The Minimum Wage and Worker Productivity: A Case Study of California Strawberry Pickers

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Abstract

This paper investigates how the minimum wage and piece rate wages interact to affect worker productivity. Piece rate wages are a common payment type in industries where supervision is costly relative to directly measuring output. For piece rate workers, the minimum wage sets a lower bound on their hourly earnings. In this paper, I use timestamp and payroll data from a California strawberry producer to examine how a minimum wage change affects worker productivity in the short and long-run. Preliminary results indicate that after the minimum wage increase, the lowest productivity workers become significantly less productive, compared with medium and high productivity workers.

Contents

1 Introduction

Over the next five years the minimum wage in California is set to increase incrementally until reaching \$15.00 per hour in 2022. Throughout the state, employers in low-wage industries have expressed concerns about their abilities to stay in business amid the skyrocketing costs of labor. In the agricultural sector, the recent passage of AB-1066 has intensified these growing concerns. Signed into law in September 2016, the bill mandates a gradual phase-in of new overtime laws for California agricultural workers. The status quo in overtime laws for California agricultural workers requires that employers pay at least 1.5 times the normal wage rate for any hours above 10 in a day or 60 in a week. By 2022, AB-1066 lowers this threshold to eight hours in a day or 40 hours in a week. Additionally, farmers will be required to pay at least double the regular rate for any working hours in excess of 12 hours in one day. Combined with increasing minimum wages, this bill will have substantial impacts on the agricultural labor market.

This paper investigates the potential effects of these legislations on worker productivity. I examine how previous changes in the minimum wage interact with piece rate wages to affect worker productivity. Piece rate wages are a common payment type in industries where supervision is costly relative to directly measuring output. Because of this, piece rate wages are very common in agriculture, particularly for harvesting. Minimum wages set a lower bound on the hourly wages for workers. This means that workers are paid whichever is highest: the minimum wage or their hourly piece rate. This paper begins by investigating productivity effects of these payment schemes with a theoretical model, then uses timestamp and payroll data from a California strawberry producer to examine how a minimum wage change affects worker productivity in the short-run.

There is a large theoretical literature on the productivity effects of payment schemes and optimal employment contracts. Most of these papers are founded constructed around the familiar theory model in which incentive pay evokes the highest levels of effort, but necessitates a task where effort is easily observable. The more influential of this literature builds off this model to examine predictors of optimal payment scheme, generally finding that firm heterogeneity can be explained by monitoring costs, asymmetric and hidden information, attitudes toward risk, the presence of collective bargaining, and, of course, job type (Gibbons, 1987; Lazear, 1986; Magnum, 1962; Robertson, 1960; and Stiglitz, 1975).

Despite the extensive theoretical literature surrounding payment schemes, empirical applications of comparable quality are sparse. Some exemplary studies use data from individual firms that change their payment method from hourly to piece rate and estimate changes in worker productivity (Bandiera, Barankay, & Rasul, 2004; Lazear, 2000; Paarsch & Shearer, 1999). These studies find positive productivity effects of the switch to piece rate payments, but acknowledge that this reflects both the incentives to productivity and selection into piece rate jobs. Later work has used data from multiple firms to separate these effects by controlling for individual and firm characteristics, and still finds that changing from fixed rates to piece rates increases worker effort (Pekkarinen & Riddell, 2006).

Empirical literature in the agricultural sector has found that local variation in both payment schemes and payment amounts allow for heterogenous workers to sort according to their comparative advantages (Foster & Rosenzweig, 1996 and Newman & Jarvis, 2000). Further, the literature suggests that piece rate payment schemes and on-farm employment increase worker effort compared with hourly wages and share-tenancy contracts (Foster & Rosenzweig, 1994). Much of this literature compares worker performance and earnings under two contract types that are offered by one or more employers. However, there is no literature that examines the common case in agriculture: employers choose to offer piece rate wages, but are bound to pay at least the minimum wage as a fixed rate.

This paper builds off the existing theoretical literature that compare the effects of hourly and piece rate payments on worker productivity. To the best of my knowledge, this is the first theoretical model and empirical application that incorporate an hourly minimum wage rate into a piece rate payment scheme. The theoretical model sets the minimum wage as a lower bound on the agricultural piece rate wage and depicts the expected productivity effects of an increase to the minimum wage. The theoretical model suggests that workers below and on the cusp of the prior minimum wage will become less productive in response to the minimum wage increase.

The empirical portion of this paper builds off of previous work that examines payment schemes in the agricultural sector, but rather than comparing piece rate and fixed payments, this paper examines how these payments interact. This paper uses a difference-in-differences regression to examine the heterogeneous effects of a minimum wage increase for workers along the productivity distribution. These unique data come from a California strawberry producer and are ideal for this analysis for many reasons.

First, productivity is directly measured as the number of strawberry flats delivered over time. Second, there is substantial variation in worker productivity over time, location, and worker. Finally, and importantly for this analysis, piece rate payments are low enough and some workers pick slow enough so that workers frequently fall below the minimum wage, but they are not fired for doing so.[1] The preliminary results from the empirical analysis indicate that after the minimum wage increase, the lowest productivity workers become significantly less productive, compared with medium and high productivity workers.

Finally, this paper frames these results in the current policy arena to determine the potential productivity losses from California's minimum wage increases. The paper concludes with a discussion of optimal producer response to these new policies.

2 Theoretical Framework

I use a principal-agent model where employers are easily able to measure worker output, but not necessarily effort. Workers have a utility function, $U(e, w(q))$ that depends on effort, e, and wages, w, which depend on hourly output, q. I assume that output, $q(e, s, \theta)$ is a function of effort, skill s, and external factors θ. These external factors can be thought of as temperature, abundance of harvest, or number of days working without a break. I assume that output is increasing at a decreasing rate in both effort and skill, i.e. $q_e,\ q_s > 0$ and $q_{ee},\ q_{ss} < 0$. Additionally, marginal output is assumed to be increasing across effort and

[1]Some employers will fire workers for persistently falling below the minimum wage, but this producer does not. This analysis is thus able to examine productivity effects even for the workers who repeatedly fall below the minimum wage.

skill, $q_{es},\ q_{se} > 0$. The worker's unconstrained utility maximization problem is:

$$\max_{e} U = w(q(e,s,\theta)) - c(e) \tag{1}$$

I assume that crew managers demand a certain minimum productivity level for their workers. Because crew managers cannot measure worker effort, this productivity threshold is a minimum hourly output, $\underline{q}(\theta)$, that varies with external conditions. In this context, a simple interpretation of θ is harvest abundance. At the peak of the harvest season, crew managers will have a higher productivity threshold than at the tails of the season. This minimum productivity level is formally represented by a constraint to the utility maximization problem, such that $q(e,s,\theta) \geq \underline{q}(\theta) \geq 0$. The worker's constrained optimization problem can be represented as:

$$\max_{e} U = w(q(e,s,\theta)) - c(e) - \lambda[\underline{q}(\theta) - q(e,s,\theta)], \tag{2}$$

where $\lambda \geq 0$. Taking the derivative with respect to e yields the first order condition:

$$w_q q_e + \lambda q_e = c'. \tag{3}$$

When $\lambda = 0$, so that $q(e,s,\theta) > \underline{q}(\theta)$, the worker's optimal effort will be such that the marginal cost equals the marginal benefit. When $\lambda > 0$, and the minimum output constraint binds so that $q(e,s,\theta) = \underline{q}(\theta)$, then the worker chooses the minimum level of effort that yields $\underline{q}(\theta)$.

Under a pure piece rate payment, the wages can be expressed as a linear contract where the hourly wage rate is equal to hourly output times the piece rate wage, $w = r \cdot q$. Under this contract, I can rewrite the first order conditions from (2) as: $r \cdot q_e = c'$. When the minimum wage and piece rate wages interact, the wages can be expressed as a linear contract with a price floor, so that $w = \max\{\underline{w_0}, r \cdot q\}$, where $\underline{w_0}$ is the minimum wage at time 0. When the minimum wage exists, the worker's first order conditions become:

$$
\begin{aligned}
\lambda q_e = c' \quad if \quad \underline{w_0} \geq r \cdot q^*; \lambda \geq 0 \\
r \cdot q_e + \lambda q_e = c' \quad if \quad \underline{w_0} < r \cdot q^*; \lambda \geq 0
\end{aligned}
\tag{4}
$$

My objective is to analyze changes in optimal worker effort and output when the minimum wage increases to $\underline{w_1}$. I consider workers of three distinct productivity types: high h, medium m, and low l. These workers are defined so that low-types receive the minimum wage when it is set at $\underline{w_0}$, medium-types receive the minimum wage when it is set at $\underline{w_1}$, and high-types never receive the minimum wage. Formally, this means that for low-types $\underline{w_0} \geq r \cdot q_l^*$, for medium-types $\underline{w_0} < r \cdot q_m^* \leq \underline{w_1}$, and for high-types $\underline{w_1} < r \cdot q_h^*$.

Figure 1 depicts example utility curves for these workers. Panel (a) shows optimal output and hourly wages under pure piece rate payments. Panel (b) shows optimal output and hourly wages under piece rate with a minimum wage. There are several important assumptions underlying these figures. First, the worker skill acts as a shifter for the utility curves,

Figure 1: Utility Curves and Optimal Wages

(a) Pure Piece Rate

(b) Minimum Wage and Piece Rate

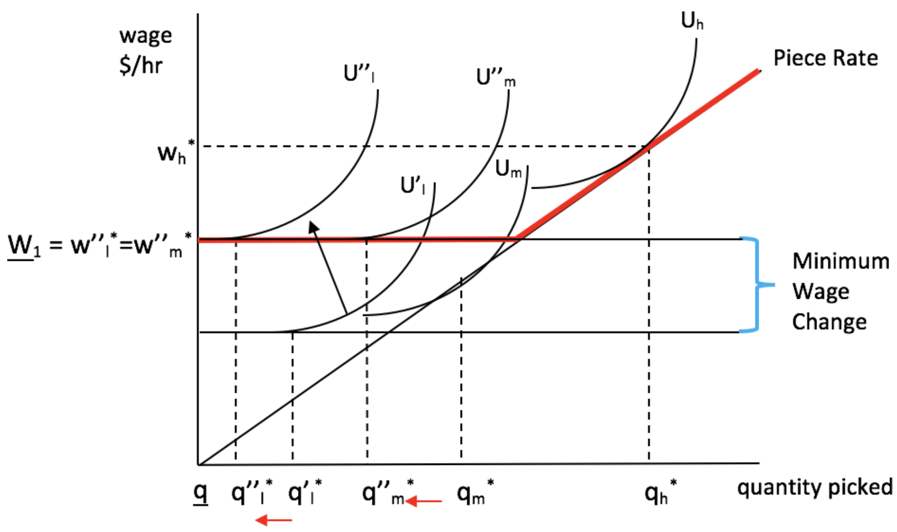
so that higher skilled workers have higher output at a lower cost. Second, the external factors, θ, are constant in each figure. Finally, the optimal wages and output depicted in these figures are determined from each worker type choosing effort e^* that maximizes utility and generates output q^*.

Under pure piece rate wages, all workers earn hourly wages that are directly proportional to their hourly output. Under the minimum wage, however, low-types have higher utility from accepting the minimum wage and exerting less effort. Panel (b) depicts these workers reducing output, but still producing above the lowest acceptable output, $\underline{q}(\theta)$, when offered the minimum wage.[2]

Figure 2 demonstrates the effects of an increase to the minimum wage on optimal worker

[2] Alternatively, these workers may decrease in productivity enough to reach the lowest acceptable output, but for simplicity I have shown the case where they still produce above the minimum. These figures depict the case where $\underline{q}$ is a negativity constraint, i.e. productivity must be positive.

Figure 2: Utility Curves and Optimal Wages with a Minimum Wage Increase



productivity and wages. After the minimum wage increase both low and medium productivity workers receive the minimum wage and both reduce their productivity. High-types are unaffected, maintaining the same output and wages after the minimum wage increase.

3 Data

The data for this paper comes from a large California strawberry producer. For three farms in California, from 2010 - 2016, I have daily productivity and payroll data. In the productivity data, for each day, I have a farmworker ID that can be tracked across days and years, time clocked in and out, a timestamp at the time of each flat delivery, the time and length of breaks, the time of a task switch, the worker's crew number, and a field identifier. In the payroll data, for each worker I have a farmworker ID that can be linked to the productivity data, total daily hours for each task, total flats of each type delivered, the piece rate wage,

Table 1: Number of Workers in the BVR Data

Year	Total Observations	Unique Farmworkers	Unique Pickers
2010	41,955	651	548
2011	71,617	920	826
2012	64,240	1,128	1,002
2013	65,500	1,398	1,092
2014	85,463	1,544	1,232
2015	105,808	2,422	1,787
2016	60,220	2,594	1,527
Total	494,803	6,676	5,020

and the hourly wage rate (calculated if the worker is not paid hourly).

Tables 1 and 2 present summary statistics from the payroll data for Buena Ventura Ranch, a 211 acre berry farm in Watsonville. There are a total of 5,020 unique strawberry pickers in the dataset. The number of pickers double from 2010 to 2012, and substantially increase from 2014 to 2015 as the farming operation expands. In 2016, the payroll service changes some aspects of their record keeping and, as an effect, the total number of observations drops, but the number of farmworkers and pickers only change slightly.

The wage rates, described in table 2, warrant significant discussion. Buena Ventura Ranch has several different categories of strawberries for payroll purposes. From 2010 through 2013 the only two varieties are regular and stem. Regular strawberries make up a majority of what is harvested and are the common strawberries bought at the store. Stems are a larger variety of strawberries that are sold to specialty stores (usually to be dipped in chocolate). These make up a very small proportion of the harvest, but workers are paid a higher rate for these berries. Workers who pick stem berries will almost always pick regular berries in the same day, and thus the payroll data will separately record two piece rates for the same worker on the same day. The piece rate for these berries is higher because they are sold at a higher rate and because they take longer to pick. Beginning in 2014, the farm begins producing Albion and Monterey Strawberries, and workers are again paid a higher rate to pick these specialty berries.

In 2010, the piece rate payment for regular strawberries was \$1.60 per box, and the rate for stem strawberries was \$2.00 per box. In 2011, the rates remained the same until early October, when the rate for picking regular berries increased to \$1.85 per box. This price increase compensates workers for the decreased productivity at the tail end of the harvest season. The following years in the data have similar payment schemes, with fluctuations in both the regular and stem rates based on year and season.

Another component of the payroll data is the incorporation of minimum wage. If a worker does not pick quickly enough, then they receive a minimum wage adjustment. In the payroll data, this is recorded as a lump sum addition to their daily earnings.

The minimum wage adjustment is very common in the data. Table 3 gives the percent of pickers who receive the minimum wage adjustment each year. The proportion of workers who need the adjustment is decreasing until 2013, then increases in 2014, and falls again in 2015.[3] For each year in the data, more than half of the pickers need the minimum wage adjustment at least one day of the year, and most need the adjustment several times.

[3]In 2016, the payroll service changed how they record the minimum wage adjustment, making it difficult to discern in the data.

Table 2: Productivity and Payment in BVR Data

Year	Rate per flat ($)		Daily Flats Delivered		Hourly Rate ($/hr)	
	Mean	Min/Max	Mean	Min/Max	Mean	Min/Max
2010	1.600248	Min: 1.60	38.21516	Min: 1	10.07174	Min: 0
	(.0099546)	Max: 2.00	(28.96382)	Max: 167	(5.568873)	Max: 60
2011	1.73344	Min: 1.60	26.74861	Min: 1	10.31373	Min: 0
	(.1390734)	Max: 2.00	(25.68252)	Max: 189	(5.337991)	Max: 137.65
2012	1.793428	Min: 1.60	30.96071	Min: 1	11.5886	Min: 0
	(.1747379)	Max: 2.15	(24.03777)	Max: 151	(5.420669)	Max: 120
2013	1.86867	Min: 1.75	29.37916	Min: 1	12.98426	Min: 0
	(.1372378)	Max: 2.15	(21.40745)	Max: 122	(6.069684)	Max: 150
2014	2.392867	Min: 1.75	26.34518	Min: 1	11.73224	Min: 0
	(.5767778)	Max: 3.00	(24.50153)	Max: 156	(6.442391)	Max: 175
2015	1.848573	Min: 1.75	24.88477	Min: 1	15.90119	Min: 0
	(.2101492)	Max: 3.00	(18.37097)	Max: 138	(6.421071)	Max: 153.13
2016	1.895148	Min: 1.85	33.73233	Min: 1	17.77925	Min: 0
	(.0923053)	Max: 2.20	(23.53863)	Max: 150	(5.165823)	Max: 82.5

Table 3: Percent of Workers Receiving the Minimum Wage Adjustment

Year	At Least 1 Time	At Least 3 Times	5+
2010	96.35	93.98	91.06
2011	91.28	83.29	78.09
2012	83.33	72.75	67.66
2013	70.79	59.34	52.11
2014	85.88	73.62	67.21
2015	67.82	52.21	44.10

4 Contextual Background

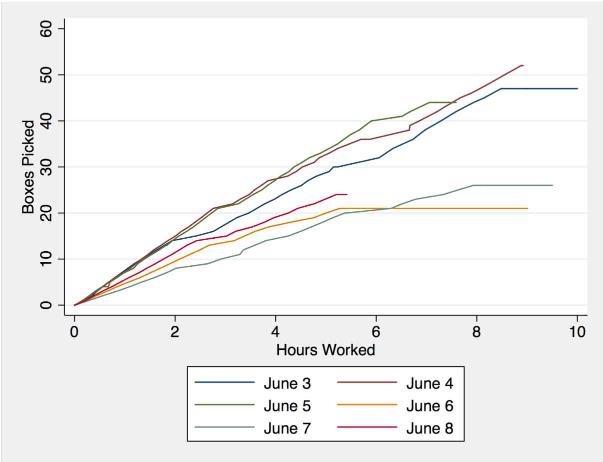
In my empirical analysis, I take advantage of a policy change to examine the effects of an increase to the minimum wage without a concurrent increase in the piece rate wage. On June 10, 2013, the minimum hourly wage rate for workers in the dataset increased from $8.80 to $9.05 per hour. I examine the immediate effects of this payment change on strawberry pickers who are paid piece rate per box of strawberries delivered. I segment the workforce into low, medium, and high productivity workers based on their average hourly piece rate wages before the minimum wage increase. Low-types have average hourly wages below $8.80, medium-types have average wages between $8.80 and $9.05, and high-types have average wages above $9.05.

To illustrate the differences in productivity between these workers, Figures 3, 4, and 5 show the productivity of three example workers, one from each productivity type, over the week prior to and the week of the minimum wage increase. These figures plot the total boxes of strawberries delivered by three different workers over the number of hours they have been working. When these curves are completely flat, the worker is either on a break or is switched to a different task.[4]

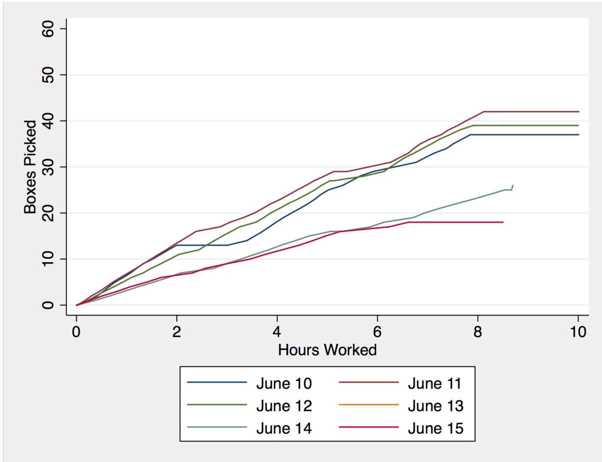
A notable difference between workers in the three categories is in their workweek productivity trends. The productivity of low and medium-type workers deteriorates over the course of a week, while the high-types exhibit little variation in their daily productivity. These

[4]Switching tasks within a day is fairly common in the data, and most frequently workers are switched to weeding. All tasks besides picking are paid hourly rates.

Figure 3: Example Low-Type Productivity



(a) Week Before Minimum Wage Change

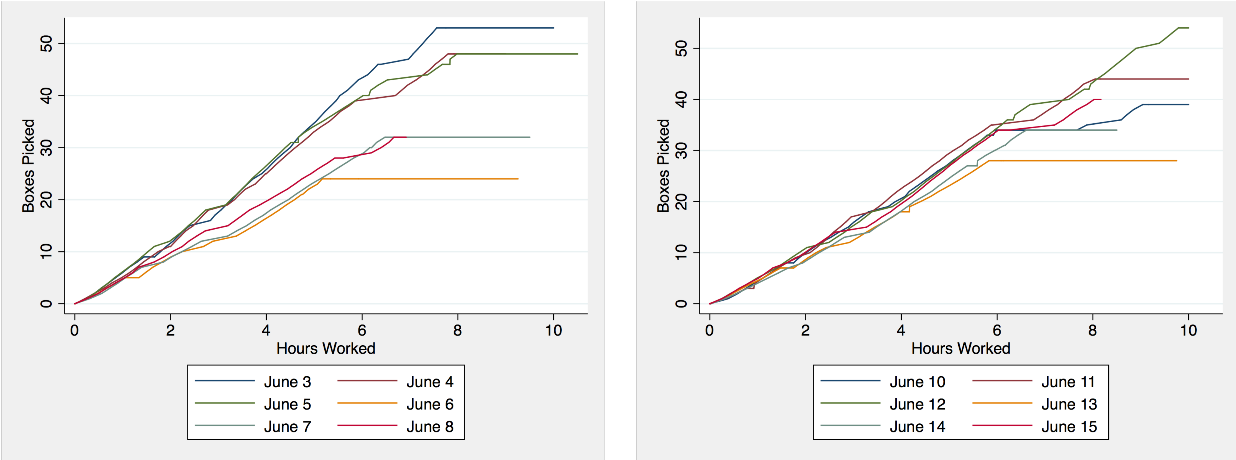


(b) Week After Minimum Wage Change

figures only provide a snapshot of the productivity of these workers, but are representative. Workers usually work 6 days a week (Monday through Saturday), and after their day off, the less productive workers return with a large productivity boost which slowly deteriorates throughout the workweek. The most productive workers, on the other hand, remain fairly consistent in their productivity across a workweek.

These workweek trends in productivity make it difficult to compare productivity responses to the minimum wage change across worker skill categories. Figures 3 and 4 reveal some decrease in worker productivity in the week following the minimum wage increase, while figure 5 shows a small productivity boost. The effects of the minimum wage change are demonstrated more clearly by comparing the productivity of the workers on each day before the minimum wage increase with their productivity on the same day in the week after the change, e.g. Monday, June 3rd with Monday June 10th.

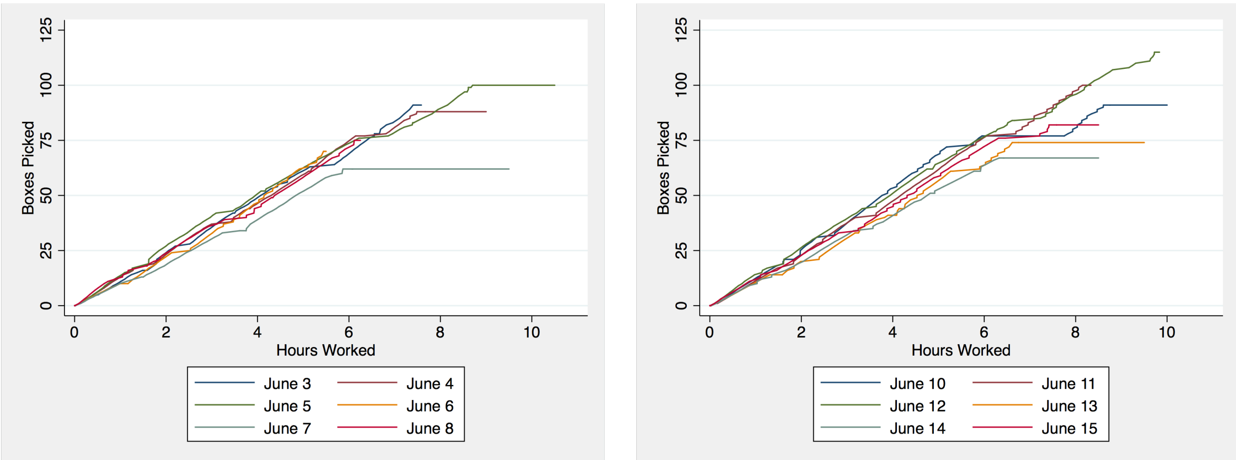
Figure 4: Example Medium-Type Productivity



(a) Week Before Minimum Wage Change

(b) Week After Minimum Wage Change

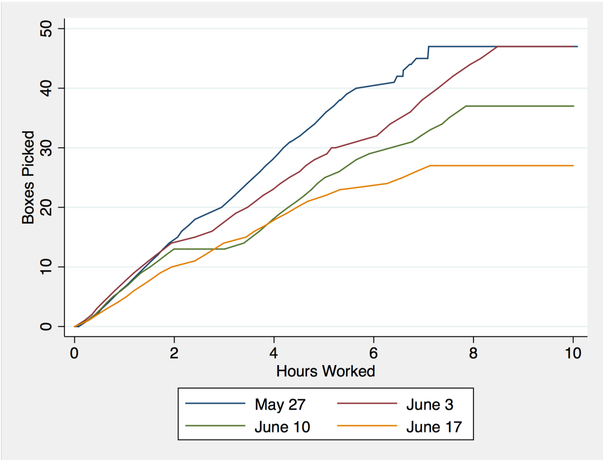
Figure 5: Example High-Type Productivity



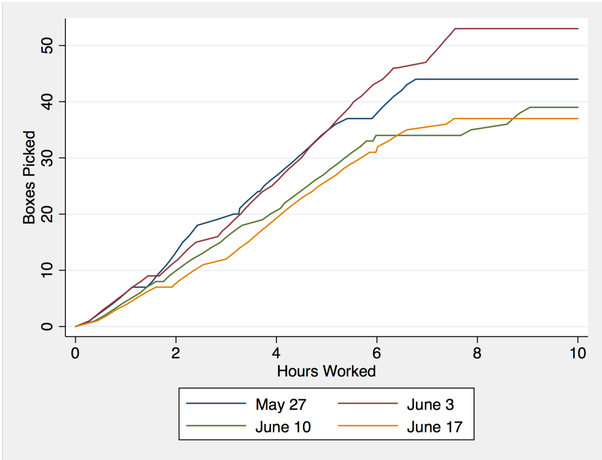
(a) Week Before Minimum Wage Change

(b) Week After Minimum Wage Change

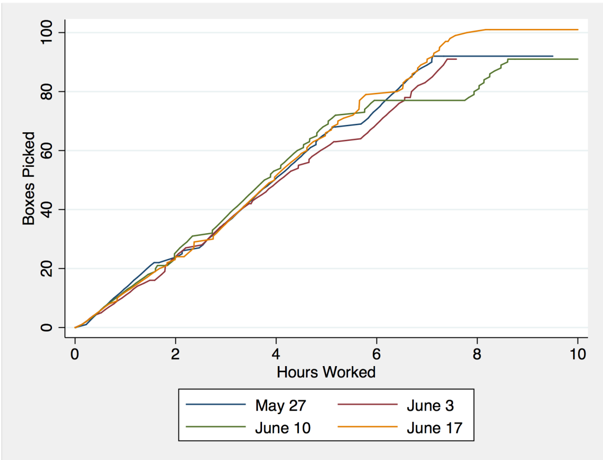
Figure 6: Monday Productivity



(a) Low Productivity Worker



(b) Medium Productivity Worker



(c) High Productivity Worker

Figure 6 compares the Monday productivity for these same three workers for the four weeks surrounding the minimum wage increase. Panels (a) and (b) show that the low and medium types used for this example have lower productivity curves following the minimum wage increase, while the productivity of the high-type worker remains constant. These graphs provide a strong motivation for the analysis that will follow. I use a difference-in-difference analysis that treats the high productivity workers as the control group and compares the change in productivity for these workers with the changes for medium and low types. The difficulty in this analysis will arise from what I include in the external factors, θ in the theoretical framework. Some relevant external factors may be correlated with worker type in a way that confounds the comparison between groups. To counter this, I will control for the field that workers are picking on, the crew they are assigned to, and the number of days working without a break.

5 Empirical Methodology

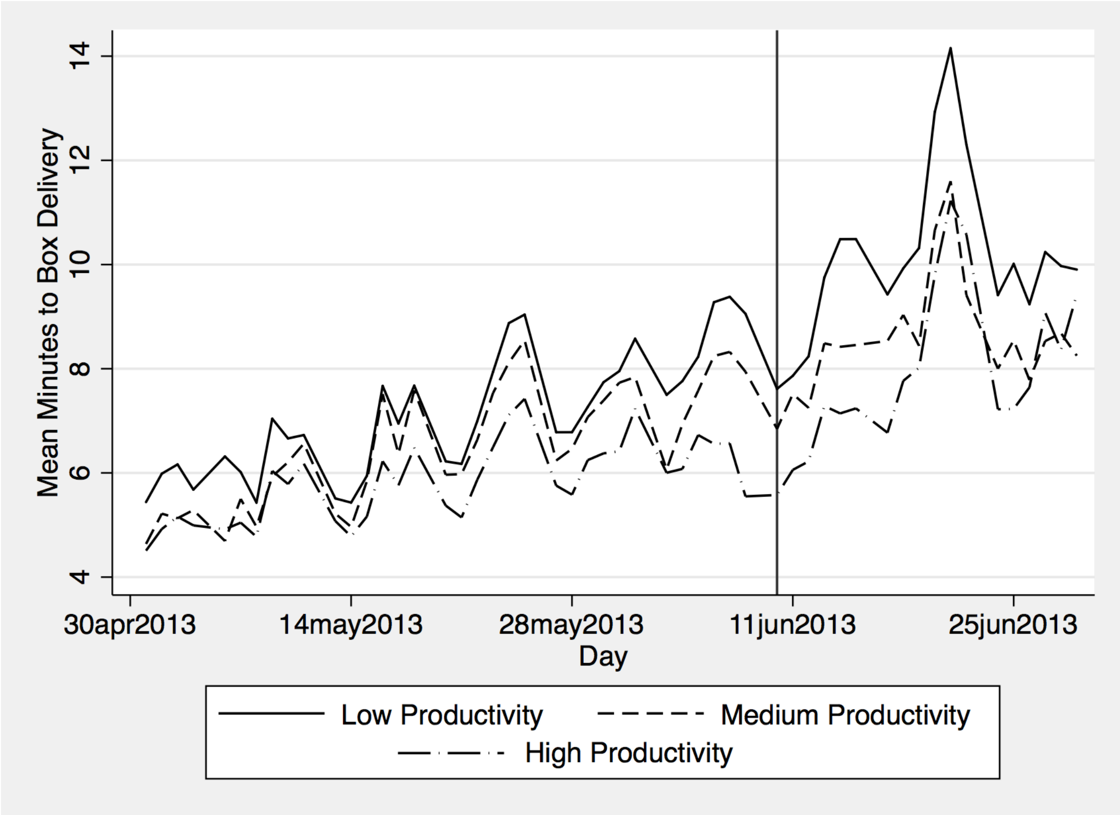
This analysis will use a simple difference-in-differences regression approach to compare the effects of the minimum wage change across these three categories of workers — low, medium, and high productivity. To capture effects of harvest abundance and account for the trends in workweek productivity, I include data over the two months surrounding the minimum wage change. The model can be represented as:

$$
\begin{aligned}
y_{it} = \beta_0 + \beta_1 t + \beta_2 L_i + \beta_3 M_i + \beta_4 dow_t + \beta_5 (L_i \cdot dow_t) + \beta_6 (M_i \cdot dow_t) \\
+ \beta_7 crew_i + \delta_1 Post_t + \delta_2 (L_i \cdot Post_t) + \delta_3 (M_i \cdot Post_t) + \epsilon_{it}
\end{aligned}
\tag{5}
$$

Where y_{it} is the mean time in minutes for worker i to deliver a box of strawberries on day t, t is a time trend, dow_t is a control variable for the day of the week (this is additionally interacted with worker type), $crew_i$ controls for characteristics of the worker's crew, $Post_t$ is a binary indicator variable equal to one for all days after the minimum wage change (June 10), and L_i and M_i indicate whether worker i is a low or medium type, respectively. $(L_i \cdot Post_t)$ and $(M_i \cdot Post_t)$ are interaction terms equal to one when the worker is of productivity type L or M, respectively, and in the post minimum wage change time period. In this regression equation, the parameter δ_2 gives the differences-in-differences estimate of the effect of the minimum wage change on the productivity of low-type workers, and δ_3 give this estimate for medium-type workers. Positive coefficients indicate increases in the time to deliver a box of strawberries, and represent decreases in productivity.

Figure 7 shows the average daily productivity for these three worker types for the months of May and June in 2013. For this figure, the workers were categorized into low, medium, and high types based on their average daily piece rate earnings the day before the minimum wage change (June 8). The solid vertical line is on the day of the minimum wage change. The workers appear to diverge in productivity beginning the week leading up to the minimum wage change. After the change, there is not a clear shift in their relative productivities.

Figure 7: May and June, 2013, Worker Productivity



Despite this, the preliminary regression results given in Table 4 indicate that there is a significant effect of the minimum wage change on the productivity of low-type workers. Table 4 gives regression results from Equation (5), including different control variables. Column (1) gives the results before including the time trend, day of the week, and crew control variables. These regression results show that low and medium type workers are significantly slower than high-types, which is not surprising. Column (1) also shows that the minimum wage change is associated with a decrease in productivity for all types, with a larger decrease for low-type workers. After adding the time trend, however, the minimum wage change only has a significant effect on the productivity of low-type workers.

The results in Columns (2) and (3) that control for the time trend and day of the week, respectively, are very similar. Both find similar baseline differences in productivity between the worker types and a significant productivity loss for low-types only after the minimum wage change. Finally, Column (4) gives the regression results after controlling for the worker crew. The worker crew is an important indicator for field factors that may affect productivity, such as harvest abundance, and is thus important to control for. However, workers tend to be grouped into crews with workers of similar productivity levels, so including crew in the regression also controls for many of the productivity differences between the worker types.

In the regression results in Column (4), the baseline differences in productivity between the workers disappear, but the minimum wage change still significantly decreases the productivity of low-type workers. These workers deliver a box of strawberries almost a minute slower as an effect of the change. In all of these regression specifications, there is no significant effect of the minimum wage change for medium-type workers.

There exist a number of avenues to improve the robustness of these findings. I plan to improve on these findings by considering alternative designations of the low-, medium-, and high-productivity workers. I will also include similar data from two other farms that adopt the new minimum wage at the same time. The results of the final analysis will elucidate the productivity differentials across worker types, demonstrated in Figure 7. These findings are important in the context of state and local policy changes for agricultural workers.

Table 4: Preliminary Diff-in-Diff Results

Variable	(1)	(2)	(3)	(4)
Type				
(High-types are base)				
Low	1.490***	1.205***	1.198***	0.416*
	(0.0910)	(0.0873)	(0.0856)	(0.182)
Medium	0.926***	0.564***	0.569***	0.0692
	(0.0939)	(0.0902)	(0.0885)	(0.187)
Min Wage Δ	2.087***	-0.317	-0.0998	0.0608
	(0.210)	(0.208)	(0.203)	(0.185)
Min Wage Δ·Type				
(High-types are base)				
Min Wage Δ·Low	0.832***	1.023***	1.026***	0.852***
	(0.215)	(0.206)	(0.200)	(0.183)
Min Wage Δ·Med	-0.202	0.101	0.100	-0.0500
	(0.219)	(0.209)	(0.203)	(0.186)
Controls Included:				
Time Trend	N	Y	Y	Y
Day of Week	N	N	Y	Y
Crew	N	N	N	Y
N	21,964	21,964	21,531	21,531
F-stat	1296.10	1511.65	1025.88	475.03
R^2	0.228	0.292	0.344	0.456

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

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