Minimum Wage and Individual Worker Productivity: Evidence from a Large US Retailer*

Decio Coviello — HEC Montréal
Erika Deserranno — Northwestern
Nicola Persico — Northwestern

May 9, 2021

Abstract

We study how individual worker productivity responds to the minimum wage. Our workers are employed by a large US retailer, work in different store locations, and are paid based on performance. By means of a border-discontinuity analysis, we document that workers become more productive and are terminated less often after a minimum wage increase. Notably, the effect primarily concerns workers whose average wage is often supported by the minimum wage, and only obtains when monitoring is high enough. We interpret these findings using a new model where the incentives to exert effort come from two channels: pay-for-performance (where the minimum wage is expected to de-motivate effort provision), and efficiency wages (where the minimum wage is expected to motivate it, provided that monitoring is sufficiently high). The evidence suggests that the efficiency wage channel predominantly shapes the worker's productivity response.

Keywords: minimum wage, worker productivity, termination, efficiency-wage, pay-for-performance. **JEL Classification**: J24, J38, J63, J88, M52

*Thanks go to the five anonymous referees and the editor, as well as Matteo Bobba, David Card, Luis Garicano, Bob Gibbons, Mitch Hoffman, Daniel Parent, Daniele Paserman, Oskar Nordstrom Skans, Chris Stranton and seminar participants at NBER-OE, SIOE 2018, EALE-SOLE 2020, Barcelona GSE forum, Columbia University, Syracuse University, UCLA Anderson, Uppsala University, University of Miami, University of Toronto, Bank of Canada, McGill University, Goethe University Frankfurt, the Productivity Partnership Labor Workshop (HEC Montreal), and the Wages and Labor Market Workshop (Helsinki). This research was conducted in collaboration with the Workforce Science Project of the Searle Center for Law, Regulation and Economic Growth at Northwestern University, and undertaken, in part, thanks to funding from the Canada Research Chairs program. We are grateful to Suhail Amiri, Vincent Chartray, Margaux Jutant, Andre Cazor Katz, and Athanasse Zafirov for their excellent research assistance. The authors declare they have no relevant or material financial interests that relate to the research described in this paper. This work has been screened to ensure no confidential information is revealed. Data and institutional background are provided in such a way as to not disclose information that may allow the firm to be identified. E-mails: decio.coviello@hec.ca; erika.deserranno@kellogg.northwestern.edu; nicola@nicolapersico.com.

1 Introduction

This paper shows that increasing the minimum wage causes individual worker productivity to increase, and it interprets this finding through the lens of an efficiency wage model.

Our employees are salespeople whose pay is, in part, based on performance (sales per hour). They work for a large US retailer operating more than 2,000 stores across all fifty states and employing more than 10% of department store employees nationwide, or roughly 1-2% of employment in the entire US retail sector. The data cover 70 minimum wage increases at the state and local levels.

Using a border-discontinuity research design, we document that an increase in the minimum wage leads to a rise in individual productivity. This effect is strongest for those workers whose pay is more often supported by the minimum wage (referred to herein as "low types"). However, this effect flips (becomes negative) when workers are relatively less monitored, as measured by a low supervisor-to-worker ratio within a store.

We interpret these findings through the lens of a new model that features two sources of incentives. Workers are incentivized both by the threat of termination, which is based on the direct monitoring of effort; and by the variable component of pay, which reflects individual performance, which in turn is a noisy signal of effort. We respectively refer to these two channels as "pay-for-performance" and "efficiency wage." In our context, performance consists of the value of sales per hour, while effort consists of meeting and greeting the customer, explaining product features, up-selling to higher-margin products, and cross-selling (warranties, loans, credit cards, etc.).

In this model, a minimum wage increase has two opposite effects on incentives: it *de-motivates* effort provision because it flattens the pay schedule (pay-for-performance channel), but it *motivates* effort provision because of the fear of losing a now-higher paying job (efficiency wage channel). We infer that the efficiency wage channel dominates in our setting because, empirically, performance increases with the minimum wage. Consistent with the efficiency wage channel, we find that the workers whose performance increases the most with the minimum wage also have the largest drop in termination rates; according to efficiency wage theory, this decrease in terminations is the reward these workers reap from exerting more effort.

While the efficiency wage channel appears to dominate in the data, our theory predicts that this channel will vanish if effort is not monitored directly. In this scenario, the only source of incentives is the pay-for-performance channel, so the minimum wage is expected to de-motivate workers. We find support for this theoretical prediction in the data when examining periods in which a store's workers are less intensely monitored. Specifically, we use the supervisor-to-worker ratio as a proxy of monitoring intensity within a store. When this ratio is low, a minimum wage increase is shown to actually *decrease* performance – contrary to that which we find on average, and consistent with our theoretical predictions.

In sum, we show that increasing the minimum wage causes individual worker productivity to increase, and the totality of the evidence points to an efficiency wage channel as being responsible for this effect.

In shifting to store-level outcomes, we document that termination, hiring, and turnover rates all decrease with the minimum wage, and that the effect is increasing in the fraction of low types in the store. This is as predicted by the model, and consistent with the minimum wage literature on aggregate flows of low-paid workers (e.g., Brochu and Green 2013, Dube et al. 2016). Further, the model has several specific predictions regarding employment and profits. Because HQ sets wages and prices uniformly across stores, average profits across all locations are expected to decrease with the minimum wage. This is indeed what we find in the data. Meanwhile, employment is expected to co-move with profits at the store level; again, we document this empirically. Finally, we quantify the employees' welfare gain from the minimum wage and find that it is positive and higher for low types.

Our paper is particularly novel in its findings on the effect of the minimum wage on individual worker productivity. Crucially, our inclusion of worker fixed effects in the estimations alleviates concerns of selection and cross-border migration. Our results are robust to different definitions of "low types," to a "state-panel" research design, and to using alternative samples. Finally, we show that the demonstrated effect is not, as far as we can measure, an artifact of demand shifts, price changes, or other organizational changes.

To our knowledge, the literature on the individual productivity effects of the minimum wage consists of Ku (2018) and Hill (2018), who study tomato and strawberry pickers, respectively, in a single farm around one or two minimum wage events. They reach apparently conflicting results: Ku (2018) finds that increasing the minimum wage increases individual productivity, while Hill (2018) finds the opposite. As they both use relatively more productive workers as the control group, their research designs only allow *relative* estimates (low vs. high types) of the productivity gain. In contrast, we observe workers in nearby establishments experiencing no minimum wage increase, permitting an estimation of the *absolute* productivity gains for low and high types. Moreover, our model and our empirical findings allow to reconcile Ku's (2018) and Hill's (2018) apparently opposing findings by appealing to variation in monitoring intensity.

The paper proceeds as follows. Section 2 presents the model while Section 3 describes the data, the institutional context, and the identification strategy. Section 4 discusses our core results: the effect of the minimum wage on worker productivity. Section 5 examines heterogeneous effects of the minimum wage on worker productivity by monitoring intensity, followed by Section 6, which introduces the store-level results on turnover, employment, and profits. Section 7 discusses two alternative channels: demand and organizational adjustments. Then, Section 8 computes the worker's welfare gain from a minimum wage increase. Section 9 turns to a discussion of the external validity of our findings and the ways they intersect with the vast minimum wage literature on turnover, employment, and profits. Section 10 concludes.

2 Model

Our model generalizes the efficiency wage model of Rebitzer and Taylor (1995, henceforth RT) in three ways. First, worker effort is continuous rather than binary. Second, workers differ by type – in this case, by productivity and cost of effort. Third, pay is allowed to depend on performance as well as on the minimum wage. The third feature implies that effort provision will follow a mixture of efficiency wage logic and pay-for-performance logic.

Each worker has a firm-specific type $x \geq 0$ and chooses a continuous effort level $e \in [0,1]$. Type x's cost of effort $c(x,e)$ is strictly increasing in effort. We assume that the marginal cost of effort vanishes at zero and is infinite at 1; these assumptions will help ensure that optimal effort is interior to $[0,1]$.

Worker performance (i.e., value of output: in our case, sales revenue per hour) is a finite non-negative random variable $Y(x,e)$ whose density $f_Y(y;x,e)$ has interval support and enjoys the strict monotone likelihood ratio property (MLRP) in x and e.[1] Intuitively, the MLRP means that higher types and greater effort levels produce stochastically higher output. The MLRP implies first-order stochastic dominance.

Consider any continuous nondecreasing compensation scheme $\overline{w}(\cdot)$ that transforms performance into pay. (For example, $\overline{w}(Y) = b + cY$ where b represents the base salary and c the commission rate.) The expected wage is denoted by:

$$w(x,e) = \mathbb{E}\left(\overline{w}\left(Y(x,e)\right)\right). \tag{1}$$

The function w is nondecreasing in each of its arguments due to the MLRP.

The per-period payoff of a type x who exerts effort e is:

$$u(x,e) = w(x,e) - c(x,e).$$

We assume that u is continuously differentiable over its domain and make the following intuitive assumptions:

Assumption 1. $u_x > 0$, $u_{xe} > 0$, *and* $u_{ee} < 0$.

The first two properties signify that higher types have higher payoffs *and* higher marginal return on effort. The third property, concavity of u in e, helps identify the optimal effort level. The required properties may be imparted to u by either of its components, w and c. For example, Assumption 1 holds if the wage w is identically equal to the minimum wage, provided that the cost function is strictly convex in e, and higher types have lower effort cost *and* lower marginal cost of effort, which are standard assumptions.

[1] This means that the ratio $f_Y(y;x,e)/F_Y(y;x,e)$ is strictly increasing in x and in e whenever $f > 0$.

The following value function represents the lifetime payoff of an agent x who always exerts effort $e \in [0,1]$:

$$V(x,e) = u(x,e) + \frac{1}{(1+r)}\left[\pi(e)\,V(x,e) + (1-\pi(e))\,V^A\right]. \tag{2}$$

The numbers $r > 0$ and V^A represent, respectively, the discount rate and the lifetime value of becoming unemployed. The function $\pi(e)$ represents the probability of continued employment, which is assumed to be nondecreasing and continuously differentiable over $[0,1]$. We interpret the magnitude of $\pi'(e)$ as reflecting the firm's monitoring intensity; the limit case where $\pi'(e) \equiv 0$ for all e will be referred to as the "no monitoring" case.[2]

Isolate $V(x,e)$ to get:

$$V(x,e) = (1+r)\,Q(x,e) + V^A, \tag{3}$$

where:

$$Q(x,e) = \frac{1}{1+r-\pi(e)}\left[u(x,e) - \frac{r}{(1+r)}V^A\right]. \tag{4}$$

The function $Q(x,e)$ has the same maxima and minima as $V(x,e)$, and is slightly more convenient to work with. The function Q is the product of two terms: an "endogenous discounting" term that is nondecreasing in e and captures the fact that working harder increases the worker's probability of being retained; and a bracketed term that is the per-period value of employment, net of opportunity cost. The two terms in expression (4) capture the dual nature of worker motivation: she is motivated by a static incentive (in brackets), which represents a standard "pay for performance" incentive and, also, by the dynamic consideration of losing her future rents from current employment (endogenous discounting term), which may be thought of as the "efficiency wage" incentive channel.

The efficiency wage channel motivates the worker to exert *more effort* than justified solely by pay-for-performance. To see this, observe that the first-order conditions for

[2] Equation (2) is a continuous-effort counterpart of RT's equations (2-4). In keeping with RT, equation (2) says that the worker is fired *after* receiving the period's pay, and that firing decisions are made based on effort provision, not on realized performance.

maximization of Q may be written as:

$$\frac{d}{de}\ln\left[1+r-\pi\left(e\right)\right]=\frac{d}{de}\ln\left[u\left(x,e\right)-r\frac{V^{A}}{\left(1+r\right)}\right]. \tag{5}$$

If the efficiency wage channel is operative, then the left-hand side in (5) is negative. The right-hand side represents the marginal benefit of effort in a pure pay-for-performance scheme. If the left-hand side in (5) is negative and equality holds, then every type x exerts *more effort* than the level at which the right-hand side equals zero, which is the pure pay-for-performance optimum.

To avoid trivialities, we assume that it is strictly optimal for all types to show up for work. Formally, we assume that the set of *individually rational effort levels*, defined as the set of effort levels e such that $Q\left(x,e\right)>0$, is non-empty for all x. Lemma 1 shows that the set of individually rational effort levels is an interval.

The next assumption helps ensure that $Q\left(x,e\right)$ is strictly quasi-concave over the interval of individually rational effort levels, and that the optimal effort level, i.e., the solution to the first-order conditions (5), is increasing in x.

Assumption 2. $1+r-\pi\left(e\right)$ *is log-convex.*

Assumption 2 requires $ln\left(1+r-\pi\left(e\right)\right)$ to be (weakly) convex. This assumption is trivially satisfied in the no monitoring case, because then $\pi'\left(e\right)\equiv 0$ for all e. Aside from this polar case, intuitively, $1+r-\pi\left(e\right)$ is required to be "sufficiently convex" or, equivalently, $\pi\left(e\right)$ must be "sufficiently concave." In Appendix B.2 we present two families of functions $\pi\left(\cdot\right)$ where this assumption is satisfied. Assumption 2 implies $\pi''\left(e\right)\leq 0$.

The next lemma says that the model behaves "nicely."

Lemma 1. *Suppose Assumptions 1 and 2 hold.*

1. *Fix x. The set of individually rational effort levels is an interval, and $Q\left(x,e\right)$ is a strictly quasi-concave function of e over this interval. Therefore $Q\left(x,e\right)$ has a unique maximizer denoted by $e^{*}\left(x\right)$.*

2. *$e^{*}\left(x\right)$ is nondecreasing in x, and it is strictly increasing if $e^{*}\left(x\right)$ is interior to $\left[0,1\right]$.*

3. *If $\pi'(e) > 0$ for all e then $e^*(x)$ is interior to $[0,1]$ for all x.*

Proof. See Appendix B.1. ■

Linking the Model to Our Empirical Setting

We study a single firm with many store locations across the U.S., and the above model describes the problem of a worker operating in a specific store. Store characteristics are introduced as covariates Z that modify the probability of continued employment $\pi_Z(e)$ and the outside option V_Z^A.

Compensation scheme Since in our firm *all workers nation-wide are subject to the same compensation scheme*, the compensation scheme cannot be optimally adapted to the local conditions of most stores. At best, it is optimal on average. Hence, in our model, we cannot assume that the compensation scheme $\overline{w}(\cdot)$ is optimally adapted to the local parameters M, Z, where M is the minimum wage. We assume, instead, that when a locality increases M, $\overline{w}$ does not change.[3] Thus, in a store that is subject to a local minimum wage M, the expected wage is:

$$w(x, e; M) = \mathbb{E}\left(\max\left[M, \overline{w}\left(Y(x, e)\right)\right]\right). \tag{6}$$

The function $w(x, e; M)$ is bounded below by M and is nondecreasing in all its arguments.[4]

Henceforth $w(x, e; M)$ will replace $w(x, e)$, and we assume that Assumption 1 holds given this replacement. The worker's optimal effort $e^*(x; M)$ will henceforth be indexed by the minimum wage level.

Low types

[3]This assumption is validated empirically in Table 2, where we show that when a locality increases M, base pay and commission rates in the store do not change.

[4]It is obviously nondecreasing in M. It is nondecreasing in x and in e by stochastic dominance, because the function $\max[M, w(Y)]$ is nondecreasing in Y.

Definition 1. ***(MMW, or low type)*** *Type x is MMW (i.e., "motivated by the minimum wage") or a "low type" if $w(x, e; M) = M$ for all $e \in [0, 1]$.*

MMW types cannot increase their wage by exerting more effort, so their only incentive to exert effort is the fear losing their job. In this respect, MMW types behave exactly as the workers in the RT model. The set of MMW types, if nonempty, is an interval including zero; this is because the function $w(x, e; M)$ is nondecreasing in x. It is therefore appropriate to refer to MMW types as "low types." Empirically, we will define a "low type" as a worker whose pay is often determined by the minimum wage and, therefore, has incentives similar to the MMW types in the theory.

Three cases nested by the model The model nests two polar cases and a "hybrid" one.

Special Cases Nested by the Model

Polar case: pure efficiency wages If $w(x, e) \equiv M$, the worker's objective function $Q(x, e)$ (expression 4) reduces to a continuous-effort and type-indexed version of the problem studied by RT, where pay does not depend on performance, and all incentives to exert effort come from reducing the probability of being terminated. This is the pure efficiency-wage model.

Polar case: pure pay-for-performance If $\pi'(e) \equiv 0$ (no monitoring case), the worker's maximization problem reduces to maximizing the per-period value of the worker's utility from employment (refer to expression 4). In this case exerting effort does not alter the probability of being fired, so all incentives to exert effort come from performance pay.

Hybrid case: (our preferred model) When $\pi'(e) > 0$ and M is not too high, our model is a hybrid of pure efficiency wages and pure pay-for-performance, meaning that some types (MMW types) will be motivated by efficiency wages only, and others (higher types) will in part be motivated by performance pay.

The pure efficiency wage case may be disregarded for empirical purposes: the great majority of our workers receive a substantial amount of variable pay. Therefore, only two cases can possibly match our setting: pure pay-for-performance, and the hybrid case.

Value of outside option The model can be extended to allow the lifetime value of a job in the local economy to depend on the minimum wage, so that $V^A = V^A(M)$. All the results go through if the function $V^A(\cdot)$ is decreasing, as would be the case if the main effect of a minimum wage increase is to slow the movement out of unemployment. If, conversely, the function $V^A(\cdot)$ rises too steeply, a minimum wage increase will be demotivating. This is not the case empirically, in our setting (see Section 4). To rule out this theoretical possibility, it suffices to assume that $V^A(M)$ has a slope no greater than $[w_M(e; M)(1+r)]/r$. This condition guarantees that the per-period value of employment, net of opportunity cost, increases with the minimum wage (refer to expression 4). The condition is guaranteed to hold if $r \approx 0$.

2.1 Core Theoretical Results: Effect of Minimum Wage on Individual Productivity

Assumption 3. *$\overline{w}(\cdot)$ is a strictly increasing function, $w_M(x, 1; M) > 0$, and $|w_{eM}(x, e; M)| < \infty$ for all $x \geq 0, e \in [0, 1]$.*

The assumption that $\overline{w}(\cdot)$ is strictly increasing is made for convenience of exposition. Note that it does *not* imply that $w(x, e; M)$ is strictly increasing in e, and indeed this is not the case for MMW types. The assumption $w_M(x, 1; M) > 0$ says that even a worker who exerts maximum effort ($e = 1$) earns the minimum wage with a positive probability, however small. The assumption that $|w_{eM}(x, e; M)| < \infty$ is purely technical.

Proposition 1. ***(Effect of the minimum wage on productivity)*** *Suppose Assumptions 1-3 hold and, in addition, $\pi'(e) > 0$ for all e.*

1. *Effort is strictly increasing in M for MMW types ("low types").*

2. *The set of types whose effort increases with M, grows with M.*

3. *For M large enough, all types' effort increases with M.*

4. *Increasing M has a negligible effect on the effort of types whose wage is negligibly affected by the minimum wage.*

Proof. See Appendix B.1. ∎

It is worth emphasizing that the result in part 1 requires the assumption that $\pi'(e) > 0$ for all e. This assumption fails in the no monitoring case, in which case increasing M does not increase the low types' effort (Proposition 2 part 2 below). Empirically, the "low types" in part 1 will correspond to the workers who benefit most from the minimum wage at a given point in time, while the "negligibly affected" in part 4 will later be called "high types" – see the discussion on page 19. We will show that, in the average store, these types show the response predicted by Proposition 1. The medium types' response will depend on the monitoring intensity, as discussed in the next section.

2.2 Role of Monitoring in Effort Exertion

Monitoring intensity must, intuitively, enter the model through the slope of $\pi(\cdot)$. We now make this idea precise.

Definition 2. ***(Monitoring intensity)*** *Monitoring is more intense under $\widetilde{\pi}(e)$ than under $\pi(e)$ if, for every e, the elasticity of $[1 + r - \widetilde{\pi}(e)]$ is larger in absolute value than that of $[1 + r - \pi(e)]$.*

When monitoring is more intense according to Definition 2, the equilibrium effort is higher for every type. To see this, refer to the first order conditions for maximization of Q, equation (5). The left-hand side of (5) is precisely the elasticity of $[1 + r - \pi(e)]$, and is a nondecreasing function of e by Assumption 2. The right-hand side is a decreasing function of e by Assumption 1. When the left-hand side function becomes more negative pointwise (more intense monitoring according to Definition 2), the crossing point of the two functions shifts to the right, i.e., optimal effort is greater.

Definition 2 establishes a partial order on the functions $\pi(\cdot)$.[5] In general, the constant function is the smallest element in this partial order – this is the previously-mentioned "no monitoring case" where $\pi'(e) \equiv 0$. On the opposite end of the spectrum, $\pi(\cdot)$ may be

[5]For example, in the parametric family $\pi(e; a) = a\frac{e}{e+1}$ monitoring is more intense when a is larger: see Appendix B.2, Example 2.

chosen so that $[1 + r - \pi(e)]$ has arbitrarily large elasticity (in absolute value), provided that r is small enough, i.e., that the worker is sufficiently patient.[6]

The next result describes how effort response to the minimum wage varies by monitoring intensity and by type.

Proposition 2. ***(Role of monitoring in effort exertion)***

1. ***(Effect of increasing monitoring)*** *When monitoring becomes more intense, all types exert more effort.*

2. ***(Effect of increasing M, no monitoring case)*** *If $\pi'(e) \equiv 0$ MMW types ("low types") exert zero effort. Increasing M does not increase their effort, and it decreases the effort of any type who exerts positive effort.*

3. ***(Effect of increasing M, high monitoring case)*** *If Assumption 3 holds and monitoring is sufficiently intense, increasing M increases the effort of all types. Functions $\pi(\cdot)$ exist under which monitoring is arbitrarily intense if r is small enough.*

Proof. See Appendix B.1. ■

Part 1 is intuitive because it confirms that increasing monitoring raises equilibrium effort as discussed above. Meanwhile, parts 2 and 3 are instructive: increasing the minimum wage *promotes effort* when monitoring is high, though it *promotes shirking* when monitoring is low. In addition, parts 2 and 3 yield testable predictions *by type*. Among the non-monitored workers, the low types do not change their effort as the minimum wage increases (because non-monitored MMW types shirk regardless of the minimum wage level), whereas higher types decrease their effort due to the attenuated pay-for-performance incentive. Among the highly monitored workers, an increase in M causes all types to exert more effort. Taken together, these predictions are a strong empirical test of the dual nature (efficiency wage *and* pay-for-performance) of the model.

Proposition 2 suggests that a store should respond differently to a minimum wage increase depending on whether monitoring is low or high in that store. To make this idea

[6] Refer to the proof of Proposition 2 part 3 in Appendix B.1.

precise, let us extend the model such that a fraction $(1-\mu)$ of workers in a store, chosen at random independently of their type, is "not monitored." That is, a shirking worker is detected with probability $\underline{\pi}$ independent of effort. The remaining fraction μ of workers is "highly monitored," meaning that shirking workers are detected with a highly elastic probability $\pi(e)$, as described in Proposition 2 part 3.[7] We think of μ as a continuous measure of monitoring coverage and, for now, take μ as given. It helps to think of the store as being partitioned into two divisions. In the non-monitored division, workers effectively operate on a "pure pay-for-performance" basis: they are never terminated for lack of effort. Workers in the highly monitored division behave as in the previous sections. Proposition 2 characterizes how effort, and therefore individual performance, changes in either division. Empirically, we expect a store to behave as described in part 2 when monitoring coverage μ is low and to behave as in part 3 when μ is high. Both predictions are found to hold in the data (see Section 5). Empirically, we find that *on average* a store behaves as a high-monitoring store.

Thus far, we have assumed that the monitoring coverage μ is not endogenous to M. In Appendix B.3 we work out a theory where μ is endogenous, and can be purchased by the firm at a cost $K(\mu)$. The theory predicts that if store profits are non-decreasing in M (as indeed we will show empirically), then μ should increase with M. However, the increase could be small depending on the shape of the function $K(\mu)$. This prediction is tested empirically in Section 5. The coefficient on M has the expected sign, but its magnitude is small and statistical significance is lacking. Overall, we believe that the evidence is consistent with the theory of endogenous coverage μ, but points to a degree of endogeneity small enough to be ignored for practical purposes. We therefore proceed under the assumption that μ is exogenous.

[7] In the context of optimal monitoring, it may seem ad-hoc to split the workers into only two groups monitored with different probabilities. Yet, in a general monitoring game, only two strategies can ever attain maximal deterrence. One is to monitor all agents with the same probability. The other is to create exactly two groups of agents (and never more than two) who are monitored with different intensities. See Lazear (2006), Eeckhout et al. (2010).

2.3 Effect of Minimum Wage on Turnover and Tenure in a Store's Steady State

In this section, we characterize the steady state turnover rate in a store where a fraction μ of workers are highly monitored and the rest are not monitored. Steady state means that, given M and the termination policy given by π, replacement workers are randomly drawn from the pool of the unemployed such that the fraction of employees terminated and hired are equal, and in the next period the type distribution in the store is reproduced identically. Note that in this definition, the absolute size of the labor force in the store is left unspecified.

Denote by H the c.d.f. of the type distribution that our firm can expect upon hiring a random worker from the unemployment pool, and let h be its density. Since types are firm-specific, unemployed workers are not negatively (or positively) selected from a hiring firm's perspective, hence H is not a function of any of the model's parameters.

Denote by $g^M(x)$ the density of the steady state type distribution in a highly monitored division given a certain M. The density $g^M(x)$ must solve:

$$g^M(x) = \pi(e^*(x;M))\, g^M(x) + \lambda(M)\, h(x),$$

where $\lambda(M)$ denotes the per capita inflow of workers (which, in steady state, coincides with the outflow) in a highly monitored division. Isolating $g^M(x)$ yields:

$$g^M(x) = \frac{\lambda(M)}{1-\pi(e^*(x;M))} h(x).$$

Because g^M must integrate to 1 we get, for all M:

$$1 = \lambda(M) \int_0^\infty \frac{1}{1-\pi(e^*(x;M))} dH(x).$$

Since in a highly monitored store $e^*(x;M)$ is increasing in M for all x (Proposition 2 part 3), $\lambda(M)$ is decreasing in M.

Turning to the non-monitored division, recall that $\underline{\pi}$ is the constant probability of retention under no monitoring. In a non-monitored division the turnover is $(1 - \underline{\pi})$ independent of type, and the steady state type distribution in that division coincides with $H(x)$.

The steady state turnover rate for the entire store, averaging across the highly-monitored and non-monitored divisions, is:

$$\mu\lambda(M) + (1 - \mu)(1 - \underline{\pi}).$$

This expression is decreasing in M because $\lambda(M)$ is decreasing in M. This proves the following result.

Proposition 3. ***(Impact of minimum wage on steady-state turnover and tenure in a store)*** *In steady state, the average turnover rate in a store is decreasing, and therefore average tenure is increasing, in the level of the minimum wage. Both effects are driven by increased effort.*

Intuitively, the decrease in turnover results from the fraction of highly monitored workers who, after an increase in the minimum wage, exert more effort and thus are terminated less frequently. Among non-monitored workers, effort decreases after a minimum wage increase (Proposition 2 part 2), but their turnover remains unchanged as their probability of termination is independent of effort.

2.4 Effect of Minimum Wage on Store Output, Profits, and Employment

Store-level output is determined by two factors: the individual performance of each worker type, and the steady state type distribution. Both change as M increases. In the highly monitored division, individual worker performance increases with the minimum wage, and this is good for output. The opposite is true in the non-monitored division. In addition, g^M also changes: as low types stick around longer in the monitored division, the type distribution will worsen, leading to a decrease in store-level output. The adverse change in g^M represents a "hidden" cost attached to incentivizing the low types through retention:

a “reverse labor-labor substitution” effect specific to the efficiency wage channel.

Let us now turn to profits. In our empirical setting, the compensation scheme $\overline{w}$ is set uniformly for all workers nationally, and is thus not adapted to local store conditions. Increasing the local minimum wage may therefore well cause profits to increase in some stores but to decrease in others.[8] However, the average effect across all stores could never be positive if $\overline{w}$ is set to maximize aggregate profits at the national level.

Next, we address store size, which we denote by L. Given a certain M, the optimal store size solves:

$$\max_{L} L \cdot \Pi\left(F_M, M\right) - \kappa\left(L\right), \tag{7}$$

where $\Pi\left(F_M, M\right)$ denotes gross store profits per worker,[9] and the convex function $\kappa\left(\cdot\right)$ captures the amortization or capital cost of operating at a given size. The solution to problem (7) depends on the value of the term $\Pi\left(F_M, M\right)$, with higher values yielding a larger optimal store size in steady state.

The above discussion is summarized in the following result.

Lemma 2. ***(Impact of minimum wage on store-level profits and employment)*** *If $\overline{w}$ is set to maximize nationwide profits, increasing M cannot increase nationwide profits. Optimal store size co-moves with store profits per worker.*

This lemma says that on average across all stores, profits must decrease with the minimum wage. However, for certain types of stores that are not representative of the average store, profits could increase. Lemma 2 additionally says that variation in per-worker profits should cause employment to co-move at the store level, regardless from where the variation in profits comes from. These predictions are shown to hold in Section 6.2.

[8] Increasing the minimum wage may increase profits in a store if the compensation scheme $\overline{w}$ is not profit-maximizing given local store conditions. Take the following example. Suppose $\pi(e) \equiv \overline{\pi}$ so that there is no monitoring, and $\overline{w}\left(Y\right) < M$ so that all workers are paid the minimum wage. Suppose the cost of effort is $c(x, e) \equiv M + \epsilon$ independent of type and effort, with ϵ an arbitrarily small number. Then no worker exerts effort. Increasing M by a finite but small amount causes all workers to switch to exerting effort, and the wage bill increases only a little. Hence profits increase with M.

[9] This is the level attained by expression (27) in Appendix B.3; empirically, it is proxied by Ebitda per hour, where Ebitda are earnings before interest, taxes, depreciation, and amortization.

2.5 Worker Welfare

An increase in M has two effects on type x's welfare. First, for fixed effort, the wage increases due to larger and more frequent top-ups. Second, because effort is endogenous, the wage and the cost of effort co-move due to the change in effort. If, for example, effort increases, so do the wage and the cost of effort. The second effect, however, vanishes at the margin due to an envelope condition. Therefore, the welfare effect of a marginal increase in the minimum wage reduces to the direct effect on the wage, for a given effort. (A third effect, which arises if V^A depends on M, is analyzed in Appendix C.1).

To make this argument formal, denote by $Q(x, e; M)$ the expression obtained by replacing replace $w(e)$ with $w(e; M)$ in expression (4). By equation (3), the marginal effect of M on type x's welfare is:

$$\begin{aligned} & (1+r)\frac{d}{dM}Q\left(x, e^*(x; M); M\right) \\ = \; & (1+r)\,Q_M\left(x, e^*(x; M); M\right) \\ = \; & \frac{1+r}{1+r-\pi(e)} w_M(x, e; M)\Big|_{e=e^*(x;M)}, \end{aligned} \tag{8}$$

where the first equality reflects an envelope condition with respect to e, and the second equality follows from expression (4). We take this expression to the data in Section 8.

3 Data and Empirical Strategy

3.1 Data and Institutional Background

We match bi-weekly worker-level payroll data with the monthly personnel records of a nation-wide American retail chain from February 2012 to June 2015. Restricting our attention to those salespeople who are paid based on their performance produces our "total sample" of more than 40,000 hourly salespeople. Further restricting the sample to border stores as per our research design (Section 3.2) leaves us with more than 200 stores with over 10,000 salespeople. Table 1 reports the summary statistics of this "border" sample.

Workers and Compensation Our workers are consultative sales associates. They answer walk-in customer questions, demonstrate product features, and record a customer purchase as their own sale. Their pay takes into account individual performance. Specifically, the latter consists of a base salary plus commissions on individual sales. "Exerting effort" consists of meeting and greeting the customer, taking the time to explain and persuade, up-selling (to higher-margin products), and cross-selling (warranties, loans, credit cards, etc.).[10]

For every salesperson, we aggregate the following at the monthly level: hours worked (avg. 107), sales (avg. 2, units shrouded for confidentiality),[11] and pay (avg. $1,361 per month; base $6.12/h, variable $5.95/h). Variable pay is the sum of various commissions earned on the sale of different items. We compute the average commission rate (avg. 3.5%) by dividing "variable pay" by the value of sales. We compute "sales per hour" – corresponding to "performance" in our model – as the value of sales divided by the number of hours worked. Tenure averages 49 months, as measured from the hiring date indicated in the HR records.

Stores and Employment There are on average 16.64 sales associates in a store. As is typical in retail, store-level turnover is high: 3.4% per month (being the average of a 4.8% termination rate and a 2.1% hiring rate).[12] Within a store, there are several departments across which worker conditions somewhat vary. We control for this heterogeneity by adding department fixed effects in all our specifications.[13] Store-level profits are measured by

[10] A job description posted on the company's website can be paraphrased as follows: "our salespeople are responsible for making customers happy, providing them with information, increasing sales, helping to maintain the sales floor appearance, facilitating customer transactions as needed, and generally cooperating with other employees." While some of these duties are "common value" activities, in Appendix F we show empirically that effort spillovers among employees do not play a large role in our findings.

[11] The number is re-scaled by a factor between 1/50 and 1/150 relative to its value in dollars.

[12] The termination (hiring) rate is defined as the percent of sales associates in the store who are terminated (hired) in a given month. We do not distinguish between voluntary and involuntary terminations as this distinction, as coded by HR, is arguably subjective. The turnover rate is defined as the percent of sales associates in the store who are terminated or hired in a given month divided by two.

[13] While pay is always base plus commission across all departments, both base and commission rates vary somewhat depending on the department.

Ebitda (earnings before interest, taxes, depreciation, and amortization; units shrouded). Profits per hour worked in the store are positive on average.

Each store has a manager and, sometimes, one or more assistant managers. They are excluded from our "workers" sample because they fall into the category of "supervisors." These figures are responsible for personnel decisions (hiring and termination) in coordination with central HR, and they monitor workers.[14] We use the ratio μ of supervisors to workers in a store as a proxy for monitoring coverage, with the caveat that such a ratio captures the extensive margin of monitoring but not the intensive margin (supervisor effort). The ratio of supervisors to workers is decided by the store manager in coordination with central HR, and varies both across and within stores. Table A.3 (Panel A) shows that within a store, variation in the supervisor-to-worker ratio over time does not correlate with turnover, profits, or with the fraction of low types as defined below.[15]

Minimum Wage Variation States, counties, and even cities can set minimum wage requirements, with the highest requirement being that applicable. The mean minimum wage in our sample is \$7.87 per hour. From February 2012 to June 2015, stores in our sample were affected by 70 minimum wage increases: 49 at the state level and 21 at the county or city level.[16] The average minimum wage increase was \$0.54.

If a worker's average hourly pay in a week (base plus variable) falls below the minimum wage, the employer is required to make up the difference as prescribed by the Fair Labor Standards Act (FLSA).[17] We create a variable called "minimum wage adjustment," which equals the amount paid by the employer to comply with the minimum wage (this variable is often zero and averages \$0.23 per hour). In an average month, 5% of our workers are paid no more than the minimum wage and 42% receive an adjustment in at least one of the four weeks. A \$1 increase in the minimum wage raises the "minimum wage adjustment"

[14] According to a job posting, the supervisor position requires "skills in selecting, assessing, coaching, and developing sales associates," "proven ability in managing and mentoring team members, leading and influencing cross-functional working groups, and achieving results," "effective oral and written communication skills necessary to communicate with all levels of internal and external team members."

[15] Without store fixed effects (Panel B), the supervisor-to-worker ratio instead correlates with store-level turnover and profits.

[16] Refer to Appendix D for a full list of the minimum wage changes.

[17] Under this law, commissioned workers can occasionally be deemed "exempt" and thus not receive a top-up. Based on administrative records, however, all of the workers in our sample are non-exempt.

by \$0.25 per hour (Table 2, column 3).[18] In addition, variable pay per hour increases by \$0.44 per hour (Table 2, column 4), reflecting the endogenous increase in performance that is the subject of this paper. Overall, a \$1 increase in the minimum wage raises average total pay per hour by \$0.65 per hour (column 5), which corresponds to a 5% increase and an elasticity of 0.38.

Definition of Worker Types We divide workers into three "types." A worker is classified as a high, medium, or low type at time t based on her performance at time $t-1$ relative to the minimum wage at $t-1$. In the spirit of Aaronson et al. (2012) and Clemens and Wither (2019), and following Definition 1 in the theory, *low types* are those paid the minimum wage in $t-1$ (about 4% of our observations). The remainder are either *medium* or *high types*, with the threshold between the two being the third quartile of the pay distribution.[19]

As expected, higher types sell more per hour, take advantage of the minimum wage adjustment less often, and are terminated less frequently: see Table 3. A low types' monthly earnings at t equal the minimum wage with a frequency of 20.5% and, moreover, are boosted by a minimum wage adjustment roughly every other week, thus suggesting that low types' incentives are significantly affected by the minimum wage. In contrast, a high types' monthly earnings at t equal the minimum wage with a frequency of only 0.6%, and they benefit from a minimum wage adjustment only once every ten weeks, implying that they are negligibly affected by the minimum wage.

HQ vs. Store-Level Decisions Headquarters set the nationwide compensation scheme (base and commission rates, not adjusted for minimum wage) uniformly across stores and

[18] A 1\$ increase in the minimum wage raises the share of workers who are topped up every single week of the month by 4.5pp (144%), while the share of workers who are topped up at least one week per month rises by 16pp (38.5%). Results available upon request.

[19] We define low types at time t as those whose total pay in month *t-1* is below 1.02*minimum wage. The 0.02 accounts for rounding errors, as the "total pay" field is occasionally off by a few cents. The results are robust to defining workers "at minimum wage" as those who earn exactly the minimum wage. The threshold between medium and high types happens to coincide with 180% $\times$ minimum wage in $t-1$; our results are robust to using alternative thresholds (120%, 140%, 160%) or various alternative classifications (e.g., dividing workers based on estimated worker fixed effects, or average performance over more than one period before the minimum wage) – refer to Section 4.3.

jurisdictions. Accordingly, when a local minimum wage changes, the base and commission rates earned by individual workers do not change systematically in that location. We show this in Table 2 (columns 1 and 2). Such wage stickiness makes sense in the presence of menu costs. Our theory reflects these institutional features in the assumption that the compensation scheme $\overline{w}$ does not vary with M, and by avoiding the assumption that $\overline{w}$ is optimized at the local level.[20]

As mentioned, local managers have relative autonomy in deciding whether to terminate a worker or hire a new one, subject to maintaining the number of workers close to an agreed upon level with HR. In the model, the total number of workers L in a store is chosen to maximize expression (7), store by store.

Pricing for our company is nationwide, as for most national retail chains (Della Vigna and Gentzkow 2019). In Section 7.2, we compute a store-level price index for our company and confirm that it does not vary with the local minimum wage.

3.2 Identification Strategy

Sample Selection and Border Discontinuity Design Our main empirical specification implements a border discontinuity design in the spirit of Card and Krueger (2000), and closely follows Dube et al. (2010) and Allegretto et al. (2011). Specifically, workers on the side of the border where the minimum wage increased (treatment group) are compared to workers on the other side, where the minimum wage did not increase (control group). This research design aims to ensure that, apart from the minimum wage change, treated and control groups are similarly situated in terms of local economic conditions and demand shocks. The pre-trend analysis in Section 4.3 supports this presumption.

An alternative research design consists of the traditional "state-panel" approach, as employed by Neumark and Wascher (1992, 2007) among others, and recently summarized by Neumark (2019). This strategy uses the entire sample of stores, regardless of their

[20] We would expect $\overline{w}$ to vary with the *federal*, as opposed to the state or local, minimum wage. We do not have federal wage increases in our sample. Recent literature on the minimum wage (Flinn and Mullins 2018) analyzes the effect of wage renegotiation between a firm and employees as the minimum wage changes.

distance from the border. In Section 4.3, we show that our core estimates are similar when applying this alternative research design.

Our sample includes minimum wage increases enacted by states, counties, and cities. Appendix D describes how the sample is constructed and presents a map of these minimum wage increases. After restricting to stores located in counties whose centroids are less than 75 km apart,[21] we are left with more than 200 stores and over 10,000 salespeople, approximately half of whom experienced variations in minimum wage during our study period.

Deriving the Testable Implications from the Model Letting $e^*(x, M)$ denote type x's optimal effort at minimum wage M, type x's equilibrium performance is given by:

$$Y^*(x, M) = Y(x, e^*(x, M)).$$

Linearizing around M yields the following estimating equation:

$$Y^*(x, M') = Y^*(x, M) + (M' - M) \cdot \beta. \tag{9}$$

When β is estimated across all worker types, $\hat{\beta} = \mathbb{E}[\Delta Y^*(x, M)/\Delta M]$ represents the effect of the minimum wage on average worker's performance *across all worker types*. The analog of equation (9) by worker type is:

$$Y^*(x, M') = Y^*(x, M) + (M' - M) \cdot [\beta_L \mathbf{1}_L(x) + \beta_M \mathbf{1}_M(x) + \beta_H \mathbf{1}_H(x)], \tag{10}$$

where each β_i represents the within-category performance effect of the minimum wage.

Our testable predictions are as follows. In the pure pay for performance case, Proposition 2 part 2 predicts $\beta_L = 0$ and $\beta_M, \beta_H \leq 0$. We will reject these predictions. In the hybrid case, Proposition 1 part 1 predicts $\beta_L > 0$. Furthermore, in the high-monitoring subcase of the hybrid case, Proposition 2 part 3 predicts β_M, $\beta_H \geq 0$. We will not reject these predictions. Recall that the pure efficiency wage case may be disregarded as the

[21]In doing so, we follow the existing literature (see Appendix D for more details). Section 4.3 shows that the analysis is robust to using different distance thresholds (i.e., 37.5km or 18.75km).

great majority of our workers receive a substantial amount of variable pay.

Empirical Specification We translate equation (9) into the following regression specification:

$$Y_{ijpt} = \alpha + \beta MinW_{jt} + X_{it} \cdot \zeta + \eta Z_{jt} + \delta_i + \phi_{pt} + \varepsilon_{ijpt}. \tag{11}$$

Y_{ijpt} is the performance (sales per hour) of worker i in store j of county-pair p in month t. $MinW_{jt}$ is the prevailing minimum wage in store j's jurisdiction in month t.[22] X_{it} is a vector of time-varying worker characteristics that are likely to predict employee performance; specifically, the worker's tenure and the department in which she works. Z_{jt} includes the monthly county unemployment rate in order to account for time-varying local economic conditions and local demand shocks (see Lemieux et al. 2012). Including worker fixed effects δ_i means that we leverage *within-worker* variation in minimum wage.[23]

Equation (11) includes county-pair $\times$ month fixed effects ϕ_{pt} that restrict the comparison to "treated" and "control" stores/workers on either side of the *same* border. We estimate this equation by "stacking" our data as in Dube et al. (2010, 2016), meaning that stores/workers located in a county sharing a border with n other counties appear n times in the final sample. The standard errors are two-way clustered at the state level and at the border-segment level.[24]

To study the heterogeneous effects of the minimum wage on worker performance by worker type, we translate equation (10) into the following regression specification:

$$\begin{aligned} Y_{ijpt} \quad = \quad & \beta_0 + \beta_1 MinW_{jt} + \beta_2 MediumType_{ijt} + \beta_3 HighType_{ijt} + \\ & \beta_4 MinW_{jt} \cdot MediumType_{ijt} + \beta_5 MinW_{jt} \cdot HighType_{ijt} + \\ & X_{it} \cdot \zeta + \eta Z_{jt} + \delta_i + \phi_{pt} + \varepsilon_{ijpt}, \end{aligned} \tag{12}$$

where $MediumType_{ijt}$ and $HighType_{ijt}$ are indicators for whether worker i is a medium or a high type. The effect of minimum wage on low, medium, and high types – i.e., the coefficients β_L, β_M, β_H in equation (10) – corresponds here to β_1, $\beta_1 + \beta_4$, and $\beta_1 + \beta_5$,

[22] This is the highest among state, county, and city minimum wages.

[23] Store fixed effects are redundant because less than 1% of the workers moved across stores.

[24] Refer to Appendix D for more details on the specification.

respectively.[25] The indicators for low, medium, and high types are pre-determined because they are defined based on a worker's pay in $t-1$ relative to the minimum wage in $t-1$: refer to the definition of types at page 19.

4 Core Empirical Results: Effect of Minimum Wage on Individual Worker Productivity

This section uses the predictions from Section 3.2 to test the pure pay-for-performance case against the hybrid case. Recall that the pure efficiency wage case may be disregarded, as the great majority of our workers receive a substantial amount of variable pay.

4.1 Core Findings

Figure 1 displays the estimates of the coefficients βs from equation (12), i.e., the effect of a \$1 minimum wage increase on the percent change in the performance of low, medium, and high types (see Table 4 column 2 for details). We find that a \$1 increase in the minimum wage increases performance – sales per hour – strongly among low types, i.e., by 0.244 (shrouded units) or 22.6%. In the notation from Section 3.2, this means that $\hat{\beta}_L > 0$, which rejects the pure pay-for-performance case, is consistent with the hybrid case.

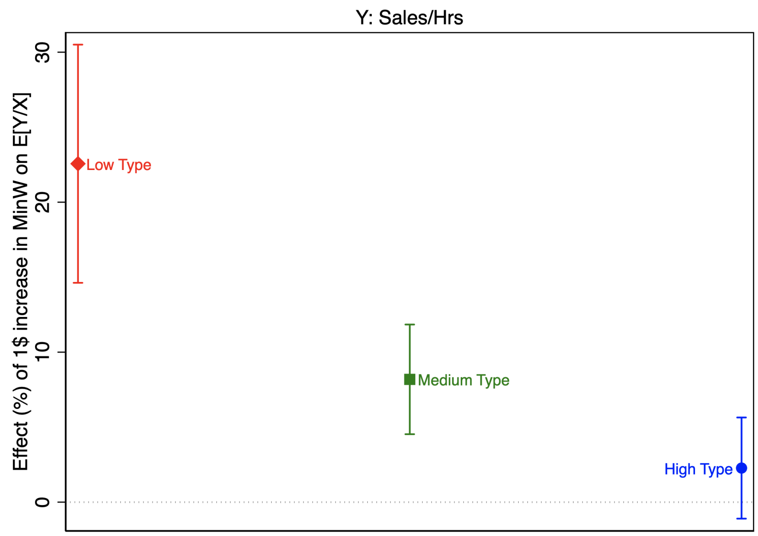
The effect is weaker, but still positive, for medium types ($\hat{\beta}_M = 0.156$, or 8.2%). Again, the pure pay-for-performance case is rejected and the hybrid case is not. According to the theory, this "productivity ripple effect" obtains because our medium types occasionally earn minimum wage,[26] thus their response somewhat aligns with that of the low types.

The effect vanishes, however, for high types ($\hat{\beta}_H = 0.062$, or 2.3%, statistically indistinguishable from zero). These workers' pay is least affected by the minimum wage, such that they barely respond to it.

[25]This specification resembles the triple difference approach used by Clemens and Wither (2019) and discussed in Neumark (2019).

[26]Our medium types receive the minimum wage adjustment 18% of the weeks, on average, compared to 47% for low types (Table 3).

Figure 1: Minimum Wage Increases Productivity for Low Types but not for High Types



Notes: Effect of a \$1 increase in minimum wage on the percent change in Y (Sales/Hrs) for low, medium, and high types. Vertical bars represent 95% confidence intervals computed using the estimated coefficients ($\hat{\beta}_1$, $\hat{\beta}_1 + \hat{\beta}_4$ and $\hat{\beta}_1 + \hat{\beta}_5$) from equation (12) and the associated standard errors.

Next, we study the effect of the minimum wage on *average* worker performance. Because the effect is nonnegative for every type, we expect average worker performance to increase. Table 4, column 1 shows that a \$1 increase in the minimum wage raises average individual performance by 0.094 (shrouded units), or 4.5%. This individual performance gain is economically sizable and statistically significant at the 5% level. The overall implied elasticity is 0.35.[27]

We conclude with a sanity check. As expected, worker pay increases with the minimum wage (Table A.1). This increase is not due to a change in the compensation scheme (recall that we do not find one), but rather to the mechanical effect of the minimum wage increase (more minimum wage adjustments) combined with the endogenous effort boost (more variable pay). Interestingly, the effect on pay is sizable for low and medium types, suggesting that both earn more due to larger and more frequents minimum wage adjustments and, also, from becoming more productive.[28]

[27] A \$1 increase in the minimum wage is equivalent to a 12.7% increase relative to the mean, and $4.5/12.7 = 0.35$.

[28] The pay increase among medium types could be viewed as an instance of the "*wage* ripple effect"

4.2 Dynamic Effects

In what follows, we explore pre-trends as well as the time pattern of the treatment effect. To this end, we estimate the following dynamic equation:

$$\begin{aligned} Y_{ijpt} &= \alpha + \sum_{m=-2}^{2} \beta_1^{3m} MinW_{j,t-3m} + \sum_{m=-2}^{2} \beta_2^{3m} MinW_{j,t-3m} \cdot MediumType_{ijt} \\ &\quad + \sum_{m=-2}^{2} \beta_3^{3m} MinW_{j,t-3m} \cdot HighType_{ijt} + \gamma_1 MediumType_{ijt} \\ &\quad + \gamma_2 HighType_{ijt} + X_{it} \cdot \zeta + \eta Z_{jt} + \delta_i + \phi_{pt} + \varepsilon_{ijpt}, \end{aligned} \tag{13}$$

where Y_{ijpt} is worker performance. The leading coefficients (β^{-6}, β^{-3}) quantify the pre-treatment effects of the minimum wage six and three months before a time-t change, respectively. Their estimates are not statistically significant for any worker type, confirming that there is no pre-trend within worker type and no differential pre-trend across types (Figure 2 and Table A.2).

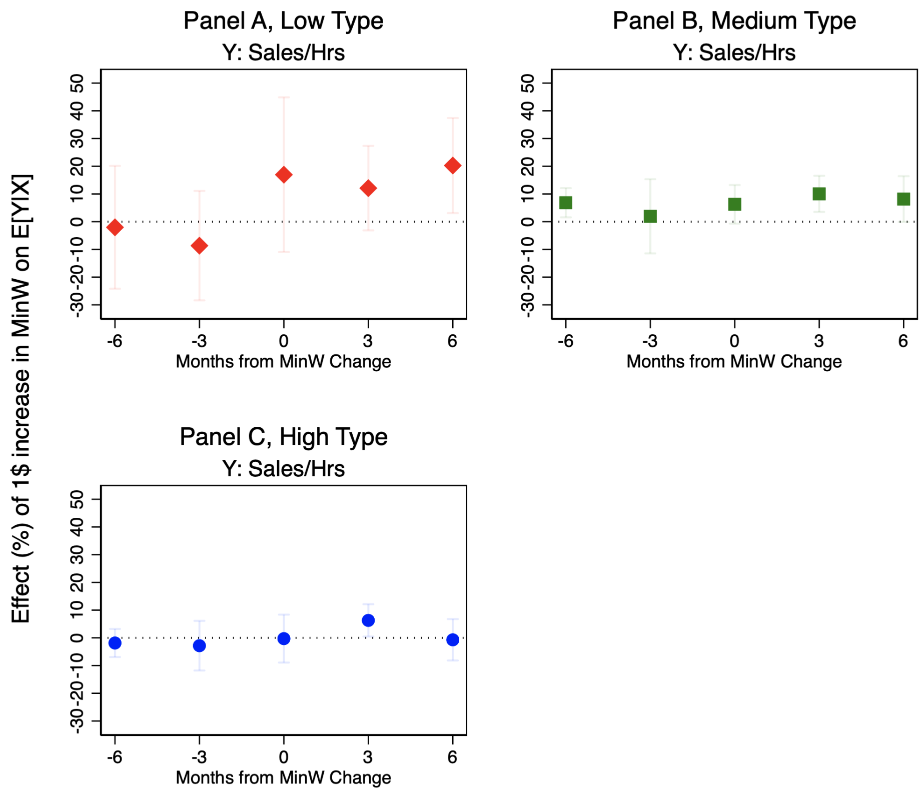
The lag coefficients (β^3, β^6) quantify post-treatment effects. Low types display a 20.3% (statistically significant) cumulative increase in performance at the six-month mark, suggesting that the performance effect is persistent. The effect sets in immediately after the minimum wage increase; possibly an indication that individual worker response is at play, rather than organizational change. High types, in contrast, do not experience a statistically significant response at the six-month mark.

Overall, we find no pre-treatment effect, and an immediate treatment effect that is persistently heterogeneous across types.[29]

which been documented in the labor literature; in our case, it is associated with a "*productivity* ripple effect."

[29]The coefficients displayed in Figure 2 are estimated for the subset of workers who remain employed throughout a 12-month window centered at the minimum wage event (102k observations). The same patterns persist if we extend the window to 24 months (the 12 prior to and following the minimum wage event), though statistical significance is lost because the sample shrinks to just 52k observations; that is, those workers continuously employed during the 24-month window. Results available upon request.

Figure 2: Dynamic Effect of Minimum Wage on Worker Productivity



Notes: Effect of a \$1 increase in minimum wage on the percent change in Y (Sales/Hrs) for low, medium, and high types. Vertical bars represent 95% confidence intervals.

4.3 Threats to Identification and Robustness Checks

This section explores two potential threats to identification: violation of the common trends assumption, and cross-border movements. We show that our core findings (a minimum wage increase leads to a rise in individual worker performance, especially among low types) are robust across various alternative implementations of our research design. We briefly discuss each of these below, while a more in-depth discussion and all of the tables are provided in Appendix E.

Pre-Trends Figure 2 displays the dynamic effects of the minimum wage, showing no pre-trends in our core outcome (individual performance by type) for the sample of workers who remain employed throughout a 12 month window around the minimum wage event.

Neither do we observe, in Table E.1 (Panel A, columns 1-3), any pre-trends for the larger sample of workers who are continuously employed for six months before the minimum wage event. That the figure and table agree is encouraging, as the difference in numerosity is nonnegligible (102k in the figure vs. 144k in the table) and any difference in the estimates could indicate the presence of sample selection effects.

Cross-border Worker Movements A concern raised relative to border-discontinuity research designs is that workers may move across borders (Neumark et al. 2014). Our core results on individual productivity (Section 4.1) should not, however, be subject to this issue given that we include worker fixed effects, thus effectively comparing the "same worker" at two minimum wage levels. Further evidence against endogenous cross-border movements is provided by the absence of a correlation between the minimum wage increases and the home-to-work distance of new hires (Table E.2, column 1), which rules out changes in our workforce's commuting patterns after a minimum wage hike. One might worry that cross-county migrants, rather than commuters, may confound store-level estimates. Zhang (2018, page 18), however, finds that after a minimum wage hike, migrants flow toward the same counties as commuters. The null effect in Table E.2, column 1 accordingly implies that migration patterns, as well, do not change among our workforce after a minimum wage hike. Furthermore, migration is likely more costly *across state lines* than *across county or city lines*. Yet our estimates are the same in the sample including only county-city minimum wage increases, as in the sample including only state-level increases (see page 29). Finally, Table E.2 shows that the minimum wage does not affect the home-to-work distance proportionally more for low, medium, or high types (Table E.2, column 3). In sum, we believe it's unlikely that the cross-border movement of workers plays a significant role in our estimates.[30]

Worker Selection Worker fixed effects control for selection in our main productivity results. If, after controlling for worker fixed effects, the estimates were still confounded by changes in the workforce type composition, then the disproportionate retention of low types which we will document in Section 6.1 would presumably imply that our estimates of the individual productivity boost are biased *downward*. Here, we further probe selection

[30] We thank an anonymous referee for helping us improve the analysis of cross-border movements.

by restricting the sample to a balanced panel of workers who are employed during the entire sample period. The sample drops in size, but its pre-trends are the same, and the results are similar to the main sample (Tables E.3 and E.4).

Alternative Classifications of Low, Medium, and High Types Our baseline definition of type does not guarantee that types in the "control" county of a given county pair occupy the same quantiles in that county's wage distribution as the quantiles occupied by the types in the treated county. To ensure a perfect quantile-quantile match across counties within a pair, we can change the type definition in the control county only, and define types using quantiles so that the quantiles in the control county exactly match the quantiles generated by our baseline type definition in the treated county. When using this alternative approach, the results remain nearly identical to our main presented findings (see Table E.5, column 1).[31]

In Table E.5 (columns 2-5), we explore alternative ways of defining types: classifying them based on average pay in the previous three months, as opposed to the previous month; and constructing time-invariant types based on pay in their first month of employment, or performance in their first quarter of employment. In Table E.6, we change the threshold that separates medium and high types to 120%, 140%, or 160% of the minimum wage. Reassuringly, the findings paint the same picture regardless of the classification method: when minimum wage increases, low types become significantly more productive, while high types do not.

Alternative Research Designs Our border-discontinuity approach discards a large portion of the sample. We now show that the results are robust to a state-level approach à la Neumark and Wascher (1992) that uses the entire sample of stores, regardless of their distance from a border. This raises the question of what controls to include in this specification. Adding more controls is generally thought to produce closer estimates to the border-discontinuity specification. Accordingly, with the aim of demonstrating the robustness of our results, we examine three minimally-controlled specifications: with worker and month fixed effects; adding linear state-trends; or adding census-division $\times$ month fixed

[31] This new approach changes the status of less than 1,000 out of more than 10,000 workers. Further details are provided in Appendix E. We thank an anonymous referee for suggesting this alternative strategy.

effects; see Table E.1 columns 2-4. The specification with division × month fixed effects is preferred because it is the only one that eliminates pre-trends in worker performance. In this specification, once again the minimum wage increases the performance of low and medium types and does not affect the performance of high types (see Table E.7 and Figure 3, Panel A).[32]

State vs. Local Variation in the Minimum Wage Restricting the analysis to state-level minimum wage changes only, or to county and city changes only (Figure 3, Panels B-C and Table E.8), does not change our findings. This is reassuring as one could worry that the cross-state variation is contaminated by other state-level policy changes.

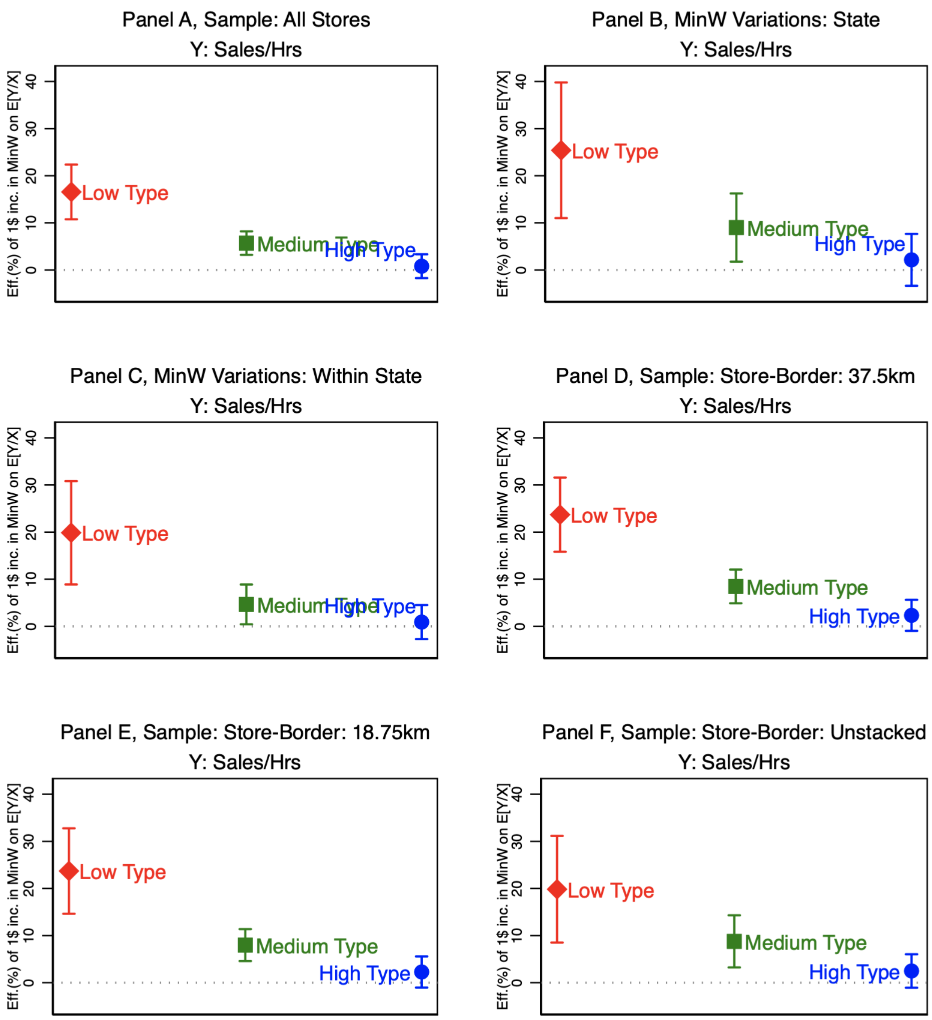
Alternative Definitions of "Bordering Stores" We explore definitions of "bordering" based on the exact location of the store rather than its county's centroid. In addition, we set distance from the border to "less than 37.5 km," or "less than 18.75 km," both shorter than in the main definition. Reassuringly, our results are consistent across these samples. See Figure 3, Panels D-E and Table E.9.

Robustness to "Unstacking" The results are also robust to using the same county-level border discontinuity design as in our main estimates but *without* stacking the observations, with border-segment × month fixed effects and clustering standard errors at the border-segment level (Figure 3, Panel F and Table E.10). This specification is closer in spirit to an experimental-event approach.

Alternative Controls The findings are similar if we control for *department* × *store* time trends and take into account potential differential trends across departments of a given store, or if we run our specifications by department. Likewise, we observe comparable outcomes if we remove potentially "bad controls," i.e., variables that might be endogenous to the minimum wage level (worker tenure and county-level unemployment). See Tables E.11 - E.12.

[32] We acknowledge that the inclusion of division × month fixed effects is criticized by Neumark, Salas, Wascher (2014), who observe that "the identifying information about minimum wage effects comes from within-division variation in minimum wages and removes a good deal of valid identifying information." The results are comparable if we use other state-level specifications (available upon request).

Figure 3: Minimum Wage Has a Robust Positive Effect on the Productivity of Low Types and no Effect on High Types



Notes: Effects of a \$1 increase in minimum wage on the percent change in Y (Sales/Hrs) for low, medium, and high types. Panel A includes all stores, regardless of their distance from the border, in a specification with division $\times$ month fixed effects (and standard errors clustered at the state level). Panel B (resp., C) considers our main sample but only for state (resp., within-state) variations in minimum wage. Panel D (resp., E) considers the sample of stores that are located less than 37.5 km (resp., 18.75 km) from the border. Panel F considers our main sample but with non-stacked data and with border-segment-month fixed effects. Vertical bars represent 95% confidence intervals computed using the estimated coefficients ($\hat{\beta}_1$, $\hat{\beta}_1 + \hat{\beta}_4$ and $\hat{\beta}_1 + \hat{\beta}_5$) from equation (12) and the associated standard errors.

5 Heterogeneous Effect by Monitoring Illuminates Dual Nature of Model

The theory (Proposition 2) makes two kinds of predictions. First, monitoring a worker more intensely weakly increases her individual performance (part 1). Second, and more interestingly, the effect of the minimum wage is heterogeneous by monitoring. Among the "non-monitored workers," the low types should not change their effort, while higher types should instead decrease their effort (part 2). If workers are "highly monitored," all types should increase their effort (part 3), at least to some extent (Proposition 1 part 4). This duality reflects the dual nature of worker incentives. That is, if highly monitored, the efficiency wage logic dominates, meaning that the increase in the wage level due to a rise in M *motivates* the worker. If not monitored, the pay-for-performance logic dominates, meaning that the worker is *demotivated* by a rise in M due to the decrease in the sensitivity of the wage to effort. This bifurcated prediction is a strong test of the dual nature of the theoretical model.

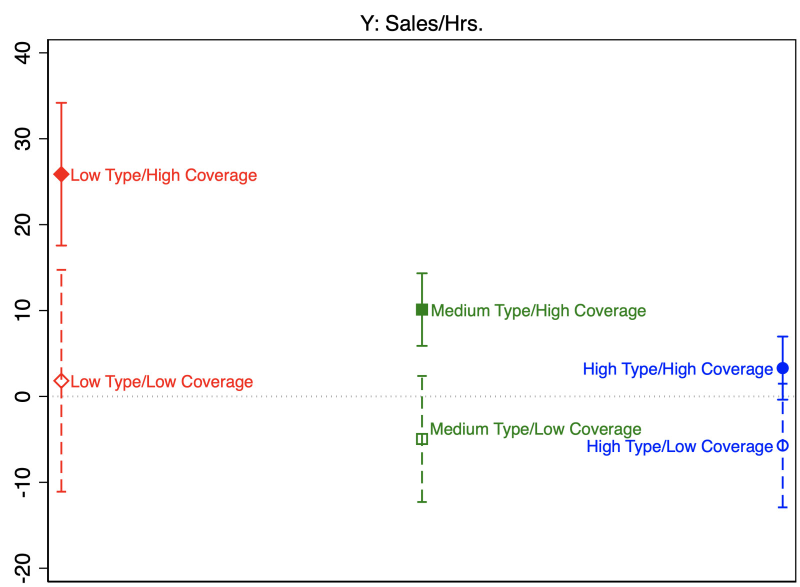
We test these predictions using within-store monitoring coverage variation μ. In the model, μ represents the fraction of workers (independent of type) who are "highly monitored." We proxy for μ using the supervisor-to-worker ratio in a store-month. A store is classified as either "low coverage" if it falls within the bottom quartile of the supervisor-to-worker ratio distribution, or otherwise "high coverage."

Consistent with Proposition 2 part 1, we find that high coverage does positively correlate with average worker performance (Table 5, column 1). While reassuring, this is not a very strong test of the dual nature of our model as the presence of supervisors could also improve performance through channels other than monitoring. We consequently test the predictions that are most revealing of our model's dual nature.

Table 5 tests the effect of the minimum wage on worker performance when monitoring coverage is low or high. Column (2) shows that a higher minimum wage significantly boosts the performance of the average worker when monitoring is high (+6.6%). When monitoring is low, a higher minimum wage instead significantly decreases the performance of the average worker (-9.4%, column 4). Figure 4 and the corresponding Table 5 (columns

3 and 5) provide similar results by *worker type*. Consistent with the distinctive predictions in Proposition 2, parts 2 and 3, we find that when coverage is high, low types become more productive as the minimum wage increases, while high types do not become less productive. When coverage is low, the low types do not change their effort while high types decrease their effort (though the p-value of the latter effect is only 0.11). This bifurcated pattern provides strong evidence in support of the dual nature of our model.

Figure 4: Minimum Wage Increases Productivity of Low Types when Monitoring Coverage is High and Reduces Productivity of High Types when Monitoring Coverage is Low



Notes: Effects of a $1 increase in minimum wage on the percent change in Y (Sales/Hrs) for low, medium, or high types for high/low monitoring coverage. Monitoring coverage is measured as the ratio of supervisors to workers. "Low coverage" is an indicator for whether the store is in the bottom quartile of the monitoring coverage distribution. Vertical bars (solid for "Low coverage," dashed otherwise) represent 95% confidence intervals.

Our assumption thus far has been that coverage μ is not endogenous to the minimum wage M. If μ were endogenous to it, the theory in Appendix B.3 predicts that it should increase with M. Table A.4 (column 1) estimates the following store-level equation:

$$Y_{jpt} = \alpha + \beta MinW_{jt} + \eta Z_{jt} + \delta_j + \phi_{pt} + \varepsilon_{jpt}, \tag{14}$$

where Y_{jt} is the outcome of interest (supervisor-to-worker ratio) in store j of county-pair p in month t, δ_j are store fixed effects, and all the other variables are defined as in equation (11). Our estimate of β is positive, consistent with our theory of endogenous monitoring, though the effect is small and not statistically significant.[33] This suggests that, if monitoring is endogenous to the minimum wage, this endogeneity is below detectable levels.

To address the concern that undetected endogeneity to the minimum wage might bias the estimates in Figure 4, we produce an analogue of this figure where monitoring coverage is measured *in the pre-minimum wage period t-1* (Panel A) or measured in our dataset's starting year (2012; Panel B). The coefficients of the interaction between M and monitoring intensity are qualitatively similar (refer to Figure A.1), a reassuring outcome as both measures of monitoring coverage are pre-determined and likely exogenous to subsequent minimum wage changes.

6 Effect of Minimum Wage on Store-level Outcomes

6.1 Testing the Predicted Decrease in Turnover

The theory (Proposition 3) predicts that termination rates should decrease after a minimum wage increase, because the highly monitored workers exert more effort and thus are terminated less frequently. In steady state, fewer separations imply less hiring, and thus less turnover and longer worker tenure.[34] As empirically, the effect is driven by the low types, we expect these effects to be stronger in stores where low types are relatively numerous.

In the spirit of Draca et al. (2011) and Harasztosi and Lindner (2019), we estimate the following store-level model:

$$Y_{jpt} = \alpha + \beta MinW_{jt} + \gamma \% LowTypes_{jt} + \delta MinW_{jt} \cdot \% LowTypes_{jt} + \eta Z_{jt} + \delta_j + \phi_{pt} + \varepsilon_{jpt} \quad (15)$$

[33] Note that the positive sign for β, albeit small, does not support the RT theory of endogenous monitoring, which predicts that an increase in the minimum wage decreases the need for monitoring, and hence the equilibrium monitoring level. We thank a referee for pointing this out.

[34] Table A.4 column 2 supports the assumption that store-level employment is in steady state conditional on store fixed effects and county-level unemployment.

where Y_{jpt} is the outcome of interest in store j of county-pair p in month t, $\%LowTypes_{jt}$ is the fraction of low type workers in store j in month t, and δ_j are store fixed effects. All the other variables are defined as in equation (11).

Panels A-D of Figure 5 plot the effect of minimum wage for the range of $\%LowTypes$ we observe in our stores (0 to 40%).[35] As predicted, an increase in the minimum wage reduces store-level termination, hiring, turnover, and raises tenure in stores with a high enough fraction of low types. The slope $\hat{\delta}$ is negative for termination, hiring, turnover, and positive for tenure. It is statistically significant at the 5% level for hiring and at the 10% level for turnover and tenure (see Table 6 for the regression coefficients).[36]

To conclude our analysis on employment flows, we look at terminations in greater depth. A worker-level, as opposed to store-level, specification allows us to measure individual outcomes by type. We return to equation (12), with a dummy as dependent variable that takes a value of one on the month of termination, and zero during employment. We control for worker tenure, as well as remove worker fixed effects to capture store-level, rather than within-worker, variation. Because a terminated worker is dropped from the sample, this specification acts like a discrete time hazard model.[37] Figure 6 and Table 7 (column 2) confirm that low types are *significantly less* likely to be terminated after a minimum wage increase (-19%, statistically significant at the 10% level). These results reinforce those in Figure 5. While medium types are also less likely to be terminated (-7%) the effect is not statistically significant. Finally, no effect is found among high types.

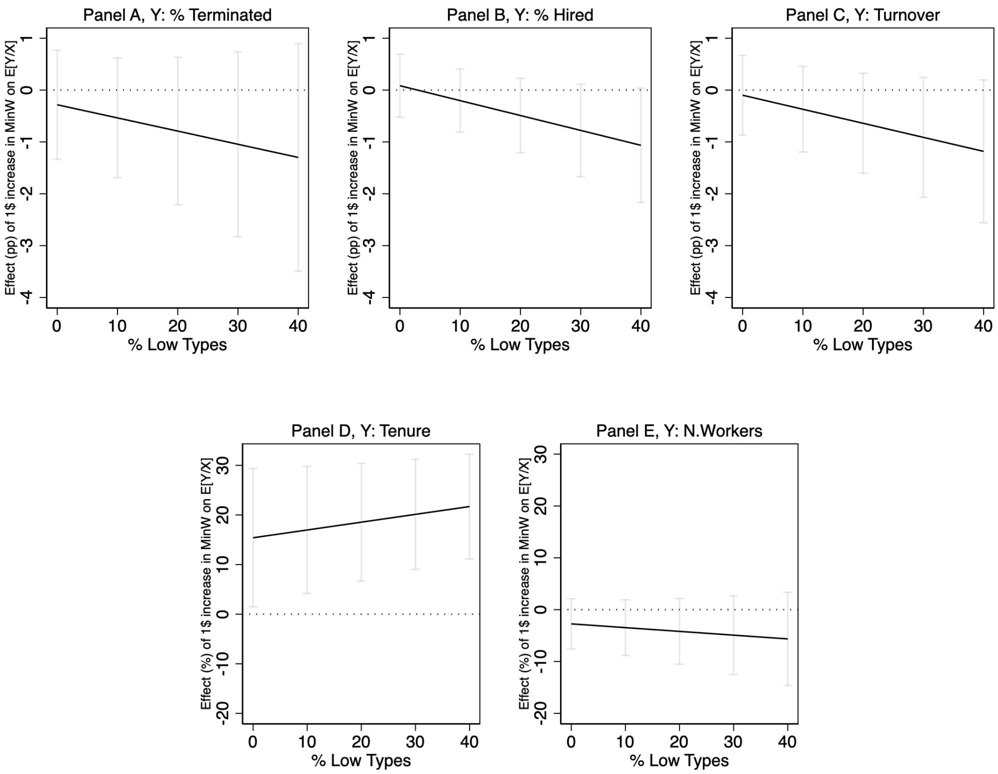
In sum, the heterogeneous effects are in the predicted direction (larger for low types), thus supporting the theoretical proposition that turnover should decrease as the minimum wage increases, especially among those types whose productivity response is stronger (empirically, the low types).

[35]The variable $\%LowTypes$ has a mean of 3.9% and a standard deviation of 7.5%.

[36] Figure A.2 reports the dynamic effects of the minimum wage on hiring and turnover within a six-month window. The effects are megative and statistically significant three months after the change in minimum wage. This same figure remains largely the same if we use a wider, one-year window, as opposed to the six-month window (results available upon request).

[37]This approach to assessing duration data is illustrated in Frederiksen et al. (2007) and Arellano (2008). Variants have also been employed by, among others, Hoffman and Tadelis (2019) and Sandvik et al. (2021).

Figure 5: Minimum Wage Reduces Turnover and Increases Tenure in Stores with a High Fraction of Low Types

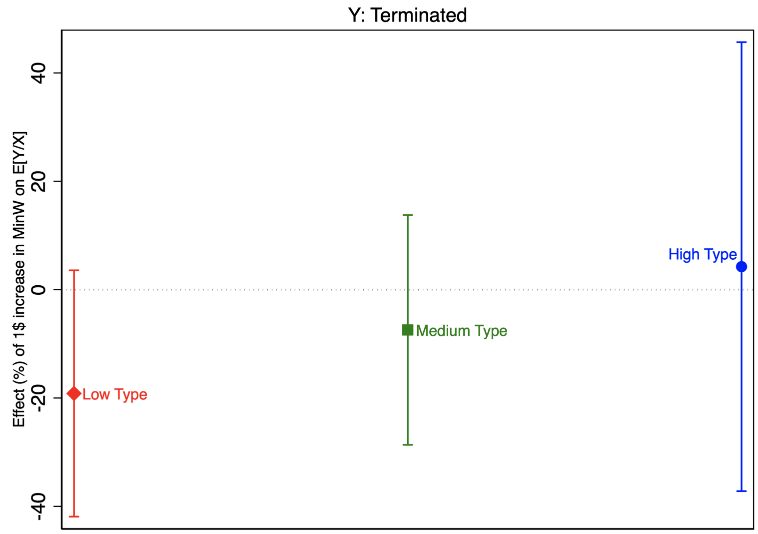


Notes: This figure plots $\hat{\beta} + \hat{\delta} \cdot \%LowTypes$ from equation (15). Y is the termination rate (Panel A), hiring (Panel B), turnover rate (Panel C), average worker tenure (Panel D), and number of sales associates (Panel E). Vertical bars represent 95% confidence intervals for the estimator of $\beta + \delta * (\%LowTypes)$. We report the effects in percentage points in Panels A-C and in percent in Panels D-E.

While the theory does propose specific predictions relative to store-level employment levels in the border sample (the next section discusses this issue in depth), it is descriptively interesting to assess how employment responds to the minimum wage in this sample. Figure 5, Panel E and the corresponding Table 6 (columns 9-10) show that, in the average store, the minimum wage has no significant effect on employment on average, nor is there any significant heterogeneous effect by the fraction of low types in the store.[38]

[38] In the average store, the elasticity is equal to -0.103 (-0.217/(16.63*.127)) – see Table 6, column 9. Though this point estimate is not statistically significant, it is worth noting that it is on the high end of the literature (about -0.2 for a teen population with around 20% of minimum wage earners, from Manning 2021) when we consider that our average store comprises 5% low types.

Figure 6: Minimum Wage Reduces Termination of Low Types but not of High Types



Notes: Effects of a \$1 increase in minimum wage on the percent change in termination (Y: Terminated) for low, medium, and high types. Vertical bars represent 95% confidence intervals computed using the estimated coefficients ($\hat{\beta}_1$, $\hat{\beta}_1 + \hat{\beta}_4$, and $\hat{\beta}_1 + \hat{\beta}_5$) from equation (12), but with store rather than worker fixed effects.

6.2 Testing the Predicted Decrease in Profits

The hypothesis that headquarters chooses the compensation scheme $\overline{w}$ to maximize nationwide profits can only be tested in the nationwide sample, and not in the border-store sample. This is because the nationwide compensation scheme $\overline{w}$ is not adapted to local conditions,[39] and border stores may not be representative of all stores. There is thus no theoretical presumption that a minimum wage hike should reduce profits *in a border store*.[40,41] However, profits are expected to decrease *in the representative store*. We accordingly check whether profits decline *in the nationwide sample.*

The controls to include in the nationwide specification is an open question. We run the three most common state-level specifications in the literature (store and month fixed

[39]See page 19 for a discussion of this institutional feature.

[40]Footnote 8 provides a counterexample where profits *increase* with the minimum wage because $\overline{w}$ is not well-adapted to local conditions.

[41]By contrast, the border sample is suitable for testing theoretical predictions about worker behavior and store-level turnover, as both are optimized store-by-store such that the theoretical predictions should hold for every worker and even in non-representative stores

effects; or with added linear state trends; or with added census-division $\times$ month fixed effects). As the only specification that eliminates pre-trends in profits, employment, and individual sales per hour is the census-division $\times$ month fixed effects (Tables A.5 and E.1), we report the results for this specification alone.[42]

Table 8, column 1 shows that the effect of minimum wage on profits is negative and statistically significant, as predicted by the theory for the nationwide sample. In line with the individual-level results, we see in Table 8, column 2 that store-level output per hour worked increases, though the latter is not large enough to offset the extra cost associated with a higher minimum wage. Indeed, profits per hour go down.[43,44]

7 Alternative Explanations for our Core Results

Our core results concern the effect of the minimum wage on individual productivity, by type. In this section, we examine two alternative channels that could explain some of our main findings. Details on the tests performed to rule out these alternative channels are provided in Appendices F and G, respectively, along with the associated tables.

7.1 Demand Channel

A demand increase that systematically coincides with a minimum wage hike might account for the *average* increase in individual productivity.[45] Yet, a demand increase is at odds with

[42] Outcomes using the other state-level specifications are similar and available upon request.

[43] For the sake of comparison, we also present the results in the border sample. To this end, we estimate equation (14) with profits per hour and output per hour as the dependent variable. We document a zero profits effect and a positive effect on output in the border sample (Table 8, columns 3-4). At the risk of overinterpreting differences in estimates across non-nested regression specifications, one might conclude that border stores are somewhat different than average stores. In any case, individual performance estimates by type are quite similar in the border and nationwide samples: compare Tables 4 and E.7.

[44] Lemma 2 predicts that store-level employment should co-move with profits per hour. In Figure A.3, we show that this prediction holds in the data. This is a sanity check for the theory, though it does not speak directly to the effect of the minimum wage given that the co-movement analysis does not isolate the effect of minimum-wage changes.

[45] The literature is divided as to whether there is pass-through from the minimum wage to the demand for retail goods. One the one hand, Aaronson et al. (2012) show a certain degree of pass-through for miscellaneous household items, which are sold by retail stores. On the other, Leung (2017) demonstrates a decrease in real sales of "General Merchandise" in mass merchandise stores after a minimum wage hike.

the *productivity reduction observed among low-monitored workers* (Section 5). In addition, a demand increase alone does not easily account for why *high types fail to experience a productivity boost* (Section 4). If the demand channel was operative, such a boost would be expected. Indeed, we show that in times of high store-level demand – as measured by satellite imagery of parking lot occupancy rates around each store – high types' sales increase more (and not less) than those of low types (Table F.3 and Figure F.3). Further evidence that high types are more sensitive to minimum wage-induced variation in demand comes from counties that have a larger share of the population who earn minimum wage; that is, where the demand channel is expected to be most powerful. In these counties, the effect of the minimum wage on productivity is found to be stronger for high than for low types, compared to less exposed counties. This suggests that in counties where the demand channel is most powerful, it is manifested disproportionately among high relative to low types (Table F.4). Overall, the demand channel seemingly has different implications than an efficiency wage channel, such that variation in demand alone cannot explain all of our findings.

7.2 Organizational Adjustments Channel

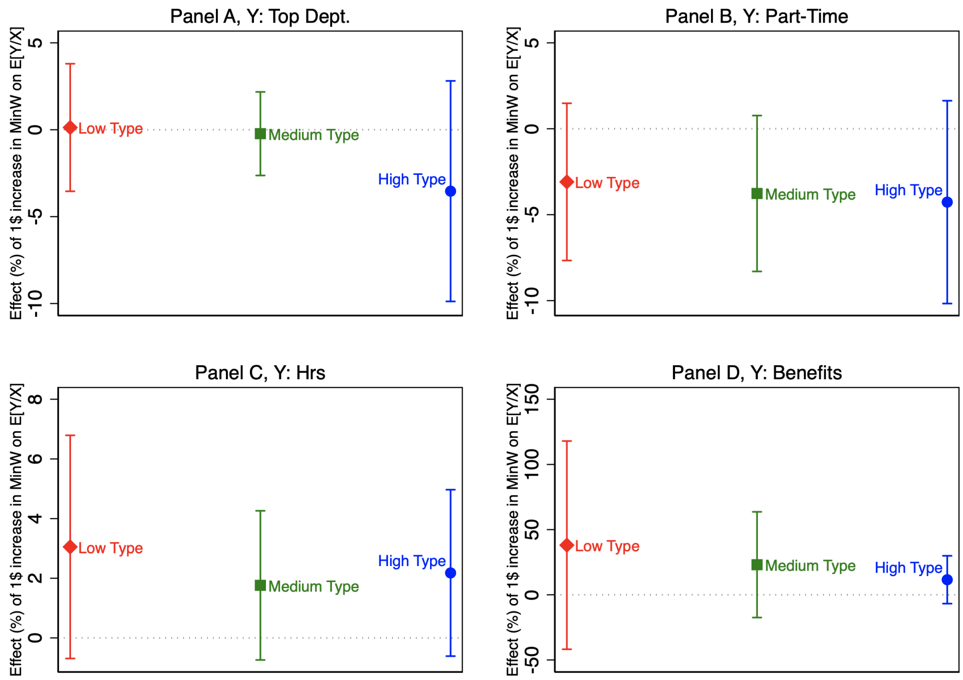
Stores could respond to a higher minimum wage with certain organizational adaptations that might disproportionately increase the low types' sales per hour. These might include, for example, reallocating them to "better-selling" departments,[46] moving them from part-time to full-time status (where they might then pick up higher-traffic work hours), reducing their number of hours (which could translate into higher productivity *per hour* if this attenuates the fatigue of working long hours), or increasing their vacation and illness benefits. Figure 7 (and the corresponding Table G.1) show that the company did not make differential adjustments across types.[47]

Another firm adjustment that could be consistent with sales associates selling a higher

[46]These are departments that, anecdotally, are viewed as more desirable for workers. We confirm that sales associates working in these departments earn higher variable pay.

[47]While Doppelt (2019) finds a disproportionate adjustment in hours worked among part-time workers, we do not observe any difference between part-time and full-time workers. The percentage change in benefits looks large for all types (though it is not statistically significant) but this is because it is calculated relative to a low mean; the absolute change is $10 per month.

Figure 7: Minimum Wage has no Differential Effect on Allocation to Best-Selling Departments, Part-Time Status, Hours Worked, or Benefits by Type



Notes: Effects of a \$1 increase in minimum wage on the percent change in Y; where Y is an indicator for working in the best-selling departments (Panel A), an indicator for being a part-time worker (Panel B), the number of hours worked per month (Panel C), or benefits (in \$) earned (Panel D). Vertical bars represent 95% confidence intervals computed using the estimated coefficients ($\hat{\beta}_1$, $\hat{\beta}_1 + \hat{\beta}_4$, and $\hat{\beta}_1 + \hat{\beta}_5$) from equation (12) and the associated standard errors.

dollar amount after a minimum wage hike is an increase in *consumer prices*. Note, however, that a rise in prices should be a tide that lifts all boats, thus increasing sales for *all* workers, not just the low types. Moreover, in line with the findings of Della Vigna and Gentzkow (2019), our company has a national pricing strategy and applies uniform prices across all US stores. We confirm this by backing out a store-level aggregate retail price index from each store's monthly financials, whereby we observe that the index does not correlate with the local minimum wage change (Table G.2).[48]

[48] Renkin et al. (2021) show evidence of an increase in consumer prices before the minimum wage implementation date. Our retail price index does not, however, display such an effect (results available upon request).

8 Worker Welfare

In this section, we compute the workers' welfare gain from a minimum wage increase. We find that low types gain the most from a marginal increase in the minimum wage, and high types the least.

The marginal effect of the minimum wage on type x's welfare was shown in Section 2.5 to be:

$$\left.\frac{1+r}{1+r-\pi(e)} w_M(x, e; M)\right|_{e=e^*(x;M)}.$$

The above expression features two competing effects. One the one hand, low types become unemployed sooner (first term), hence they benefit from the minimum wage increase for less time than the high types. On the other hand, while employed, low types receive larger and more frequent minimum wage adjustments (second term). Here we address which of the two effects dominates.

The term w_M is the marginal effect of the minimum wage on type x's wage. When evaluated at $e^*(x; M)$, this is is equivalent to the equilibrium probability that type x requires a minimum wage adjustment. The proof of Proposition 1 shows this equivalence formally,[49] and can be understood intuitively as follows. A marginal increase in M only affects wages in the event that type x requires a minimum wage adjustment. In this case, the marginal impact of M on wages equals 1; otherwise it is zero. Therefore, the expected impact of M on type x's wages coincides with the probability that this type requires a minimum wage adjustment. The term π, when evaluated at $e^*(x; M)$, is simply the probability of type x's continued employment. The parameter r is the worker's monthly discount factor.

To bring the expression to the data, we set r equal to 0.04. The probability π of continued employment is set equal to 1 minus the average monthly termination by type (the latter being 6.8% for low types, 5.2% for medium types, and 3% for high types, see Table 3). Finally, w_M is set equal to the monthly likelihood that earnings are equal to the minimum wage: 20.5% for low types, 3.1% for medium types, and 0.6% for high types

[49] Refer to expression (24).

(see Table 3).

Plugging these values into the above equation, we get that the marginal effect of the minimum wage on worker welfare is 2.71 for low types, 0.56 for medium types, and 0.21 for high types. In our empirical setting, therefore, low types gain the most from a marginal increase in the minimum wage, and high types the least. This pattern holds even though lower types enjoy the minimum wage for a shorter time span. The same empirical pattern will hold a fortiori when we allow the value of being unemployed to increase with the minimum wage, as this effect disproportionately benefits low types: see Appendix C.2.

9 External Validity

Large employers like the one studied here are not unrepresentative. In fact, 23% of the US workforce is employed by firms with more than 20,000 employees, and the average such firm has about 1,200 establishments.[50] The generalizability of our findings to smaller firms must, however, be carefully assessed.

First, we look at the generalizability of the individual worker estimates. In our large firm, product prices and the wage schedule $\overline{w}$ do not respond to local minimum wage changes. This could be different for small employers. The most generalizable estimates are therefore those for our low types because they, among our workers, have a pay level that most frequently coincides with the minimum wage and that, as such, is least affected by firm-specific factors such as product price changes or the shape of the wage schedule. These types' compensation is comparable to workers in the US economy who occasionally earn above minimum wage, but are often "at minimum wage," such as tipped workers or fixed minimum wage workers. Such workers are especially policy-relevant in that they are the most vulnerable sub-population and, also, the target of minimum wage policy. In contrast, our estimates for the "medium types" are specific to the particular incentive scheme $\overline{w}$, and to the fact that this scheme does not adapt to the minimum wage in our setting. Our estimates for high types (non-response) are generalizable to workers/jobs who earn much above the minimum wage, and whose compensation does not change after

[50]Source: 2017 Statistics of U.S. Businesses (SUSB), Annual Data Tables by Establishment Industry.

a minimum wage increase.

Next, we turn to the generalizability of the store-level estimates. Quantitatively, a store's response to a minimum wage increase depends, according to the theory, on its type composition – how many workers are at minimum wage in that specific store, for example. That being said, our store-level estimates on labor flows, employment, and profits qualitatively align with aggregate estimates from the empirical labor literature, as detailed next.

We document a decrease in store-level terminations, hiring, and turnover, as the minimum wage increases. Earlier macro-labor papers show a similar pattern by analyzing aggregate flows of low-paid workers.[51] Our micro-level analysis adds to these studies by connecting this effect to an endogenous increase in worker productivity. As regards store-level employment, the absence of any statistically significant effect is typical within the border-discontinuity literature.[52] Finally, empirical work on the profit effect of the minimum wage is relatively sparse and tends to find non-positive effects, as do we.[53] One caveat is that prices and wages in our stores do not adjust to the minimum wage: if a firm can freely adjust its wages and prices, economic theory suggests that its profits would be somewhat more resilient to the minimum wage than in our stores.[54]

10 Conclusions

We assess individual worker productivity among more than 40,000 salespeople employed by a large US retailer that operates more than 2,000 stores and whose pay is partly based on performance.

[51] These papers use county- or state-level data to demonstrate that the minimum wage reduces worker turnover. See, e.g., Portugal and Cardoso (2006), Brochu and Green (2013), Dube et al. (2016), Gittings and Schmutte (2016), and Jardim et al. (2018).

[52] See Manning (2021) for a recent review of the large body of work on the employment effects of minimum wage (Figures 1-4).

[53] (Albeit for a single firm, visibility on establishment-level profits is, to our knowledge, a novel contribution in the US context. See Clemens (2021) pg. 63 for review of the literature on profits.

[54] Pass-through of the minimum wage on prices has been documented in both the manufacturing (Harasztosi and Lindner 2019) and retail (Renkin et al. 2021; Leung 2017) sectors. See Clemens (2021, pg. 53) for a review of the literature.

Using a border-discontinuity research design, we document the effect of the minimum wage on individual productivity. Workers whose pay is most likely to be topped up by the minimum wage (referred to as low types) exhibit a sizable productivity boost after a minimum wage increase. They are also terminated less often. However, these effects reverse in sign when workers are monitored less intensely. We organize these findings using a new theoretical model that features two sources of worker incentives: an efficiency wage channel and a pay-for-performance channel. When read through the lens of this model, our empirical results indicate that the efficiency wage channel is responsible for the increase in productivity, our headline finding.

The theory predicts that profits should decrease and worker welfare should increase with the minimum wage. Closed-form expressions for the effect of a minimum wage increase on worker welfare are provided. A calibration exercise indicates that welfare increases most for the low types. While this is intuitive because the low types' pay is the most likely to be topped up by the minimum wage, it is not obvious in that the low types are also the most likely to become unemployed, and hence to stop earning the minimum wage.

The issue of external validity must necessarily be approached with care as in our large firm, product prices and the wage schedule do not respond to local minimum wage changes. This could be different for small employers. The most generalizable estimates are therefore those for our low types because they, among our different kinds of workers, are those whose pay level most frequently coincides with the minimum wage and which is, as such, least affected by firm-specific factors such as product price changes or the shape of the wage schedule. The focus on lowest-wage workers is particularly policy-relevant as they constitute the most vulnerable sub-population and, also, the target of minimum wage policy.

By documenting the endogenous effort response of low-paid workers, this paper has highlighted another channel through which the minimum wage may affect firm profits and worker welfare, above and beyond the conventional channel that labor becomes more expensive, causing profits to shrink and workers to lose their job. This endogenous effort response adds a potentially important dimension to the minimum wage debate.

References

Aaronson, D., S. Agarwal and E. French (2012). "The Spending and Debt Response to Minimum Wage Hikes." *The American Economic Review*, 102(7), pg.3111-39.

Allegretto, S., A. Dube and M. Reich (2011). "Do Minimum Wages Really Reduce Teen Employment? Accounting for Heterogeneity and Selectivity in State Panel Data." *Industrial Relations*, 50(2), pg.205-240.

Allegretto, S., A. Dube, M. Reich and B. Zipperer (2013). "Credible Research Designs for Minimum Wage Studies."IZA Discussion Paper No. 7638.

Allegretto, S., A. Dube, M. Reich and B. Zipperer (2017). "Credible Research Designs for Minimum Wage Studies: A Response to Neumark, Salas, and Wascher." *ILR Review*, 70(3), pg.559-592.

Arellano, M. (2008). "Duration Models."Class notes. www.cemfi.es/arellano/durationmodels.pdf.

Autor, D. H., A. Manning and C. L. Smith (2016). "The Contribution of the Minimum Wage to US Wage Inequality over Three Decades: A Reassessment." *American Economic Journal: Applied Economics*, 8(1), pg.58-99.

Brochu, P. and D. A. Green (2013). "The Impact of Minimum Wages on Labour Market Transitions." *The Economic Journal*, 123(573), pg.1203-1235.

Card, D. and A. B. Krueger (1994). "Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania." *The American Economic Review*, 84(4), pg.772-93.

Card, D. and A. B. Krueger (2000). "Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania: Reply." *The American Economic Review*, 90(5), pg.1397-1420.

Cengiz, D., A. Dube, A. Lindner, A. and B. Zipperer (2019). "The Effect of Minimum Wages on Low-Wage Jobs." *The Quarterly Journal of Economics*, 134(3), pg.1405-1454.

Clemens, J. and M. Wither (2019). "The Minimum Wage and the Great Recession: Evidence of Effects on the Employment and Income Trajectories of Low Skilled Workers." *Journal of Public Economics*, 170(2), pg.53-67.

Clemens, J. (2021). "How Do Firms Respond to Minimum Wage Increases?" *Journal of Economic Perspectives*, 35(1), pg.51-72.

Della Vigna, S. and M. Gentzkow (2019). "Uniform Pricing in US Retail Chains." *The Quarterly Journal of Economics*, 134(4), pg.2011-2084.

Doppelt, R. (2019). "Minimum Wages and Hours of Work."Working Paper.

Draca, M., S. Machin and J. Van Reenen (2011). "Minimum Wages and Firm Profitability." *American Economic Journal: Applied Economics*, 3(1), pg.129-51.

Dube, A., T.W., Lester, and M. Reich (2010). "Minimum Wage Effects Across State Borders: Estimates Using Contiguous Counties." *The Review of Economics and Statistics*, 92(4), pg.945-964.

Dube, A., T. W. Lester and M. Reich (2016). "Minimum Wage Shocks, Employment Flows and Labor Market Frictions." *Journal of Labor Economics*, 34(3), pg.663-704.

Eeckhout, J., N. Persico and P. Todd (2010). "A Theory of Optimal Random Crackdowns." *The American Economic Review*, 100(3), pg.1104-35.

Flinn, C. J. and J. Mullins (2018). "Firms' Choices of Wage-Setting Protocols in the Presence of Minimum Wages." *Mimeo.*

Frederiksen, A., B. Honoré, and L. Hud (2007). "Discrete Time Duration Models with Group-Level Heterogeneity." *Journal of Econometrics*, 141(2), pg.1014-1043

Gittings, R. K. and I. M. Schmutte (2016) "Getting Handcuffs on an Octopus: Minimum Wages, Employment, and Turnover." *ILR Review*, 69(5), pg.1133-1170.

Harasztosi, P. and A. Lindner (2019). "Who Pays for the Minimum Wage?" *The American Economic Review*, 109(8), pg.2693-2727.

Hill, A. E. (2018). "The Minimum Wage and Productivity: A Case Study of California Strawberry Pickers." *Mimeo.*

Hoffman, M. and S. Tadelis (2021). "People Management Skills, Employee Attrition, and Manager Rewards: An Empirical Analysis." *Journal of Political Economy*, 129(1), pg. 243-285.

Jardim, E., M. C. Long, R. Plotnick, E. van Inwegen, J. Vigdor and H. Wething (2018). "Minimum Wage Increases and Individual Employment Trajectories."NBER Working Paper 25182.

Ku, H. (2018). "Does Minimum Wage Increase Labor Productivity? Evidence from Piece Rate Workers." *Journal of Labor Economics*, *forthcoming.*

Lazear, E. (2006) "Speeding, Terrorism, and Teaching to the Test." *The Quarterly Journal of Economics*, 121(3), pg.1029-1061.

Leung, J. (2020). "Minimum Wage and Real Wage Inequality: Evidence from Pass-Through to Retail Prices." *Review of Economics and Statistics*, pg.1-47.

Lemieux, T., W. B. MacLeod, and D. Parent (2012). "Contract Form, Wage Flexibility, and Employment." *The American Economic Review: Papers & Proceedings*, 102(3), pg.526-531.

Manning, A. (2021). "The Elusive Employment Effect of the Minimum Wage." *Journal of Economic Perspectives*, 35(1), pg.3-26.

Neumark, D. and W. Wascher (1992). "Employment Effects of Minimum and Subminimum Wages: Panel Data on State Minimum Wage Laws." *ILR Review*, 46(1), pg.55-81.

Neumark, D. and W. Wascher (2007). "Minimum Wages and Employment."IZA Discussion Paper No. 2570.

Neumark, D., J.I. Salas and W. Wascher (2014). "Revisiting the Minimum Wage—Employment Debate: Throwing Out the Baby with The Bathwater?" *ILR Review*, 67(3), pg.608-648.

Neumark, D. (2019). "The Econometrics and Economics of the Employment Effects of Minimum Wages: Getting from Known Unknowns to Known Knowns." *German Economic Review*, 20(3), pg.293-329.

Portugal, P. and A. R. Cardoso (2006). "Disentangling the Minimum Wage Puzzle: An Analysis of Worker Accessions and Separations." *Journal of the European Economic Association*, 4(5), pg.988-1013.

Rebitzer, J. B. and L. J. Taylor (1995). "The Consequences of Minimum Wage Laws Some New Theoretical Ideas." *Journal of Public Economics*, 56(2), pg.245-255.

Renkin, T., C. Montialoux and M. Siegenthaler (2021). "The Pass-Through of Minimum Wages into US Retail Prices: Evidence from Supermarket Scanner Data." *Review of Economics and Statistics*, *forthcoming.*

Sandvik, J., N. Seegert, R. Saouma and C. Stanton (2021). "Employee Responses to Compensation Reductions: Evidence from a Sales Firm." *Management Science*, Articles in Advance, pg.1-21.

Zhang, W. (2018). "Distribution Effects of Local Minimum Wage Hikes: A Spatial Job Search Approach." *Mimeo.*

Table 1: Descriptive Statistics

Variables	Mean (1)	S.D. (2)	p10 (3)	p50 (4)	p90 (5)	N (6)
Panel A. Worker-level Variables						
Productivity						
Sales/Hrs (Shrouded Units)	2.085	1.468	0.781	1.872	3.522	217,822
Tenure and Hours						
Tenure (in months)	48.92	65.01	4	24	126	217,822
Part-Time (in %)	60.25	48.94	0	100	100	217,822
Number of Hours (Hrs)	106.5	44.12	46.47	107.6	162.3	217,822
Compensation						
Base Rate: Regular Pay/Hrs (in $)	6.120	1.181	4.500	6	7	217,822
Comm. Rate: Variable Pay/Sales (in %)	3.462	3.188	1.057	2.343	7.531	213,726
Variable Pay/Hrs (in $)	5.947	4.936	1.740	4.610	11.78	217,822
MinW Adj/Hrs (in $)	0.225	1.736	0	0	0.771	217,822
Total Pay (in $)	1,361	831.2	494.6	1,218	2,343	217,822
Total Pay/Hrs (in $)	12.51	4.620	8.734	11.15	17.94	217,822
Panel B. Store-level Variables						
Termination, Hiring, and Turnover						
Terminated (in %)	4.755	7.692	0	0	12.50	12,359
Hired (in %)	2.060	4.285	0	0	7.692	12,359
Turnover (in %)	3.408	4.404	0	2.500	8.333	12,359
Employment and Profits						
Number of Workers	16.64	6.855	8	16	26	12,359
Supervisor-to-Worker Ratio (in %)	6.990	4.886	3.448	5.882	11.11	12,359
Ebitda/Hrs (Shrouded Units)	5.946	11.97	-8.010	5.630	19.97	12,359

Notes: This table presents summary statistics of worker-level variables in Panel A and store-level variables in Panel B. *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *Tenure* is the number of months of tenure. *Part-Time (in %)* is the percent probability that an employee is part-time in a given month (0 means full-time and 100 means part-time). *Number of Hours* is the total number of hours for which employee receives compensation in a given month. *Base Rate: Regular Pay/Hrs* are monthly regular earnings per hour worked (in $ per hour). *Comm.Rate: Variable Pay/Sales* are earnings from commissions and incentives divided by sales (in %). *Variable Pay/Hrs* are earnings from commissions and incentives per hour worked (in $ per hour). *MinW Adj/Hrs* are the monthly earnings from minimum wage adjustments per hour worked (in $ per hour). *Total Pay (in $)* is the monthly total pay from total take home pay. *Total Pay/Hrs* is the monthly total pay from total take home pay per hour worked (in $ per hour). *Terminated (in %)* is the percent of sales associates in the store who are terminated in a given month. *Hired (in %)* is the percent of sales associates who are hired in a store in a given month. *Turnover (in %)* is defined as the percent of sales associates in the store who are terminated or hired in a given month divided by two. *Number of Workers* is the number of sales associates employed by a store in a given month. *Supervisor-to-Worker Ratio* is measured as the number of supervisors per 100 sales associates. *Ebitda/Hrs* are equal to earnings before interest, tax, depreciation, and amortization, per hour worked in the store. We do not disclose the units for confidentiality reasons.

Table 2: Effect of Minimum Wage on Compensation Scheme $\overline{w}$, and on Overall Pay Inclusive of Minimum Wage Adjustment

Dep.Var.	Compensation scheme ($\overline{w}$)		Overall pay inclusive of minimum wage adjustment			
	Base Rate:	*Comm. Rate:*				
	Reg.Pay/Hrs	Var.Pay/Sales	MinW.Adj./Hrs	Var.Pay/Hrs	Tot.Pay/Hrs	Tot.Pay
	(in \$)	(in %)	(in \$)	(in \$)	(in \$)	(in 100\$)
	(1)	(2)	(3)	(4)	(5)	(6)
MinW	-0.059	0.126	0.250***	0.439*	0.645***	0.856**
	(0.042)	(0.077)	(0.044)	(0.235)	(0.172)	(0.336)
Observations	217,822	213,697	217,822	217,822	217,822	217,822
Units	Workers	Workers	Workers	Workers	Workers	Workers
Mean Dep.Var.	6.120	3.462	0.225	5.947	12.51	13.61
Effect MinW (%)	-0.957	3.628	111.3	7.390	5.154	6.289

Notes: All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, worker department and county-level unemployment. *Reg.Pay/Hrs* is the base rate: monthly regular earnings per hour worked (in \$ per hour). *Var.Pay/Sales* is the commission rate: earnings from commissions and incentives divided by sales (in %). *MinW.Adj./Hrs* are monthly earnings from minimum wage adjustments per hour worked (in \$ per hour). *Var.Pay/Hrs* are earnings from commissions and incentives per hour worked (in \$ per hour). *Tot.Pay/Hrs* is the monthly total pay from total take-home pay per hour worked (in \$ per hour). *Tot.Pay* is the monthly total pay from total take-home pay (in 100\$). *MinW* is the predominant monthly minimum wage (in \$). *Effect MinW (%)* is the percent effect of a \$1 increase in MinW on the outcomes. Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Descriptive Statistics for Low, Medium, and High Types

Worker Types:	Low Types (1)	Medium Types (2)	High Types (3)
% Workers	3.9%	72.4%	23.7%
% Terminated	6.8%	5.2%	3.0%
Sales/Hrs	1.08	1.94	2.73
% Weeks with MinW Adjustment	48.9%	18.5%	12.2%
% Months with MinW Adjustment All Weeks	20.5%	3.1%	0.6%

Notes: This table presents summary statistics for low, medium, and high types. *Low Types* are workers paid at the minimum wage. *Medium Types* are workers paid between the minimum wage and 180% of the minimum wage. *High Types* are workers paid more than 180% of the minimum wage. The number of observations is 210k, as in our main specifications. *% Terminated* is the fraction of workers terminated. *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *% Weeks with MinW Adjustment* is the fraction of weeks per month in which a worker's pay is topped up by the firm. *% Months with MinW Adjustment All Weeks* is the fraction of months in which a worker's pay is topped up by the firm each single week.

Table 4: Effect of Minimum Wage on Individual Worker Productivity

Dep.Var.	Sales/Hrs (1)	Sales/Hrs (2)
MinW	0.094**	0.244***
	(0.039)	(0.042)
Medium Type		0.354***
		(0.032)
High Type		1.169***
		(0.072)
MinW · Medium Type		-0.085***
		(0.025)
MinW · High Type		-0.182***
		(0.032)
Observations	217,822	209,513
Units	Workers	Workers
Mean Dep.Var.	2.085	2.085
Effect MinW (%)	4.485	
Effect MinW for Low Type (%)		22.56
p-value		0.001
Effect MinW for Med. Type (%)		8.186
p-value		0.001
Effect MinW for High Type (%)		2.273
p-value		0.179

Notes: All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, worker department, and county-level unemployment. *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *MinW* is the predominant monthly minimum wage (in $). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage." *Effect MinW (%)* is the percent effect of a $1 increase in MinW on the outcomes. Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Effect of Minimum Wage on Worker Productivity for High vs. Low Monitoring Coverage

Dep.Var.	Sales/Hrs	Sales/Hrs	Sales/Hrs	Sales/Hrs	Sales/Hrs
Sample	All	High Coverage		Low Coverage	
	(1)	(2)	(3)	(4)	(5)
Coverage	0.010***				
	(0.003)				
MinW		0.140***	0.281***	-0.192**	0.020
		(0.040)	(0.044)	(0.081)	(0.067)
Medium Type			0.368***		0.336***
			(0.033)		(0.044)
High Type			1.185***		1.121***
			(0.071)		(0.080)
MinW · Medium Type			-0.083***		-0.111*
			(0.027)		(0.054)
MinW · High Type			-0.188***		-0.168**
			(0.031)		(0.075)
Observations	217,822	132,384	126,852	84,549	81,800
Units	Workers	Workers	Workers	Workers	Workers
Mean Dep.Var.	2.085	2.118	2.085	2.030	2.085
Effect (%)	1.461	6.588		-9.444	
Effect MinW for Low Type (%)			25.87		1.824
p-value			0.001		0.773
Effect MinW for Med. Type (%)			10.11		-4.953
p-value			0.001		0.176
Effect MinW for High Type (%)			3.298		-5.714
p-value			0.077		0.114

Notes: All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, worker department, and county-level unemployment. *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *Coverage* is measured as the supervisor-to-worker ratio (number of supervisors per 100 sales associates). Low (High) coverage is an indicator for whether the store is in the bottom quartile (not in the bottom quartile) of coverage. *MinW* is the predominant monthly minimum wage (in $). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay at *t-1* is "at minimum wage." *Effect MinW (%)* is the percent effect of a $1 increase in MinW on the outcomes. Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1

Table 6: Effect of Minimum Wage on Store-Level Outcomes, by Fraction of Low Types (Store-level)

Dep.Var.	% Terminated		% Hired		% Turnover		Tenure		N.Workers	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
MinW	-0.272	-0.282	0.213	0.084	-0.029	-0.099	7.205**	7.537**	-0.217	-0.451
	(0.503)	(0.538)	(0.308)	(0.310)	(0.368)	(0.393)	(3.513)	(3.479)	(0.423)	(0.405)
% Low Types		0.222		0.276**		0.249*		-0.740*		0.146
		(0.207)		(0.118)		(0.124)		(0.375)		(0.117)
MinW · % Low Types		-0.025		-0.029**		-0.027*		0.077*		-0.012
		(0.025)		(0.013)		(0.014)		(0.044)		(0.014)
Observations	12,359	12,025	12,359	12,025	12,359	12,025	12,359	12,025	12,359	12,025
Units	Stores	Stores	Stores	Stores	Stores	Stores	Stores	Stores	Stores	Stores
Mean Dep.Var.	4.755	4.877	2.060	2.073	3.408	3.475	49.65	49.62	16.64	16.63

Notes: All the regressions include pair-month fixed effects, store fixed effects, and control for county-level unemployment. *% Terminated* is the percent of sales associates in the store who are terminated in a given month. *% Hired* is the percent of sales associates who are hired in a store in a given month. *% Turnover* is the percent of sales associates in the store who are terminated or hired in a given month divided by two. *Tenure* is the average number of months of tenure in the workforce. *N.Workers* is the number of sales associates in the store. *MinW* is the predominant monthly minimum wage in the store (in $). *% Low Types* is the percent of workers who are low types in the store (pay at minimum wage at t-1). Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Effect of Minimum Wage on Individual Worker Termination

Dep.Var.	Terminated (1)	Terminated (2)
MinW	-0.159	-1.297*
	(0.517)	(0.756)
Medium Type		-2.240***
		(0.755)
High Type		-3.753***
		(0.817)
MinW · Medium Type		0.912
		(0.620)
MinW · High Type		1.424**
		(0.573)
Observations	217,822	209,734
Units	Workers	Workers
Mean Dep.Var.	4.562	4.562
Effect MinW (%)	-3.482	
Effect MinW for Low Type (%)		-19.16
p-value		0.096
Effect MinW for Med. Type (%)		-7.434
p-value		0.480
Effect MinW for High Type (%)		4.247
p-value		0.836

Notes: All the regressions include pair-month fixed effects, store fixed effects (not worker fixed effects), and control for worker tenure, worker department ,and county-level unemployment. *Terminated* is a dummy for whether a worker is terminated in a given month. *MinW* is the predominant monthly minimum wage (in $). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage." *Effect MinW (%)* is the percent effect of a $1 increase in MinW on the outcomes. Standard errors are two-way clustered at the state level and at the border-segment level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 8: Effect of Minimum Wage on Profits with Border-Discontinuity and State-Level Specification

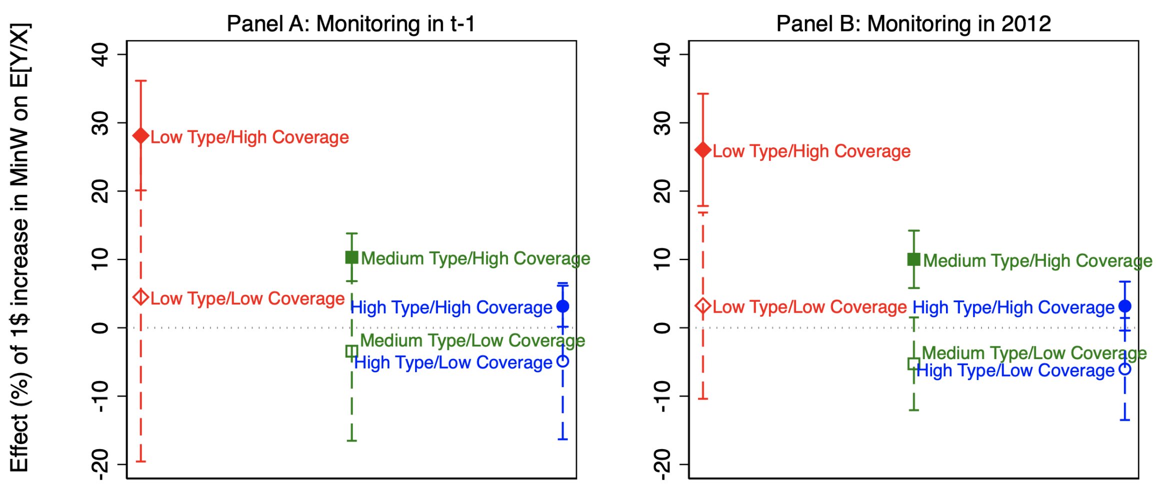
Dep.Var.	Ebitda/Hrs	Output/Hrs	Ebitda/Hrs	Output/Hrs
Sample	All Stores	All Stores	Border Stores	Border Stores
	(1)	(2)	(3)	(4)
MinW	-0.781*	0.029*	0.383	0.062**
	(0.436)	(0.017)	(1.317)	(0.026)
Observations	30,969	30,969	12,359	12,359
Units	Stores	Stores	Stores	Stores
Mean Dep.Var.	4.824	0.830	5.946	0.827
Effect MinW (%)	-16.18	3.457	6.441	7.551

Notes: In cols. 1-2, the sample comprises all stores (bordering + non-bordering). The regressions include census division-month fixed effects, month fixed effects, store fixed effects, and control for county-level unemployment. Standard errors are clustered at the state-level. In cols. 3-4, the sample is restricted to bordering stores. The regression includes pair-month fixed effects, store fixed effects, and controls for county-level unemployment. Standard errors are two-way clustered at the state level and at the border-segment level. *Ebitda/Hrs* is equal to earnings before interest, tax, depreciation, and amortization, per hour worked in the store. *Output/Hrs* is equal to total store revenues per hour worked in the store. We do not disclose the units for confidentiality reasons. *MinW* is the predominant monthly minimum wage (in \$). *Effect MinW (%)* is the percent effect of a \$1 increase in MinW on the outcomes. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Appendices

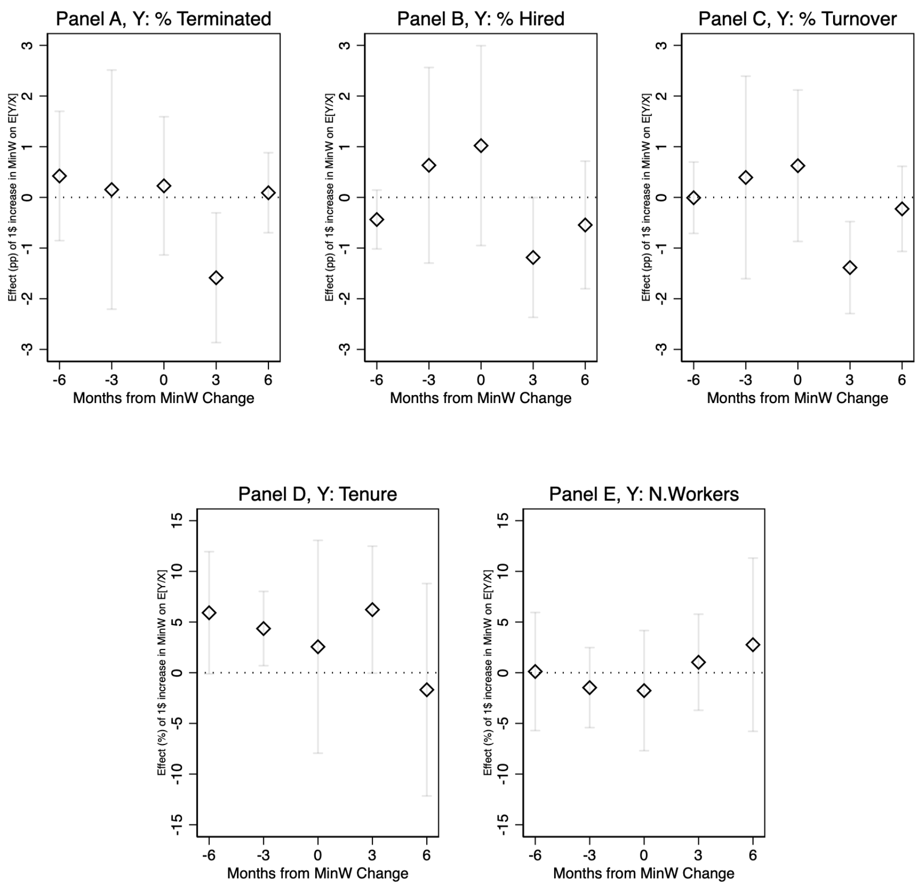
A Appendix Tables and Figures

Figure A.1: Effect of Minimum on Worker Productivity, by Monitoring Coverage



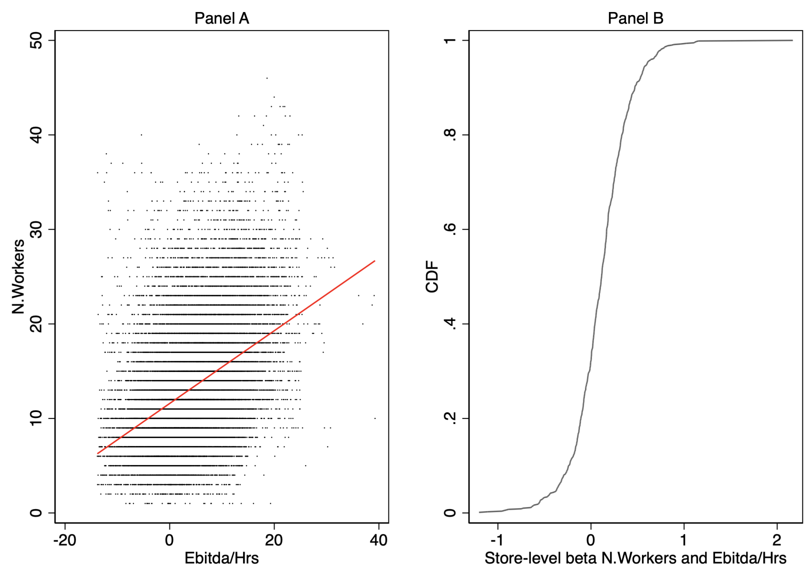
Notes: Effects of a \$1 increase in minimum wage on the percent change in performance (Y: Sales/Hrs) for low, medium, or high types for high/low monitoring coverage. Monitoring coverage is measured as the ratio of supervisors to workers in time t-1 in Panel A, and in 2012 (the starting year in our dataset) in Panel B. "Low coverage" is an indicator for whether the store is in the bottom quartile of the monitoring coverage distribution. Vertical bars (solid for "Low coverage," dashed otherwise) represent 95% confidence intervals.

Figure A.2: Dynamic Effect of Minimum Wage on Store-level Outcomes – 6 Months Time Window



Notes: Panels A-C present the dynamic effects of a \$1 increase in minimum wage on the store-level percentage point change in Y; where Y is the percent of sales associates who are terminated (Panel A), the percent of sales associates who are hired (Panel B), or the turnover rate of a store in a given month (Panel C). Panel D-E present the dynamic effect of a \$1 increase in minimum wage on the percent change in average worker tenure (Panel D) and on the number of sales associates in a store (Panel E). Vertical bars represent 95% confidence intervals.

Figure A.3: Comovement of Employment and Profits Per Worker



Notes: In Panel A, the coordinates of each dot are a store's *N.Workers* in a given month, and that store's *Ebitda/Hrs* averaged over the previous six months. The slope of the regression line, which is 0.32, is the "pooled" estimate of the linear relationship between these two variables. A positive slope is consistent with the theoretical prediction that an increase in profits per worker causes a store to hire more workers, though we do not interpret the present evidence causally. The same regression, but with store fixed effects, yields a coefficient of 0.12, still positive. Panel B digs deeper into the within-store variation by reporting the c.d.f. of the coefficients of many regressions, one for each store, where *N.Workers* in a given month is regressed on the average *Ebitda/Hrs* in the previous six months. The c.d.f. in Panel B shows that 68% of the coefficients are positive, which we interpret as further supporting evidence for a comovement *within store* between employment, and store-level profits per worker in previous periods. *N.Workers* is the number of sales associates in the store. *Ebitda/Hrs* is equal to earnings before interest, tax, depreciation and amortization, per hour worked in the store. We do not disclose the units for confidentiality reasons.

Table A.1: Effect of Minimum Wage on Worker Total Pay per Hour

Dep.Var.	Tot.Pay/Hrs (1)	Tot.Pay/Hrs (2)
MinW	0.645***	0.807***
	(0.172)	(0.225)
Medium Type		0.469***
		(0.087)
High Type		1.037***
		(0.115)
MinW · Medium Type		-0.097
		(0.105)
MinW · High Type		-0.141*
		(0.083)
Observations	217,822	209,513
Units	Workers	Workers
Mean Dep.Var.	12.51	12.51
Effect MinW (%)	5.154	
Effect MinW for Low Type (%)		8.146
p-value		0.001
Effect MinW for Med. Type (%)		6.281
p-value		0.001
Effect MinW for High Type (%)		3.978
p-value		0.002

Notes: All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, worker department and county-level unemployment. *Tot.Pay/Hrs* is the monthly total pay from total take-home pay per hour worked (in \$100 per hour). *MinW* is the predominant monthly minimum wage (in \$). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage." *Effect MinW (%)* is the percent effect of a \$1 increase in MinW on the outcomes. Standard errors are two-way clustered at the state level and at the border-segment level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A.2: Dynamic Effect of Minimum Wage on Worker Productivity

Dep.Var	Sales/Hrs
	(1)
$t = -6$	-0.019
	(0.102)
$t = -3$	-0.081
	(0.091)
$t = 0$	0.159
	(0.128)
$t = +3$	0.113
	(0.069)
$t = +6$	0.190**
	(0.079)
$t = -6 \cdot$ Medium Type	0.146
	(0.096)
$t = -3 \cdot$ Medium Type	0.117
	(0.074)
$t = 0 \cdot$ Medium Type	-0.042
	(0.079)
$t = 3 \cdot$ Medium Type	0.073**
	(0.036)
$t = 6 \cdot$ Medium Type	-0.038
	(0.023)
$t = -6 \cdot$ High Type	-0.029
	(0.069)
$t = -3 \cdot$ High Type	0.008
	(0.062)
$t = 0 \cdot$ High Type	-0.166
	(0.132)
$t = 3 \cdot$ High Type	0.050
	(0.061)
$t = 6 \cdot$ High Type	-0.208***
	(0.043)
Observations	102,252
Mean Dep.Var. Low Type	.936
Mean Dep.Var. Medium Type	1.853
Mean Dep.Var. High Type	2.596

Notes: *t = -6, -3* are leading coefficients (pre-change). *t = 3, 6* are cumulated lag coefficients (post-change). All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, worker department, county-level unemployment. Sample restricted to workers who stayed on the job at least 12 consecutive months (six before the minimum wage change and six after). *t = 0* is the period of the minimum wage change. *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage." Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

Table A.3: Store-Level Correlations with Monitoring Coverage

Dep.Var.	N.Workers	% Turnover	Ebitda/Hrs	% Low Types	Exposure
	(1)	(2)	(3)	(4)	(5)
Panel A: With Store Fixed Effects					
Monitoring Coverage	-0.319***	0.017	-0.054	-0.063	0.001
	(0.053)	(0.046)	(0.052)	(0.062)	(0.001)
Observations	12,359	12,359	12,359	12,025	12,359
Units	Stores	Stores	Stores	Store	Stores
Mean Dep.Var.	16.64	3.408	5.946	3.911	9.291
Effect (%)	-9.384	2.406	-4.471	-7.854	0.043
Panel B: Without Store Fixed Effects					
Monitoring Coverage	-0.720***	0.132***	-0.274*	-0.076	-0.018
	(0.143)	(0.032)	(0.136)	(0.072)	(0.014)
Observations	12,359	12,359	12,359	12,027	12,359
Units	Stores	Stores	Stores	Stores	Stores
Mean Dep.Var.	16.64	3.408	5.946	3.911	9.291
Effect (%)	-21.15	18.96	-22.53	-9.540	-.957

Notes: All the regressions include pair-month fixed effects and those in Panel A also control for store fixed effects. *Monitoring Coverage* is the supervisor-to-worker ratio (number of supervisors per 100 sales associates). *N.Workers* is the number of sales associates in the store. *% Turnover* is the percent of sales associates in the store who are terminated or hired in a given month divided by two. *Ebitda/Hrs* is equal to earnings before interest, tax, depreciation and amortization, per hour worked in the store. We do not disclose the units for confidentiality reasons. *% Low Types* is the percent of workers who are low types in the store (pay at minimum wage in t-1). *Exposure* corresponds to the difference (in $) between the average hourly wage in the county and the predominant monthly minimum wage. *MinW* is the predominant monthly minimum wage in the store (in $). Standard errors are two-way clustered at the state level and at the border-segment level.*** p<0.01, ** p<0.05, * p<0.1.

Table A.4: Test of Endogenous Monitoring Coverage and Steady State

Dep.Var.	Monitoring Coverage (1)	N.Workers (2)
MinW	0.202	
	(0.490)	
Time Trend		-0.026
		(0.017)
Observations	12,359	12,359
Units	Stores	Stores
Mean Dep.Var.	6.990	16.64
Effect (%)	2.883	-0.159

Notes: All the regressions include pair fixed effects, store fixed effects, and control for county-level unemployment. The regression in column 1 also controls for pair-month fixed effects. *Monitoring Coverage* is the supervisor-to-worker ratio (number of supervisors per 100 sales associates). *N.Workers* is the number of sales associates employed by a store in a given month. *MinW* is the predominant monthly minimum wage (in $). *Linear Trend* is a montly linear time trend. Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

Table A.5: Test of Pre-Trends in Stores-Level Outcomes with Border-Discontinuity and State-Level Specifications

Dep.Var.	% Turnover	Ebitda/Hrs	N.Workers	% Turnover	Ebitda/Hrs	N.Workers	% Turnover	Ebitda/Hrs	N.Workers	% Turnover	Ebitda/Hrs	N.Workers
Sample	Store-Border	Store-Border	Store-Border	All Stores	All Stores	All Stores	All Stores	All Stores	All Stores	All Stores	All Stores	All Stores
Model	County-Pair· Month FE			Month FE			Month FE + State-Trend			Division · Month FE		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Panel A: 6-Months Pre-Trend											
Pre-Trend	0.333	-2.252	-0.355	0.064	-0.853*	-0.034	0.097	-0.696	-0.209	-0.004	-0.343	-0.129
(6 Months)	(0.970)	(1.364)	(0.333)	(0.155)	(0.486)	(0.133)	(0.157)	(0.466)	(0.168)	(0.236)	(0.562)	(0.181)
Observations	12,073	12,073	12,073	30,156	30,156	30,156	30,156	30,156	30,156	30,156	30,156	30,156
	Panel B: 12-Months Pre-Trend											
Pre-Trend	-0.127	1.811	0.002	0.179	0.171	-0.099	0.182	0.337	-0.363*	0.161	0.268	-0.164
(12 Months)	(0.410)	(1.372)	(0.398)	(0.157)	(0.835)	(0.0962)	(0.166)	(0.895)	(0.214)	(0.169)	(0.879)	(0.176)
Observations	11,753	11,753	11,753	29,176	29,176	29,176	29,176	29,176	29,176	29,176	29,176	29,176
Units	Stores	Stores	Stores	Stores	Stores	Stores	Stores	Stores	Stores	Stores	Stores	Stores

Notes: In Panel A, Pre-Trend $= \eta_{3-0} - \eta_{6-3}$ estimated from: $Y_{jt} = \alpha + \eta_{6-3}(MinW_{j,t+6} - MinW_{j,t+3}) + \eta_{3-0}(MinW_{j,t+3} - MinW_{j,t}) + \rho MinW_{j,t} + \eta Z_{jt} + \delta_j + \varepsilon_{jt}$, where $MinW_{j,t+m}$ is the minimum wage m months after month t, η_{6-3} (η_{3-0}) is a leading coefficient that captures variations in the Y-variable 6 to 3 (3 to 0) months *before* each change in the minimum wage (see Dube et al. 2010). In Panel B, we report the estimates from a longer-trend model: Pre-Trend $= \eta_{12-6} - \eta_{6-0}$ estimated from: $Y_{jt} = \alpha + \eta_{12-6}(MinW_{j,t+12} - MinW_{j,t+6}) + \eta_{6-0}(MinW_{j,t+6} - MinW_{j,t}) + \rho MinW_{j,t} + \eta Z_{jt} + \delta_j + \varepsilon_{jt}$. In columns 1-3 *(4-12)* pre-trends are tested in the sample of bordering stores *(bordering+non-bordering stores)*. All regressions include store fixed effects, and control for county unemployment rate. The regressions vary in the time controls: we include pair-month fixed effects in columns 1-3, month fixed effects in columns 4-6, month fixed effects and state-specific linear trends in columns 7-9, census division·month fixed effects in columns 9-12. *% Turnover* is the percent of sales associates in the store who are terminated or hired in a given month divided by two. *Ebitda/Hrs* is equal to earnings before interest, tax, depreciation and amortization, per hour worked in the store. We do not disclose the units for confidentiality reasons. *N.Workers* is the number of sales associates employed by a store in a given month. Standard errors are two-way clustered at the state level and at the border-segment level in columns 1-3 and at the state-level in col. 4-12. *** p<0.01, ** p<0.05, * p<0.1.

B Model Appendix

B.1 Proofs

Proof of Lemma 1

Proof. **Part 1.** Because the term $1/\left[1+r-\pi(e)\right]$ in equation (4) is positive, the set of individually rational efforts equals $\left\{e : u(x,e) > \frac{r}{(1+r)}V^A\right\}$. Assumption 1 then guarantees that the set of individually rational effort levels is an interval. Next, let us establish that $\ln Q(x,e)$ is strictly concave.

$$\begin{aligned} & \ln Q(x,e) \\ = \; & \ln\left(u(x,e) - r\frac{V^A}{(1+r)}\right) - \ln\left(1+r-\pi(e)\right). \end{aligned}$$

The first addend is strictly concave because the argument of the log is strictly concave (Assumption 1), and strict concavity implies strict log-concavity. The argument of the second log is log-convex (Assumption 2), so the negative log of it is weakly concave. Therefore $\ln Q(x,e)$ is strictly concave, because it is the sum of a strictly concave and a weakly concave function.

Since $\ln(Q)$ is strictly concave it is strictly quasi concave. Because strict quasi-concavity is preserved by a strictly monotone transformation such as exponentiation, we have that $Q = \exp(\ln(Q))$ is strictly quasi-concave in e. Since for every x the function $Q(x,e)$ is strictly quasi-concave, it has a unique maximizer $e^*(x)$ over any closed interval, including the interval that is the closure of individually rational effort levels. It follows that $V(x,e)$ has a unique maximizer among all individually rational effort levels, and hence among all effort levels.

Part 2. The statement holds if we can prove that $Q_e(x,e)$ is strictly increasing in x, for all e. We have:

$$\begin{aligned} Q_{xe}(x,e) &= \frac{d}{de}\left[\frac{1}{1+r-\pi(e)} \cdot u_x(x,e)\right] \\ &= \left[\frac{d}{de}\frac{1}{1+r-\pi(e)}\right] \cdot u_x(x,e) + \frac{1}{1+r-\pi(e)} \cdot u_{xe}(x,e) > 0, \end{aligned}$$

where the inequality holds because $u_x, u_{xe} > 0$ by Assumption 1, and the term $1/\left(1+r-\pi(e)\right)$ is positive and nondecreasing in e.

Part 3. Because the logarithm is an increasing function, $\frac{d}{de}Q(x,e)$ has the same sign as:

$$\begin{aligned}
& \frac{d}{de}\ln Q\left(x,e\right) \\
= & \frac{d}{de}\ln\left(u\left(x,e\right)-r\frac{V^{A}}{\left(1+r\right)}\right)-\frac{d}{de}\ln\left(1+r-\pi\left(e\right)\right) \\
= & \frac{u_{e}\left(x,e\right)}{\left[u\left(x,e\right)-r\frac{V^{A}}{\left(1+r\right)}\right]}+\frac{\pi'\left(e\right)}{\left[1+r-\pi\left(e\right)\right]}. \qquad (16)
\end{aligned}$$

The denominator of the first fraction must be positive around the optimal effort level, and the denominator of the second fraction is positive because $r > 0$. At $e = 0$ this expression is strictly greater than zero because: $w_e(x, e) \geq 0$ and $c_e(x, 0) = 0$, hence $u_e(x, e) \geq 0$; and $\pi'(0) > 0$. Therefore $e = 0$ cannot be optimal. At $e = 1$ this expression equals negative infinity because: $w_e(x, 1) < \infty$ because $w_e(x, e)$ is continuously differentiable over $[0, 1]$ and $c_e(x, 1) = \infty$, hence $u_e(x, 1) = -\infty$; also $\pi'(1)$ is finite and $r > 0$. Therefore $e = 1$ cannot be optimal. ■

Proof of Proposition 1

Proof. Denote by $Q(x, e; M)$ the expression obtained by replacing $w(x, e)$ with $w(x, e; M)$ in expression (4). Then:

$$\begin{aligned}
Q_{eM}\left(x,e;M\right) &= \frac{d}{de}\left[\frac{1}{\left(1+r-\pi\left(e\right)\right)}w_{M}\left(x,e;M\right)\right] \\
&= \frac{1}{1+r-\pi\left(e\right)}\left(\frac{\pi'\left(e\right)}{1+r-\pi\left(e\right)}w_{M}\left(x,e;M\right)+w_{eM}\left(x,e;M\right)\right) \\
&= \frac{w_{M}\left(x,e;M\right)}{1+r-\pi\left(e\right)}\left(\frac{\pi'\left(e\right)}{1+r-\pi\left(e\right)}+\frac{w_{eM}\left(x,e;M\right)}{w_{M}\left(x,e;M\right)}\right). \qquad (17)
\end{aligned}$$

Because $w_M(x, 1; M) > 0$ (Assumption 3), stochastic dominance implies that $w_M(x, e; M) > 0$. Therefore $Q_{eM}(x, e; M)$ has the same sign as:

$$\frac{\pi'\left(e\right)}{1+r-\pi\left(e\right)}+\frac{w_{eM}\left(x,e;M\right)}{w_{M}\left(x,e;M\right)}. \qquad (18)$$

Part 1. Lemma 1 shows that the optimal effort level $e^*(x; M)$ is interior. Therefore, if $Q_{eM}(x, e; M) > 0$ at $e^*(x; M)$, worker x's optimal effort will be strictly increasing in M. For MMW types $w_{eM}(x, e; M) = 0$ in equation (18) and since $\pi'(e) > 0$ by assumption, in fact $Q_{eM} > 0$. This proves that optimal effort is strictly increasing in M for MMW types.

Part 2. Suppose, by contradiction, that there are some types whose response to the minimum wage switches sign and becomes negative between $\widehat{M}$ and $\widehat{M} + \varepsilon$. Then by continuity there must be a "borderline" type $\widehat{x}$ such that $\frac{de^*(\widehat{x};M)}{dM} = 0$ at $\widehat{M}$ and $\frac{de^*(\widehat{x};M)}{dM} < 0$ at $\widehat{M} + \varepsilon$. We now show that such a type does not exist.

From the implicit function theorem we have:

$$sgn\left[\frac{de^*\left(x;M\right)}{dM}\right] = sgn\left[Q_{eM}\left(x,e;M\right)\big|_{e^*(x;M)}\right],$$

so the definition of $\left(\widehat{x},\widehat{M}\right)$ implies that

$$\begin{aligned} Q_{eM}\left(\widehat{x},e;\widehat{M}\right)\Big|_{e^*\left(\widehat{x};\widehat{M}\right)} &= 0 & (19)\\ Q_{eM}\left(\widehat{x},e;\widehat{M}+\varepsilon\right)\Big|_{e^*\left(\widehat{x};\widehat{M}+\varepsilon\right)} &< 0. & (20)\end{aligned}$$

These two equations imply:

$$\begin{aligned} 0 &\geq \frac{d}{dM}\, Q_{eM}\left(\widehat{x},e^*\left(\widehat{x};M\right);M\right)\big|_{\widehat{M}} & (21)\\ &= Q_{eeM}\left(\widehat{x},e^*\left(\widehat{x};\widehat{M}\right);\widehat{M}\right)\left[\frac{de^*\left(\widehat{x};M\right)}{dM}\right]_{\widehat{M}} + Q_{eMM}\left(\widehat{x},e^*\left(\widehat{x};\widehat{M}\right);\widehat{M}\right)\\ &= Q_{eMM}\left(\widehat{x},e^*\left(\widehat{x};\widehat{M}\right);\widehat{M}\right),\end{aligned}$$

where the last equality holds because $\frac{de^*(\widehat{x};M)}{dM} = 0$ at $\widehat{M}$, and Q_{eMM} represents the partial derivative of the function $Q_{eM}\left(x,e;M\right)$ with respect to M, keeping (x,e) fixed at $\left(\widehat{x},e^*\left(\widehat{x};\widehat{M}\right)\right)$. Formally,

$$Q_{eMM}\left(\widehat{x},e^*\left(\widehat{x};\widehat{M}\right);\widehat{M}\right) = \left[\frac{\partial}{\partial M}Q_{eM}\left(\widehat{x},e;M\right)\right]_{e^*\left(\widehat{x};\widehat{M}\right),\widehat{M}}.$$

From (17) we know that for any triple (x,e,M):

$$sgn\left[Q_{eM}\left(x,e;M\right)\right] = sgn\left[\frac{\pi'\left(e\right)}{1+r-\pi\left(e\right)} + \frac{w_{eM}\left(x,e;M\right)}{w_M\left(x,e;M\right)}\right],$$

and so in light of (19), equation (21) implies:

$$
\begin{aligned}
0 &\geq sgn\left[\frac{\partial}{\partial M}Q_{eM}\left(\widehat{x},e;M\right)\right]_{e^*\left(\widehat{x};\widehat{M}\right),\widehat{M}} \\
&= sgn\left[\frac{\partial}{\partial M}\left(\frac{\pi'\left(e\right)}{1+r-\pi\left(e\right)}+\frac{w_{eM}\left(\widehat{x},e;M\right)}{w_M\left(\widehat{x},e;M\right)}\right)\right]_{e^*\left(\widehat{x};\widehat{M}\right),\widehat{M}} \\
&= sgn\left[\frac{\partial}{\partial M}\left(\frac{w_{eM}\left(\widehat{x},e;M\right)}{w_M\left(\widehat{x},e;M\right)}\right)\right]_{e^*\left(\widehat{x};\widehat{M}\right),\widehat{M}} \quad . \qquad (22)
\end{aligned}
$$

To finish the proof by contradiction, we will show that (22) is strictly positive. To this end, we provide expressions for $w_{eM}\left(\widehat{x},e;M\right)$ and $w_M\left(\widehat{x},e;M\right)$. Let $F_W\left(w;\widehat{x},e\right)$ denote the c.d.f. of $W\left(\widehat{x},e\right)=\overline{w}\left(Y\left(\widehat{x},e\right)\right)$ and $\overline{F}\left(z;\widehat{x},e,M\right)$ the c.d.f. of $Z=\max\left[M,W\left(\widehat{x},e\right)\right]$. Since

$$
\overline{F}\left(z;\widehat{x},e,M\right)=\begin{cases} 0 & \text{if } z<M \\ F_W\left(z;\widehat{x},e\right) & \text{if } z\geq M, \end{cases}
$$

we have:

$$
\begin{aligned}
w\left(\widehat{x},e;M\right) &= \mathbb{E}\left(\max\left[M,\overline{w}\left(Y\left(\widehat{x},e\right)\right)\right]\right) \\
&= \int_0^\infty \max\left[M,w\right]dF_W\left(w;\widehat{x},e\right) \\
&= \int_0^\infty z d\overline{F}\left(z;\widehat{x},e,M\right) \\
&= \int_0^\infty \left[1-\overline{F}\left(z;\widehat{x},e,M\right)\right]\ dz \\
&= M+\int_M^\infty \left[1-F_W\left(z;\widehat{x},e\right)\right]\ dz. \qquad (23)
\end{aligned}
$$

From this we get:

$$
\begin{aligned}
w_M\left(\widehat{x},e;M\right) &= F_W\left(M;\widehat{x},e\right) \qquad (24) \\
w_{eM}\left(\widehat{x},e;M\right) &= \frac{d}{de}F_W\left(M;\widehat{x},e\right). \qquad (25)
\end{aligned}
$$

Plug back into (22) to get:

$$
\begin{aligned}
&\frac{\partial}{\partial M}\left(\frac{\frac{d}{de}F_W\left(M;\widehat{x},e\right)}{F_W\left(M;\widehat{x},e\right)}\right)\\
=\;&\frac{F_W\left(M;\widehat{x},e\right)\frac{d}{de}f_W\left(M;\widehat{x},e\right)-f_W\left(M;\widehat{x},e\right)\frac{d}{de}F_W\left(M;\widehat{x},e\right)}{\left[F_W\left(M;\widehat{x},e\right)\right]^2}\\
=\;&\frac{f_W\left(M;\widehat{x},e\right)}{\left[F_W\left(M;\widehat{x},e\right)\right]}\left[\frac{\frac{d}{de}f_W\left(M;\widehat{x},e\right)}{f_W\left(M;\widehat{x},e\right)}-\frac{\frac{d}{de}F_W\left(M;\widehat{x},e\right)}{F_W\left(M;\widehat{x},e\right)}\right]\\
=\;&\frac{f_W\left(M;\widehat{x},e\right)}{\left[F_W\left(M;\widehat{x},e\right)\right]}\left[\frac{d}{de}\ln f_W\left(M;\widehat{x},e\right)-\frac{d}{de}\ln F_W\left(M;\widehat{x},e\right)\right]\\
=\;&\frac{f_W\left(M;\widehat{x},e\right)}{\left[F_W\left(M;\widehat{x},e\right)\right]}\left[\frac{d}{de}\ln\frac{f_W\left(M;\widehat{x},e\right)}{F_W\left(M;\widehat{x},e\right)}\right].
\end{aligned}
$$

But this quantity is strictly positive because $f_W\left(M;\widehat{x},e\right)>0$ for every e (Assumption 3) and $\frac{f_W(M;\widehat{x},e)}{F_W(M;\widehat{x},e)}$ is increasing in e. The latter claim holds because by assumption $f_Y\left(y;\widehat{x},e\right)$ has the strict MLRP w.r.t. e. Milgrom and Weber (1982) show that if $Y\left(\widehat{x},e\right)$ has the MLRP wrt e then so does $\overline{w}\left(Y\right)$ for any monotone transformation $\overline{w}\left(\cdot\right)$. (This is because if $Y\left(\widehat{x},e\right)$ has the MLRP wrt e then Y and e are affiliated, see their discussion at p. 1099, and then their Theorem 3 yields the result). Strictness follows because $\overline{w}\left(\cdot\right)$ is strictly increasing by assumption.

Part 3. Because $Y\left(x,e\right)$ is finite and $\overline{w}\left(\cdot\right)$ is continuous, $\overline{w}\left(Y\left(x,e\right)\right)$ is bounded on $[0,1]$ and so for M large enough it must be the case that $w\left(x,e;M\right)\equiv M$ for all e. For such M we have $w_{eM}\left(x,e;M\right)=0$, and so the second addend in (18) vanishes. The first addend is greater than zero for any e because $\pi'\left(e\right)$ is positive and continuous on $[0,1]$, so $\min_{e\in[0,1]}\pi'\left(e\right)>0$. Therefore for such M we have $Q_{eM}\left(x,e;M\right)>0$ for all x,e.

Part 4. Equating expression (16) to zero yields the following condition for optimal effort in the presence of the minimum wage:

$$
\frac{w_e\left(x,e;M\right)-c_e\left(x,e\right)}{\left[w\left(x,e;M\right)-c\left(x,e\right)-r\frac{V^A}{(1+r)}\right]}+\frac{\pi'\left(e\right)}{\left[1+r-\pi\left(e\right)\right]}=0.
$$

When $w\left(x,e;M\right)$ barely varies with M, the effort level that solves this equation also barely varies with M. ■

Proof of Proposition 2

Proof. **Part 1.** This part has been proved discursively in the paragraph following Definition 2.

Part 2. MMW types maximize a function

$$u(x,e;M) = w(x,e;M) - c(x,e)$$

that is strictly concave in e (Assumption 1) and whose derivative u_e equals zero at $e=0$. Therefore, their optimal effort level is zero independent of M.

For types who exert positive effort in equilibrium, their optimal effort response to M has the same sign as expression (18). The first addend in (18) vanishes because $\pi'(e) = 0$ by assumption. The second addend is negative because

$$w_{eM}(x,e;M) = \frac{d}{de} F_W(M;x,e) < 0, \tag{26}$$

where the first equality is expression (25), and the inequality holds because the strict MLRP implies strict stochastic dominance. The inequality in (26) must be strict because at $e = e^*(x,M)$ we have $F_W(M;x,e) \in (0,1)$: indeed, $F_W(M;x,e) \geq F_W(M;x,1) > 0$ where the first inequality reflects MLRP and the second one reflects Assumption 3 (refer to expression 24); and $F_W(M;x,e) < 1$ at $e = e^*(x,M)$ because if not then $w(x,e;M) = M$ at $e = e^*(x,M)$ (again, refer to expression 24) which, since the cost of effort is strictly increasing, implies that $e^*(x,M)$ must equal zero contradicting our premise that type x exerts positive effort. Equation (26) shows that increasing M decreases the effort of any type who exerts positive effort.

Part 3. If the ratio $\pi'(e)/[1+r-\pi(e)]$ is positive at $e=0$ then expression (16) is strictly greater than zero at $e=0$, which implies that optimal effort is interior. If, furthermore, this ratio is large enough at all effort levels, then expression (18) is positive because the ratio $w_{eM}(x,e;M)/w_M(x,e;M)$ is bounded below (Assumption 3). This implies that optimal effort is strictly increasing in M. Let us now construct a function $\pi(\cdot)$ such that the ratio $\pi'(e)/[1+r-\pi(e)]$ is arbitrarily large at any level e, for suitably low r. This will conclude the proof of part 3. Define:

$$\begin{aligned} \pi(e) &= (1+r) - \frac{C}{K}\exp(-Ke) \\ K &= \ln\left(\frac{1+r}{r}\right) \\ C &= K(1+r). \end{aligned}$$

Substituting $e = 0, 1$ shows that this function satisfies $\pi(0) = 0, \pi(1) = 1$. Moreover,

$\pi'(e) = C\exp(-Ke)$ and so:

$$\frac{\pi'(e)}{1+r-\pi(e)} = K = \ln\left(\frac{1+r}{r}\right).$$

Choosing r arbitrarily small makes $\pi'(e)/[1+r-\pi(e)]$ arbitrarily large, as desired. ■

B.2 Examples of Log Convex π

Assumption 2 is that:

$$\begin{aligned}
\frac{d}{de}\frac{\pi'(e)}{[(1+r)-\pi(e)]} &< 0\\
\frac{\pi''(e)[(1+r)-\pi(e)]+(\pi'(e))^2}{[(1+r)-\pi(e)]^2} &< 0\\
\pi''(e)(1+r)-\pi''(e)\pi(e)+(\pi'(e))^2 &< 0
\end{aligned}$$

Example 1. *Suppose $\pi(e) = e^a$ for $e \in [0,1]$ and any parameter $a \in (0,1)$. Then the term $\frac{\pi'(e)}{[(1+r)-\pi(e)]}$ is decreasing in e if $r > \frac{a}{(1-a)}$.*

To see this, compute: $\pi'(e) = ae^{a-1}$ and $\pi''(e) = a(a-1)e^{a-2}$ so we get:

$$\begin{aligned}
&\frac{\pi'(e)}{[(1+r)-\pi(e)]}\\
=\;& a\frac{e^{a-1}}{(1+r)-e^a}.
\end{aligned}$$

$$\begin{aligned}
\frac{d}{de}\frac{\pi'(e)}{[(1+r)-\pi(e)]} &< 0\\
\pi''(e)(1+r)-\pi''(e)\pi(e)+(\pi'(e))^2 &< 0\\
a(a-1)e^{a-2}(1+r)-a(a-1)e^{a-2}e^a+a^2e^{2(a-1)} &< 0\\
(a-1)e^{2a-2}(1+r)e^{-a}-(a-1)e^{2a-2}+ae^{2a-2} &< 0\\
(a-1)(1+r)e^{-a}-(a-1)+a &< 0\\
(a-1)(1+r)e^{-a}+1 &< 0
\end{aligned}$$

Since $a \in (0,1)$ the RHS is increasing in e, whence

$$(a-1)(1+r)e^{-a}+1 < (a-1)(1+r)+1$$

and then the RHS is smaller than zero for all e if:

$$\begin{aligned} (a-1)(1+r)+1 &< 0 \\ (1-a)(1+r)-1 &> 0 \\ (1+r) &> \frac{1}{(1-a)} \\ r &> \frac{1}{(1-a)}-1 \\ r &> \frac{a}{(1-a)}. \end{aligned}$$

Example 2. *Suppose $\pi(e) = a\frac{e}{e+1}$ for $e \in [0,1]$, and parameter $a \in (0,2)$. Then the term $\frac{\pi'(e)}{[(1+r)-\pi(e)]}$ is decreasing in e if $a < \frac{4}{3}(1+r)$.*

To see this, compute:

$$\begin{aligned} \pi(e) &= a\frac{e}{e+1} \\ \pi'(e) &= a\frac{(e+1)-e}{(e+1)^2} = a\frac{1}{(e+1)^2} \\ \pi''(e) &= -2a\frac{1}{(e+1)^3} \end{aligned}$$

$$\begin{aligned} &\frac{\pi'(e)}{[1+r-\pi(e)]} \\ &= a\frac{1}{(e+1)^2}\left[1+r-a\frac{e}{e+1}\right]^{-1} \\ &= a\frac{1}{(e+1)^2}\left[\frac{(1+r)(e+1)-ae}{e+1}\right]^{-1} \\ &= a\frac{1}{(e+1)[(1+r)(e+1)-ae]}, \end{aligned}$$

which is increasing in a.

$$\begin{aligned}
\frac{d}{de}\frac{\pi'(e)}{[(1+r)-\pi(e)]} &< 0 \\
\pi''(e)(1+r)-\pi''(e)\pi(e)+(\pi'(e))^2 &< 0 \\
-2a\frac{1}{(e+1)^3}(1+r)-\left(-2a\frac{1}{(e+1)^3}\right)a\frac{e}{e+1}+\left(a\frac{1}{(e+1)^2}\right)^2 &< 0 \\
-2a\frac{1}{(e+1)^3}(1+r)+2a^2\frac{e}{(e+1)^4}+a^2\frac{1}{(e+1)^4} &< 0 \\
-2a(e+1)(1+r)+2a^2e+a^2 &< 0 \\
-2(e+1)(1+r)+2ae+a &< 0 \\
-2(e+1)(1+r)+a(2e+1) &< 0 \\
a(2e+1) &< 2(e+1)(1+r) \\
\frac{a}{(1+r)} &< \frac{2(e+1)}{(2e+1)}=1+\frac{1}{(2e+1)}
\end{aligned}$$

Since the RHS is decreasing in e, this condition is verified for all $e \in [0,1]$ if it is verified at $e=1$, that is, if:

$$a<\frac{4}{3}(1+r).$$

B.3 Endogenous Monitoring

For a given M, optimal monitoring coverage solves:

$$\max_{\mu}(1-\mu)\cdot\pi^{NM}(M)+\mu\cdot\pi^{HM}(M)-K(\mu), \tag{27}$$

where $\pi^{NM}(M)$ and $\pi^{HM}(M)$ denote steady-state profits from the non-monitored and highly monitored divisions, respectively, and $K(\cdot)$ is a convex cost function with $K'(0)=0$, that captures the cost to the firm of increasing monitoring.

Next, we leverage Lemma 2 to rank-order steady-state profits.

Assumption 4. ***(profits increase with effort)*** *Fix M. For every x, $Y(x,e)-w(x,e;M)$ is increasing in e.*

This is a mild assumption. It says that if type x exerts effort, profits are greater than with no effort. If $\overline{w}(Y)=b+cY$ (the "base plus commission" wage schedule), then the resulting schedule w satisfied the assumption if $c<1$.

If this assumption holds, then with no monitoring, profits are decreasing in the minimum wage. This is because increasing M worsens the wage bill and, in addition, causes fewer workers to exert effort (Lemma 2). Thus the profit term $\pi^{NM}(M)$ in expression (27) is decreasing in M.

The second profit term in expression (27) could, according to theory, be either increasing or decreasing in M. Empirically, however, expression (27) in its entirety is shown not to decrease with M, at least within the border-store sample, which is the sample used in our empirical strategy. This means that the value of the firm's maximization problem has not decreased. This is only possible if $\pi^{HM}(M)$ is increasing in M. If that's the case, then the firm's optimal μ must increase with M, as indeed it does in the data. This discussion is summarized in the following lemma.

Lemma 3. ***(testable prediction of minimum wage on endogenous monitoring)*** *Suppose that Assumption 4 holds, and that store-level profits in expression (27) do not decrease as the minimum wage increases. Then optimal monitoring in the store must increase with the minimum wage.*

C Worker Welfare Appendix

C.1 Theory

This appendix generalizes expression (8) to the case where the lifetime value of being currently unemployed, $V^A(M)$, increases with M. In this section $V^A(M)$ will be increasing in M because the unemployed worker will, in time, regain employment and then, occasionally, earn minimum wage. Obviously, then, the welfare of all types will increase with M. However, the welfare of high types will increase by less than that of low types, and this disparity will be more pronounced than in Section 8. Intuitively, the low types' *relative* improvement reflects the fact that, relative to the analysis in Section 8, lower types benefit more from the minimum wage in the outside labor market because they separate earlier than high types.

When the worker's outside option is a function of the minimum wage, that is, $V^A = V^A(M)$, expression (8) is amended to:

$$\frac{d}{dM}\left[V(x,e;M) - V^A(M)\right]_{e=e^*(x;M)} = (1+r)\,Q_M(x,e^*(x;M);M) \tag{28}$$

$$= \frac{1+r}{1+r-\pi(e)}\left[w_M(x,e;M) - \frac{r}{(1+r)}\frac{d}{dM}V^A(M)\right]\Bigg|_{e=e^*(x;M)} \tag{29}$$

Next we compute $V_M^A(M)$ based on the following description of the labor market. Write:

$$\overline{V}(M) = \max_e \left[\widetilde{w}(e;M) - c(e)\right] + \frac{1}{1+r}\left[p\overline{V}(M) + (1-p)V^A(M)\right] \tag{30}$$

$$V^A(M) = \frac{s\overline{V}(M) + (1-s)V^A(M)}{(1+r)}. \tag{31}$$

The first equation describes a worker's value $\overline{V}(M)$ from being employed in the outside market, which is a random job in the representative firm with salary structure $\widetilde{w}(e;M)$. The functions $\widetilde{w}$ and c are independent of the type x because x is assumed to be specific to the current employer. This worker is retained with probability p and laid off with complementary probability, which we assume is independent of effort. The second equation represents the value of being unemployed. When laid off, the worker makes zero flow utility; the worker exits unemployment with probability s and stays unemployed with probability $(1-s)$. Denote

$$\widehat{u}(M) = \max_e \left[\widetilde{w}(e;M) - c(e)\right], \tag{32}$$

and solve system (30, 31) to get:

$$V^A(M) = \frac{s(1+r)}{r(1+r-p+s)}\widehat{u}(M).$$

Therefore,

$$\begin{aligned} \frac{d}{dM}V^A(M) &= \frac{s(1+r)}{r(1+r-p+s)}\frac{d}{dM}\widehat{u}(M) \\ &= \frac{s(1+r)}{r(1+r-p+s)}\widetilde{w}_M(e^*(M);M), \end{aligned}$$

where the second equation reflects an envelope condition from problem (32). Plugging into (29) we get type x's value of being matched with our firm:

$$\frac{1+r}{1+r-\pi(e^*(x;M))}\left[w_M(x,e^*(x;M);M) - \frac{s}{(1-p+s+r)}\widetilde{w}_M(e^*(M);M)\right]. \tag{33}$$

The negative term in brackets is the only difference from expression (8). This term is type-independent but, when multiplied by the term outside of brackets, results in a greater hindrance for the welfare of high types than low types, compared with expression (8).

C.2 Empirics

To take expression (33) to data, we use Census and BLS data to compute $s = 0.265$ and $(1-p) = 0.018$. The first number is the ratio of "hires from non-employment in a month" over "total average annual unemployed between 2012-2015," a rough proxy of the probability of transitioning from unemployment into employment; the second number is the ratio of "separations to non-employment in a month" over "total average annual employed between 2012-2015," a rough proxy for the reverse transition probability.[55] The term $\widetilde{w}_M$ is set to 8.6%, based on Cengiz et al.'s (2019) computation of the fraction of minimum wage jobs in the US labor market (refer to the discussion in Section 8).

Plugging these values into (33) we get $(1.64, -0.92, -2.14)$ for low, medium, and high types, respectively.[56] Negative numbers do *not* mean that the welfare *levels* decrease with the minimum wage – indeed, they increase. Rather, negative numbers mean that a minimum wage increase has a more beneficial impact on the outside option (discounted future value of being currently unemployed) than on the "inside option" (discounted future value of being currently employed): refer to the left-hand side of equation (28). This outside option effect operates on all types, but it is less beneficial for the higher types' match value (the left-hand side of equation 28) because they are terminated less frequently. Thus, compared to the effects in Section 8 where the outside option is fixed, here lower types are even more benefited by a minimum wage increase *relative to higher types*.

[55] We computed $s = (2.77M)\,/\,(10.46M) = 0.265$, and $(1-p) = (2.6M)\,/\,(145M) = 0.018$, where the data for the numerators are obtained from Census, https://j2jexplorer.ces.census.gov/, and the data for the denominators from the BLS, https://data.bls.gov/cgi-bin/surveymost?bls.

[56] Results are comparable $(2.09, -0.30, -1.16)$ if we set $\widetilde{w}_M$ to 5%, based on Autor et al. (2016).

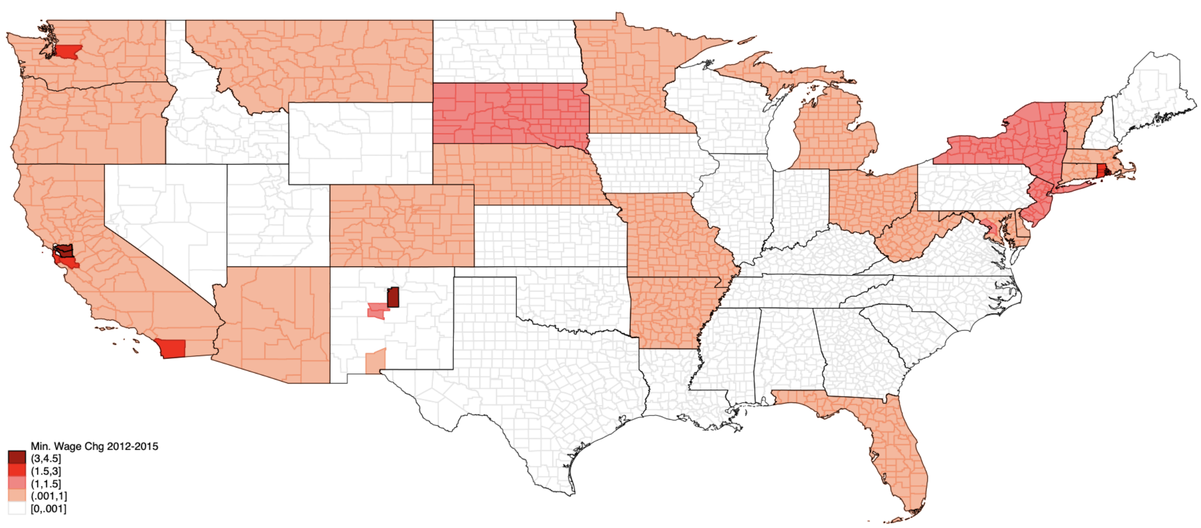
D Data Appendix

Minimum Wage Data Our data contain information on the geographical location of stores (latitude and longitude), which we match with the monthly statutory minimum wage level in that store, extracted from the public dataset maintained by the Washington Center for Equitable Growth. Variations in minimum wage take place at state, county, and city levels; with city and county minimum wages always set to be higher than the state minimum wage.

From February 2012 to June 2015, our sample of stores is affected by 70 variations in minimum wage: 49 variations are at the state level, and 21 are at the county or city level. The exact timing of each minimum wage change is reported in Table D.1 and presented visually in Figure D.1.

There is a notable event related to the minimum wage that is specific to California. In November 2014 our company chose to increase the base pay in its California stores to the prevailing minimum wage levels, not in response to a minimum wage increase (there was none in November 2014) but, rather, to avoid costly record-keeping requirements regarding the hour-by-hour nature of each worker's task. We account for this variation by including an interaction term for California post-November 2014 in all specifications throughout the paper. The results are qualitatively and quantitatively robust to removing the post-November 2014 data from California.

Figure D.1: Variations in Minimum Wage from February 2012 to June 2015



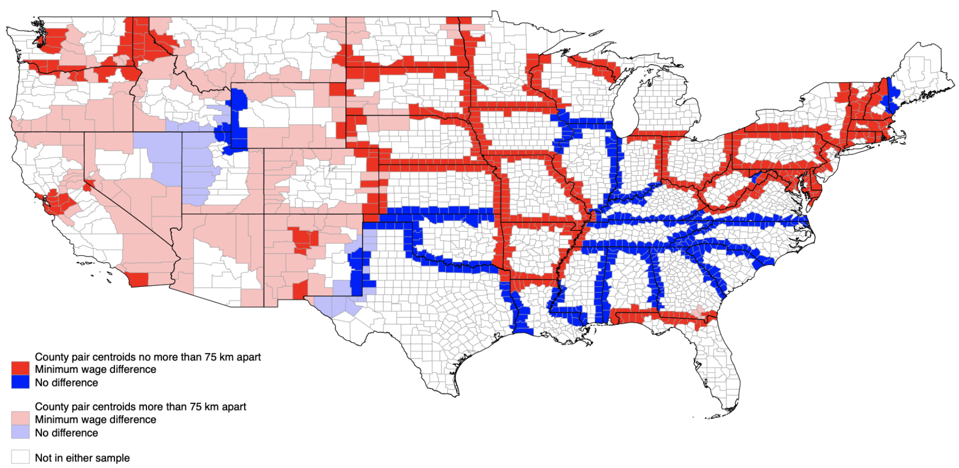
Notes: Store locations are withheld for confidentiality reasons.

Border Discontinuity Design We use a border discontinuity design, as implemented in Card and Krueger (2000), Dube et al. (2010, 2016), Allegretto et al. (2013, 2017). This approach exploits minimum wage policy discontinuities at the state- or county-border by comparing workers on one side of the border where the minimum wage increased (treatment group) to workers on the other side where the minimum wage did not increase (control group). As shown in Dube et al. (2010), this research design has desirable properties for identifying minimum wage effects since workers on either side of the border are more likely to face similar economic conditions and are likely to experience similar shocks at the same time.

Following Card and Krueger (2000), Dube et al. (2010, 2016), and Allegretto et al. (2013, 2017), we restrict our sample to stores (and their respective workers) located in adjacent counties that share a border. For *state*-level minimum wage variations, we keep stores located in county pairs that: share a *state* border, and whose centroids are within 75 km of each other (see Figure D.2). For *county*-level minimum wage variations, we "seed" the sample with stores located in those counties that increased their minimum wage, and then add as controls all adjacent counties whose centroids are within 75 km of the seed county. Minimum wage changes at the *city* level are attributed only to stores within the city limits, but not to stores in the county containing that city. Such stores are included as controls, as are stores in all neighboring counties. (In our sample there are no municipalities that lie in more than one county). For instance, for the city of San Francisco (which increased its minimum wage) we include all the counties that share a county-border with San Francisco County and whose centroids are within 75 km of its centroid (i.e., the counties of Marin, Alameda, and San Mateo).

As explained in the main text, our key specifications (11) and (12) include county-pair $\times$ month fixed effects ϕ_{pt}. These interact 113 unique county-pair identifiers with 41 month dummies. We "stack" our data as in Dube et al. (2010, 2016), meaning that stores/workers located in a county sharing a border with n other counties appear n times in the final sample. The presence of a single county in multiple pairs along a border segment induces a mechanical correlation across county-pairs, and potentially along an entire border segment (Dube et al. 2010). This requires standard errors to be clustered both at the state level and at the border-segment level (32 states and 44 border segments).

Figure D.2: Variations in Minimum Wage in Bordering Counties



Notes: Store locations are withheld for confidentiality reasons.

Table D.1: Changes in Minimum Wages from February 2012 and June 2015

State	State	Date C.1	W_{t-1}	W_t	Date C.2	W_{t-1}	W_t	Date C.3	W_{t-1}	W_t	Date C.4	W_{t-1}	W_t
Alaska	AK	2015m2	7.75	8.75									
Arkansas	AR	2015m1	7.25	7.5									
Arizona	AZ	2013m1	7.65	7.8	2014m1	7.8	7.9	2015m1	7.9	8.05			
California	CA	2014m7	8	9									
Colorado	CO	2013m1	7.64	7.78	2014m1	7.78	8	2015m1	8	8.23			
Connecticut	CT	2014m1	8.25	8.7	2015m1	8.7	9.15						
DC	DC	2014m7	8.25	9.5									
Delaware	DE	2014m6	7.25	7.75	2015m6	7.75	8.25						
Florida	FL	2013m1	7.67	7.79	2014m1	7.79	7.93	2015m1	7.93	8.05			
Hawaii	HI	2015m1	7.25	7.75									
Massachusetts	MA	2015m1	8	9									
Maryland	MD	2015m1	7.25	8									
Michigan	MI	2014m9	7.4	8.15									
Minnesota	MN	2014m8	7.25	8									
Missouri	MO	2013m1	7.25	7.35	2014m1	7.35	7.5	2015m1	7.5	7.65			
Montana	MT	2013m1	7.65	7.8	2014m1	7.8	7.9	2015m1	7.9	8.05			
Nebraska	NE	2015m1	7.25	8									
New Jersey	NJ	2014m1	7.25	8.25	2015m1	8.25	8.38						
New York	NY	2013m12	7.25	8	2014m12	8	8.75						
Ohio	OH	2013m1	7.7	7.85	2014m1	7.85	7.95	2015m1	7.95	8.1			
Oregon	OR	2013m1	8.8	8.95	2014m1	8.95	9.1	2015m1	9.1	9.25			
Rhode Island	RI	2013m1	7.4	7.75	2014m1	7.75	8	2015m1	8	9			
South Dakota	SD	2015m1	7.25	8.5									
Vermont	VT	2014m1	8.6	8.73	2015m1	8.73	9.15						
Washington	WA	2013m1	9.04	9.19	2014m1	9.19	9.32	2015m1	9.32	9.47			
West Virginia	WV	2015m1	7.25	8									
County	State	Date C.1	W_{t-1}	W_t	Date C.2	W_{t-1}	W_t	Date C.3	W_{t-1}	W_t			
Bernalillo	NM	2013m7	7.5	8	2014m1	8	8.5	2015m1	8.5	8.65			
Johnson	IA	2015m11	7.25	8.2									
Montgomery	MD	2014m10	7.25	8.4									
Prince George's	MD	2014m10	7.25	8.4									
Santa Fe	NM	2014m4	7.5	10.66	2015m3	10.66	10.84						
City	State	Date C.1	W_{t-1}	W_t	Date C.2	W_{t-1}	W_t	Date C.3	W_{t-1}	W_t	Date C.4	W_{t-1}	W_t
Alburquerque	NM	2013m1	7.5	8.5	2014m1	8.5	8.6	2015m1	8.6	8.75			
Berkeley	CA	2014m10	9	10									
Las Cruces	NM	2015m1	7.5	8.4									
Oakland	CA	2015m3	9	12.25	2016m1	12.25	12.55						
Richmond	CA	2015m1	9	9.6	2016m1	9.6	11.52						
San Diego	CA	2015m1	9	9.75									
San Francisco	CA	2013m1	10.24	10.55	2014m1	10.55	10.74	2015m1	10.74	11.05	2015m5	11.05	12.25
San Jose	CA	2013m3	8	10	2014m1	10	10.15	2015m1	10.15	10.3			
Santa Fe	NM	2012m3	9.5	10.29	2013m3	10.29	10.51	2014m3	10.51	10.66	2015m3	10.66	10.84
SeaTac	WA	2013m1	9.04	9.19	2014m1	9.19	15						
Seattle	WA	2013m1	9.04	9.19	2014m1	9.19	9.32	2015m1	9.32	9.47	2015m4	9.47	11
Sunnyvale	CA	2015m1	9	10.3									
Tacoma	WA	2013m1	9.04	9.19	2014m1	9.19	9.32	2015m1	9.32	9.47			
Washington	DC	2014m7	8.25	9.5									

Notes: This table reports all state/county/city variations in statutory minimum wage from 2/1/2012 to 6/30/2015, irrespective of whether there is a store located in that state/county/city. The data are extracted from the public dataset maintained by the Washington Center for Equitable Growth. Our identification strategy effectively leverages only a sub-sample of these changes (70 out of 89), i.e., those that affect at least one store in our sample. We do not report which ones are the 70 variations we leveraged in the paper for confidentiality reasons. W_t (W_{t-1}) refers to the minimum wage level after (before) the change. The states with no change in minimum wage from February 2012 and June 2015 are: AL, GA, IA, ID, IL, IN, KS, KY, LA, ME, MS, NC, ND, NH, NM, NV, OK, PA, SC, TN, TX, UT, VA, WI, WY.

E Threats to Identification and Robustness Appendix

Pre-Trends Our test of pre-trends follows Dube et al. (2010).

Table E.1, Panel A tests for pre-trends in the 6 months preceding the minimum wage change by estimating $\eta_{3-0} - \eta_{6-3}$ from the following specification:

$$\begin{aligned} Y_{ijpt} &= \alpha + \eta_{6-3}(MinW_{j,t+6} - MinW_{j,t+3}) + \eta_{3-0}(MinW_{j,t+3} - MinW_{j,t}) \\ &\quad + \rho MinW_{j,t} + X_{it} \cdot \zeta + \eta Z_{jt} + \delta_i + \phi_{pt} + \varepsilon_{ijpt}, \end{aligned} \tag{34}$$

where $MinW_{j,t+m}$ is the minimum wage m months after month t and all other variables are defined as in equation (11). η_{6-3} (η_{3-0}) is a leading coefficient that captures variations in the Y-variable 6 to 3 (3 to 0) months *before* each change in the minimum wage. We test for the presence of pre-trends by estimating whether $\eta_{3-0} - \eta_{6-3}$ is statistically different from zero.

Table E.1, Panel B tests for pre-trends in the 12 months preceding the minimum wage change by estimating $\eta_{12-6} - \eta_{6-0}$ from the following specification:

$$\begin{aligned} Y_{ijpt} &= \alpha + \eta_{12-6}(MinW_{j,t+12} - MinW_{j,t+6}) + \eta_{6-0}(MinW_{j,t+6} - MinW_{j,t}) \\ &\quad + \rho MinW_{j,t} + X_{it} \cdot \zeta + \eta Z_{jt} + \delta_i + \phi_{pt} + \varepsilon_{ijpt}, \end{aligned} \tag{35}$$

(11). η_{12-6} (η_{6-0}) is a leading coefficient that captures variations in the Y-variable 12 to 6 (6 to 0) months *before* each change in the minimum wage.

We also present the type-interacted version of equation (34) and (35) in the bottom of Panels A and B.

Cross-border Worker Movements See Table E.2.

Worker Selection See Tables E.3 and E.4.

Alternative Classifications of Low, Medium and High Types In Section 4, we defined low, medium, or high types as those whose total pay in month *t-1* is "at minimum wage," between the minimum wage and 180% of the minimum wage, and above 180% of the minimum wage (about equal to the top quartile), respectively. We now assess the robustness of our results to alternative classifications.

Using the 180% threshold, Table E.5 column 1 defines low, medium and high types in the control county using the same percentile as in the treated county of the same county-pair. To illustrate the approach, imagine a treated county with a higher minimum wage than in the control county of the same county-pair. Moreover, imagine that in the treated county 5% of the workers are categorized as low-types (paid minimum wage) and 70% as medium-types. The approach consists in defining control workers as low types if their total pay is in the bottom 5% of the pay distribution in that county, medium types if their pay is in the 5% to 75% percentile, and high types if the pay is above the 75% percentile.

Using the 180% threshold, Table E.5 column 2 divides workers into low, medium, or high types based on their average pay in the *three months* before a minimum wage change (*t-1*, *t-2* and *t-3*) rather than on the past month only. Table E.5 column 3 follows a similar approach but divides workers based on their maximum pay in the *three months* before a minimum wage change. This reduces the likelihood of mis-categorizing a high type as a low one due to surprisingly low demand in t-1, but also shrinks the sample size.[57] Similarly, Table E.5 column 4 divides workers into low-medium-high types based on their pay in the *first* month on the job.

Table E.5 column 5 divides workers in low-medium-high types using their performance (sales per hour) during the first quarter on the job. To do so, we estimate workers' fixed effects based on their sales per hour in the first quarter and we use that to then divide workers into terciles. This latter classification has the advantage of better isolating permanent unobserved heterogeneity from state dependence or mean-reverting shocks, but it has the disadvantage of being time-invariant and does not allow us to quantify level effects in our specification with worker fixed effects. Reassuringly, the findings paint the same picture regardless of the classification method: the low types become significantly more productive, while the high types do not become more productive when minimum wage increases.

Table E.6 presents the results with alternative thresholds: 120%, 140%, or 160% (rather than 180%). Notice that as the threshold increases (i.e., from 120% to 180%), the mass of low types remains unchanged but the top category of high types becomes thinner and more outstanding. In this sense, the highest the threshold, the most "productive" is the top category and the least affected this category should be by the minimum wage hike. Consistent with this, we find that the performance effect on the top category of workers vanishes as the threshold increases, achieving a precisely estimated zero at the highest (180%) threshold.[58] In contrast, the performance of low types is found to increase by 19% - 23% regardless of the threshold; while the performance of medium types increases by 7% - 9%.

[57] We define low types as those whose average (or maximum) pay per hour in the past three months equal to the minimum wage, while medium (high) types are defined as those whose average (or maximum) pay per hour in the past three months is below (above) 180% of the minimum wage.

[58] Mean reversion is an unlikely explanation for this phenomenon because the estimated coefficient for "high type" is consistently positive, not negative.

Alternative Research Designs See Table E.7.

State vs. Local Variation in the Minimum Wage See Table E.8

Alternative Definitions of "Bordering Stores" We show that our results are robust to changing the definition of a "bordering" store. In our main estimates, we follow the existing literature by restricting the sample to all stores located in counties that: (a) share a border and (b) whose centroids are less than 75 km apart (Card and Krueger 1994, Dube et al. 2010, Allegretto et al. 2013). In Table E.9, we check the robustness of our results to restricting our sample to a subset of stores: those stores whose distance from the border is less than 75 km, less than 37.5 km, and less than 18.75 km. The rationale behind this test is that by narrowing down the definition of "bordering" store in our main sample, we lose a few observations but we increase the comparability of treated and control stores around the borders. Reassuringly, our results are broadly consistent across these samples.

Robustness to "Unstacking" In Table E.10 we show that our results are robust to an *experimental approach* that considers each of the 44 unique border-segments as an "experimental event" with a treated and a control county each. The effect of minimum wage is estimated in a regression model similar to equation (12) but without stacking the data,[59] with experimental event $\times$ month (border-segment $\times$ month) fixed effects and standard errors clustered at the experimental event (border-segment) level.

Alternative Controls Table E.11 columns 1-2 show that the results are robust to extending our main equation (12) to also include *department* $\cdot$ *store* time-trends (i.e., unique department ID $\cdot$ time), in order to account for potential differential trends across departments of a given store. We do so because one may be concerned that a higher minimum wage induces demand/price changes that are confined into departments that exclude the most performing salespeople, thus potentially confounding the heterogeneous performance effects identified in the paper. We attenuate this concern by showing that our findings are unaffected by the inclusion of department-specific trends.

The results are also robust to running our main specification department-by-department (Table E.12).

Finally, the results are also robust to removing worker tenure and unemployment. This is reassuring as one might worry that these are "bad controls" directly affected by the minimum wage increase. Refer to Table E.11 columns 3-4.

[59] As a result, the sample size drops.

Table E.1: Test of Pre-Trends in Worker Productivity with Border-Discontinuity and State-Level Specifications

Dep.Var.	Sales/Hrs	Sales/Hrs	Sales/Hrs	Sales/Hrs
Sample	Border Stores	All Stores	All Stores	All Stores
Model	Pair·Month FE	Month FE	Month FE+State-Tr.	Division·Month FE
	(1)	(2)	(3)	(4)
	Panel A: 6-Months Pre-Trend			
Uninteracted Model				
Pre-Trend (6 Months)	-0.126	-0.089**	-0.081**	-0.021
	(0.095)	(0.037)	(0.036)	(0.040)
Observations	149,642	276,825	276,825	276,825
Interacted Model				
Pre-Trend (6 Months)	-0.035	0.127	0.132	0.190
	(0.108)	(0.119)	(0.119)	(0.123)
Pre-Trend · Medium Type	-0.064	-0.228	-0.226	-0.230*
	(0.087)	(0.141)	(0.141)	(0.131)
Pre-Trend · High Type	-0.003	-0.151	-0.151	-0.150
	(0.112)	(0.174)	(0.173)	(0.162)
Observations	144,298	266,702	266,702	266,702
	Panel B: 12-Months Pre-Trend			
Uninteracted Model				
Pre-Trend (12 Months)	0.029	-0.038	-0.027	0.036
	(0.069)	(0.046)	(0.041)	(0.030)
Observations	111,057	201,106	201,106	201,106
Interacted Model				
Pre-Trend (12 Months)	-0.013	0.132	0.139	0.164*
	(0.126)	(0.115)	(0.105)	(0.086)
Pre-Trend · Medium Type	0.083	-0.120	-0.125	-0.101
	(0.116)	(0.090)	(0.090)	(0.085)
Pre-Trend · High Type	0.028	-0.232***	-0.238***	-0.200***
	(0.068)	(0.065)	(0.064)	(0.061)
Observations	106,981	193,434	193,434	193,434
Units	Workers	Workers	Workers	Workers

Notes: In Panel A, *Pre-Trend* $= \eta_{3-0} - \eta_{6-3}$ estimated from equation (34). In Panel B, *Pre-Trend* $= \eta_{6-0} - \eta_{12-6}$ estimated from equation (35). We also present the type-interacted version of equation (34) and (35) in the bottom of Panels A and B. In columns 1 *(3-4)* pre-trends are tested in the sample of bordering stores *(bordering+non-bordering stores)*. All regressions include worker fixed effects, and control for worker tenure, worker department and for county unemployment rate. The regressions vary in the time controls: we include pair-month fixed effects in column 1, month fixed effects in column 2, month fixed effects and state-specific linear trends in column 3, census division · month fixed effects in column 4. Standard errors are two-way clustered at the state level and at the border-segment level in column 1 and at the state-level in columns 3-4. *** p<0.01, ** p<0.05, * p<0.1.

Table E.2: Effect of Minimum Wage on Work-to-Home Distance

Dep.Var.	Distance	Distance	Distance
Sample of Workers	New hires	All	All
	(1)	(2)	(3)
MinW	-0.309	0.409	0.052
	(0.909)	(0.573)	(0.653)
Medium Type			-0.012
			(0.416)
High Type			0.482
			(0.510)
MinW · Medium Type			0.442
			(0.441)
MinW · High Type			0.138
			(0.432)
Observations	10,783	212,509	204,761
Units	Stores	Workers	Workers
Mean Dep.Var.	9.666	9.779	9.779
Effect MinW (%)	-3.201	4.186	
Effect MinW for Low Type (%)			0.557
p-value			0.937
Effect MinW for Med. Type (%)			5.126
p-value			0.392
Effect MinW for High Type (%)			1.837
p-value			0.764

Notes: All the regressions include pair-month fixed effects, store fixed effects, and control for county-level unemployment. Columns 2 and 3 also include worker fixed effects, tenure and worker departments. Column 1 restricts the sample to the newly hired workers in the month in which they are hired in a given store. *Distance* is the distance between the worker's home and the store in which he/she works in a given month. *MinW* is the predominant monthly minimum wage (in $). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage." *Effect MinW (%)* is the percent effect of a $1 increase in MinW on the outcomes. Standard errors are two-way clustered at the state level and at the border-segment level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table E.3: Test of Pre-Trends in Worker Productivity for Balanced vs. Not Balanced Sample

Dep.Var.	Sales/Hrs (1)	Sales/Hrs (2)
Pre-Trend (6 Months)	-0.128	
	(0.091)	
Pre-Trend (6 Months) · Balanced Sample	-0.016	
	(0.052)	
Pre-Trend (12 Months)		0.043
		(0.077)
Pre-Trend (12 Months) · Balanced Sample		-0.055
		(0.046)
Observations	149,615	111,035
Units	Workers	Workers

Notes: See equation (34) and (35) for details on the underlying empirical specification, which we further interact with "Balanced Sample." All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, worker department and county-level employment. *Balanced Sample* is a time-invariant indicator for whether the worker is observed throughout the entire sample period. *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

Table E.4: Effect of Minimum Wage on Worker Productivity with Balanced Sample

Dep.Var.	Sales/Hrs	Sales/Hrs
Sample	Balanced	Balanced
	(1)	(2)
MinW	0.137*	0.264*
	(0.0675)	(0.135)
Medium Type		0.413***
		(0.086)
High Type		1.317***
		(0.114)
MinW · Medium Type		-0.060
		(0.083)
MinW · High Type		-0.168**
		(0.080)
Observations	32,224	31,439
Units	Workers	Workers
Mean Dep.Var.	2.093	2.096
Effect MinW (%)	6.524	
Effect MinW for Low Type (%)		32.46
p-value		0.063
Effect MinW for Med. Type (%)		10.54
p-value		0.002
Effect MinW for High Type (%)		3.734
p-value		0.305

Notes: The sample is restricted to workers who we observe throughout the entire sample period (i.e., balanced sample). All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, worker department and county-level employment. *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *MinW* is the predominant monthly minimum wage (in $). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage." *Effect MinW (%)* is the percent effect of a $1 increase in MinW on the outcomes. Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

Table E.5: Effect of Minimum Wage on Worker Productivity with Alternative Classifications of Low, Medium and High Types

Dep.Var. "Type" Definition	Sales/Hrs Tot.Pay in t-1 (1)	Sales/Hrs Avg pay from t=-1,-3 (2)	Sales/Hrs Max pay from t=-1,-3 (3)	Sales/Hrs Pay in 1st month (4)	Sales/Hrs Sales/Hrs in 1st Q. (FE) (5)
MinW	0.210***	0.131**	0.174***	0.168***	0.178***
	(0.040)	(0.048)	(0.048)	(0.033)	(0.045)
Medium Type	0.316***	0.247***	0.309***		
	(0.031)	(0.028)	(0.058)		
High Type	0.974***	0.745***	0.759***		
	(0.074)	(0.029)	(0.055)		
Min · Medium Type	-0.076***	-0.077*	-0.071*	-0.104***	-0.113**
	(0.020)	(0.040)	(0.041)	(0.023)	(0.044)
Min · High Type	-0.109***	-0.133***	-0.181***	-0.028	-0.121***
	(0.037)	(0.043)	(0.043)	(0.070)	(0.026)
Observations	209,559	184,107	184,107	209,513	216,444
Units	Workers	Workers	Workers	Workers	Workers
Mean Dep.Var.	2.085	2.085	2.085	2.092	2.085
Effect MinW for Low Type (%)	19.42	11.85	16.45	9.709	16.50
p-value	0.001	0.011	0.001	0.001	0.001
Effect MinW for Med. Type (%)	6.625	2.827	5.552	3.030	4.395
p-value	0.001	0.068	0.001	0.057	0.152
Effect MinW for High Type (%)	3.662	-0.061	-0.280	6.483	2.449
p-value	0.034	0.967	0.884	0.043	0.220

Notes: All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, worker department and county-level employment. In column 1, we constrain the fraction of low, medium and high types to be comparable in the treatment and control county-pairs. In column 2, *Medium Type* (*High Type*) is an indicator for whether the worker's average pay in the three months before the minimum wage change is between the minimum wage and 180% of minimum wage (above 180% of minimum wage). In column 3, *Medium Type* (*High Type*) is an indicator for whether the worker's maximum pay in the three months before the minimum wage change is between the minimum wage and 180% of minimum wage (above 180% of minimum wage). In column 4, *Medium Type* (*High Type*) is an indicator for whether the worker's total pay in the *first* month in which she appears in our dataset is between the minimum wage and 180% of minimum wage (above 180% of minimum wage). In column 5, *Medium Type* (*High Type*) is an indicator for whether the worker's performance in the *first* quarter in which he/she appears in the dataset is in the second *(third)* tercile of the performance distribution based on the estimated worker fixed effects. *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *MinW* is the monthly predominant minimum wage (in $). *MinW* is the predominant monthly minimum wage (in $). Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

Table E.6: Effect of Minimum Wage on Worker Productivity with Alternative Classifications of Low, Medium and High Types (Continued)

Dep.Var.	Sales/Hrs	Sales/Hrs	Sales/Hrs	Sales/Hrs
Threshold	120%	140%	160%	180%
				main spec.
	(1)	(2)	(3)	(4)
MinW	0.209***	0.228***	0.234***	0.244***
	(0.035)	(0.035)	(0.035)	(0.042)
Medium Type	0.230***	0.283***	0.326***	0.354***
	(0.028)	(0.030)	(0.032)	(0.032)
High Type	0.625***	0.870***	1.051***	1.169***
	(0.043)	(0.055)	(0.068)	(0.072)
MinW · Medium Type	-0.099***	-0.076***	-0.075***	-0.085***
	(0.026)	(0.026)	(0.025)	(0.025)
MinW · High Type	-0.056***	-0.079***	-0.130***	-0.182***
	(0.016)	(0.021)	(0.029)	(0.032)
Observations	209,513	209,513	209,513	209,513
Units	Workers	Workers	Workers	Workers
Mean Dep.Var.	2.087	2.087	2.087	2.087
Effect MinW for Low Type (%)	19.23	21.02	21.56	22.45
p-value	0.001	0.001	0.001	0.001
Effect MinW for Med. Type (%)	7.382	8.995	8.655	8.172
p-value	0.001	0.001	0.001	0.001
Effect MinW for High Type (%)	6.618	5.961	3.943	2.273
p-value	0.001	0.001	0.009	0.179

Notes: All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, worker department and county-level employment. *Medium Types* is an indicator for whether the worker's total pay in month $t-1$ is between the minimum wage and X% of minimum wage, where X is 120 in column 1, 140 in column 2, 160 in column 3 and 180 in column 4. (column 4 is equivalent to our main specification). *High Types* is an indicator for whether the worker's total pay in month $t-1$ is above X% of minimum wage. As the threshold increases (i.e., from 120% to 180%), the mass of low types remains unchanged but the top category of high types becomes thinner and more outstanding. High types represent 75% of the workforce with the 120% threshold, 52% with the 140% threshold, 35% with the 160% threshold and 25% with the 180% threshold. *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *MinW* is the predominant monthly minimum wage (in $). Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

Table E.7: Effect of Minimum Wage on Worker Productivity with State-Level Specification

Dep.Var.	Sales/Hrs	Sales/Hrs
Sample	All stores	All stores
	(1)	(2)
MinW	0.038	0.175***
	(0.031)	(0.030)
Medium Type		0.293***
		(0.032)
High Type		1.140***
		(0.055)
MinW · Medium Type		-0.059***
		(0.021)
MinW · High Type		-0.151***
		(0.029)
Observations	416,439	399,100
Units	Workers	Workers
Mean Dep.Var.	2.196	2.196
Effect MinW (%)	1.753	
Effect for Low (%		16.57
p-value		0.001
Effect for Med. (%)		5.703
p-value		0.001
Effect for High (%)		0.804
p-value		0.526

Notes: The sample comprises of all stores (bordering + non-bordering). All the regressions include census division · month fixed effects, worker fixed effects, month fixed effects, and control for worker tenure, worker department and county-level unemployment. *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *MinW* is the predominant monthly minimum wage (in $). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage." *Effect MinW (%)* is the percent effect of a $1 increase in MinW on the outcomes. Standard errors are clustered at the state level. *** p<0.01, ** p<0.05, * p<0.1.

Table E.8: Effect of Minimum Wage on Worker Productivity with State and Local Variations in the Minimum Wage

Dep.Var.	Sales/Hrs	Sales/Hrs	Sales/Hrs	Sales/Hrs
MinW Variations	State	State	Local	Local
	(1)	(2)	(3)	(4)
MinW	0.100	0.271***	0.102	0.195***
	(0.066)	(0.076)	(0.071)	(0.052)
Medium Type		0.350***		0.339***
		(0.024)		(0.029)
High Type		1.163***		1.192***
		(0.051)		(0.047)
MinW · Medium Type		-0.096***		-0.099***
		(0.028)		(0.025)
MinW · High Type		-0.212***		-0.168***
		(0.028)		(0.050)
Observations	212,916	204,641	192,663	184,638
Units	Workers	Workers	Workers	Workers
Mean Dep.Var.	2.088	2.088	2.253	2.253
Effect MinW (%)	4.810		4.533	
Effect MinW for Low Type (%)		25.39		19.85
p-value		0.001		0.001
Effect MinW for Med. Type (%)		9.003		4.657
p-value		0.016		0.032
Effect MinW for High Type (%)		2.150		0.905
p-value		0.435		0.610

Notes: All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, worker department and county-level employment. Columns 1-2 leverage state-level minimum wage variations only. Columns 3-4 leverage within-state (county or city) minimum wage level variations. Refer to Table D.1 for the list of minimum wage variations in our sample. *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *MinW* is the monthly predominant minimum wage (in $). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage." *Effect MinW (%)* is the percent effect of a $1 increase in MinW on the outcomes. Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

Table E.9: Effect of Minimum Wage on Worker Productivity with Alternative Definitions of "Bordering Stores"

Dep.Var.	Sales/Hrs	Sales/Hrs	Sales/Hrs	Sales/Hrs	Sales/Hrs	Sales/Hrs
Distance Store-Border	75km	75km	37.5km	37.5km	18.75km	18.75km
	(1)	(2)	(3)	(4)	(5)	(6)
MinW	0.094**	0.244***	0.098**	0.255***	0.088**	0.261***
	(0.039)	(0.042)	(0.038)	(0.042)	(0.042)	(0.049)
Medium Type		0.354***		0.359***		0.370***
		(0.032)		(0.033)		(0.041)
High Type		1.169***		1.171***		1.173***
		(0.072)		(0.073)		(0.082)
MinW · Medium Type		-0.085***		-0.091***		-0.108***
		(0.025)		(0.027)		(0.039)
MinW · High Type		-0.182***		-0.192***		-0.199***
		(0.032)		(0.034)		(0.042)
Observations	217,822	209,513	208,451	200,506	159,352	153,329
Units	Wrk	Wrk	Wrk	Wrk	Wrk	Wrk
Mean Dep.Var.	2.085	2.085	2.089	2.089	2.077	2.077
Effect MinW (%)	4.485		4.701		4.234	
Effect for Low Type (%)		22.56		23.69		23.68
p-value		0.001		0.001		0.001
Effect for Med. Type (%)		8.186		8.476		7.981
p-value		0.001		0.001		0.001
Effect for High Type (%)		2.273		2.339		2.269
p-value		0.179		0.158		0.171

Notes: All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, worker department and county-level employment. Columns 1-2 (3-4) [5-6] restrict the sample to stores within 75 km (37.5 km) [18.75 km] from the border. *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *MinW* is the predominant monthly minimum wage (in $). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage." *Effect MinW (%)* is the percent effect of a $1 increase in MinW on the outcomes. Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

Table E.10: Effect of Minimum Wage on Worker Productivity without "Stacking" the Data (Experimental Event Approach)

Dep.Var.	Sales/Hrs (1)	Sales/Hrs (2)
MinW	0.112**	0.221***
	(0.051)	(0.063)
Medium Type		0.314***
		(0.029)
High Type		1.159***
		(0.051)
MinW · Medium Type		-0.049
		(0.031)
MinW · High Type		-0.152***
		(0.032)
Observations	128,958	123,745
Units	Workers	Workers
Mean Dep.Var.	2.094	2.094
Effect MinW (%)	5.365	
Effect MinW for Low Type (%)		19.83
p-value		0.001
Effect MinW for Med. Type (%)		8.773
p-value		0.003
Effect MinW for High Type (%)		2.485
p-value		0.165

Notes: The sample comprises of bordering stores *without* stacking the data. All the regressions include worker fixed effects, border-segment-month fixed effects, and control for worker tenure, worker department and county-level unemployment. *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *MinW* is the predominant monthly minimum wage (in $). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage." *Effect MinW (%)* is the percent effect of a $1 increase in MinW on the outcomes. Standard errors are clustered at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

Table E.11: Effect of Minimum Wage on Worker Productivity with Alternative Controls

Dep.Var.	Sales/Hrs	Sales/Hrs	Sales/Hrs	Sales/Hrs
Controls	Dept.-Trends	Dept.-Trends	No Tenure&UR	No Tenure&UR
	(1)	(2)	(3)	(4)
MinW	0.121*	0.271***	0.094**	0.244***
	(0.063)	(0.064)	(0.038)	(0.042)
Medium Type		0.349***		0.354***
		(0.033)		(0.032)
High Type		1.159***		1.169***
		(0.071)		(0.072)
MinW · Medium Type		-0.085**		-0.085***
		(0.032)		(0.025)
MinW · High Type		-0.187***		-0.182***
		(0.033)		(0.032)
Observations	217,822	209,513	217,822	209,513
Units	Workers	Workers	Workers	Workers
Mean Dep.Var.	2.085	2.085	2.085	2.085
Effect MinW (%)	5.788		4.526	
Effect for Low Type (%)		25.06		22.56
p-value		0.001		0.001
Effect for Med. Type (%)		9.566		8.186
p-value		0.004		0.001
Effect for High Type (%)		3.074		2.273
p-value		0.236		0.179

Notes: All the regressions control for pair-month fixed effects, worker fixed effects, worker department. Columns 1 and 2 also controls for worker tenure, unemployment rate, and *department-store specific time-trends* (unique department ID · time-trend). *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *MinW* is the predominant monthly minimum wage (in $). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage." *Effect MinW (%)* is the percent effect of a $1 increase in MinW on the outcomes. Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

Table E.12: Effect of Minimum Wage on Worker Productivity by Department

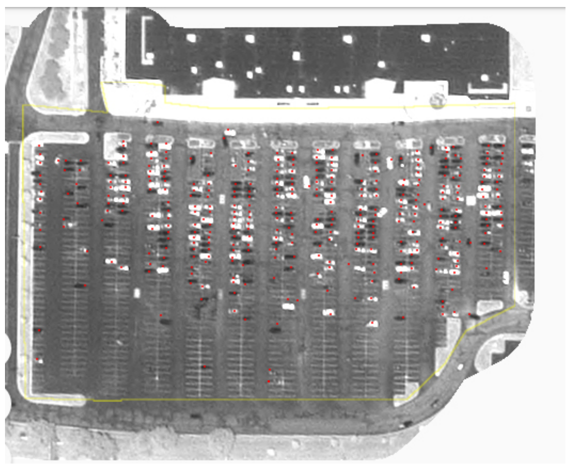
Dep.Var.	Sales/Hrs	Sales/Hrs	Sales/Hrs	Sales/Hrs
Department	Dpt 1	Dpt 2	Dpt 3	Dpt 4
	(1)	(2)	(3)	(4)
MinW	0.395***	0.259*	0.139	0.726
	(0.104)	(0.139)	(0.092)	(0.586)
Medium Type	0.513***	0.388***	0.306***	0.365***
	(0.109)	(0.047)	(0.062)	(0.128)
High Types	1.354***	1.015***	0.743***	1.321***
	(0.160)	(0.062)	(0.077)	(0.197)
MinW · Medium Type	-0.238***	-0.161***	-0.145*	-0.073
	(0.080)	(0.041)	(0.084)	(0.134)
MinW · High Type	-0.208***	-0.259***	-0.087	0.298
	(0.063)	(0.072)	(0.110)	(0.234)
Observations	72,616	48,062	36,107	19,793
Units	Workers	Workers	Workers	Workers
Mean Dep.Var.	2.587	2.123	1.595	2.639
Effect MinW for Low Type (%)	27.19	24.90	15.32	44.75
p-value	0.001	0.0719	0.146	0.226
Effect MinW for Med. Type (%)	6.462	5.559	-0.499	25.85
p-value	0.001	0.474	0.924	0.248
Effect MinW for High Type (%)	4.768	-0.007	2.748	22.78
p-value	0.027	0.999	0.449	0.112

Notes: This specification isolates the four largest departments, making up approximately 90% of the observations. The remaining observations are split among eight small departments, not reported here. All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, and county-level unemployment. *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *MinW* is the predominant monthly minimum wage (in $). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage." *Effect MinW (%)* is the percent effect of a $1 increase in MinW on the outcomes. Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

F Demand Channel Appendix

We start by checking directly for demand shifts caused by changes in the minimum wage. To do so, we introduce parking lot occupancy as a proxy for demand (see Figure F.1 for an example of the satellite pictures from which the data are coded). These data have been used by financial traders to forecast revenues for nationwide retailers,[60] and they are suitable for our purposes because they capture *customer volume*, which is exogenous to worker effort, as opposed to *quantity purchased* which is not.[61]

Figure F.1: Satellite Image of One Store with Parking Lot Area and Car Counts Highlighted



Notes: Data © 2018 RS Metrics; Imagery © (CNES) 2018; Distribution Airbus DS Imagery © 2018 DigitalGlobe

Each satellite image is digitized using a machine learning and computer vision algorithm which (1) identifies parking lot areas around each store, (2) counts the number of parking spaces in the parking lot, and (3) counts the number of cars parked. We aggregate these high-frequency satellite data at the store-month level and create a store-specific monthly measure of parking occupancy, i.e., the average proportion of parking spaces that are filled in a given store and a given month.[62] In our sample, the average parking lot

[60]page 49, J.page Morgan's Guide to Big Data and AI Strategies. Published on May 29, 2017 https://www.cfasociety.org/cleveland/Lists/Events%20Calendar/Attachments/1045/BIG-Data_AI-JPMmay2017.pdf

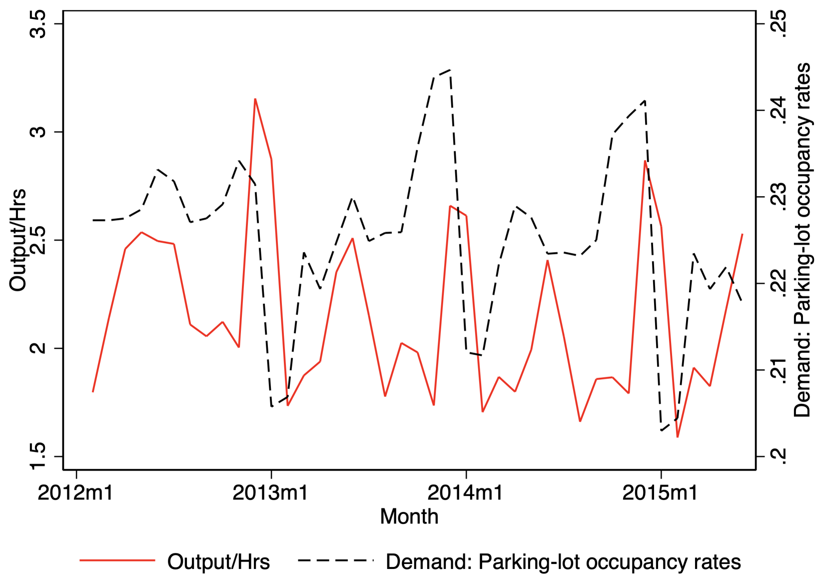
[61]However, a limitation is that we have no specific visibility on spending per shopper. This might be problematic if there are distributional effects of the minimum wage such that the number of shoppers does not change but spending per shopper increases.

[62]During our sample period, the data contain about 51,000 satellite images of the parking lots of the stores in our data. Images cover 93% of the stores in our dataset and, conditional on having at least one picture in a given month, the average store has 2.6 images per month. Missing images are attributable to

holds 125 cars and the average occupancy rate is 23%.[63]

To validate our proxy for store-level demand, we start by showing that it is highly co-moves with store output. Table F.1 column 1 shows that a one-unit increase in occupancy rate is associated with a statistically significant 12% increase in store output. Figure F.2 moreover shows that the two variables co-move over time with peaks around holiday seasons.

Figure F.2: Parking-lot Occupancy Rates Co-move With Store Output



Notes: This figure plots the evolution over time of "store output" and "parking lot occupancy rates", averaged at the store-month level. *Output/Hrs* is the (average) total monthly store sales generated by all sales associates in our sample divided by the total number of hours worked by these sales associates. We do not disclose the units for confidentiality reasons. *Parking lot occupancy rates* is the (average) occupancy rate of the store's parking lot.

Next, we use the data on parking occupancy to show that variations in the minimum wage do not cause variations in our proxy of store-level demand. First, an increase in minimum wage does not affect parking lot occupancy rate (Table F.1, column 2). Second, the effect of minimum wage on individual worker performance does not shrink when we control for parking lot occupancy rate, indicating that the observed performance gains are not explained by a demand surge (Table F.2, columns 2-3).[64]

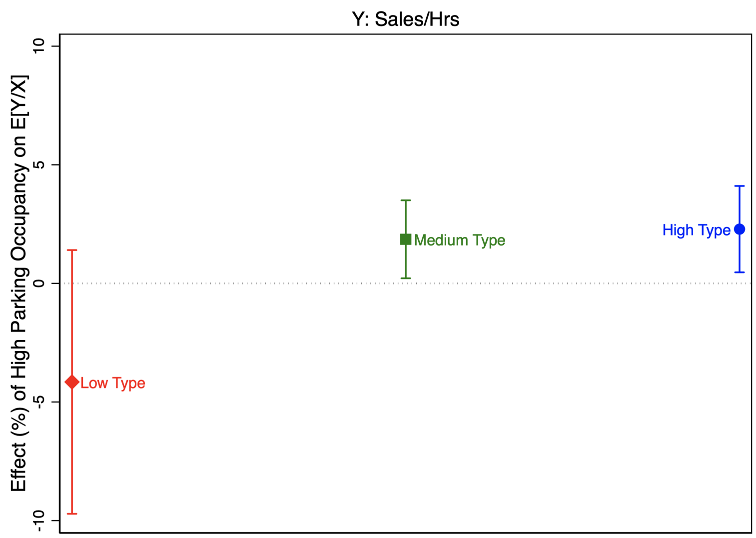
indoor parking lots that could not be caught by satellites, and to the lower frequency of satellite images in less populated areas.

[63]Because we control for store fixed effects, using the occupancy rate as a proxy of demand is equivalent to using the number of cars in the parking lot.

[64]The results hold if we further control for parking lot occupancy rate interacted with a county measure of how binding the minimum wage is ("county-level exposure", see below for more information).

Table F.3 (and the corresponding Figure F.3) show that – even if there was a positive demand shock as a result of a higher minimum wage – this shock would unlikely be concentrated among low types only. We use a regression model similar to equation (12) with the only difference that indicators for worker types are interacted with a dummy for high demand (top quartile of occupancy rate) rather than with the minimum wage. Figure F.3 plots the estimated coefficients $\hat{\beta}_1$, $\hat{\beta}_1 + \hat{\beta}_4$ and $\hat{\beta}_1 + \hat{\beta}_5$ and the associated confidence intervals. We find that sales per hour are higher in high-occupancy than low-occupancy periods only for medium and high types, while higher occupancy does not increase sales per hour of low types. The fact that minimum wage raises the performance of low types only is thus inconsistent with a demand shock.

Figure F.3: A Positive Demand Shock Increases the Productivity of High Types but not of Low Types



Notes: Effects of being in the top quartile of demand on the percent change in Y (Sales/Hrs) for low, medium, and high types. Top quartile of demand is defined as being in the top quartile of the parking-lot occupancy rates in a given month t. Vertical bars represent 95% confidence intervals.

One may wonder whether the performance boost we observe among low types is explained by these workers being disproportionately located in high-exposure counties (where the demand response might be stronger) relative to high types. This is unlikely the case. First, all our estimates are based on comparisons across types within the same store. Second, Table F.1 shows that low types are not disproportionately located in high-exposure counties (column 4) and, moreover, that the effect of the minimum wage on parking occupancy rates is not stronger in high-exposure counties (column 3).

Finally, we show that the minimum wage affects our workers' performance independently of the share of the population who earn minimum wage (Table F.4). We compute two measures of "exposure to the minimum wage:" one at the county level and the other at the state level. The former uses the QWI data to calculate the quarterly, county-level difference between the average hourly wage and the prevailing minimum wage (as in Renkin et al. 2021).[65] The latter uses the individual-level NBER Merged Outgoing Rotation Group of the Current Population Survey for 2012-2015 (CPS) to calculate the quarterly, state-level fraction of workers whose earnings per hour is equal to the prevailing minimum wage (as in Cengiz et al. 2019).

A conceptually related channel is a change in *demand per worker*. Fix employee i. Any decrease in the number of co-workers $-i$ might change i's residual demand, and thus increase i's individual performance mechanically, quite apart from any incentive effect on i. Such spillovers across workers do not exist in our model, but they could exist in reality. We can rule out that our results on individual productivity are confounded by variation in store-level employment because in Section 6.2 the number of salespeople employed by a store does not correlate significantly with the minimum wage. Furthermore, controlling for store-level employment does not affect our core estimates, either on average or by type (Table F.5). A similar form of negative spillover would exist if increased effort by co-workers at the *intensive* margin (choice of e_{-i}, in our model) reduces worker i's individual performance through, e.g., "demand stealing."[66] This effect is difficult to control for directly, but if such a spillover existed it would depress every worker's performance given effort, and so our estimated coefficients (which are based on performance) would under-represent the true effect of the minimum wage on effort.

[65] The assumption is that counties with a low average wage relative to the minimum wage are states in which the minimum wage is binding for a larger share of the population.

[66] We presume that spillovers are negative because, assuming that the intensive margin of $-i$'s effort has the same spillover effect on i as a change in the extensive margin, Table F.5 shows this effect to be negative, if small.

Table F.1: Minimum Wage, Parking Occupancy and Store Output

Dep.Var.	Output/Hrs	Parking Occupancy	Parking Occupancy	% Low Types
	(1)	(2)	(3)	(4)
MinW		-0.005	0.001	
		(0.017)	(0.019)	
Parking Occupancy	0.252**			
	(0.096)			
Exposure			0.020	-0.117
			(0.021)	(0.250)
MinW * Exposure			-0.002	
			(0.002)	
Observations	12,359	12,359	12,359	12,275
Units	Stores	Stores	Stores	Stores
Mean Dep.Var.	2.135	0.230	0.230	5.964
Effect (%)	11.81	-2.028	0.343	-

Notes: All the regression includes pair-month fixed effects, store fixed effects, and controls for county-level unemployment. *Output/Hrs* are computed by aggregating the sales produced by all sales associates in our sample in a given month divided by the total number of hours these sales associates worked in that month (the units are hidden for confidentiality reason). *MinW* is the predominant monthly minimum wage (in $). *Parking Occupancy* is the average occupancy rate of the store's parking lot (0 means no-occupancy, 1 means full-occupancy). Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

Table F.2: Effect of Minimum Wage on Worker Productivity Controlling for Demand

Dep.Var.	Sales/Hrs (1)	Sales/Hrs (2)	Sales/Hrs (3)
MinW	0.092**	0.230***	0.085**
	(0.039)	(0.042)	(0.038)
Medium Type		0.383***	
		(0.030)	
High Type		1.174***	
		(0.046)	
MinW · Medium Type		-0.041	
		(0.025)	
MinW · High Type		-0.165***	
		(0.031)	
Controls included in the regression:			
Parking Occupancy	Yes	Yes	Yes
Parking Occupancy · Med. Type	No	Yes	No
Parking Occupancy · High Type	No	Yes	No
Exposure	No	No	Yes
Parking Occupancy*Exposure	No	No	Yes
Observations	217,822	209,513	217,822
Units	Workers	Workers	
Mean Dep.Var.	2.085	2.085	2.085
Effect MinW (%)	4.424		4.055
Effect MinW for Low Type (%)		21.30	
p-value		0.000	
Effect MinW for Med. Type (%)		9.766	
p-value		0.000	
Effect MinW for High Type (%)		2.400	
p-value		0.153	

Notes: All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, worker department and county-level unemployment. *Parking Occupancy* is the average occupancy rate of the store's parking lot (0 means no-occupancy and 100 means full occupancy). *Exposure* corresponds to the difference (in $) between the average hourly wage in the state and the predominant monthly minimum wage. *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *MinW* is the predominant monthly minimum wage (in $). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage". *Effect MinW (%)* is the percent effect of a $1 increase in MinW on the outcomes. Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

Table F.3: Effect of Positive Demand Shock on Worker Productivity

Dep.Var.	Sales/Hrs (1)	Sales/Hrs (2)
High Parking Occupancy	0.045**	-0.045
	(0.020)	(0.029)
Medium Type		0.291***
		(0.039)
High Type		1.102***
		(0.093)
High Parking Occupancy · Medium Type		0.081***
		(0.021)
High Parking Occupancy · High Type		0.107***
		(0.030)
Observations	217,822	209,513
Units	Workers	Workers
Mean Dep.Var.	2.085	2.085
Effect High Occupancy (%)	2.156	
Effect High Occupancy for Low Type (%)		-4.155
p-value		0.138
Effect High Occupancy for Med. Type (%)		1.859
p-value		0.028
Effect High Occupancy for High Type (%)		2.287
p-value		0.016

Notes: All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, worker department and county-level unemployment. *High Parking Occupancy* is an indicator for whether the average occupancy rate is in the top quartile of the store distribution. *MinW* is the predominant monthly minimum wage (in $). *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *MinW* is the predominant monthly minimum wage (in $). *MinW* is the predominant monthly minimum wage (in $). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage". *Effect MinW (%)* is the percent effect of a $1 increase in MinW on the outcomes. Standard errors are two-way clustered at the state level and at the border-segment level. s*** p<0.01, ** p<0.05, * p<0.1.

Table F.4: Effect of Minimum Wage on Worker Productivity by Exposure

Dep.Var.	Sales/Hrs (1)	Sales/Hrs (2)	Sales/Hrs (3)	Sales/Hrs (4)
MinW	0.082*	0.231***	0.115**	0.278***
	(0.042)	(0.040)	(0.045)	(0.050)
Exposure	-0.033	-0.038*	-1.028	-0.768
	(0.022)	(0.021)	(0.816)	(1.171)
MinW · Exposure	0.002	0.002	-0.685	-1.469
	(0.006)	(0.009)	(0.950)	(0.977)
MinW · Medium Type		-0.089***		-0.099***
		(0.020)		(0.021)
MinW · High Type		-0.201***		-0.180***
		(0.023)		(0.065)
MinW · Exposure · Medium Type		-0.002		0.316
		(0.007)		(0.335)
MinW · Exposure · High Type		0.021**		2.831**
		(0.010)		(1.306)
Other regressors:				
Medium Type	No	Yes	No	Yes
High Type	No	Yes	No	Yes
Exposure · Medium Type	No	Yes	No	Yes
Exposure · High Type	No	Yes	No	Yes
Observations	217,822	209,513	217,822	209,513
Units	Workers	Workers	Workers	Workers
Mean Dep.Var.	2.085	2.085	2.085	2.085

Notes: All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, worker department and county-level unemployment. In columns 1-2, *Exposure* corresponds to the difference (in $) between the average hourly wage in the county and the predominant monthly minimum wage. In columns 3-4, *Exposure* corresponds to the fraction of workers in the state (in %) whose earnings are at minimum wage. *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *MinW* is the predominant monthly minimum wage (in $). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage". Standard errors are two-way clustered at the state level and at the border-segment level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table F.5: Effect of Minimum Wage on Worker Productivity Controlling for Employment

Dep.Var.	Sales/Hrs (1)	Sales/Hrs (2)
MinW	0.090**	0.237***
	(0.038)	(0.043)
N.Workers	-0.019**	-0.048**
	(0.007)	(0.018)
Parking Occupancy	0.212**	0.178**
	(0.104)	(0.083)
Medium Type		0.220***
		(0.035)
High Type		0.901***
		(0.049)
MinW · Medium Type		-0.081***
		(0.026)
MinW · High Type		-0.173***
		(0.035)
N.Workers · Medium Type		0.025*
		(0.012)
N.Workers · High Type		0.048***
		(0.014)
Observations	217,822	209,513
Mean Dep.Var.	2.085	2.092
Effect N.Workers (%)	-0.932	
Effect N.Workers for Low Type (%)		-2.305
p-value		0.0101
Effect N.Workers for Med. Type (%)		-1.126
p-value		0.002
Effect N.Workers for High Type (%)		-0.028
p-value		0.949

Notes: All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, worker department and county-level unemployment. *N.Workers* is the number of sales associates in the store. *Parking Occupancy* is the average occupancy rate of the store's parking lot (0 means no-occupancy and 100 means full occupancy). *Sales/Hrs* are the sales per hour rescaled by a factor between 1/50 and 1/150 relative to its $ value. *MinW* is the predominant monthly minimum wage (in $). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage". *Effect (%)* is the percent effect of a 1 unit increase in the independent variable on the outcomes. Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

G Organizational Adjustments Channel Appendix

Table G.1 (and the corresponding Figure 7) show that the minimum wage has no statistically significant effect on the proportion of low vs. high types who are moved to a best-selling department (columns 1-2) or moved to part-time status (with worse shifts, columns 3-4). The effect of minimum wage on hours worked (columns 5-6) and formal benefits (vacation and illness benefits, columns 7-8) also does not differ for low vs. high types.

Concerning the results on hours, note that the effect of minimum wage on hours is positive for all worker types but is never statistically significant, even when we aggregate data across all worker types. Moreover, unlike Doppelt (2019), we do not find any differential effect of minimum wage on hours for part-time vs. full-time workers (result available upon request).

An increase in prices as a result of a higher minimum wage is also unlikely to explain our core results. First, any price change should affect sales for *all* types, not specifically for the low types. Second, as with many national nationwide retailers, our company has a national pricing strategy and has uniform prices across all US stores (Della Vigna and Gentzkow 2019). In line with this, Table G.2 shows that the minimum wage does not affect our company's cost-to-price index. We compute the cost-to-price index as the ratio between: (a) monthly store output minus gross margin (cost $\times$ quantity), and (b) store output (price $\times$ quantity).

Table G.1: Effect of Minimum Wage on Allocation to Best-Selling Departments, Part-Time Status, Hours Worked and Benefits

Dep.Var.	Top Dept.		Part-Time		Hrs		Benefits	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MinW	-0.454	0.044	-2.395	-2.291	1.942	2.720	8.006	7.402
	(0.655)	(0.623)	(1.434)	(1.665)	(1.265)	(1.637)	(7.281)	(7.622)
Medium Type		-0.092		-2.220		4.762***		0.213
		(0.283)		(1.392)		(1.181)		(2.144)
High Type		-1.218***		-2.381		5.439***		4.904*
		(0.265)		(1.768)		(1.549)		(2.609)
MinW · Medium Type		-0.160		-0.028		-0.856		1.406
		(0.218)		(0.826)		(0.851)		(1.161)
MinW · High Type		-0.878*		0.036		-0.240		2.424
		(0.466)		(0.917)		(1.236)		(1.961)
Observations	217,822	209,514	217,822	209,513	217,822	209,513	217,822	209,513
Units	Workers	Workers	Workers	Workers	Workers	Workers	Workers	Workers
Mean Dep.Var.	44.29	44.29	60.25	60.25	106.5	106.5	48.23	48.23
Effect MinW (%)	-1.024		-3.975		1.824		16.60	
Effect MinW for Low (%)		0.128		-3.090		3.052		38.08
p-value		0.944		0.178		0.106		0.339
Effect MinW for Med. (%)		-0.225		-3.790		1.754		22.68
		0.849		0.100		0.161		0.255
Effect MinW for High (%)		-3.535		-4.268		2.179		11.56
p-value		0.265		0.150		0.121		0.209

Notes: All the regressions include pair-month fixed effects, worker fixed effects, and control for worker tenure, worker department and county-level unemployment. *Top-Dept.* is an indicator for being in the top (best-selling) departments (takes value 0 in a given month if a worker is not in top-departments and takes value 100 if the worker is in top-departments). *Part-time* is the percent probability that an employee is a part-time employee in a given month (takes value 0 in a given month if a worker is full-time and takes value 100 if the worker is part-time). *Hrs* is the total number of hours for which employee receives a compensation in a given month. *Benefits* are the vacation and illness benefits (in $) received by an employee in a given month. *MinW* is the predominant monthly minimum wage (in $). *Medium Type* is an indicator for whether the worker's total pay in month *t-1* is between the minimum wage and 180% of minimum wage. *High Type* is an indicator for whether the worker's total pay in month *t-1* is above 180% of minimum wage. The omitted group (*Low Types*) are workers for whom total pay in *t-1* is "at minimum wage." *Effect (%)* is the percent effect of a 1 unit increase in the independent variable on the outcomes. Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.

Table G.2: Effect of Minimum Wage on Cost-to-Price Index

Dep.Var.	Costs/Prices Ratio
	(1)
MinW	-0.004
	(0.003)
Observations	12,359
Units	Stores
Mean Dep.Var.	0.693
Effect (%)	-0.531

Notes: The regression includes pair-month fixed effects, store fixed effects, and controls for county-level unemployment. *Costs/Prices Ratio* is computed as the ratio between: (a) store output minus gross margin, and (b) store output. *MinW* is the predominant monthly minimum wage (in $). Standard errors are two-way clustered at the state level and at the border-segment level. *** p<0.01, ** p<0.05, * p<0.1.