates $\hat{\theta}_i^P$, (ii) under relative incentives assuming that workers do not internalize the externality $\hat{\theta}_i^{RN}$, (iii) under relative incentives assuming that workers fully internalize the externality, namely that they play cooperatively $\hat{\theta}_i^{RC}$.

Section 5.2 first compares the distribution of $\hat{\theta}_i^P$ to $\hat{\theta}_i^{RN}$ and shows that the observed change in productivity is too large to be consistent with workers maximizing their individual payoff net of the costs of effort. This is not surprising considering that under this behavioral assumption, the only difference in effort between the two schemes arises from the externality each worker imposes on herself, which, for the group sizes observed in the data, is negligible.

At the same time, the comparison of the distributions of $\hat{\theta}_i^P$ and $\hat{\theta}_i^{RC}$ reveals that workers do not behave as if maximizing the sum of individual payoffs either. In other words, productivity under relative incentives is actually too high for workers to be fully internalizing the externality they impose onto co-workers.

In section 5.3 we posit that workers have social preferences and recover the weight workers place on the net benefits of all others that is consistent with the observed change in productivity.

5.1 Workers' Effort

To estimate worker effort, we first run the productivity regression (9) 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 $s \in \{R, P\}$ is each worker's estimated fixed effect added to the residual from this regression;

$$\widehat{e}_{ift}^s = \widehat{\alpha}_i^s + \widehat{u}_{ift}^s \tag{11}$$

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 (measured in kilograms per hour) 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

[27] The results are robust to taking the mean of the $\widehat{\theta}_{ift}$'s.

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 (11) into each of its components - the residual, $\widehat{u}^s_{ift}$, and the worker fixed effect, $\widehat{\alpha}^s_i$. 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 or Cooperative Behavior

Figure 8a shows the kernel density estimate of the distribution of workers' cost of effort $\hat{\theta}_i^P$ and $\hat{\theta}_i^{RN}$, namely under the assumption that workers ignore the externality they impose on others under the relative scheme. These are derived from the first order conditions (2) and (6) as discussed above.

Figure 8a shows that the distribution of cost parameters under relative incentives lies almost entirely to the *right* of the distribution under piece rates, indicating that the implied cost of effort is higher under relative incentives than under piece rates.

Taken together, the assumption that the cost of effort is an innate parameter and the evidence that the same distribution of costs cannot be fitted to both incentive schemes indicate that effort choices are not consistent with a model where workers ignore the externality they impose on others under relative incentives.

Next, we estimate of the distribution of workers' cost of effort $\hat{\theta}_i^P$ and $\hat{\theta}_i^{RC}$, namely under the assumption that workers maximize the welfare of the group under the relative incentive scheme. This behavioral assumption is plausible if the conditions of the folk theorem apply. Namely, 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 alongside each other, and because workers interact along a number of social dimensions.[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] Workers live together on the farm for the picking season. Many workers also study with their co-workers in

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 (2) and (7).

Figure 8b shows the implied distributions of the cost parameter θ_i, by incentive scheme. The distribution of $\hat{\theta}_i^P$ under piece rates is, by definition, unchanged to that derived above. However, the distribution of costs under relative incentives $\hat{\theta}_i^{RC}$ now lies almost entirely to the *left* of the distribution under piece rates.

If workers chose their effort levels cooperatively, then the cost 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.

Figures 8a and 8b together reveal an interesting pattern. The observed change in productivity is too large to be reconciled with the assumption of individualistic behavior but too small to be reconciled with the assumption of cooperative behavior. This suggests workers behave as if they internalize the negative externality to some extent. The next subsection explores this idea in more detail.

5.3 Social Preferences

We now posit that workers have "social preferences", namely that they place some weight on their own benefit and the benefits that accrue to their co-workers. We then retrieve the "social weights" (π_i) that fit the observed change in productivity.

To do so, we assume the true cost of effort of each worker is that derived under piece rates $\widehat{\theta}_i^P$.[30] Given $\widehat{\theta}_i^P$, we solve the first order conditions of the maximization problem when workers have social preferences, (4), for the implied social weight of each worker under the relative incentive scheme ($\widehat{\pi}_{ift}$). We take the median of these to derive $\widehat{\pi}_i$. Note that the weight is worker specific, namely we assume that each worker gives the same weight to all co-workers in a given day. We thus obtain the 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 under piece rates.[31]

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 (10).

their home country, or are already friends before arriving at the farm.

[30] Using this measure of ability, we find that groups were equally heterogeneous, in terms of ability, before and after the change in incentives. Hence there is no evidence of management sorting workers by ability under the relative incentive scheme.

[31] The results are robust to calibrating the first order condition (4) for each of the estimated $\widehat{\theta}_{ift}^P$'s under the piece rate, and then taking the median or mean of the implied $\widehat{\pi}_{ift}$'s to derive an unique estimate of $\widehat{\pi}_i$.

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.[32]

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.[33] 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.[34]

To investigate this issue, table 5 reports estimates of the productivity regression (9) 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 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, at the average group size, if worker i moved from a group with no friends to a group where all her five friends are present, her productivity would fall by 21%.

Column 1b controls for the share of workers in the same field that are friends of worker i,

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

[33] 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".

[34] We also have information on two alternative social networks - house mates (each worker shares a caravan with up to 5 other workers), and workers that arrived to the farm together from the same country on the same day. Using these measures of social network, the results are very similar to those reported and available from the authors on request.

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.[35]

The number of co-workers has no significant direct effect on productivity. Workers therefore appear to internalize to some extent the externality they impose on their friends, but not on all other co-workers.

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 identity of co-workers and productivity that is *unrelated* to the incentive scheme in place, such as socializing with friends, will be present under both incentive schemes. If however the relationship between the identity of co-workers and productivity is related to the externality, it should affect productivity only 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.

The finding that the share of friends is a significant negative determinant of productivity under relative incentives only may however still be spurious for the following reason. If workers are more likely to chat with friends, and work less hard, when they first arrive, the effect of friends on productivity will only be picked up under the relative incentives scheme, as they were 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 6 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

[35] 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.

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.

In summary, the evidence indicates that workers behave as if they internalize the externality more under relative incentives, when they work alongside their friends. The data does not allow us to tell whether this happens because workers are altruistic towards their friends, or because they fear punishment and retaliation by their friends. The fact that workers' productivity is not affected by the presence of friends under piece rates, however indicates that group composition affects productivity only in the presence of the externality.[36]

7 Conclusions

This paper uses personnel records to compare workers' productivity under a relative incentive scheme to productivity under piece rates. Our estimates indicate that the causal effect of moving from relative incentives to piece rates is to increase productivity by at least 50%.

We show the difference 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 welfare. Overall, workers behave as if they internalize the externality they impose on fellow co-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 effect of two common types of incentive scheme on worker productivity. Second, we provide evidence on how workers behave in a real world situation where individual and social optima do not coincide. In doing so, we integrate recent insights from the experimental literature on social preferences 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.[37]

[36] 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%.

[37] 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

Throughout we have taken the incentive schemes as given. Our focus has been the response of workers to an exogenous change in incentives. A separate issue is whether the observed incentive schemes are optimally designed by the principal. In other words, if the relative incentive scheme was so 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 to productivity. Such common shocks are important in the workplace environment analyzed here.[38]

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.[39] The findings thus provide insights for further developments of incentive theory and shed new light on and old idea - the interplay between social effects and the provision of incentives within firms.[40]

8 Appendix

8.1 Piece Rates and Productivity Over Time

Table A1 presents further 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

endogenously choose their level of altruism towards co-workers.

[38] 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 lowers informational rents to high types (Bhaskar (2002)), and reduces incentives of workers to exert effort in influence activity (Milgrom(1988)).

[39] 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.

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

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.

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.

8.2 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 container. After fruit has been picked it is transported to a cooled warehouse for packing. In the packhouse each container passes through a quality check. Whenever a class two fruit is detected in a class one container, it is removed - downgraded - and transferred to a class two container. 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.[41]

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 1: Productivity (kilogram/hour) Over the Season

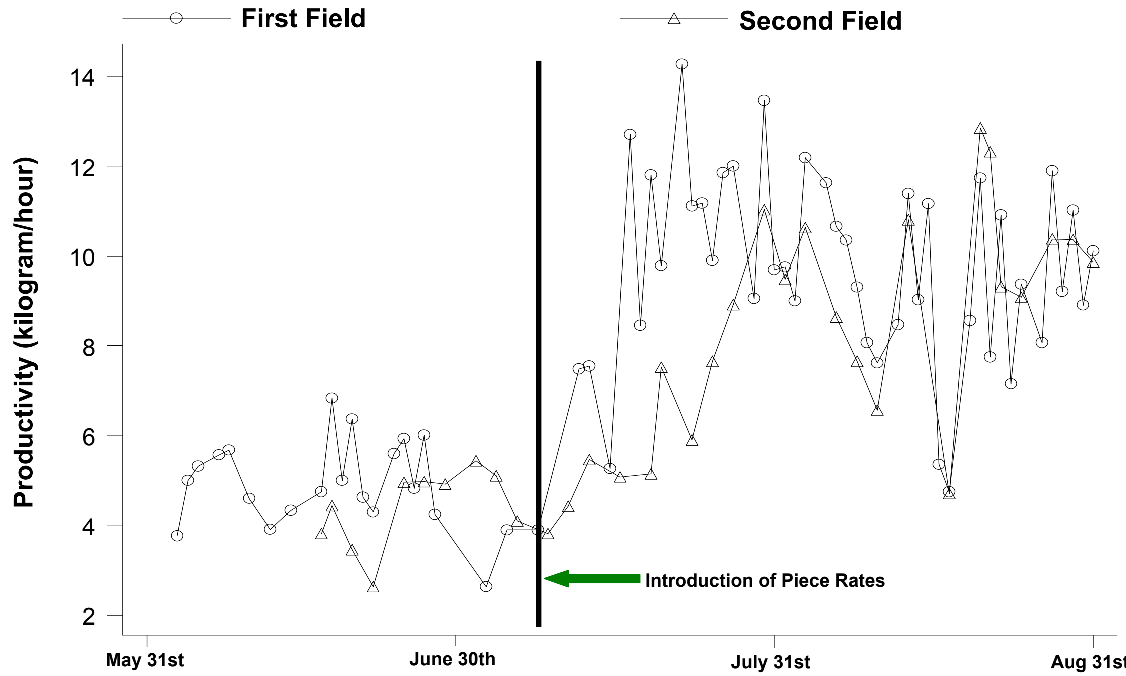
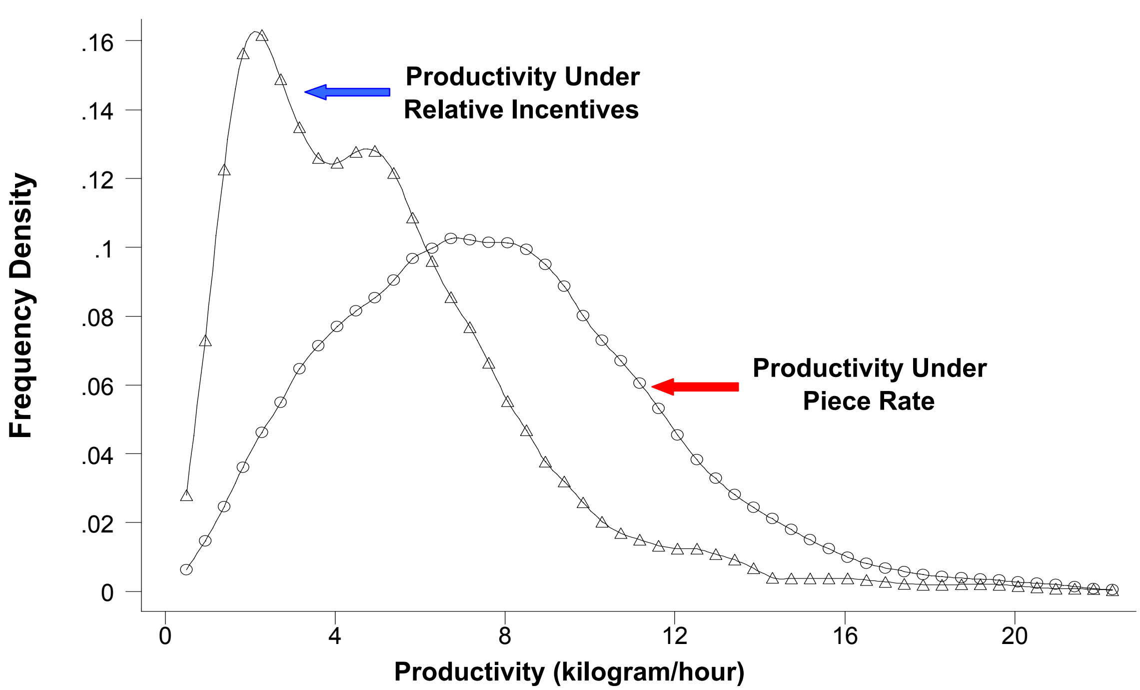
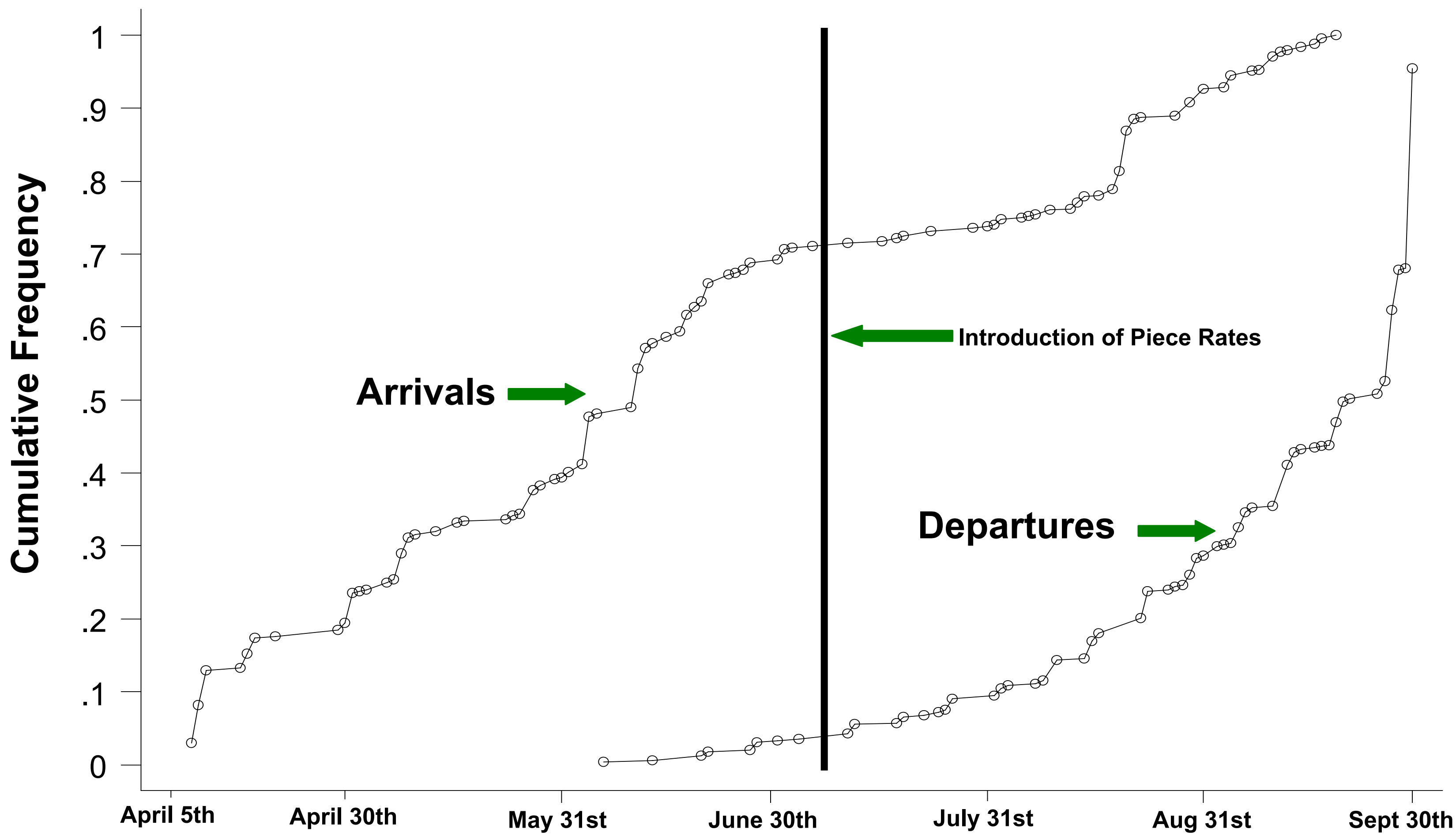


Figure 2: Distribution of Productivity (kg/hr) by Incentive Scheme



Notes: In figure 1, 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 2 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

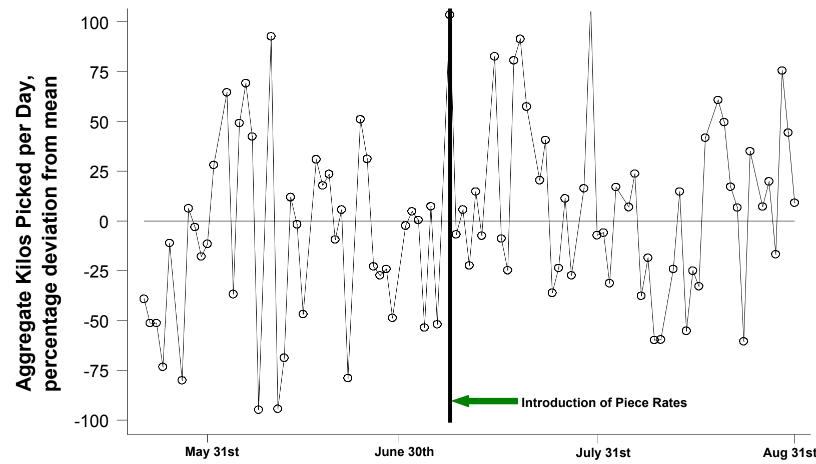


Figure 4b: Aggregate Hours Worked Per Day Over the Season

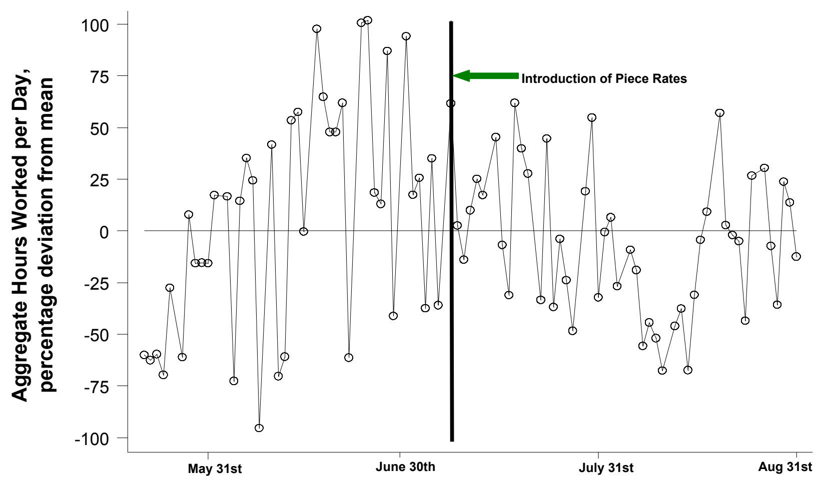
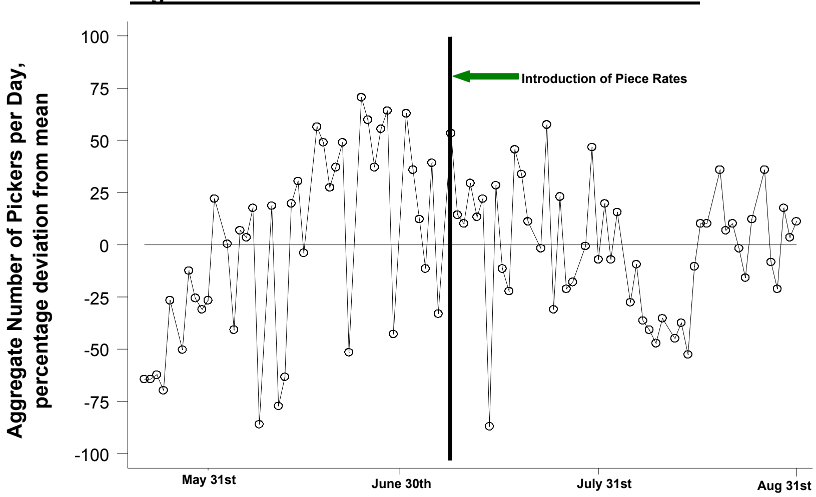


Figure 4c: Total Number of Pickers Over the Season



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

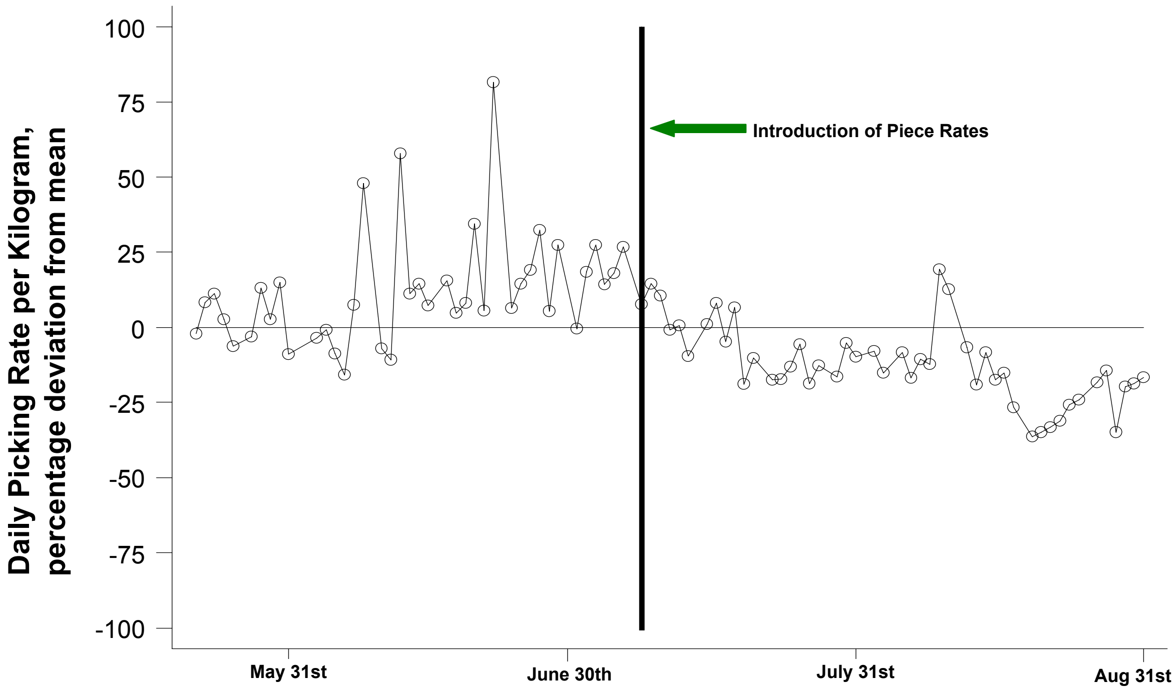
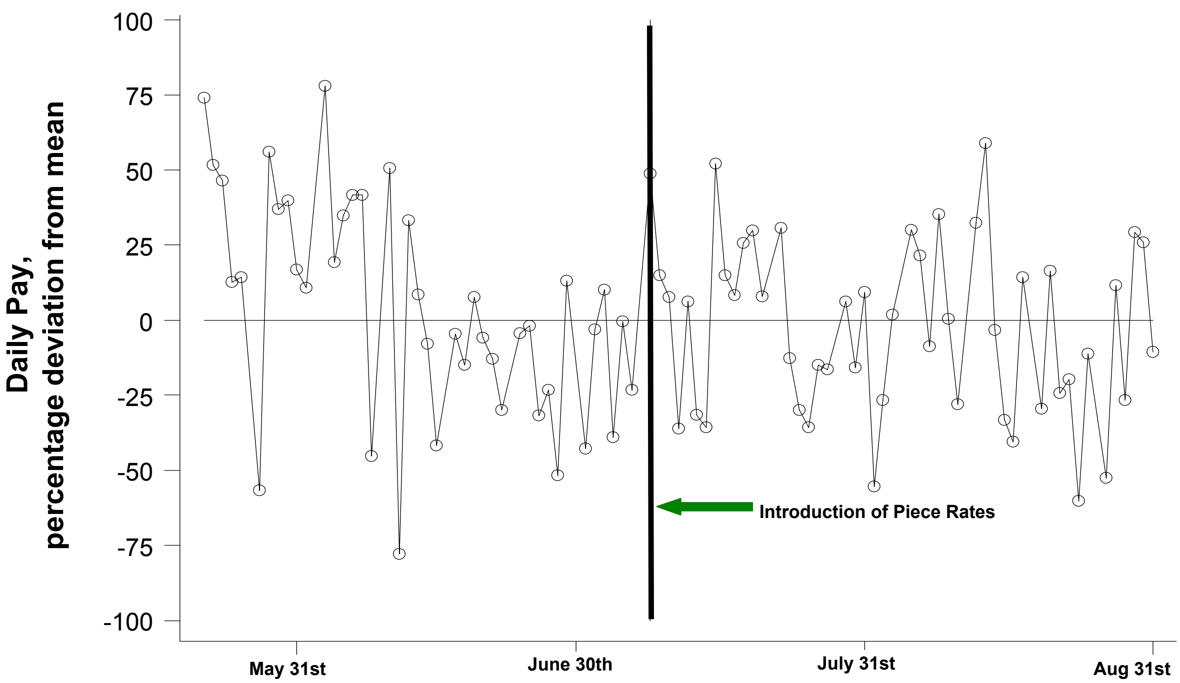


Figure 5b: Daily Pay Over the Season



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

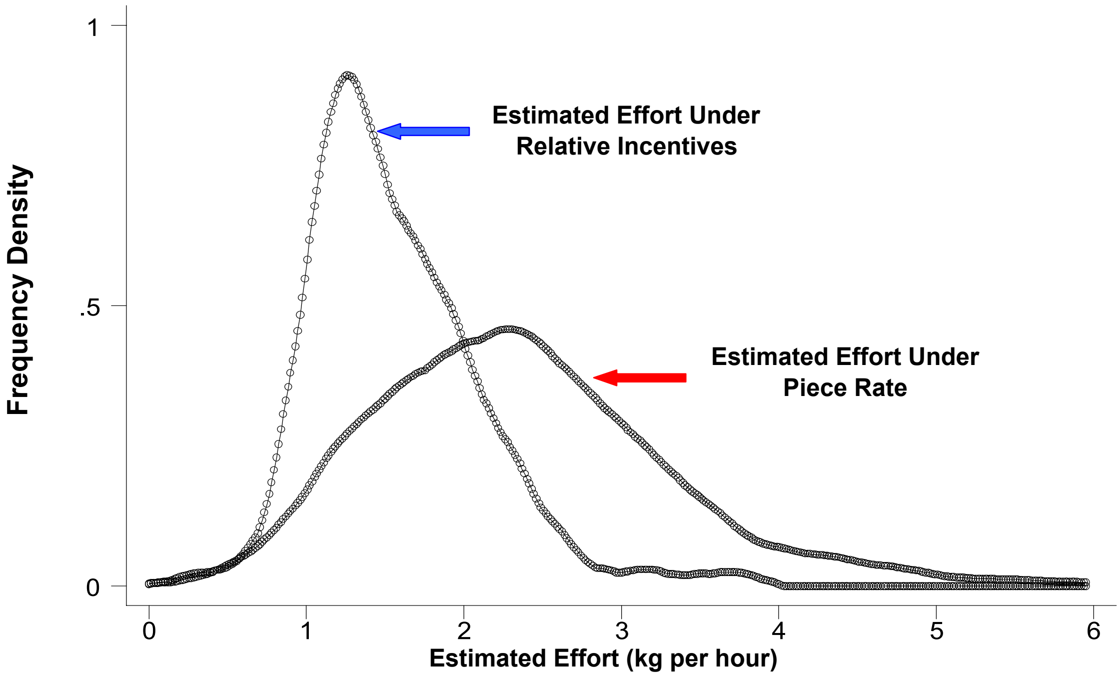
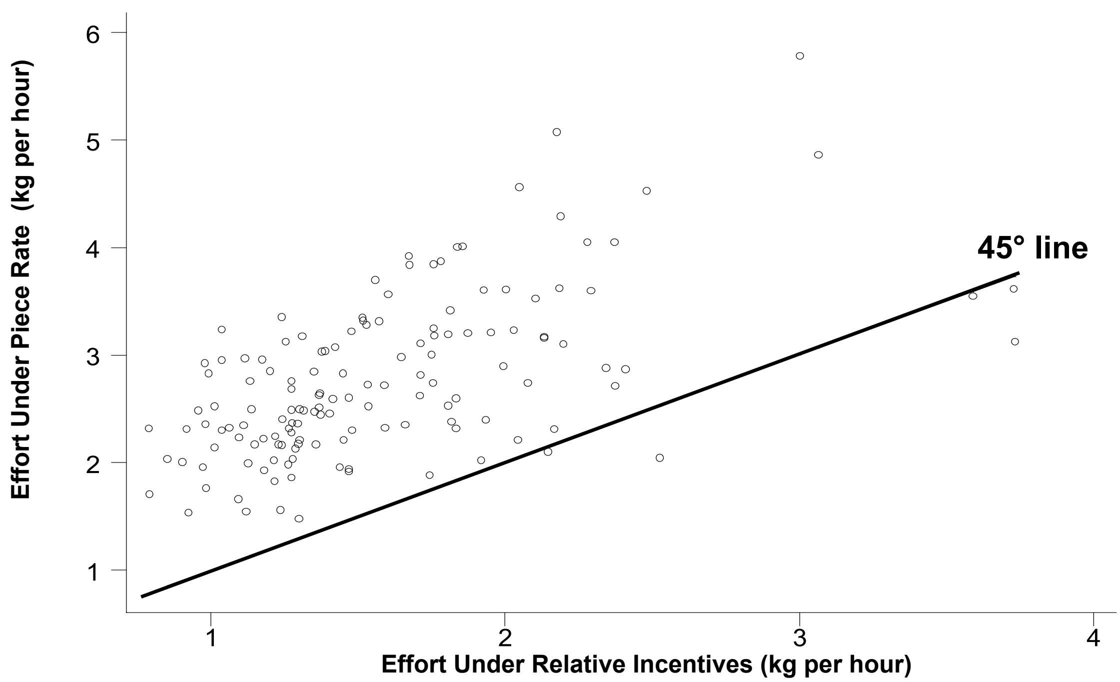


Figure 6b: Scatter Plot of Efforts in the Two Incentive Schemes



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

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

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

Figure 7a: Residuals by Incentive Scheme

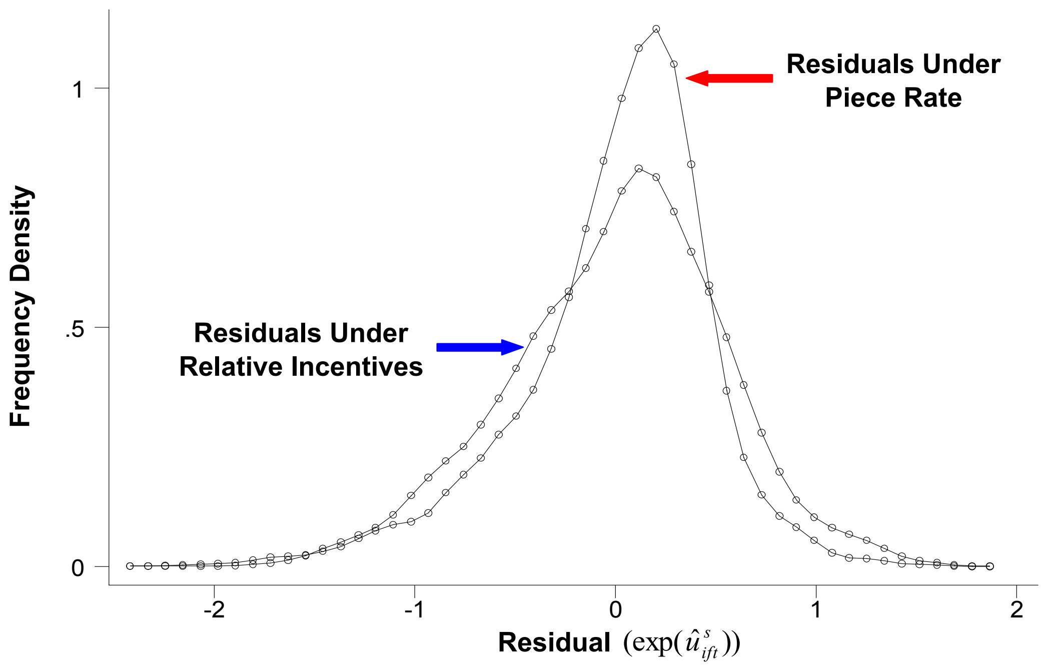
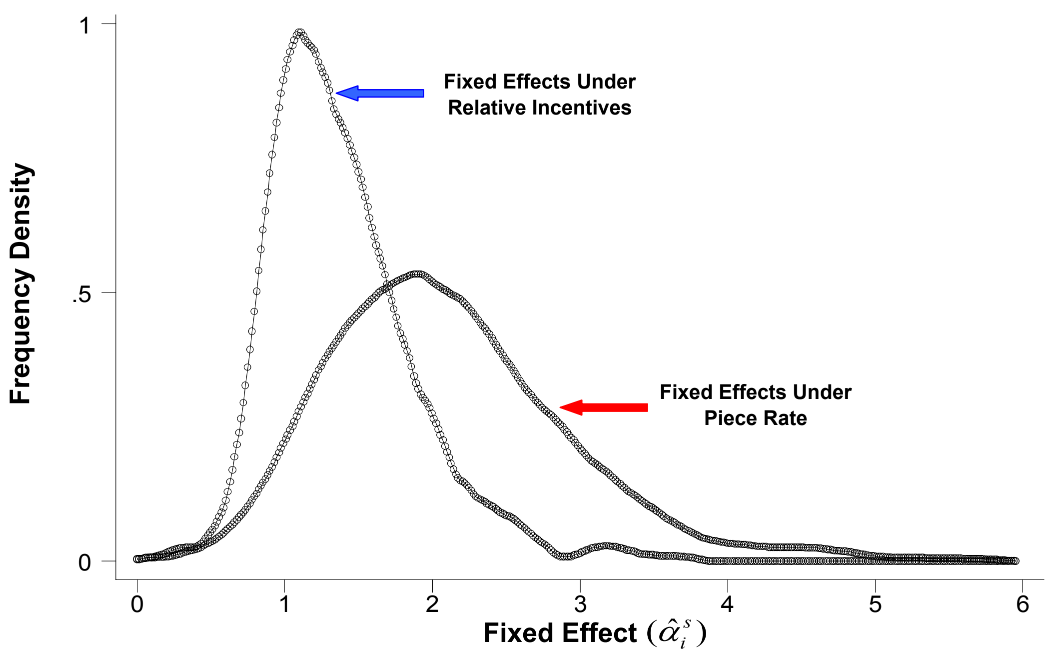


Figure 7b: Kernel Density Estimates of Fixed Effects by Incentive Scheme



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 Cost of Effort Parameter, by Incentive Scheme Assuming Individualistic Behavior

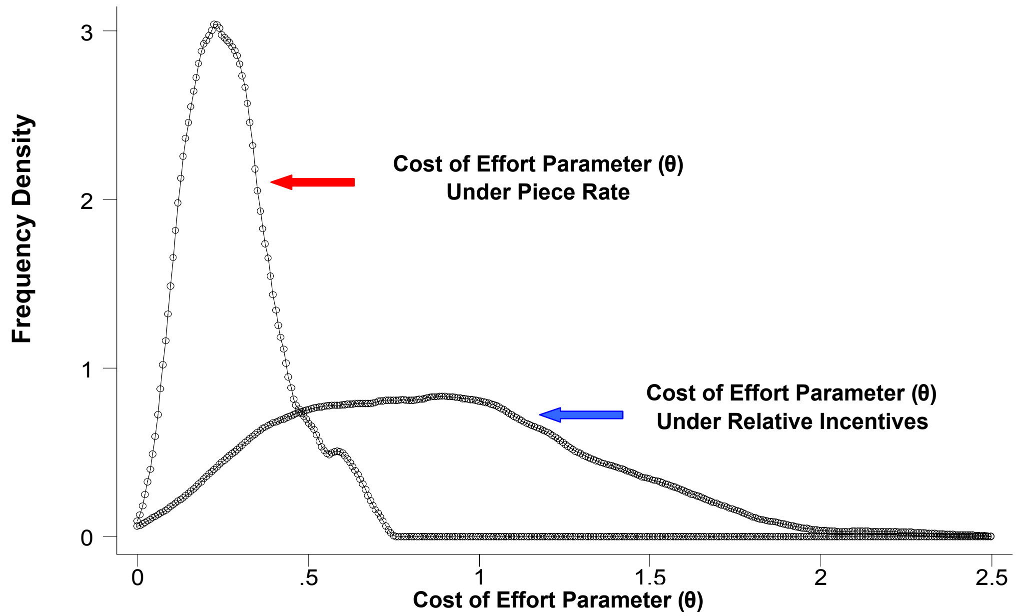
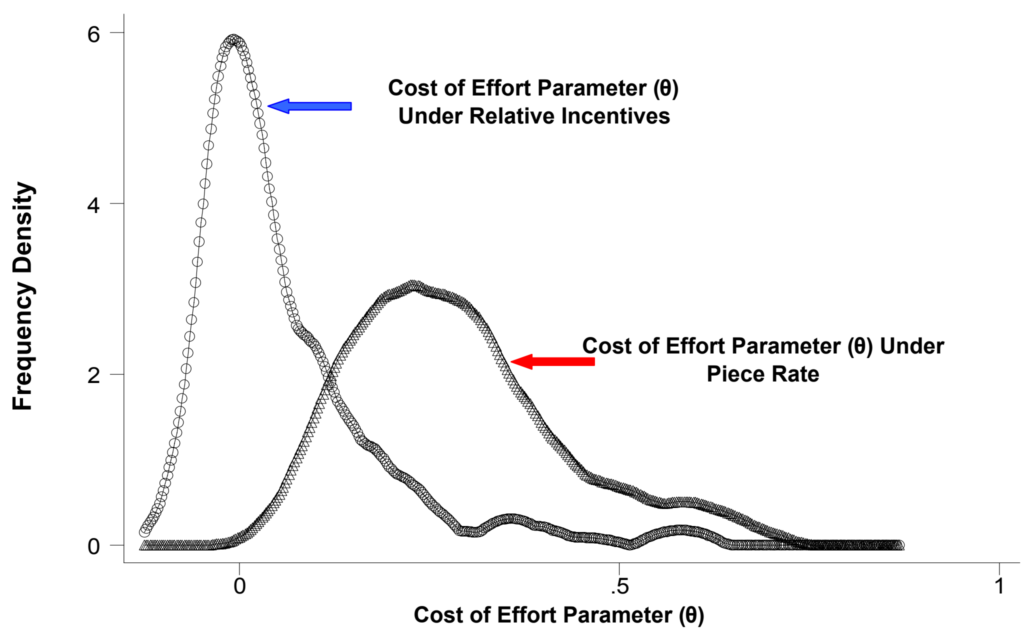


Figure 8b: Kernel Density Estimates of Cost of Effort Parameter, by Incentive Scheme Assuming Cooperative Behavior

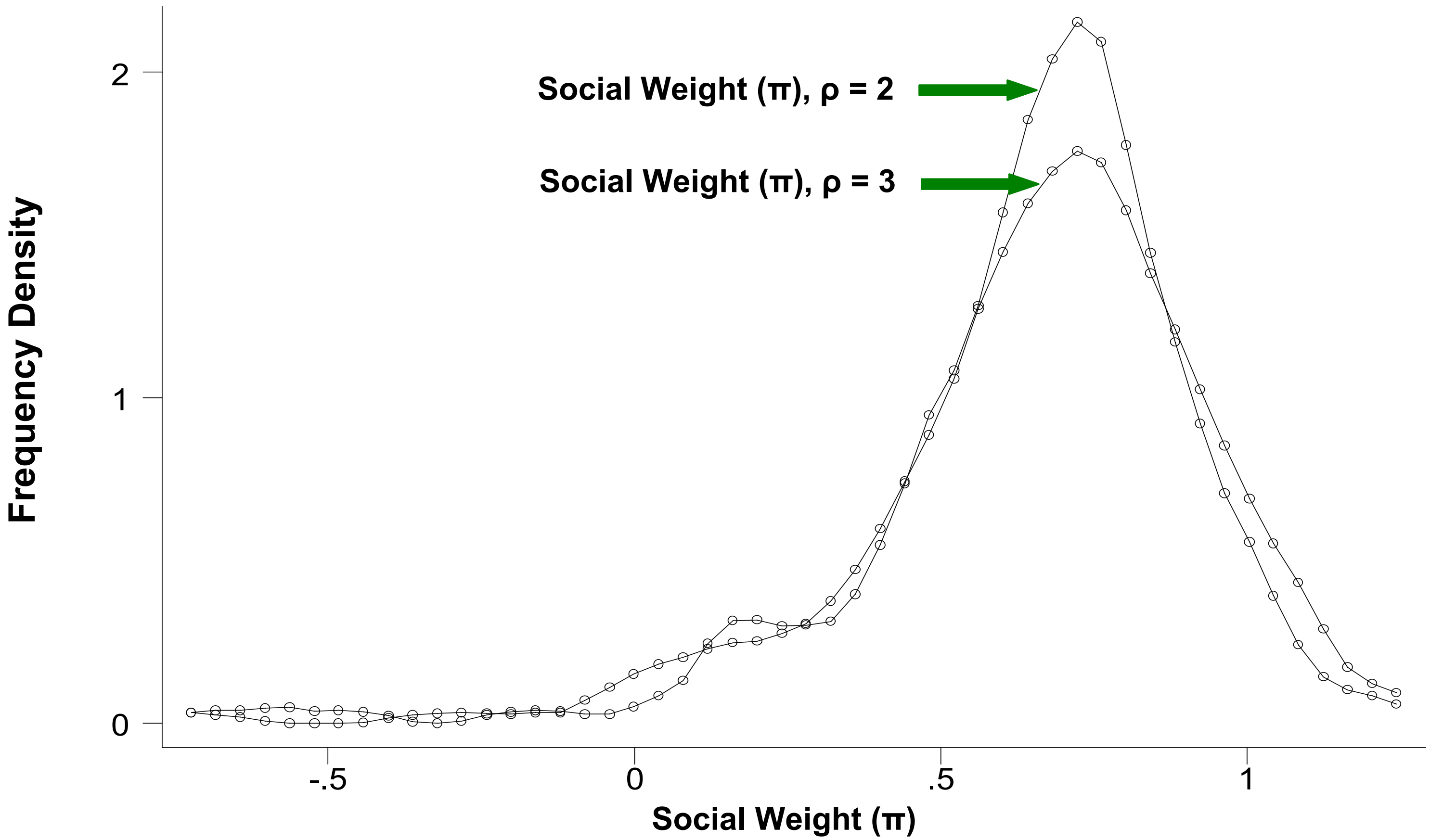


Notes: Kernel density estimates are calculated using an Epanechnikov kernel. The underlying benefit function is assumed to be;

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

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 and other Farm Variables.

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

	Relative Incentives	Piece Rates	Difference
Worker Productivity	5.01 (.243) [4.53, 5.49]	7.98 (.208) [7.57, 8.39]	2.97***
Kilos Picked Per Day	Confidential		23.2***
Hours Worked Per Day	Confidential		-.475
Group Size	41.1 (2.38)	38.1 (1.29)	-3.11
Daily Pay	Confidential		1.80
Rate per Kilogram Picked	Confidential		-.105***

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. Daily pay refers to pay from picking only. Some information in the table is not shown due to confidentiality requirements.

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***	.515***	.460***	.577***
	(.059)	(.056)	(.070)	(.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: Econometric Concerns - Spurious Time Effects

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) Main Fields	(3) Twenty Days	(4) Fake Piece Rate: Fields	(5) Fake Piece Rate: Workers
Piece rate	.644***	.610***	.387***		
	(.113)	(.070)	(.110)		
Fake piece rate based on field life cycle				.156	
				(.196)	
Fake piece rate based on number of days present on the farm					-.009
					(.091)
Worker fixed effects	Yes	Yes	Yes	Yes	Yes
Field fixed effects	Yes	Yes	Yes	Yes	Yes
Other Controls	Yes	No	No	Yes	Yes
Adjusted R-squared	.3704	.4032	.2922	.4927	.5921
Number of observations (worker-field-day)	7077	3404	2969	2863	879

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 the two main fields operated on over the season. The sample in column 3 is restricted to 10 days either side of the change in incentive schemes. Other controls include worker picking experience, field life cycle, and a linear time trend.

Table 4: Econometric Concerns - Endogenous Responses

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) Anticipation	(2) Drop Last 10 Days Under Relative Incentives	(3) Drop First 10 Days Under Piece Rate	(4) Last Week	(5) 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)				
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
Field fixed effects	Yes	Yes	Yes	Yes	Yes
Other Controls	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	.3665	.3813	.4245	.3640	.3950
Number of observations (worker-field-day)	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. 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 5: 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 6: 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] x 10^{-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.