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Abstract: We examine worker effort as a potential margin of adjustment to a minimum wage hike using unique data on piece rate workers who perform a homogenous task and whose individual output is rigorously recorded. By employing a difference-in-differences strategy that exploits the increase in Florida's minimum wage from $6.79 to $7.21 on January 1, 2009, and worker location on the pre-2009 productivity distribution, we provide evidence consistent with incumbent workers' positive effort responses.

Key words: minimum wage; incentive; effort; labor productivity
JEL Codes: J20, J38, M50

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1. Introduction

Worker *effort* as a potential margin of adjustment to a minimum wage was raised in early studies such as Obenauer and von der Nienburg (1915) and Stigler (1946). Yet rigorous empirical investigation on this issue has been lacking in the literature, despite the significant progress made in recent decades on the minimum wage's (dis)employment effect.[1]

In this paper, we employ a direct and high frequency measure of individual worker productivity on a homogenous task to examine possible worker effort responses to a minimum wage increase. In particular, we use personnel records from a large tomato farm in Florida—where piece-rate workers hand-harvest tomatoes in the field—together with the change in the state minimum wage from $6.79 to $7.21 on January 1, 2009. In piece rate settings, the employer must make up any shortfall between a worker's raw productivity (output in dollars/hour) and the minimum wage for all work hours during a given pay period (in this context, one week).[2] Hence, firm's compliance costs increase with the minimum wage, which may (at least in part) be offset by the increased effort of low productivity workers.

This is a unique setting conducive to examining worker *effort* responses to a minimum wage increase for several reasons. First, due to the pay scheme being piece-rate based, the productivity of individual workers is rigorously recorded.[3] Not only do the workers clock in and out for each work spell, but an electronic system keeps track of their output in the field. Second, the minimum wage increase of January 1, 2009 occurs within a given harvesting season (autumn

[1] See Card and Krueger (1995), Brown (1999) and Neumark, Salas and Wascher (2014) for reviews, and Cengiz et al. (2019) and Harasztosi and Lindner (2019) for more recent evidence.
[2] Workers whose raw productivity (output in dollars/hour) is above the minimum wage get paid according to their actual output.
[3] One salient feature of this work environment is that the output of individual workers is readily *observable*, which is conducive to the adoption of a piece rate pay scheme (Lazear 1986).

2008 season), which allows us to compare the same worker's productivity before and after the hike. Third, the nature of the task and workforce allows us to rule out other potential determinants of worker productivity. In particular, hand-harvesting of fresh tomatoes is a low skilled, labor-intensive process and there is little scope for technological adjustments (e.g. shift towards capital) or innovation, at least in the short run (within season).[4] In addition, due to the seasonal nature of the harvesting task and high workforce turnover, firm investment in worker training (Acemoglu and Pischke 1999, 2003; Arulampalam, Booth and Bryan 2004; Dustmann and Schönberg 2009) is virtually nonexistent and largely irrelevant in this sector.

In order to isolate the effects of worker effort from external determinants of labor productivity (e.g. field lifecycle or weather), we employ a difference-in-differences (DID) strategy. Similar to Mas and Moretti (2009), we first capture each worker's "baseline" or "permanent" productivity by estimating their fixed effects using data from outside our main estimation window. We then look for possibly differential productivity changes of individual workers around January 1, 2009 by their baseline productivity. Using high productivity workers (who are always above the minimum wage either in the old or new regime) to difference out the effects of farm-level common shocks such as weather conditions, we isolate the minimum wage-induced effort responses based on a disproportionate productivity increase on the lower part of the fixed effects distribution when the minimum wage increases. This is analogous to the approach in Cengiz et al. (2019) and Dustmann et al. (2019), for instance, where workers on the upper part of the wage distribution are viewed as a "control" when evaluating the effect of a higher minimum wage on low wage workers.

[4] In the US the markets for fresh- and processing-tomatoes are entirely separate. Not only are different varieties of tomatoes grown to serve each market but they are harvested differently. In particular, processing tomatoes (which are common in California) are machine-harvested whereas fresh-market tomatoes are hand-harvested. The Florida farm studied here serves the market for fresh tomatoes only and the incidence of hand harvesting is 100 percent.

We find evidence consistent with incumbent workers' positive effort responses. As the minimum wage increases by 6% ($6.79 to $7.21) on January 1, 2009, worker productivity (i.e. output per hour) in the bottom 40th percentile of the worker fixed effects distribution increases by about 4.6% relative to that in the higher percentiles. Examining the employment outcomes of individual workers over time, we find that while low productivity workers have 6-10% lower chances of being employed on any given day than high productivity workers, this existing difference is not further amplified when the minimum wage increases. This lack of significant employment effects attributable to the minimum wage hike may have several explanations. In a competitive framework, the positive effort responses of sub-minimum wage workers should obviate the need for reducing employment opportunities assigned to these workers. Moving beyond competition, it is also possible that workers simply reacted to a *perceived* threat, even in the absence of any *actual* pressure coming from the employer, and/or are driven by other motives such as gift exchange (Akerlof 1982). Overall, our back-of-the-envelope calculation shows that the increased productivity among the low fixed effect workers can offset about half of the projected rise in the firm's wage bill, suggesting a roughly equal sharing of the minimum wage cost between the employer and the workers.

By taking advantage of rare data on piece-rate workers whose physical output (pieces per hour) is rigorously recorded around a minimum wage hike where the piece rate itself remains the same throughout, we are able to test for workers' effort responses as a plausible channel of adjustment to a minimum wage hike. Such responses are extremely difficult to detect in observational data, since in most settings we lack data that repeatedly measure the same worker's productivity on the same task around a minimum wage hike. Although it is difficult to know the exact extent to which the effort responses shown here will apply to other low wage settings, the hypothesized effort responses do not rest on the pay scheme being piece-rate based. For instance, a recent study by Coviello, Desseranno and Persico (2019) illustrates a minimum wage-related productivity increase among salespeople of a retail chain, where the compensation scheme at use is a base pay plus a performance-based commission. Moreover, even in settings where workers are paid a fixed hourly wage, we know that the employer and co-workers can to a varying extent assess/observe the productivity of different employees.[5] It is the ability to tell apart low vs. high productivity workers, and not the pay scheme per se, that dictates the relevance of the effort margin as a possible response to minimum wage changes. Moreover, when it comes to low wage workers at whom the minimum wage is targeted, farm laborers are a relevant yet understudied group. We show in Appendix Table A.1 that farmworkers feature prominently in the list of lowest paying occupations in Florida as of 2009, both in terms of major/broad occupation groups, and by detailed occupations. In particular, the wages of farmworkers are not dissimilar to those of workers at fast food restaurants (see e.g. Card and Krueger 1994) or care homes (see e.g. Machin, Manning and Rahman 2003), the subgroups often studied in leading papers in the minimum wage literature.

By providing clean evidence on the minimum wage effect on the worker *effort*, we add to the recent and growing literature that explores alternative channels (other than employment) through which firms may absorb the rising labor cost associated with the minimum wage. These channels include increased worker retention and reduced turnover (Portugal and Cardoso 2006; Dube, Lester and Reich 2016; Gittings and Schmutte 2016), labor-labor substitution (Lang and Kahn 1998; Portugal and Cardoso 2006; Fairris and Bujanda 2008; Giuliano 2013; Clemens, Kahn

[5] Observable characteristics such as experience, for instance, may serve as a proxy for productivity. In Jardim et al. (2018)'s evaluation of Seattle's minimum wage, they find that all of the earnings increases from a higher minimum wage accrue to the more experienced half of the low-wage workforce whereas the less experienced half saw no significant change in earnings due to decreases in their hours worked offsetting their wage gains.

and Meer 2020; Butschek 2019), changes in non-wage job attributes (Clemens, Kahn and Meer 2018), an increase in prices (Aaronson 2001; Aaronson, French and MacDonald 2008; Leung 2018; Harasztosi and Lindner 2019), and a decrease in profits (Draca, Machin and Van Reenen 2011; Bell and Machin 2018).[6] In particular, we speak directly to *effort-driven labor productivity*, by taking advantage of rare data on piece rate workers whose physical output (pieces per hour) is rigorously recorded around a minimum wage hike where the piece rate itself remains the same throughout.[7]

This paper also relates to the personnel economics literature that explores how incumbent workers' productivity may be related to labor market conditions. In an earlier work, Rebitzer (1987) showed that the level of unemployment raises productivity growth using US data at two-digit manufacturing industries for 1960-1980. In addition, a recent work of Lazear, Shaw and Stanton (2016) shows that incumbent workers may work harder during recession and when the unemployment rates are higher. While similar in the usage of personnel records from a US firm, Lazear, Shaw and Stanton (2016)'s study of recession effects focuses on the increased *cost* in case of discharge for workers with a relatively long employment contract, whereas our analysis of minimum wage effects concentrates on the increased *risk* of not being picked up for daily employment for workers operating in a casual labor market, where daily employment is decided on an ad hoc basis in the absence of any longer-term contract.

[6] Hirsch, Kaufman and Zelenska (2015) simultaneously examine all the channels above as well as wage compression and raised performance standards.

[7] This is in contrast to approaches that are based on firm-level, revenue-based productivity such as Total Factor Productivity (TFP). For instance, Mayneris, Poncet and Zhang (2018) document in the context of China that minimum wage leads to the exit of low productivity firms and increases firm-level TFP conditional on survival.

2. Background and Data

2.1 Minimum Wage for Piece Rate Workers

For a given pay period (here, one calendar week), consider a worker i with a transaction profile of (h_i, Y_i), where h_i denotes the total field hours spent and Y_i the total output (in pieces) produced. Applying the *constant* piece rate (dollars/piece) p, the total output can be expressed as pY_i in dollars. This worker's average productivity then is $pY_i/h_i \equiv py_i$ (dollars per hour). Since the piece rate p remains constant throughout, there is a one-to-one correspondence between a worker's physical productivity y_i (pieces per hour) and his productivity expressed in dollars py_i.

For all hours employed during the pay period, workers whose average raw productivity is above (below) the minimum wage are paid according to actual output (minimum wage).[8] Hence, worker i's hourly wage is

$$Hourly\ wage_i = \begin{cases} py_i & \text{if } py_i \geq MW \\ MW & \text{if } py_i < MW \end{cases}$$

where MW denotes the minimum wage. Worker i's total weekly earnings are

$$Earnings_i = \begin{cases} pY_i & \text{if } py_i \geq MW \\ h_i MW & \text{if } py_i < MW \end{cases}$$

so the firm's total wage bill is

$$\sum_j pY_j + \sum_{py_{j'} < MW} h_{j'}(MW - py_{j'})$$

where the first and second parts represent (i) the unadjusted wage bill for all workers and (ii) the compliance cost for the minimum wage expended on subminimum wage workers, respectively.

[8] This is similar to the piece rate scheme with a guarantee modelled in Lazear (2000). The difference is that in Lazear (2000) the guarantee is chosen by the firm whereas here the minimum wage is imposed by the government.

When worker productivity is held constant, firm's compliance costs increase with the minimum wage for two reasons: first, a higher minimum wage makes the minimum wage bite for more workers than previously, and second, it increases the gap between the (new) minimum wage and the raw productivity of subminimum wage workers. A minimum wage increase thus creates an incentive for firms to reduce (either at the extensive or intensive margins) the employment hours assigned to low productivity workers. On the other hand, low productivity workers can preempt the firm's action by increasing their efforts and productivity, thereby (at least partially) relieving the firm of the expanding compliance cost.[9] Whether either or both effects exist is examined empirically below.

2.2 Setting and Data

The setting of our analysis is a large tomato farm in Florida where piece-rate workers hand-harvest fresh tomatoes in the field. Our main data come from the personnel records of the farm covering the 12-week autumn harvesting season from November 2008 to January 2009. Because this firm uses one calendar week pay periods, the timeline in Figure 1 shows the harvesting periods by week. During the 9th week of this season, in particular on January 1, 2009, the state minimum wage rose from $6.79 to $7.21, an increase by 42 cents or 6% of the baseline minimum wage.

[Figure 1]

The minimum wage increase comes from Article X, Section 24 of the Florida Constitution. Enacted in 2004 and first implemented in 2005, Florida's minimum wage is indexed to inflation.

[9] Note that increased productivity of workers who are *above* the minimum wage makes little difference for the firm's labor cost since compensation is purely piece-rate based, which means that the total wage bill is determined by the total output (pieces) harvested and the piece rate only and *not* by the speed or productivity (output/hour) of (above minimum wage) workers.

In particular, on September 30th of each year, an adjusted minimum wage rate is computed based on the current minimum wage and the inflation rate (based on CPI-W) during the twelve months prior to each September 1st, which is then published and takes effect on the following January 1st.[10] As Table A.2 shows, the minimum wage hike on January 1, 2009 is relatively large in absolute magnitude. This has to do with the high inflation rate that prevailed during the twelve months prior to September 1, 2008, as shown in Appendix Figure A.1.

Although the farm operates several different fields and grows different tomato varieties, due to a confidentiality agreement with the firm, this analysis is constrained to the harvesting of two main varieties, round and grape tomatoes, which represent over 70 percent of total man hours. All field workers are paid by piece rate based on individual output, meaning no team element in production or compensation, and may be asked to pick either tomato variety depending on the day's harvesting requirements.

During the season workers stay in a living quarter located near the farm in rural Florida. The available worker pool may change as new workers arrive and existing workers exit during the season (see Section 4.3 for further details). There is no long-term contract and employment is decided on a day-to-day basis. Specifically, the harvesting manager decides based on the field capacity (i.e. how many mature crops are there to be harvested on that day, which is predetermined by the acreage planted and the field lifecycle) and weather conditions, whether they will harvest

[10] Specifically, part (c) of Article X, Section 24 of the Florida Constitution reads "MINIMUM WAGE. Employers shall pay Employees Wages no less than the Minimum Wage for all hours worked in Florida. Six months after enactment, the Minimum Wage shall be established at an hourly rate of $6.15. On September 30th of that year and on each following September 30th, the state Agency for Workforce Innovation shall calculate an adjusted Minimum Wage rate by increasing the current Minimum Wage rate by the rate of inflation during the twelve months prior to each September 1st using the consumer price index for urban wage earners and clerical workers, CPI-W, or a successor index as calculated by the United States Department of Labor. Each adjusted Minimum Wage rate calculated shall be published and take effect on the following January 1st. For tipped Employees meeting eligibility requirements for the tip credit under the Fair Labor Standards Act (FLSA), Employers may credit towards satisfaction of the Minimum Wage tips up to the amount of the allowable FLSA tip credit in 2003."

or not for a given day, and how many workers will be needed (based on some heuristic he has figured out through many years of experience). As shown in Figure A.2, the number of workers employed each day is closely related to the "field capacity", with an R-squared of 0.7695.[11] Once the day's harvesting plan is known, an appropriate number of workers are recruited from the available worker pool. We do not know exactly how this is achieved in practice but in the data we clearly see that it is not the same number of workers or the same set of workers being employed each day. In Section 4.3 we investigate whether workers' employment outcomes are in any way related to their productivity.

The harvesting workers, if working that day, arrive in the field by buses organized by crew leaders, and once the day's harvesting is finished, leave by the same buses. To track each worker's output and work hours electronically, an ID card with a magnetic chip is attached to each worker's bucket and scanned at the beginning and end of each work spell. Although a work day may comprise multiple work periods, there is typically a morning and afternoon work spell with a lunch break separating the two. During a work period, workers spread around the field to pick tomatoes from different rows of thick tall bushes and then carry their filled buckets to a truck parked in the middle of the field. Several "dumpers" standing on the back of the truck empty the full buckets into a large collection bin and scan the worker's ID card with a scanning device to add the output unit to the system. This procedure is repeated throughout the day until the day's designated fields are completely picked.

Output is measured in 32 pound bucket, for which the piece rate for round (grape) tomatoes is a constant $0.50 ($3.75) throughout. Therefore, for ease of comparison, workers' physical output is always converted to dollars (pieces times piece rate for the relevant variety), and productivity

[11] Since it is not possible to measure the (predetermined) field capacity, we use the actual output as a proxy.

(output per hour) is expressed in dollars per hour. For each variety separately, we remove the transactions that fall in the bottom and top 1 percent of the productivity distribution to ensure that the results are not driven by outliers. Further, we focus on workers with at least five spells (transactions) during weeks 1-5 (so that we can obtain reliable estimates of their fixed effects).[12] This results in 31,762 transactions for 974 unique workers. The average output per hour (dollars/hour) in the sample is $9.53 with a standard deviation of $3.62. In Table A.3 we report the mean daily employment (1 if working and 0 otherwise), daily hours worked (if working that day), and productivity (output per hour) by quintiles of worker fixed effects (see Section 3) and by time periods (weeks 1-5, 6-8 and 9-12).

To address the relevant question of how substantive this new $7.21 minimum wage is, the incidence and extent of the old and the new minimum wages are tabulated in Table 1. As the minimum wage rises from $6.79 to $7.21, the share of worker-weekly paychecks for which the minimum wage binds rises from 12 to 16 percent. Moreover, the share of workers for whom the minimum wage will *ever* bite increases from 42 to 51 percent. At the same time, the share of farm-level employment hours assigned to worker-weeks below the minimum wage rises from 10 to 14 percent, and the minimum wage compliance cost increases from $8,339 to $13,217 (about 58% increase).

[Table 1]

2.3 Compliance

The minimum wage is part of the Fair Labor Standards Act (FLSA), which also sets overtime, recordkeeping, and child labor standards. Contrary to popular misconceptions, all agricultural

[12] Our main results are robust to alternative choices of minimum spell numbers in the vicinity.

workers on any but small farms, while exempt from the law's overtime pay provision, are covered by its minimum wage requirement.[13] Since the state of Florida has its own minimum wage, whichever one is higher binds between the federal and state minimum wages (see Table A.2).

As with any empirical research on minimum wage, one important concern here is noncompliance.[14] The most common violation of minimum wage regulation is manipulating the manual records of workers' compensable hours. The recordkeeping standards at the farm studied here, however, makes *ex post* manipulation of employment hours highly implausible. Workers are *clocked in and out* in the field by magnetic chips. Nevertheless, we perform several tests to eliminate this possibility, including an inspection of workers' actual paystubs to verify that subminimum wage workers were indeed paid the minimum wage. To illustrate, the worker whose weekly paystub is shown in Figure A.3 worked a total of 15.28 hours over two days during the reference week in 2008. Based on his output, his raw (unadjusted) earnings were $87.75 dollars ($29.00 + $7.50 + $11.25 + $40.00), which translates into an hourly productivity (dollars/hour) of $5.74. Because the relevant minimum wage for this period was $6.79, the worker was paid $6.79 and not $5.74 for all 15.28 hours worked, resulting in a total earnings of $103.75 ($6.79 times 15.28). The firm's compliance costs were thus $16 ($103.75 minus $87.75), which appears as a line item labeled "minimum wage."

We also check for any sign of *ex post* manipulation in the payroll data, in particular, any downward adjustment of employment hours for workers whose raw hourly productivity falls

[13] An agricultural employer who does not use more than 500 man days (days on which a worker provides at least one hour of agricultural work) in any calendar quarter of the preceding calendar year is exempt from the FLSA minimum wage provision for the current calendar year. The farm studied here hires 300–600 workers *per day* and thus is *not* exempt from the provision.
[14] See Ashenfelter and Smith (1979) and Clemens and Strain (2020) for discussion on employer noncompliance with the minimum wage.

below the minimum wage. Figure A.4 plots the mean of worker-weekly total hours of employment by 5 cents bins of worker-weekly average productivity (output per hour) for a 2 dollar window around the relevant minimum wage. Data are pooled across weeks with week fixed effects controlled for. The plot for weeks 1-8 (minimum wage = $6.79) is in part (a) whereas that for weeks 9-12 (minimum wage = $7.21) is in part (b). As the figure illustrates, the individual work hours in any given (calendar week) pay period are smooth along the distribution of each worker's contemporaneous productivity. That is, there is no sign of a discontinuous drop in field hours for workers below the productivity threshold of $6.79 (or $7.21), which could be expected if the firm had adjusted subminimum wage workers' field hours downward.[15]

On the other hand, if the firm were to make a uniform downward adjustment to *everyone's* employment hours, such adjustment could not be detected without having access to the unadulterated records. Even if such uniform downward adjustment were to happen, it would not threaten the analysis because the difference-in-differences strategy used examines possible *differential* changes in the outcomes of low versus high productivity workers when both groups are exposed to the same shocks at the firm level. Such shocks would include both the January 1 minimum wage hike and the (highly unlikely) uniform downward adjustment of everyone's employment hours.

[15] Relatedly, Figure A.5 shows the McCrary plot, which tests for selective sorting around the threshold on the worker-weekly average productivity (output per hour). Consistent with no *ex post* manipulation of production records by the firm, the figure shows no discontinuity in the density of observations around the minimum wage either in the pre or in the post period.

3. Empirical Strategy

Outdoor production of agricultural crops tends to be characterized by natural fluctuations in average productivity due to external factors such as weather conditions and the field lifecycle. It is therefore tenuous to attribute to effort any changes in worker productivity observed before and after a minimum wage hike. To isolate the effects of worker *effort* from external determinants of labor productivity, we therefore employ a difference-in-differences (DID) strategy. Similar to Mas and Moretti (2009), we first capture each worker's "baseline" or "permanent" productivity by estimating their individual fixed effects using data from weeks 1-5 of the harvesting season. Based on the estimated fixed effects, we classify workers into high versus low productivity types.

We then look for possibly differential productivity changes of individual workers from weeks 6-8 to weeks 9-12 by their baseline productivity. Since low fixed effect workers are more likely to fall below a minimum wage than high fixed effect workers when subject to a common production environment, to the extent workers respond to the fear of selective non-employment (or other related motives) we should expect a disproportionate increase in observed productivity in the lower part of the fixed effects distribution as the minimum wage increases.

Based on data from weeks 1-5, we first estimate by OLS the following regression:

$$(1) \quad y_{ivft} = \phi_{vf} + \psi_t + \gamma_1 \boldsymbol{Z}_{it} + \gamma_2 \boldsymbol{X}_{vft} + \alpha_i + u_{ivft},$$

where y_{ivft} denotes (log) worker i's output per hour for variety v in field f on day t. We include variety-field fixed effects (ϕ_{vf}) to capture any between-variety differences that are also field specific, and day fixed effects (ψ_t) to account for such day-specific common shocks as weather. Worker fixed effects, which capture each worker's baseline productivity, are denoted by α_i. As a result, the estimates of α_i capture the differences between workers who harvest the same variety in the same field while eliminating day-specific common shocks. Further, we also include variety-field-day specific observed characteristics such as a cubic polynomial of the variety-field lifecycle,[16] supervisor fixed effects (collected in $\boldsymbol{X}_{vft}$), and a cubic polynomial of worker experience, measured as cumulative work hours from the beginning of the season to day t, $\boldsymbol{Z}_{it}$. Essentially, we want to capture in α_i worker's fixed characteristic, which we refer to as baseline productivity, while accounting for other determinants of worker's observed productivity.

Next, based on the estimated fixed effects $\hat{\alpha}_i$, we classify workers into different bins (e.g. percentiles or quintiles), and then estimate variants of the following regression (based on transactions over weeks 6–12):

$$(2) \quad y_{ivft} = \delta(Post_t \times D_i) + \pi_i + \psi_t + \phi_{vf} + \beta_1 \boldsymbol{Z}_{it} + \beta_2 \boldsymbol{X}_{vft} + e_{ivft},$$

where y_{ivft} again denotes (log) worker i's output per hour for variety v in field f on day t. The variable $Post_t$ assumes the value of unity if day t belongs to weeks 9-12 and zero otherwise, while D_i indicates whether worker i is, say, in the bottom 40th percentile on the (pre-estimated) worker fixed effects distribution.[17] We include dummies indicating each percentile of the pre-estimated worker effects π_i (which subsumes D_i) and day fixed effects ψ_t (which subsumes $Post_t$). As in equation (1), we also control for variety-field fixed effects ϕ_{vf}, and for the variables in $\boldsymbol{Z}_{it}$ and $\boldsymbol{X}_{vft}$. The DID estimate δ measures the disproportionate productivity changes of workers in the bottom 40th percentile of the fixed effects distribution relative to those in the upper part. All standard errors are clustered by day.[18]

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[16] The variety-field lifecycle is computed as the number of days the variety has been picked in that field by day t divided by the total number of days it has been harvested in that field during the season.
[17] We also consider a more flexible approach where we allow quintile-specific productivity changes.
[18] Our main results are robust to clustering at the worker level.

We start by comparing the productivity changes in the bottom two quintiles with those in the upper quintiles. Because the quintiles are based on predefined characteristics (i.e. worker fixed effects in weeks 1-5), this method of classifying treatment status is exogenous to workers' actual effort choices during the analytic window (weeks 6-12). The identifying assumption for this approach is that conditioning on the included controls, in particular, the harvesting day fixed effects that capture farm-level common shocks specific to each day (e.g. weather), there are no significant changes on or around January 1, 2009, other than the new minimum wage that might *differentially* influence the effort choices of workers in the lower versus upper part of the worker fixed effects distribution.

4. Results

4.1 Worker Fixed Effects

Based on a sample of 13,291 transactions (974 unique employees) from weeks 1-5, we first estimate equation (1). Based on the estimated fixed effects (whose mean is zero by normalization with a standard deviation of 0.2254), we classify workers into different bins (quintiles or percentiles).[19] We then examine the relationship between worker's *observed* productivity in weeks 6-8 (the "pre" period with respect to the minimum wage hike) and their baseline productivity (i.e. fixed effects).[20]

Below we present evidence that the pre-estimated fixed effects are indeed a good predictor of worker's observed productivity and hence the risk of falling below the minimum wage. In the

[19] The distribution of the estimated worker fixed effects is presented in Figure A.6.

[20] The correlation in the *observed* productivity of each worker between periods is 0.6886 (between periods 1 and 2), 0.5544 (between periods 1 and 3) and 0.6597 (between periods 2 and 3), where periods 1, 2 and 3 refer to weeks 1-5, 6-8 and 9-12, respectively.

graphical analysis below, we use worker-week as the unit of observation—the unit at which paychecks are issued and minimum wage adjustments are made—without using additional controls. In our regression analysis (Section 4.2), we use a finer variation with an extensive list of controls to account for external determinants of productivity.

Figure 2 plots the worker-week level productivity distribution for weeks 6–8 by quintiles of the worker fixed effects based on weeks 1-5. Because of such external factors as weather and field lifecycle, there is a fair amount of dispersion in worker productivity even for the same quintiles. However, *on average*, workers in the lower quintiles tend to have lower productivity, suggesting that the estimated worker fixed effects (from weeks 1-5) are indeed informative. The monotonic relationship between worker productivity (in weeks 6-8) and the pre-estimated worker fixed effects is also visualized in Figure 3, which displays the mean of worker-weekly productivity against the percentile of the worker fixed effects. Based on these figures, the pre-estimated worker fixed effects (based on weeks 1-5) seem to be a good proxy for workers' baseline productivity.[21]

[Figures 2 and 3]

Given the monotonicity in Figure 3, it is easy to imagine that workers in the lower part of the fixed effects distribution are more likely to fall below the new (and old) minimum wage than those in the upper part. Figure 4 illustrates this. Based on worker-weekly productivity observations (from weeks 6-8), we compute for each percentile of the worker fixed effects the share of observations that fall below the current and new minimum wages. As shown, the probability to fall below the minimum wage is greater at the lower part of the distribution than at the higher part. Moreover, the probability shifts upwardly as we apply the new minimum wage to the same

[21] This stability can also be established using fixed effects based on weeks 1-3 and observed productivity in weeks 4-5 albeit for a smaller sample than used here.

productivity data, and the upward shift is more pronounced on the lower part of the fixed effects distribution than in the upper part. Therefore, low fixed effect workers have a greater incentive to increase effort than high fixed effect workers when both are subject to the minimum wage hike on January 1, 2009.

[Figure 4]

4.2 Minimum Wage Effect on Worker Effort

<u>4.2.1 Main results</u>

Panel A of Table 2 presents the estimates of equation (2) (or its variants), which contrasts the effort responses of workers in the lower part of the distribution with those of workers further up the distribution. Column (1) compares the productivity change in quintiles 1-2 of the worker fixed effects distribution with that of the upper quintiles (quintiles 3-5). The estimates reveal that there is a positive productivity change in the bottom two quintiles relative to the upper quintiles. Here, the coefficients on $Post_t \times Quintile\ 1_i$ and $Post_t \times Quintile\ 2_i$ are not significantly different from each other. In column (2), we then estimate the average changes among quintiles 1-2 relative to quintiles 3-5. The estimates show that the output per hour for workers below the 40^{th} percentile increases a disproportionate 4.6 percent relative to workers in the comparison group (above 40^{th} percentile).[22]

[Table 2]

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[22] In Table A.4 we present estimates using alternative ways to account for workers' baseline productivity. Columns (1)-(2) replicate our baseline estimates from columns (1)-(2) of Table 2. In columns (3)-(4), we include dummies for each quintile of the pre-estimated worker fixed effects, requiring coarser information on worker types than in the baseline. In columns (5)-(6), we include the pre-estimated worker fixed effects in levels, imposing a linear effect and reducing the number of parameters to be estimated. As shown, the results are robust to these alternative (and less demanding) specifications to account for the baseline productivity.

To address the concern that what constitutes the pre and post period may not be so clear-cut, we exclude the transition weeks (weeks 8-9). While January 1 falls in week 9, the new and higher minimum wage may take time to sink in with the workers rather than having an immediate effect. On the contrary, workers may respond proactively in the week before the scheduled increase in the minimum wage. When we focus on these pre and post periods that are more clearly apart, the coefficient becomes larger (see columns (3) and (4)). In columns (5) and (6), we exclude the final week from the sample as the incentives may be weaker when workers know that the season will end after that. The magnitude of the main estimates changes only slightly. Overall, these findings suggest that the increase of the minimum wage from $6.79 to $7.21 increases the relative productivity of workers in the bottom 40th percentile by 4-7%.

So far we focused on the dichotomous distinction between low vs. high productivity workers. We now take a more flexible approach and estimate a variant of equation (2) where we replace $Post_t \times D_i$ with $Post_t$ interacted with dummies for each quintile, using quintile 3 as the reference category. The estimated coefficients along with 95th percent confidence intervals are plotted in Figure 5. As expected, the productivity response of quintiles 1 and 2 are clearly positive relative to that of quintile 3 (the reference category). Moreover, there are also modest increases in the productivity of quintiles 4 and 5 albeit smaller in magnitude than that for quintiles 1 and 2 and imprecisely estimated.[23] Such responses on the upper part of the distribution may be driven by peer pressure as in Mas and Moretti (2009) and/or high-productivity workers' preferences for maintaining their rank ordering as in Kuziemko et al. (2014). The pattern shown in Figure 5 also

[23] The difference between the estimated coefficients plotted in Figure 5 and the p-value associated with each test are as follows: $\widehat{Post \times} Q2 - \widehat{Post \times} Q4 = 0.0503$ (p-value = 0.004); $\widehat{Post \times} Q2 - \widehat{Post \times} Q5 = 0.0392$ (p-value = 0.015); and $\widehat{Post \times} Q2 - \widehat{Post \times} Q1 = 0.0068$ (p-value = 0.684).

ensures that the estimates in Table 2 are indeed driven by positive effort responses of low productivity workers (who are more "at risk" than others) rather than potentially negative effort responses of high productivity workers that may be activated by fairness concerns as in Breza, Kaur and Shamdasani (2017) and Dube, Giuliano and Leonard (2019).

[Figure 5]

4.2.2 Robustness Checks

Our DID estimates show a disproportionate increase in observed productivity in the lower part of the fixed effects distribution than in the upper part as the minimum wage increases from the pre to the post periods. There are potential threats to interpreting these effects as "effort response" to the minimum wage including composition changes and reliability of the estimated worker effects. Below we report a series of additional robustness checks to address these concerns.

First, we investigate whether the baseline effects detected might result from changes in worker composition (i.e. differential selection *within* high vs. low quintile bins over time). We repeat our main analysis using a balanced sample of workers who worked in both the pre (weeks 6–8) and post (weeks 9–12) periods. In these estimates, reported in Panel B of Table 2, the sample size becomes slightly smaller, but the patterns are similar to those in Panel A of the same table.[24] Thus, the increase in output per worker detected is unlikely to be driven by differential compositional changes within high vs. low quintile bins.

Next, we address concerns regarding the reliability of the estimated worker effects. In estimating worker fixed effects in equation (1), we imposed the restriction of at least 5 spells per

[24] Note that in either sample, the main coefficient of interest, Post*Low FE, is identified from workers who worked in both the pre and post periods. However, in panel A, the part-season workers still contribute to the estimation of other included controls such as day FE or variety-field FE.

worker, resulting in on average 13 spells per worker, which should be considered "large" by the standard of panel data models (see Fernández-Val and Weidner (2018)). To check nevertheless whether smaller spell numbers for some workers may be an issue, we vary the minimum number of spells we require when estimating equation (1). In Table 3, column (3) replicates the result in column (2) of Table 2. Columns (1) and (2) show results with lower numbers of minimum spells and columns (4)-(6) with higher numbers. As we move from column (1) through column (6), the DID estimate of productivity changes remains largely stable.

[Table 3]

As an additional check for the reliability of our estimated worker effects, we also conduct a simulation exercise. In particular, we randomly draw individual effects from a distribution with mean of zero and standard deviation of 0.2254 (see Figure A.6) and estimate the δ in equation (2) with these randomly assigned individual effects. We repeat this exercise 500 times and plot the distribution of the estimated δ's in Figure A.7. To assess how likely it is that the baseline estimate of 0.046 (column (2) of Table 2) happens "by chance" even when the underlying worker effects are completely random, the short dashed line indicates the 95th percentile of the distribution of $\hat{\delta}$'s based on randomly assigned individual effects. Our baseline estimate of $\hat{\delta}$=0.046 lies clearly outside this threshold.

4.3 Employment Outcomes

Our analysis so far focused on the effort responses of workers. In this section, we examine (i) whether the employment outcomes differ between high and low productivity workers (irrespective of the minimum wage) and (ii) whether any pre-existing differences may be further amplified because of the minimum wage increase.

Before we proceed, it is worthwhile understanding the evolution of farm-level employment during the season. As Panel (a) of Figure 6 shows, the farm's lifecycle and hence its labor demand cycle peaks in the middle of the season. In keeping with this employment requirements, the farm needs to build up its worker pool at the beginning of the season and shed it once the peak has reached and as the season is winding down. In Panel (b) of Figure 6, we plot the cumulative inflows, cumulative outflows, and the stock of workers in each week. The inflows in week K are measured as workers whose first harvesting day occurs in week K, and the outflows in week K are defined as those whose last harvesting day occurs in week K-1. The stock of workers in week K are the cumulative inflows by week K minus the cumulative outflows by week K, proxying for the size of the worker pool available for hire in week K. As the figure shows, we see large inflows at the beginning of the season, the pace of which then slows down as the season progresses. In contrast, worker outflows are negligible at the beginning of the season, but then steadily increases over time.

[Figure 6]

In order to understand whether worker productivity matters at all in the day-to-day allocation of employment opportunities, we estimate the following equation:

$$(3)\quad employment_{it} = \eta_1 D_i + \eta_2 (Post_t \times D_i) + \psi_t + \omega_{it},$$

where $employment_{it}$ is worker i's employment outcome on day t. The variable D_i indicates whether worker i is in below the 40th percentile in the baseline productivity distribution. The variable $Post_t$ assumes the value of unity if day t belongs to weeks 9-12 and zero otherwise. Day fixed effects are absorbed in ψ_t (which subsumes $Post_t$). As before, the treatment status D_i is based on the worker's pre-determined characteristic (from weeks 1-5) and is orthogonal to his contemporaneous decisions. Standard errors are clustered by day.

In the absence of the second term, the equation estimates the simple difference between low versus high productivity workers, i.e. whether low productivity workers are *overall* employed less frequently than high productivity workers. Once we include the interaction term ($Post_t \times D_i$), the coefficient η_2 picks up the excess selectivity in the post period (weeks 9-12) *over and above* that (η_1) in the pre period (weeks 6-8), which we may attribute to the minimum wage hike.

Table 4 displays the estimates of equation (3) (or its variants) using worker-day as the unit of analysis. Columns (1) through (4) use daily employment (1 if working that day and 0 otherwise) as the dependent variable. The estimate in column (1) of Panel A shows that *overall*, workers below the 40th percentile have a 0.025 percentage point lower probability of being employed each day than those above the 40th percentile, which is about 6% (0.025/0.397) of the mean. Column (2) shows that the pre-existing difference (-0.019) is about twice as large as the additional effect in the post period (-0.011).

[Table 4]

So far, we have included all worker-days in the sample including workers who may have already left the farm and are no longer available for hire for a given day. For instance, a worker whose last day of employment during the season falls in week K-4 is unlikely to be available for hire in week K. By including such workers and recording them as not working, we may overstate the true extent of non-working status at this farm. In columns (3) and (4), we therefore exclude worker-days from the sample if the worker's last day of employment at this farm during this season occurs in any week prior to the week of the present worker-day. The mean employment probability in this restricted sample is 0.642 as opposed to 0.397 in the full sample. The estimates in columns (3) and (4) show that while low productivity workers are 8.4% (0.054/0.642) less likely to be employed than high productivity workers in general, there is no strong evidence that this pre-existing employment gap widens when a higher minimum wage takes effect. Based on columns (2) and (4), a possible reduction in the employment of low productivity workers attributable to the minimum wage hike is at most 4.6% (0.030/0.642).

Further, we examine in columns (5) and (6) the intensive margin effect (i.e. total hours worked conditional on working that day) on employment.[25] While low productivity workers work 5.7% (0.323/5.596) fewer hours than high productivity workers, we do not find any evidence of a further reduction in the hours worked by low productivity workers after the minimum wage hike. This is consistent with the fact that harvesting workers, once in the field, tend to work the same hours until the day's harvesting finishes (and leave by the same buses on which they arrived in the morning), leaving little scope for intensive margin adjustments.

Based on Table 4, it appears that while low productivity workers in general have lower chances of being employed than high productivity workers, this existing employment gap is not further widened because of the higher minimum wage. This lack of significant employment effects attributable to the minimum wage hike may be reconciled based on various grounds. In a competitive framework, the positive effort responses of sub-minimum wage workers should obviate the need for reducing employment opportunities assigned to these workers. The fact that not all workers whose raw productivity falls below the minimum wage are discharged is also in line with earlier findings of Holzer, Katz and Krueger (1991) that some positive rents (for workers) are associated with minimum wage jobs. Moving beyond competition, it is also possible that workers simply reacted to a *perceived* threat—even in the absence of any *actual* pressure coming

[25] Columns (5) and (6) include worker-days with non-zero employment hours only, hence the smaller number of observations than in other columns.

from the employer—and/or are driven by fairness concerns between the worker and the employer in the spirit of gift exchange (Akerlof 1982).

4.4 Discussion

The results of our analysis above indicate that in response to the January 1, 2009 minimum wage hike, the productivity of workers in the bottom 40th percentile of the productivity distribution increased by a disproportionate 4.6% relative to those in the higher percentiles (column (2), Table 2). In the absence of such worker responses, a higher minimum wage means a higher labor cost for the firm because of higher associated compliance costs. If, however, some subminimum wage workers increase their efforts, it may (at least partially) offset these rising costs.[26] We examine these alternatives in Table 5. Based on data for weeks 1–8, when the prevailing minimum wage is $6.79, we compute a compliance cost by subminimum wage workers of $8,339. [27]

[Table 5]

We then consider the consequence of a minimum wage increase from $6.79 to $7.21. In the absence of worker effort responses this will raise the firm's compliance cost by $4,878 (from $8,339 to $13,217). However, as earlier analyses show, low productivity workers may increase their efforts, which would bring the firm's compliance cost down to $10,660, which is $2,557 (or 52 percent) less than the projected increase of $4,878. On the other hand, any additional saving implied by possible employment adjustment is rather minor (at most $375 or 8%) even if we allow

[26] The positive productivity response to the minimum wage may suggest the new minimum wage functioning as an efficiency wage (Shapiro and Stiglitz 1984; Rebitzer and Taylor 1995). However, efficiency wage is a concept applicable to settings where workers are paid a fixed wage (salary) while their effort or output is difficult to monitor. In our context, workers are compensated by pure piece rate and their output is readily *observable* by the employer, which obviates the firm's need to employ efficiency wage. See Shapiro and Stiglitz (1984) and Katz (1986) for further discussion on the characteristics of workplaces conducive to adoption of efficiency wage.

[27] For this counterfactual exercise, we fix the production schedule at the period of pre-minimum wage hike so as not to confound the minimum wage effect with a seasonality effect.

for a significant reduction in the employment hours assigned to low productivity workers by 4.6% (0.030/0.642 based on column (4), Table 4). Overall, this calculation indicates that increased worker productivity can offset about half of the projected rise in the minimum wage compliance cost, suggesting a roughly equal sharing of the projected increase between the employer and the workers.

5. Conclusions

By employing a direct and high frequency measure of individual-level productivity on a homogenous task in the context of Florida's minimum wage hike on January 1, 2009 (from $6.79 to $7.21), we examine worker effort responses as a possible margin of adjustment to a minimum wage hike. When the statutory minimum wage increases, workers in the lower part of the productivity distribution face increased risk of falling below the minimum wage relative to those on the upper part of the distribution. Low productivity workers may therefore increase their efforts (and hence productivity) to preempt possible discharge. We find that in response to the 42 cents or 6% increase in the minimum wage, worker productivity (i.e. output per hour) in the bottom 40th percentile of the worker fixed effects distribution increases by about 4.6% relative to that in the higher percentiles, suggesting that productivity increases driven by worker effort may help mitigate the higher labor costs associated with the minimum wage.

Several cautions are warranted. First, this margin of adjustment can only work within relatively low ranges of the minimum wage. If the minimum wage continues to rise to a higher level, workers may no longer be able to keep up their effort (and productivity) with the minimum wage due to physical or cognitive limits. At that point, the firm may adopt an entirely different personnel policy (or different production technology) than observed here and worker effort responses may no longer be a valid channel to absorb the rising labor cost associated with the minimum wage.

Second, we focus here on workers who do not have a long-term contract and are hired on a day-to-day basis within a harvesting season. If workers had extended-term contracts, the incentive structure in place may look quite different. On the one hand, the fact that the job is more or less guaranteed—at least for the fixed term—may reduce the incentive to increase effort in response to the minimum wage. On the other hand, the job is worth more (in present discounted values) than a daily laboring, hence the workers may find a greater incentive to increase effort to keep it.

Although a plausible channel of adjustment to the minimum wage, incumbent workers' effort responses have been largely overlooked in the literature, probably because in most settings, measuring individual-level productivity around a minimum wage hike—without convolution with task and workforce composition—is difficult. This work, although focused on a particular firm in a particular industry, opens a new avenue for future research, particularly in terms of whether labor productivity serves as a mechanism for adjusting to the minimum wage in other firms or industries.

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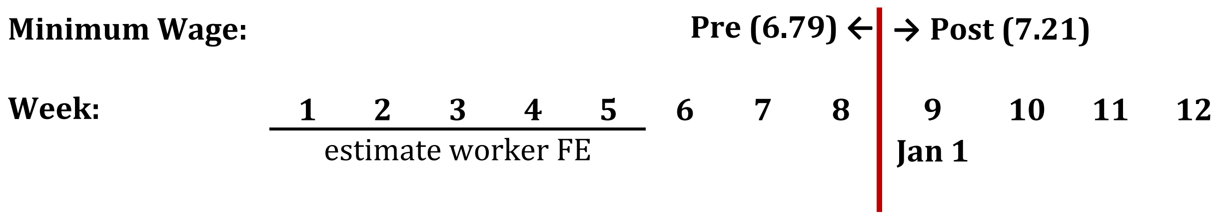
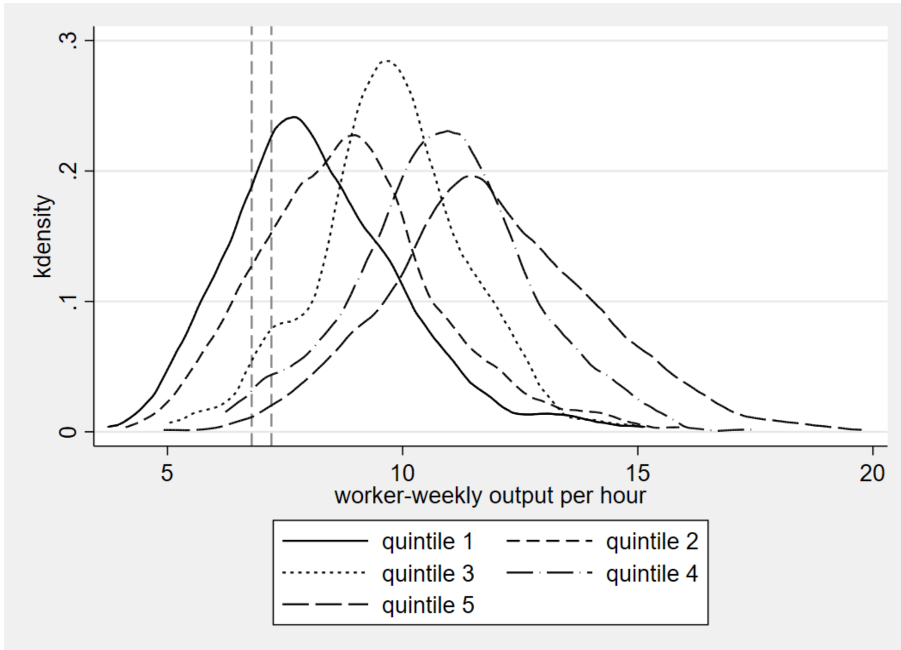
Figure 1: Timeline of the 2009 minimum wage hike



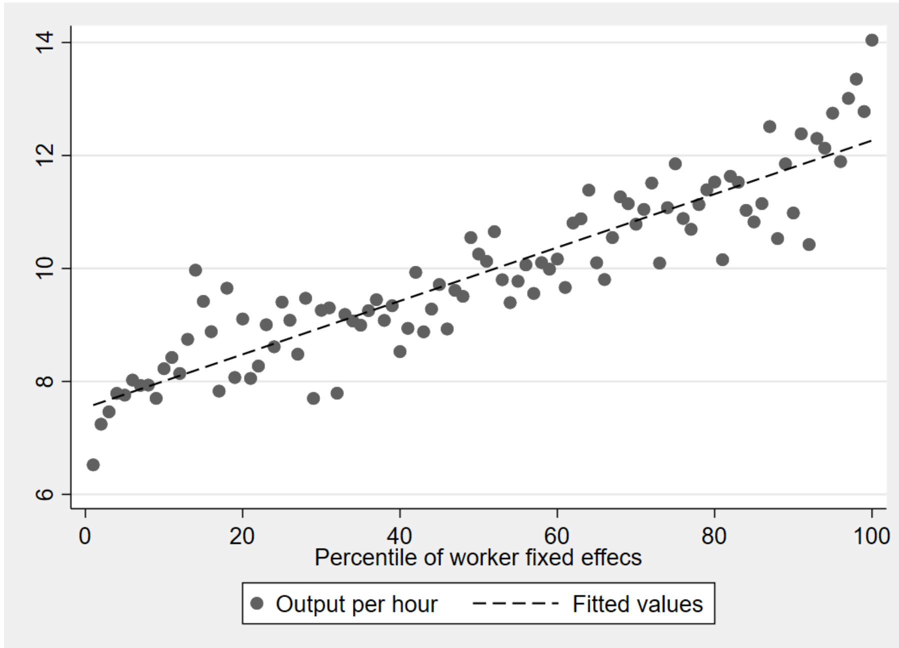
The harvesting season being investigated spans 12 weeks from November 2008 to January 2009, during which Florida's state minimum wage rose from $6.79 to $7.21 on January 1, 2009, a date that falls in week 9 of the analytic window. The pre period is defined as weeks 1-8; the post period as weeks 9-12. The estimation of worker fixed effects is based on transactions during the initial 5 weeks; that of worker effort responses on those during weeks 6-12.

Figure 2: Distribution of worker productivity by quintiles of worker fixed effects



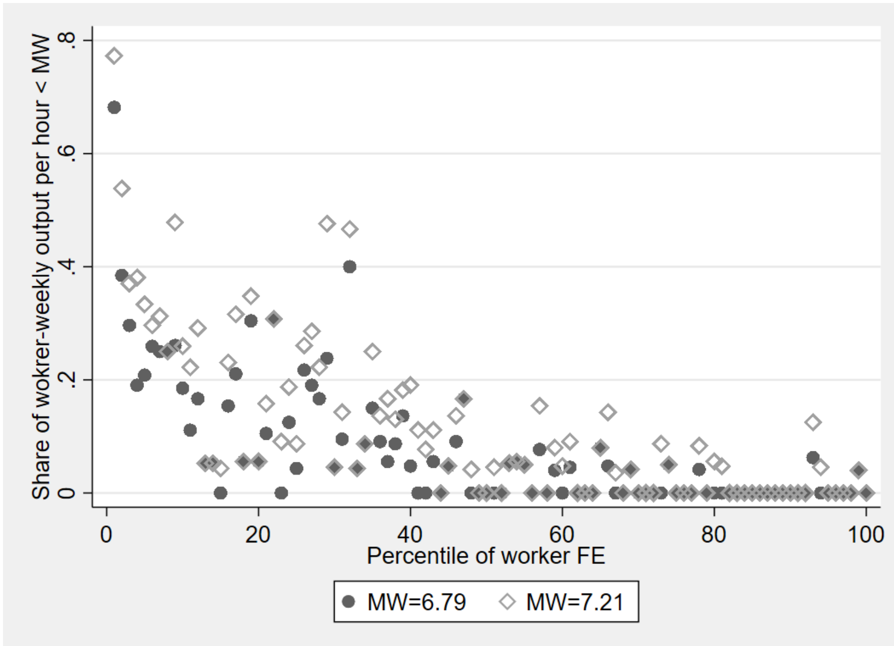
Worker-weekly output per hour during weeks 6-8. The worker fixed effects as pre-estimated by equation (1) using transactions during weeks 1-5. The dashed vertical line indicates the old and new minimum wages of $6.79 and $7.21, respectively.

Figure 3: Average productivity by percentiles of worker fixed effects



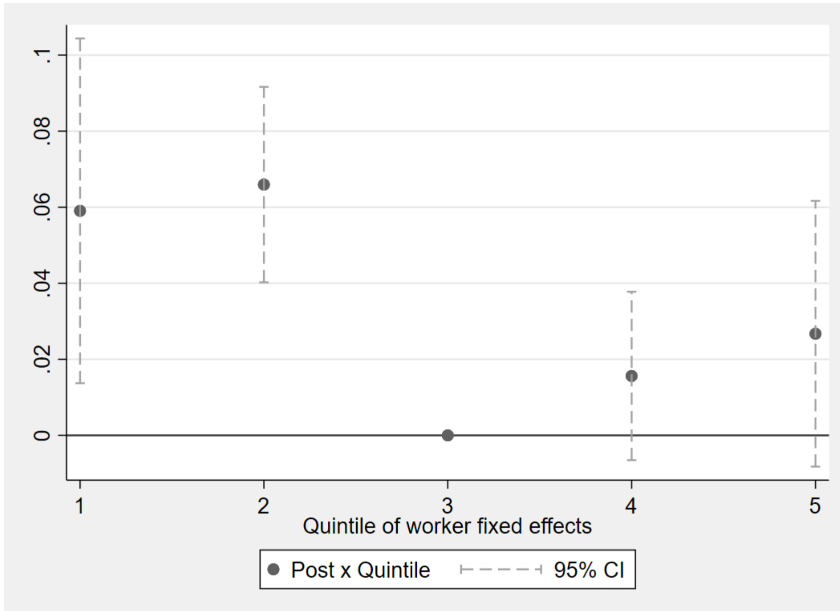
This figure plots the mean of worker-weekly productivity during weeks 6-8 by percentiles of worker fixed effects. The worker fixed effects are pre-estimated by equation (1) using transactions during weeks 1-5. The coefficient (SE) of the fitted line is 0.0473 (0.0021) and the R-squared is 0.8302.

Figure 4: Propensity to fall below the minimum wage by worker fixed effects



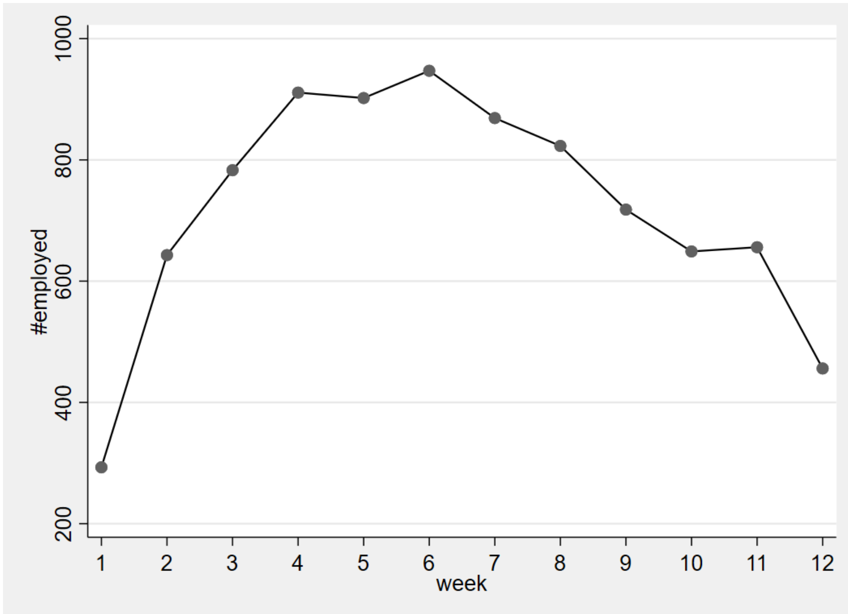
This figure plots for each percentile of worker fixed effects, the share of worker-weekly productivity observations during weeks 6-8 that fall below the current ($6.79) and new ($7.21) minimum wages, respectively. The worker fixed effects are pre-estimated by equation (1) using transactions during weeks 1-5.

Figure 5: Productivity change from pre- to post-MW hike by quintiles of worker fixed effects

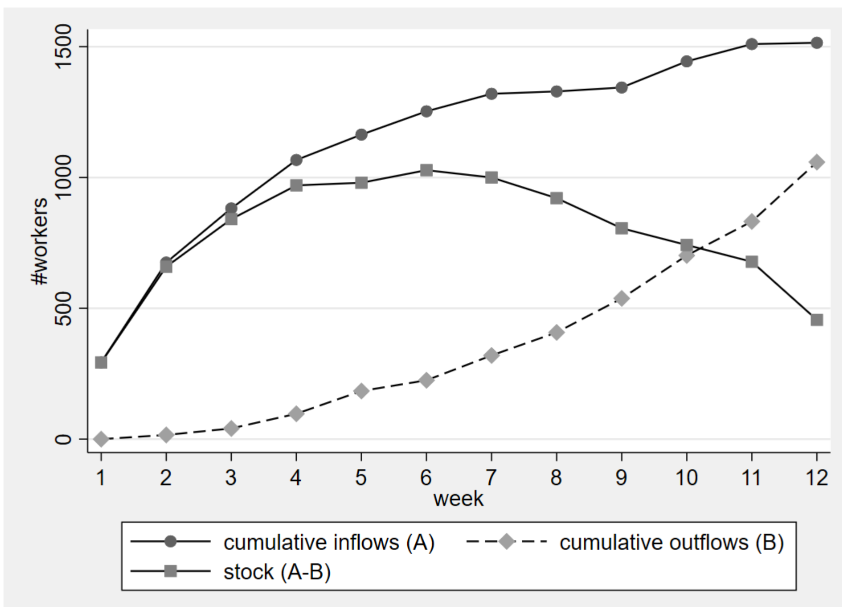


Based on transactions during weeks 6-12. Post=1 if week 9 or later. This figure plots the changes in productivity (output per hour) from Pre to Post periods by quintiles of worker fixed effects (relative to quintile 3). It plots the DID coefficients from estimating a variant of equation (2), where we replace Post x D with Post x dummy for each quintile except for quintile 3. Regression includes percentile dummies for pre-estimated worker effects, day FE, a cubic polynomial of worker experience, variety-field FE, a cubic polynomial of variety-field life-cycle, and supervisor FE. Standard errors are clustered by day.

Figure 6: Employment and worker flows during the season



(a) Employment



(b) Cumulative inflows, cumulative outflows and stock of workers

Panel (a) shows the total number of workers employed in each week. Panel (b) shows the cumulative inflows, cumulative outflows, and stock of workers in each week. The inflows in week K are measured as workers whose first harvesting day occurs in week K, and the outflows in week K are defined as those whose last harvesting day occurs in week K-1. The stock of workers in week K are the cumulative inflows by week K minus the cumulative outflows by week K, proxying for the size of worker pool available for hire in week K.

Table 1: Incidence and extent of the new minimum wage

	MW=$6.79	MW=$7.21
Minimum wage bites for the following share of:		
worker-weekly paychecks	0.118	0.158
workforce (for whom MW ever bites)	0.422	0.514
employment hours	0.096	0.135
Minimum wage compliance cost:		
in dollars	8,339	13,217

Notes: Both columns are based on 5,400 worker-weekly observations (974 unique workers) for weeks 1-8. The first column applies the low MW of $6.79 (the current MW in weeks 1-8) and the second column applies the high MW of $7.21 (the new MW to take effect in weeks 9-12).

Table 2: Worker output per hour by quintiles of worker fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent var.: log (output per hour)					
	All		***Exclude transition weeks***		***Exclude final week***	
			A. Full sample			
Post x Low FE		0.046***		0.070***		0.043**
		(0.016)		(0.020)		(0.017)
Post x Quintile 1	0.045*		0.080***		0.044*	
	(0.024)		(0.028)		(0.025)	
Post x Quintile 2	0.052***		0.065***		0.046***	
	(0.012)		(0.016)		(0.012)	
Observations	18,471	18,471	12,675	12,675	17,445	17,445
R-squared	0.565	0.564	0.577	0.577	0.536	0.536
			B. Balanced sample			
Post x Low FE		0.043**		0.068***		0.040**
		(0.016)		(0.019)		(0.017)
Post x Quintile 1	0.043*		0.080***		0.041	
	(0.024)		(0.028)		(0.026)	
Post x Quintile 2	0.049***		0.061***		0.044***	
	(0.012)		(0.015)		(0.012)	
Observations	16,756	16,756	11,247	11,247	15,730	15,730
R-squared	0.567	0.567	0.574	0.574	0.538	0.538
Percentile FE	Yes	Yes	Yes	Yes	Yes	Yes
Day FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Panel A is based on the full sample. Panel B is based on the balanced sample including workers who worked in both the pre (weeks 6-8) and post (weeks 9-12) periods. Based on transactions during weeks 6-12. Post=1 if week 9 or later. Transition weeks refer to weeks 8 and 9. The quintiles are based on the worker fixed effects estimated based on equation (1) using data from weeks 1-5. Low FE indicates worker fixed effects are in the bottom 40th percentile. All regressions include percentile dummies for pre-estimated worker effects, day FE, a cubic polynomial of worker experience, variety-field FE, a cubic polynomial of variety-field life-cycle, and supervisor FE. Robust standard errors clustered by day in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Imposing restrictions on the minimum number of spells when estimating worker fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent var.: Log (output per hour)					
Post x Low FE	0.050***	0.049***	0.046***	0.034**	0.043**	0.041**
	(0.016)	(0.015)	(0.016)	(0.016)	(0.016)	(0.016)
Observations	19,446	19,249	18,471	17,827	17,460	16,752
R-squared	0.566	0.568	0.564	0.567	0.570	0.568
Minimum #spells	3	4	5	6	7	8
Average #spells	12	13	13	14	14	15

Notes: Column (3) replicates the result in column (2) of Table 2. Columns (1) and (2) show results with lower numbers of minimum spells and columns (4)-(6) with higher numbers. Based on transactions during weeks 6-12. Post=1 if week 9 or later. The quintiles are based on the worker fixed effects estimated based on equation (1) using data from weeks 1-5. All regressions include percentile dummies for pre-estimated worker effects, day FE, a cubic polynomial of worker experience, variety-field FE, a cubic polynomial of variety-field life-cycle, and supervisor FE. Robust standard errors clustered by day in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4: Daily employment outcomes by low versus high fixed effect workers

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent var.:					
	Daily employment (extensive margin)				Daily hours worked (intensive margin)	
	All workers		*Exclude workers who likely exited the farm*		*Conditional on working that day*	
Mean of D.V.:	0.397		0.642		5.596	
Post x Low FE		-0.011		-0.030		0.028
		(0.020)		(0.027)		(0.125)
Low FE	-0.025**	-0.019	-0.066***	-0.054***	-0.312***	-0.323***
	(0.010)	(0.016)	(0.013)	(0.015)	(0.070)	(0.109)
Day FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	36,038	36,038	22,313	22,313	14,323	14,323
R-squared	0.106	0.106	0.167	0.167	0.340	0.340

Notes: Based on worker-day level data for weeks 6-12. Post=1 if week 9 or later. Low FE indicates pre-estimated worker fixed effects are in the bottom 40th percentile. Daily employment is 1 if the worker is working that day and 0 otherwise. Daily hours worked are total hours worked by the worker conditional on working that day. Columns (1) and (2) include all workers in our sample. Columns (3) and (4) exclude worker-days if the worker's last day of employment at this farm during this season occurs in any week prior to the week of the present worker-day. Columns (5) and (6) restrict sample to worker-days with non-zero employment hours. All regressions include day FE. Post is subsumed in day FE. Robust standard errors clustered by day in parentheses. *** p<0.01, ** p<0.05, * p<0.1

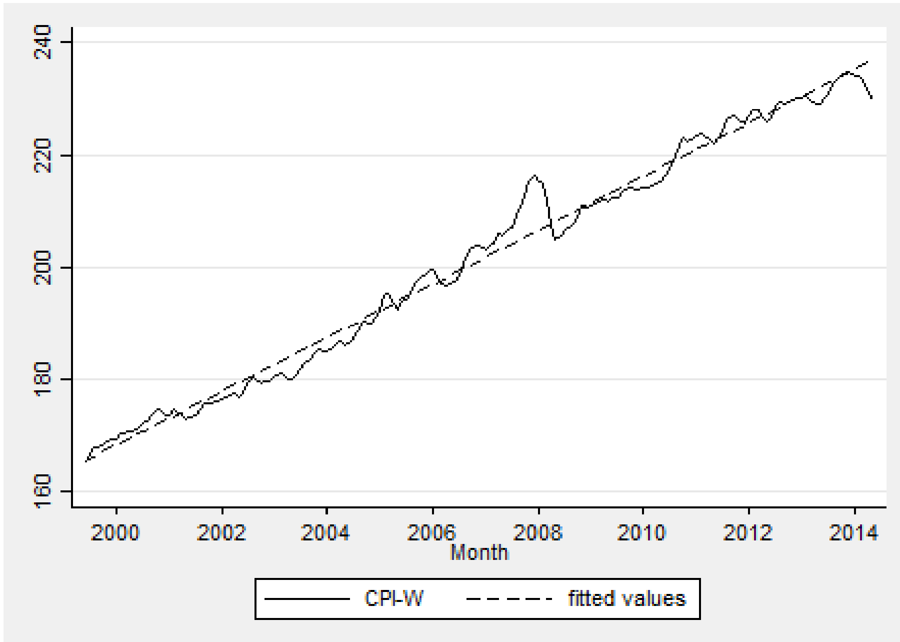
Table 5: Implication of worker effort responses on the firm's minimum wage compliance cost

	(1)	(2)	(3)	(4)
	MW=6.79		**MW=7.21**	
Minimum wage compliance cost ($)	8,339	13,217	10,660	10,285
Worker effort response		No	Yes	Yes
Change in the allocation of employment hours		No	No	Yes
Implied reduction in compliance cost ($)		N/A	2,557	2,932

Notes: Based on 5,400 worker-weekly observations (974 unique workers) for weeks 1-8. Columns (3) and (4) apply productivity increase of 4.6 percent for workers in the bottom 40th percentile. Column (4) additionally applies a decreased share of employment hours for workers in the bottom 40th percentile by 4.6 percent.

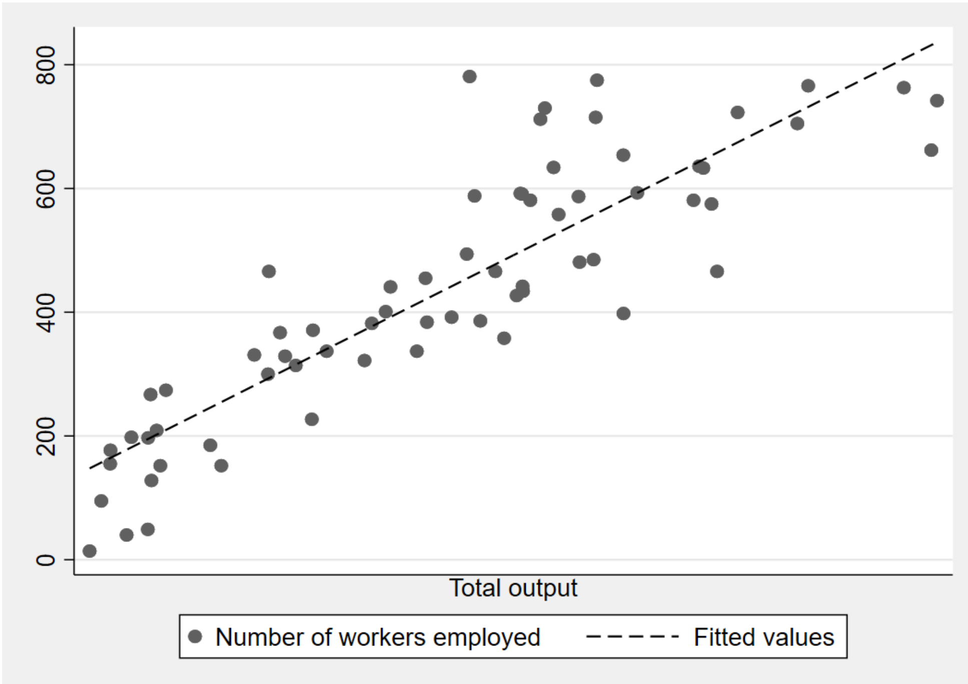
Appendix A

Figure A.1: Monthly Consumer Price Index for urban wage earners and clerical workers (CPI-W)



Source: US Bureau of Labor Statistics (Series ID: CWUR0000SA0). 1982-84=100. August for each year is marked on the horizontal axis.

Figure A.2: Daily number of workers employed and daily total output



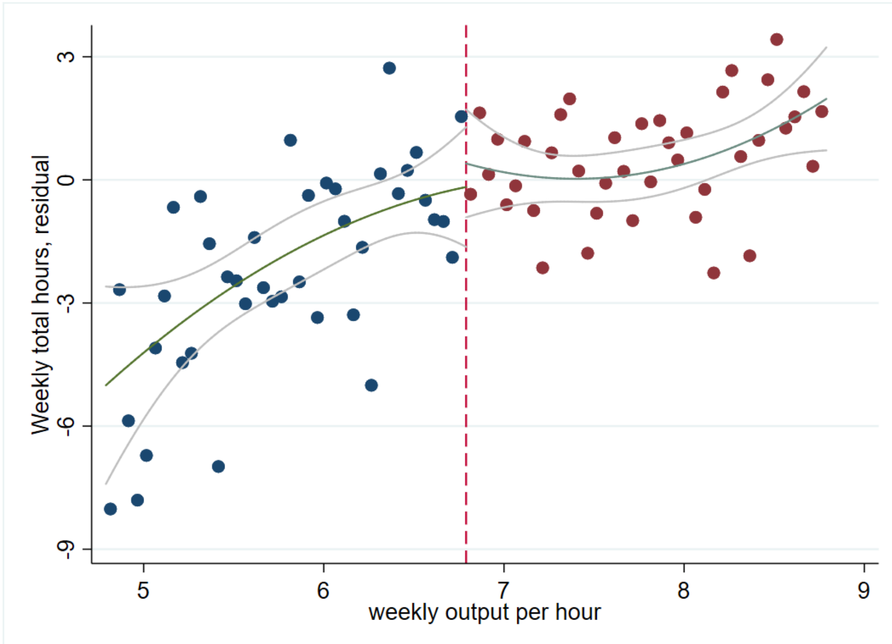
This figure plots the relation between the number of workers employed each day and the "field capacity" proxied by the total output. The label for x-axis (total output) is suppressed to not reveal the farm's day-specific scale of operation. R-squared associated with the regression line is 0.7695.

Figure A.3: Example worker paystub

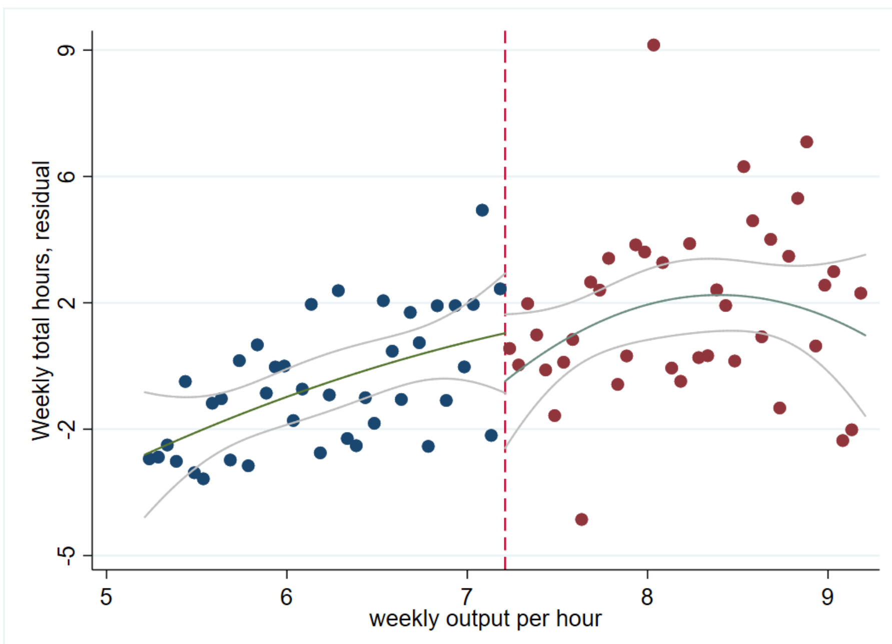
Employee ID: ABCXYZ
From: Nov 16, 2008   To: Nov 22, 2008

Date	Type	Hours	Rate	Pieces	Earnings
Nov 16, 2008	Minimum Wage				16.00
Nov 16, 2008	Round	5.33	0.5	58	29.00
Nov 16, 2008	Grape	1.67	3.75	2	7.50
Nov 17, 2008	Grape	3.65	3.75	3	11.25
Nov 17, 2008	Round	4.63	0.5	80	40.00
Total		15.28			103.75

Figure A.4: Worker-weekly total hours of employment against worker-weekly average productivity



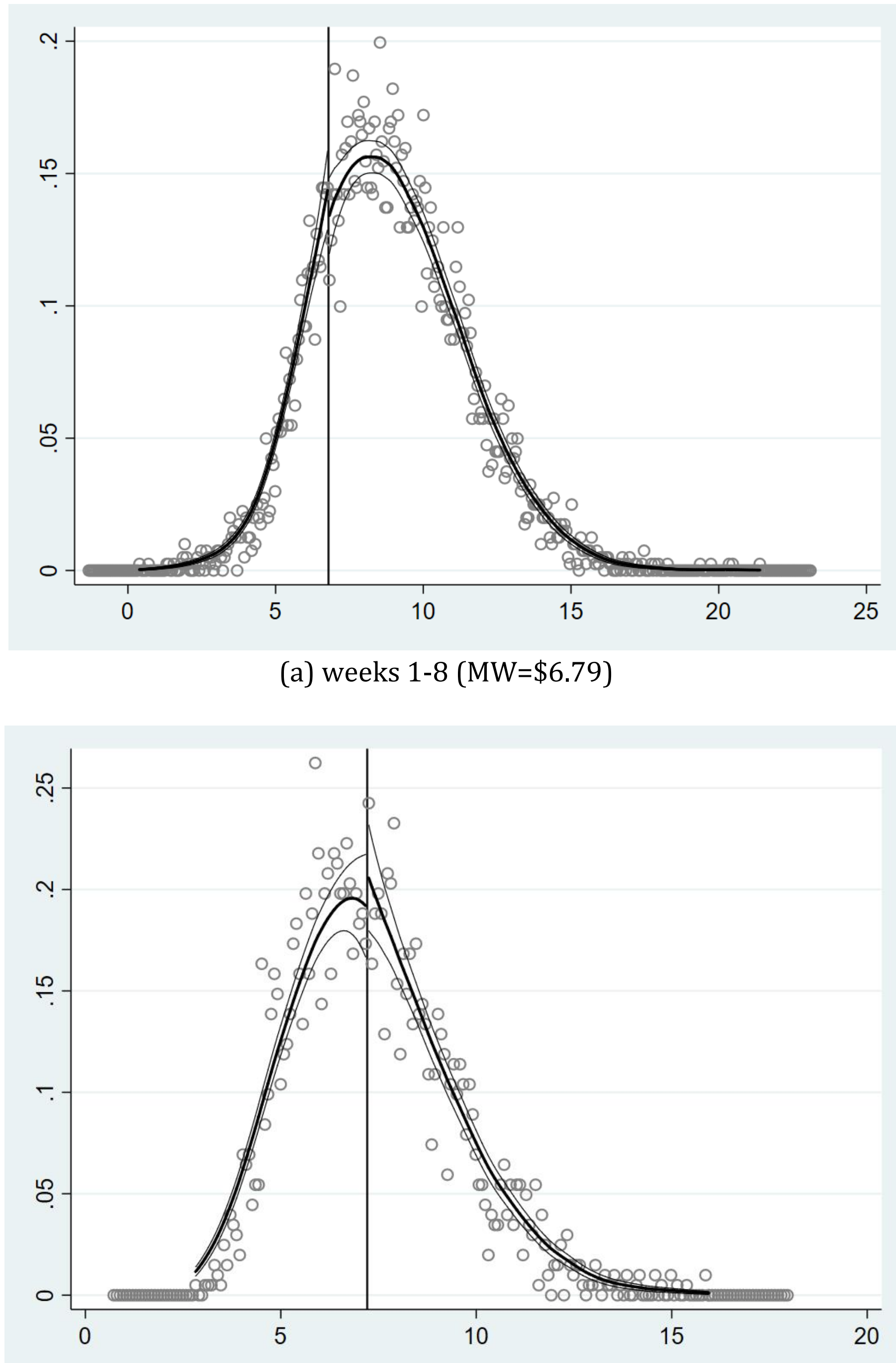
(a) weeks 1-8 (MW=$6.79)



(b) weeks 9-12 (MW=$7.21)

This figure plots the mean of residual of worker-weekly total hours of employment (after accounting for week fixed effects) by 5 cents bins of worker-weekly average productivity (output per hour) for a 2 dollar window around the relevant minimum wage ($6.79 in panel (a) and $7.21 in panel (b)). Quadratic fit with 95 percent confidence interval is shown on either side of the minimum wage. It shows that the employment hours in the record are smooth around the minimum wage with no sign of a discontinuous drop before the minimum wage.

Figure A.5: McCrary test: density of worker-weekly productivity around the minimum wage threshold

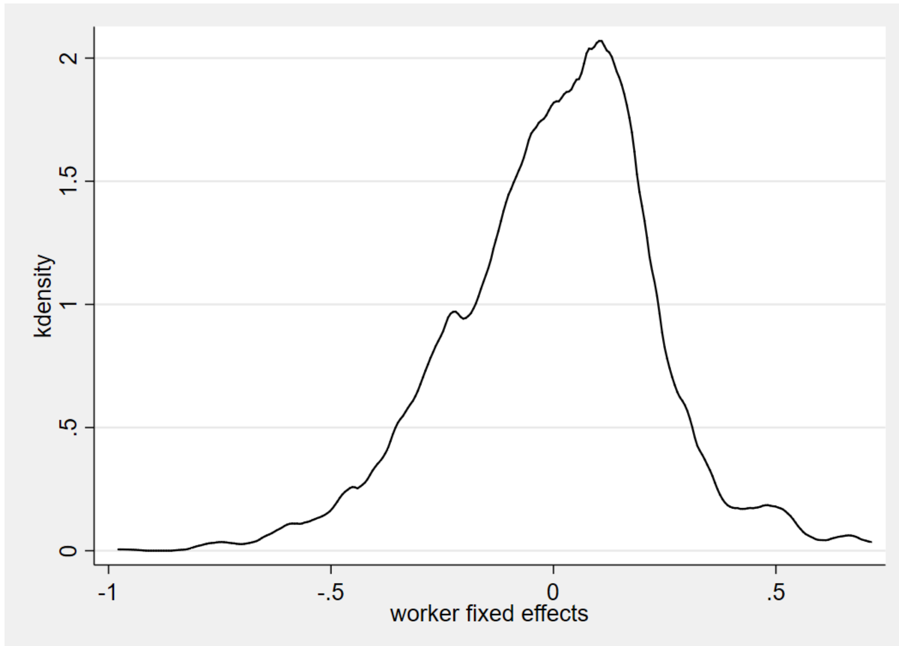


(a) weeks 1-8 (MW=$6.79)

(b) weeks 9-12 (MW=$7.21)

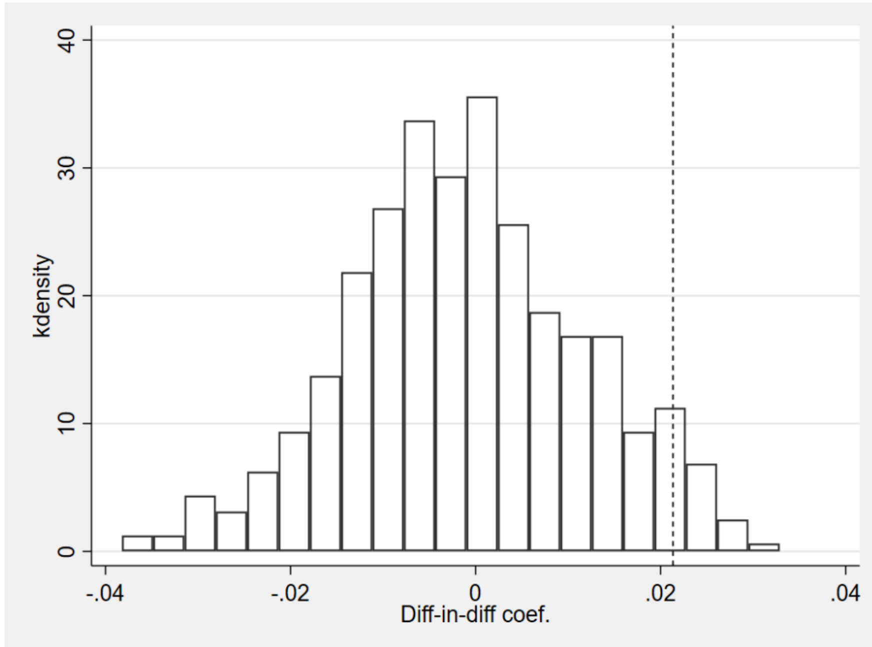
This figure shows the McCrary plot, which tests for selective sorting around the threshold on the worker-weekly average productivity (output per hour). The vertical line is the relevant minimum wage, $6.79 in panel (a) and $7.21 in panel (b). The figure shows no discontinuity in the density of observations around the minimum wage.

Figure A.6: Distribution of worker fixed effects



This figure shows the distribution of worker fixed effects as estimated by equation (1) using 13,291 observations from 974 unique workers during weeks 1-5. The mean (standard deviation) of the estimated FE is 0.0000 (0.2254).

Figure A.7: Distribution of estimated productivity change based on simulated worker effects



This figure plots the historgram of the estimated productivity change from the pre to the post period (parameter δ in equation (2)) based on simulated worker effects. Worker effects are drawn from the normal distribution with mean (standard deviation) of 0.0000 (0.2254), the sample mean and SD among the estimated fixed effects). Based on 500 reps. The short dashed line shows the 95th percentile.

Table A.1: Lowest wage occupations in Florida

Occupation title	Hourly wages: 10th percentile	25th percentile	median	75th percentile	90th percentile	mean
A. All Occupations	8.02	10.06	14.58	22.58	34.26	18.96
B. Major occupation groups						
Food preparation and serving related occupations	7.41	7.71	8.82	11.22	14.69	10.09
Farming, fishing, and forestry occupations	7.43	7.80	8.86	11.35	15.32	10.34
Personal care and service occupations	7.51	8.10	9.75	12.99	18.80	11.63
C. Detailed occupations						
Combined food preparation and serving workers, including fast food	7.35	7.57	8.10	9.15	10.80	8.66
Dining room and cafeteria attendants and bartender helpers	7.35	7.57	8.16	9.33	11.41	8.81
Cooks, fast food	7.36	7.57	8.20	9.28	10.83	8.65
Dishwashers	7.36	7.57	8.23	9.27	10.78	8.62
Amusement and recreation attendants	7.37	7.62	8.39	9.95	12.69	9.27
Counter attendants, cafeteria, food concession, and coffee shop	7.38	7.64	8.39	9.45	11.28	8.83
Cashiers	7.34	7.54	8.44	9.41	11.18	8.83
Waiters and waitresses	7.37	7.61	8.56	11.21	14.54	9.91
Bartenders	7.38	7.62	8.66	11.19	15.29	10.11
Farmworkers and laborers, crop, nursery, and greenhouse	7.41	7.73	8.66	10.58	13.16	9.63

Notes: This table shows the mean and various percentiles of hourly wages for the lowest paying occupations in Florida. Based on May 2009 estimates for Florida from Occupational Employment Statistics (OES) provided by the US Bureau of Labor Statistics. Panel A shows the statistics for all occupations in the state. Panel B lists the three lowest paying major occupation groups, out of 22 in the Standard Occupational Classification (SOC). Panel C lists the ten lowest paying detailed occupations with at least 20,000 employment count. There are about 800 detailed occupations in the SOC.

Table A.2: Minimum wage in Florida, 2000-2015

		Federal Minimum Wage	Florida Minimum Wage	Change in Florida Minimum Wage	Florida Effective Date	
*	2000	$5.15	$5.15			
	2001	$5.15	$5.15	$0.00		
	2002	$5.15	$5.15	$0.00		
	2003	$5.15	$5.15	$0.00		
	2004	$5.15	$5.15	$0.00		
**	2005	$5.15	$6.15	$1.00	05/02/2005	12/31/2005
	2006	$5.15	$6.40	$0.25	01/01/2006	12/31/2006
	2007	$5.85	$6.67	$0.27	01/01/2007	12/31/2007
	2008	$6.55	$6.79	$0.12	01/01/2008	12/31/2008
	2009	**$6.55**	**$7.21**	**$0.42**	**01/01/2009**	**7/23/2009**
***	2009	$7.25	$7.25	$0.04	7/24/2009	12/31/2009
***	2010	$7.25	$7.25	$0.00	01/01/2010	12/31/2010
***	2011	$7.25	$7.25	$0.00	01/01/2011	5/31/2011
****	2011	$7.25	$7.31	$0.06	06/01/2011	12/31/2011
	2012	$7.25	$7.67	$0.36	01/01/2012	12/31/2012
	2013	$7.25	$7.79	$0.12	01/01/2013	12/31/2013
	2014	$7.25	$7.93	$0.14	01/01/2014	12/31/2014
	2015	$7.25	$8.05	$0.12	01/01/2015	12/31/2015

Source: Florida Department of Economic Opportunity, October 2015

* 2000-2004, The Federal Minimum Wage

** Florida enacted a state minimum wage (Florida Minimum Wage Amendment approved through election ballot on November 2, 2004).

*** Florida defaulted to the Federal minimum wage

**** Legal ruling raising the minimum wage to $7.31

Table A.3: Mean employment, hours worked, and productivity

	(1)	(2)	(3)	(4)
	daily employment			
	all workers	exclude workers who likely exited the farm	daily hours if worked that day	output per hour
		A. weeks 1-5		
Quintile 1	0.49	0.53	4.90	7.59
Quintile 2	0.51	0.55	4.96	8.85
Quintile 3	0.53	0.59	5.06	9.97
Quintile 4	0.55	0.57	5.03	11.13
Quintile 5	0.52	0.55	4.96	11.94
All	0.52	0.56	4.99	10.00
		B. weeks 6-8		
Quintile 1	0.47	0.59	4.98	8.16
Quintile 2	0.50	0.64	5.33	8.91
Quintile 3	0.48	0.69	5.36	9.77
Quintile 4	0.53	0.66	5.41	10.83
Quintile 5	0.49	0.63	5.45	11.88
All	0.49	0.64	5.31	9.93
		C. weeks 9-12		
Quintile 1	0.26	0.57	5.76	6.84
Quintile 2	0.31	0.61	5.90	7.59
Quintile 3	0.30	0.68	6.03	7.86
Quintile 4	0.36	0.70	6.25	8.76
Quintile 5	0.30	0.65	6.14	9.70
All	0.31	0.64	6.03	8.21
		D. all weeks		
Quintile 1	0.41	0.56	5.12	7.62
Quintile 2	0.44	0.59	5.30	8.56
Quintile 3	0.45	0.64	5.37	9.41
Quintile 4	0.48	0.63	5.45	10.39
Quintile 5	0.44	0.59	5.39	11.37
All	0.44	0.60	5.33	9.54
Obs.	56,976	41,966	25,252	31,762

Notes: Based on 974 unique workers, this table shows the mean employment, hours, and productivity (output per hour) by quintiles of individual FE, separately for the weeks 1-5, 6-8, and 9-12, and for the overall season. Observations in columns 1-3 are at the worker-day level. Observations in column 4 are at the spell level (more than one spell is possible for a given day). Column 1 includes all possible worker-days. Column 2 excludes worker-days from week K if the worker's last day of employment during the season falls in any week prior to week K. Column 3 reports daily hours worked conditional on working that day. Column 4 reports output per hour measured in $/hr.

Table A.4: Using different specifications in accounting for the baseline productivity of workers

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent var.: log (output per hour)					
	Percentile		***Quintile***		***Linear***	
Post x Low FE		0.046***		0.039**		0.048***
		(0.016)		(0.016)		(0.014)
Post x Quintile 1	0.045*		0.037		0.061***	
	(0.024)		(0.024)		(0.021)	
Post x Quintile 2	0.052***		0.048***		0.044***	
	(0.012)		(0.012)		(0.010)	
Baseline productivity	Yes	Yes	Yes	Yes	Yes	Yes
Day FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	18,471	18,471	18,471	18,471	18,471	18,471
R-squared	0.565	0.564	0.543	0.543	0.559	0.558

Notes: This table employs different specifications to account for the baseline productivity of workers. Columns (1)-(2) use the same specification as in Table 2 and include dummies for each percentile of the pre-estimated worker effects. Columnns (3)-(4) include dummies for each quintile of the worker effects. Columns (5)-(6) include the pre-estimated worker effects in levels. Based on transactions during weeks 6-12. Post=1 if week 9 or later. All regressions include day FE, a cubic polynomial of worker experience, variety-field FE, a cubic polynomial of variety-field life-cycle, and supervisor FE. Robust standard errors clustered by day in parentheses. *** p<0.01, ** p<0.05, * p<0.1