# Schedule Volatility and the Minimum Wage*

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February 28, 2025

**Abstract**

The effects of minimum wage policies are an ongoing subject of debate. We study a margin related to labor supply that has so far received little attention – the volatility of workers' schedules. We first introduce a measure of schedule volatility that exploits the longitudinal nature of the Current Population Survey (CPS). We then provide causal evidence that increases in the minimum wage have reduced the volatility of workers' schedules by about 5%. To interpret these results, we introduce a frictional model of search and bargaining in the labor market, where minimum wages affect workers' bargaining power, allowing them to negotiate contracts with less volatile schedules.

**Keywords:** schedule volatility, minimum wages, search and matching

**JEL Codes:** J22, J31

*We thank Edoardo Ciscato, Iris Kesternich, and Erwin Ooghe for invaluable guidance and support. We are also grateful to Clément de Chaisemartin and Jesse Wursten for useful comments and suggestions. We gratefully acknowledge financial support from the Research Foundation Flanders (FWO) through PhD Fellowships (project grants 11I7822N and 11I6522N). All errors are ours.

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# 1 Introduction

> "And after I get hired at McDonalds, I have to quit the choir – my work hours are just too unpredictable to commit to rehearsals or even Sunday morning services. Our schedule at McDonald's is posted less than a day before it starts, and I never have any idea how many or which hours I'll be scheduled for. [...] I can't imagine how people with kids make this work".
>
> Emily Guendelsberger (2020) – On the Clock

The employment effects of minimum wage policies are an ongoing subject of debate. Early predictions of job loss derived from perfectly competitive models have long been challenged. On the one hand, by more realistic labor market settings with search frictions and monopsony power that offer contrasting predictions, such as those of Flinn (2006) and Dube et al. (2022). On the other, by empirical evidence that finds limited to no employment reactions. For example, recent work by Cengiz et al. (2019) finds no evidence for reduced job counts nor total hours. Various summary papers such as Manning (2021), Dube and Zipperer (2024), and Dube and Lindner (2024) reach similar conclusions.

While much has been written about how minimum wages affect employment and hours, there is little evidence on how they influence workers' schedules. Yet this is a valuable margin to both sides of the market. A growing literature finds that workers place a high value on the stability of employment and income, see for example the work by Mas and Pallais (2017), Chen et al. (2019), and Maestas et al. (2023) that highlights the importance of worker-driven schedules. More broadly, it has been shown that uncertainty about employment and earnings may lead to significant welfare losses because it hinders consumption smoothing and complicates household planning and fertility choices, as highlighted by Low et al. (2010) and Sommer (2016).

In many occupations, having discretion over employees' hours is profitable to firms, because it allow them to smooth out demand shocks. Competitive models of the labor market then predict schedules to become more volatile when minimum wages increase – see the review in Clemens (2021). The intuition is that firms offset part of the additional wage cost by saving money on other margins. But this does not always hold when frictions are introduced. Recent work by

Dube et al. (2022) stresses that, in markets with monopsony power, amenities may rise or fall depending on the relative magnitude of the elasticity of labor supply the firm faces, and worker's elasticity of substitution between wages and amenities. We provide causal evidence in line with the latter class of models, and find that schedules become less volatile when minimum wages are increased. To further interpret these results, we estimate a model of search and bargaining.

The first step in our analysis is to introduce a measure of schedule volatility. We do so by exploiting the longitudinal nature of the Current Population Survey (CPS), which collects monthly information about workers' hours. We leverage variation over the four months of participation to construct an individual level measure of schedule volatility in each quarter. We show that the schedules of low wage workers are almost 50% more volatile than those of higher earning workers. This is in line with the patterns in Maestas et al. (2017) and Katz and Krueger (2019) that highlight a significant wage gradient in the probability of being on-call or having an unpredictable schedule. We also document substantial heterogeneity in volatility across occupations, and find that schedules are particularly volatile in food- and retail occupations. An important reason for this result is that employers in these occupations often resort to just-in-time-scheduling practices to deal with high demand uncertainty, as discussed in Kamalahmadi et al. (2021).

The next step is to estimate how schedule volatility reacts to minimum wage changes. We use the stacked event study approach recently introduced in Cengiz et al. (2019) to estimate a causal relation. We find that an increase in the minimum wage reduces the volatility of workers' schedules by about five percent. Contrarily, we find limited to no effects on the fraction of workers that reports having varying hours nor on the number of hours. These results are broadly in line with earlier evidence such as Gopalan et al. (2021) and Dube and Lindner (2024), who find no effects of minimum wages on hours worked, and are robust to alternative choices of the measure, various sample restrictions, and the choice of estimator.

To interpret these findings, we introduce minimum wages into a search and bargaining model with job amenities based on Flabbi and Moro (2012). We model schedule volatility as a productive amenity that is disliked by workers but positively valued by firms. To study how minimum wages affect the volatility of workers' schedules, we first derive the equilibrium level of volatility, and then study how it changes when a minimum wage is imposed. As in Cahuc et al. (2006), minimum wages improve the bargaining power of workers by altering their outside options to be jobs with a volatile schedule that pays the minimum wage. Some workers use this improved fallback option to negotiate employment contracts with less volatility.

We estimate the model using recent data from the Current Population Surveys **[work in progress]**

- model results

- welfare analysis: supply side gains from stable schedules

- simulation: imposing a higher federal minimum wage

- simulation: imposing a federal fair workweek law

The remainder of this paper is structured as follows. Section 2 reviews the related literature. Section 3 discusses the data and provides motivating evidence. Section 4 introduces the model and outlines the identification and estimation strategy. Section 5 presents the results and the counterfactual simulations. Section 6 concludes.

## 2 Related Literature

*Minimum Wages.* This paper is related to the large literature that studies various effects of minimum wage policies. In line with the early evidence in Card and Krueger (1994), recent work by Cengiz et al. (2019), Gopalan et al. (2021), Manning (2021), Dube and Lindner (2024), and Dube and Zipperer (2024) concludes that aggregate effects on employment and hours are negligible.[1] As noted in Flinn (2006), this could indicate that competitive models of the labor market may have important shortcomings.

Several papers have addressed these limitations by studying minimum wages in labor market models with search frictions and other sources of monopsony power (Bontemps et al., 1999, 2000; Van Den Berg, 2003; Flinn, 2006; Cahuc et al., 2006; Flinn and Mabli, 2009; Dube et al., 2022). Similar to Flinn (2006), Cahuc et al. (2006), and Flinn and Mabli (2009), we study a model where the introduction of a minimum wage affects the bargaining process between workers and firms. But different from these papers, we consider an explicit amenity dimension in a search and bargaining setting, as in Flabbi and Moro (2012). This makes our paper closely related to Dube et al. (2022), who study minimum wages and amenities in a job design model with monopsony power.

[1] Some recent papers such as Cengiz et al. (2022) and Godøy et al. (2024) highlights that these aggregate estimates hide a significant amount of heterogeneity. The latter documents substantial positive effects for mothers with young children – a group with large fixed costs to employment.

They derive predictions about the relation between minimum wages and amenities that differ from those in the perfectly competitive markets discussed in Clemens (2021). Whether minimum wages increase or decrease the supply of amenities now depends on the relative magnitudes of the labor supply elasticity faced by the firm and the worker's elasticity of substitution between wages and amenities. They find empirical evidence in support of their model and find no evidence that minimum wages have reduced amenities.

*Workplace Flexibility.* We also relate to the literature that studies the valuation of various dimensions of scheduling flexibility (Mas and Pallais, 2017; Wiswall and Zafar, 2018; Chen et al., 2019; He et al., 2021; Maestas et al., 2023). For example, Mas and Pallais (2017) document that workers are willing to sacrifice twenty percent of their wages to avoid employer discretion over their hours. They find that the average valuation of flexible schedules – the ability of workers to set their hours or days – is low but has a large right tail. Contrasting evidence is provided in Chen et al. (2019), who estimate that the freedom to set one's own hours allows workers to earn more than twice the surplus. An important reason for the differences in these estimates is selection into the particular jobs under consideration.[2] Related work by Maestas et al. (2023) conducts an experiment on a smaller but more representative sample, and finds that the ability to set one's own schedule is valued at ten percent of wages. We study preferences for an alternative aspect of workplace flexibility, and explore how the equilibrium provision is affected by labor market policies.

The schedule volatility dimension to flexibility has received increasing attention. Recent work by Adams-Prassl et al. (2023) and Datta (2024) studies the mechanisms behind the increasingly widespread phenomenon of zero hour contracts. More closely related is Kamalahmadi et al. (2021), who document a negative productivity effect of real-time scheduling. This has lead to various policy efforts aimed at increasing the predictability and stability of work hours – see the discussion in Mas and Pallais (2020) – with several states introducing Fair Workweek Laws. Recent work by Kwon and Raman (2023) uses shift-level administrative records to study the effectiveness of these laws. They find that this lead to workers knowing about their schedules significantly earlier, and also document a reduction in the number of adjustments, with no effect on hours or

[2] Mas and Pallais (2017) consider applicants to call-center jobs, while Chen et al. (2019) study Uber drivers.

shifts worked. We show that minimum wage policies are able to achieve similar results.[3]

# 3 Motivating Evidence

## 3.1 Data

We use Current Population Survey (CPS) data from 1994 to 2019 provided by the Integrated Public Use Microdata Series (IPUMS). We select a sample of individuals aged 16 to 64 from basic monthly files. We remove those that are self-employed, in unpaid family work, or in the army, and keep only observations without missing information on demographics and labor market outcomes. To construct our measure of schedule volatility, we exploit the panel nature of the data. The monthly files contain two questions about respondents' hours. We discuss below how these are used to construct a measure of schedule volatility for each individual at the quarterly level. We then select the outgoing rotation group sample, which contains information about wages.[4] We then merge in quarterly data on state-level minimum wages from Vaghul and Zipperer (2022).

Table 1 provides an overview of our the data. We report aggregate summary statistics, and study separately the people with wages less than ten and less than fifty percent above the minimum wage, those with wages higher than fifty percent above the minimum wage, and those with a high school degree or less. We find that about half our sample is women, but in the low earning groups this fraction goes up to more than sixty percent. Teenagers make up only a small fraction of the aggregate sample and are over represented in the lower earning groups. We document only small differences in races across subsamples, with roughly 80% white, 10% black, 5% Asian, and 5% other.

When we look at earnings and employment, we find that average hourly wages are 18$ (deflated to 2019). In the group that earns less than ten percent more than the minimum wage, the average is less than half (just below 8$), while in the group earning less than fifty percent over the minimum wage, the average is just below 10$. In terms of labor supply, we find that the

[3]Recent work by Yu et al. (2023) finds the opposite effect. They argue that minimum wages have made schedules more volatile in their sample of workers from a medium sized chain in fashion retail. The extent to which their findings generalize are questionable, because their other effects such as a large 30% reduction in hours are hard to reconcile with the zero effects found in recent work such as Cengiz et al. (2019) and Gopalan et al. (2021).

[4]Note that hours are available each month, but earnings are only asked once, when respondents leave the panel. This is the outgoing rotation group (ORG) sample.

Table 1: Summary Statistics (CPS)

| Variable | Total | < 110% MW | < 150% MW | > 150% MW | HS or Less |
|---|---|---|---|---|---|
| ***Observations*** | | | | | |
| Nr. Observations | 4,961,730 | 305,818 | 934,108 | 1,993,962 | 2,039,536 |
| Sample Share | 1 | 0.1 | 0.32 | 0.68 | 0.41 |
| ***Sample Shares*** | | | | | |
| Women | 0.49 | 0.62 | 0.6 | 0.47 | 0.45 |
| Teen | 0.05 | 0.28 | 0.19 | 0.02 | 0.11 |
| Asian | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 |
| Black | 0.1 | 0.11 | 0.12 | 0.1 | 0.12 |
| White | 0.83 | 0.81 | 0.8 | 0.84 | 0.82 |
| Other | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| ***Hours and Wages*** | | | | | |
| Hourly Wage | 18.04 | 7.91 | 9.7 | 21.94 | 15.56 |
| Hourly Wage (std. dev.) | 10.78 | 2.04 | 2.15 | 10.98 | 8.09 |
| Hours | 38.16 | 27.2 | 30.53 | 38.26 | 37 |
| Hours (std. dev.) | 11.96 | 12.41 | 12.25 | 10.4 | 11.92 |
| ***Employment*** | | | | | |
| Employed | 0.94 | 1 | 1 | 1 | 0.92 |
| Months Unemployed | 1.82 | | | | 1.77 |

*Notes.* This table reports demographics, hours, and wages for different samples of the Current Population Survey (CPS) data from 1994 to 2019. We include individuals aged 16 to 64 without any missing information that are not self employed or in unpaid family work, nor in the army.

individuals in our sample work on average 38 hours per week, and just 6% is unemployed – this fraction is 8% in the group with a high school degree or less. The hours of those in the groups earning less than ten or fifty percent of the minimum wage are lower, at 27.2 and 30.5 respectively, whereas the higher earning group works slightly more than the average. We do find that the variation in hours is higher in the lower earning groups, with standard deviations of around 12 as opposed to 10 in the high earning group.

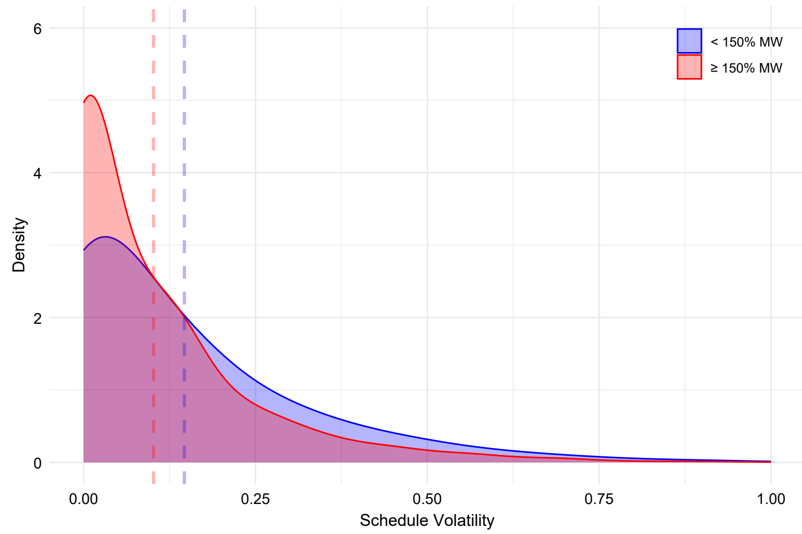
*Schedule Volatility.* To construct an individual level measure of schedule volatility in each quarter ($V_i^{t_q}$), we use both monthly data on actual hours worked last week ($h_i^{t_m}$) combined with information on usual hours worked ($\bar{h}_i^{t_{m,q}}$). We thus construct for each individual their relative schedule volatility as:

$$V_i^{t_q} = \sqrt{\mathbb{E}_m\left[\left(h_i^{t_{m,q}}/\mathbb{E}_m[\bar{h}_i^{t_{m,q}}]\right)^2\right]}. \tag{1}$$

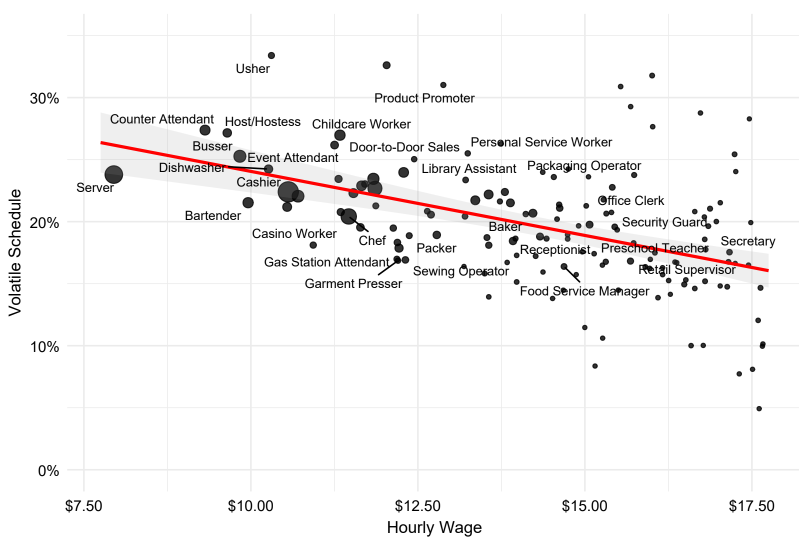
We thus measure volatility relative to the respondent's usual hours worked in a quarter $\mathbb{E}_m[\bar{h}_i^{t_{m,q}}]$. In Appendix **??** we show that similar patterns emerge without this normalization, and even for alternative schedule volatility measures such as the maximum difference in hours within a quarter.

Figure 1: The Distribution of Schedule Volatility

(a) Schedule Volatility by Wage




(b) Schedule Volatility by Occupations




*Notes.* This figures highlights the distribution of our schedule volatility measure computed in the Current Population Survey (CPS) data from 1994 to 2019. Panel (a) shows the means (dotted lines) and smoothed density functions for individuals that earn more, or less, than 150% of the minimum wage. We omit outliers with volatility above one. Panel (b) shows how schedule volatility differs across occupations.

Figure 1 highlights several features of the schedule volatility distribution. Panel (a) shows that workers who earn less than fifty percent more than the minimum wage have significantly more volatile schedules than those with wages above this threshold. The average schedule volatility in the former group is almost 50% higher, at 14.7% as opposed to 10.2% in the latter group, a difference that is significant at the 95% level. The main difference stems from many higher earnings workers having very stable schedules. These results are in line with recent work such as Maestas et al. (2017) and Katz and Krueger (2019) that documents lower-earning and -educated workers being more likely to be on-call and have unpredictable or irregular work.

In Panel (b) we show differences in schedule volatility across lower earning occupations. We find that the schedules of individuals in low skill service occupations are particularly volatile. A large fraction do food-related work, such as Servers, Hosts and Hostesses, Bartenders, Bussers, and Dishwashers. The widespread practice of short notice scheduling in these occupations is well documented – see for example Kamalahmadi et al. (2021). Workers in sales-related jobs, like Counter or Gas Station Attendants and Door-to-Door Sales, and those working in at events, like Ushers and Event Attendants also have volatile schedules. Overall, these results are in line with the narrative of Kalleberg (2011) about the *precarious* working conditions in low skill service occupations.

As another verification of our measure, we merge study how it relates to workers reporting 'varying' hours and having an 'irregular' shift schedule. The former is measured for the entire sample, since respondents answering questions about their usual hours can respond that they vary. The latter we measure with data from the last three Work Schedule Supplements (1997, 2001, and 2004). These question a limited subsample of respondents about their work schedules. We expect both measures to be positively related with schedule volatility. Table 2 shows the results from regressing both variables on our schedule volatility measure. In Panel (a) we show that respondents who report that their hours vary have schedules that are about one third more volatile. The association is similar the full sample and the low wage subsample, and holds when we introduce state and year fixed effects. In Panel (b) we consider the irregular schedule measure. We find that respondents that report having an irregular schedule also have higher volatility, but the association is weaker at 6 to 7% and is not statistically significant, although an important reason for the latter is the small sample size.

Table 2: Schedule Volatility, Varying Hours, and Irregular Schedules

(a) Hours Vary

| | *Dependent Variable*: log(Schedule Volatility) | | | |
|---|---|---|---|---|
| | Full Sample | Full Sample | Low Wage | Low Wage |
| Hours Vary | **0.33** | **0.33** | **0.27** | **0.27** |
| | (0.00) | (0.00) | (0.01) | (0.01) |
| State Fixed Effects | | ✓ | | ✓ |
| Year Fixed Effects | | ✓ | | ✓ |
| $R^2$ | 0.01 | 0.01 | 0.01 | 0.01 |
| Num. obs. | 654,387 | 654,387 | 236,591 | 236,591 |

(b) Irregular Schedule

| | *Dependent Variable*: log(Schedule Volatility) | | | |
|---|---|---|---|---|
| | Full Sample | Full Sample | Low Wage | Low Wage |
| Irregular Schedule | 0.06 | 0.06 | 0.07 | 0.07 |
| | (0.04) | (0.04) | (0.07) | (0.07) |
| State Fixed Effects | | ✓ | | ✓ |
| Year Fixed Effects | | ✓ | | ✓ |
| $R^2$ | 0.00 | 0.02 | 0.00 | 0.05 |
| Num. obs. | 2,880 | 2,880 | 1,022 | 1,022 |

*Notes.* This table reports the result from least squares regressions of our schedule volatility measure on information about workers' schedules from the three last Work Schedule Supplements (1997, 2001, and 2004) of the Current Population Survey (CPS). We include individuals aged 16 to 64 without any missing information that are not self employed nor work for the army. Bold faced estimates are significant at the 5% level. The low wage sample are individuals that earn less than 150% of the minimum wage.

### 3.2 Causal Evidence on Minimum Wages and Schedule Volatility

To estimate how minimum wages affect the volatility of hours, we run stacked event study regressions as introduced in Cengiz et al. (2019). This approach can accommodate the complexity of minimum wage reforms, which are staggered across states, repeated over time, and can potentially have dynamic effects. Both traditional fixed-effects models and recent staggered difference in differences approaches – see De Chaisemartin and d'Haultfoeuille (2020) or Callaway and Sant'Anna (2021) – have difficulties to accommodate all these features.[5]

[5]The stacked event study approach has recently been used in various other minimum wage studies, see for example Cengiz et al. (2019), Clemens and Strain (2021), Piqueras (2023), Blau et al. (2023), Wursten and Reich (2023), Li

The approach essentially consists of considering each minimum wage reform as its own event study, making sure that the control group is appropriately selected. The treated states are those that have had a minimum wage increase, and these are compared with states that did not have any increase over the given time window. We thus partition and duplicate our sample into various treatment and control cohorts ($c$) based on the period relative to each minimum wage increase. Time is defined in relation to the change in minimum wages within each cohort. We pool all cohorts into a single panel, on which we estimate the following regression equation:

$$\log V_i^{t_q} = \sum_{\tau=-2}^{3} \alpha_\tau I_{s,t}^{\tau} + \mu_s + \rho_t + \gamma_t^{\tau} + \Omega_{s,t} + u_{s,t}. \tag{2}$$

The log volatility of hours $\mathcal{V}_i^{t_q}$ in state $s$ at quarter $t$ is modeled as a function of $I_{s,t}^{\tau}$, which are indicators for a minimum wage increase $\tau$ periods from time $t$ of at least five percent. The main parameter of interest $\alpha_\tau$ measures the dynamic treatment effects at different times around the event. We include state $\mu_s$, period $\rho_t$, and cohort fixed effects $\gamma_t^{\tau}$ into the regression. We also control for minimum wage increases smaller than five percent through $\Omega_{s,t}$ in both the control and treatment groups. Standard errors are clustered at the cohort level.

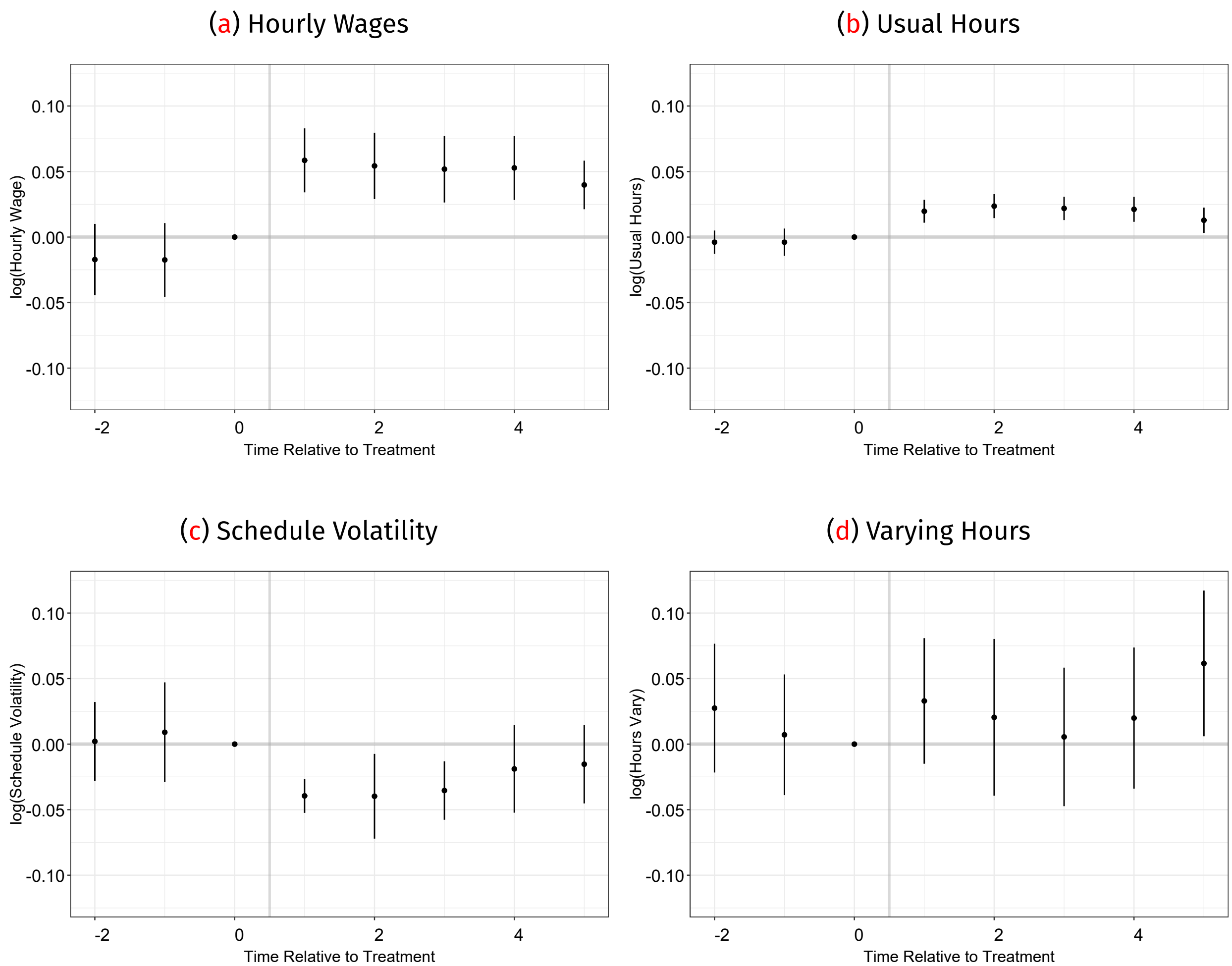
The results from our stacked event studies estimated on the group of respondents that earn less than 150% of the minimum wage can be found in Figure 2. We first show in Panel (a) that minimum wage increases have the expected effect of increasing hourly wages. The point estimates of a persistent increase of about seven percent are similar to those reported in other recent work such as Wursten and Reich (2023). Panel (b) highlights the effect on usual hours. In line with recent work such as Cengiz et al. (2019) and Gopalan et al. (2021) we almost no effect on hours worked. We even document a slight increase, the effect is less than two percent.

The first main result is shown in Panel (c). We find that minimum wage increases significantly lower scheduling volatility, which reduces by about four percent. The effect does seem to fade slightly over time, with the reduction halving by the next year. In Panel (d) we document a small but statistically insignificant increase in the fraction of workers that reports having varying hours. We show in Appendix **??** that our results are robust to the selection of our method (e.g. compared to a two way fixed effects model) and of volatility measure. We also find that restricting the

and Liu (2024), Godøy et al. (2024), and Schanzenbach et al. (2024).

sample to individuals that did not change jobs or tasks within their job yields the same result. On the other hand, we find that the schedule volatility of people that earn more than twice the minimum wage is not affected.

Figure 2: Stacked Event Studies




*Notes.* Results from the stacked event study regressions highlighted in Equation (2). Data from the Current Population Survey (CPS) from 1994 to 2019. We include individuals aged 16 to 64 without any missing information that are not self employed nor work in the army.

# 4 A model of Schedule Volatility

We interpret our results through a continuous time model of search and bargaining with an explicit job amenity, based on Flabbi and Moro (2012) but with consumption leisure complementarity in the sense of Becker (1965). Jobs are defined by their wages $w$ and a work schedule characterized by its level of volatility $v \in \{0, 1\}$. The worker's flow utility is:

$$U(w, v) = (1 - \alpha v)w - \gamma v, \tag{3}$$

where $\gamma$ captures a dislike of having a more volatile schedule, which we allow to be increasing with wages through $\alpha$. Their instantaneous utility when unemployed is denoted $U_b$.[6]

The flow profits of firms are given by:

$$\Pi(w, v, x) = (1 + \epsilon v)\, x + \kappa v - w, \tag{4}$$

where $x$ denotes the match specific productivity, $\kappa$ is a fixed benefit to the firm of having the ability to vary workers' schedules, and $\epsilon$ captures an interaction between having employees work volatile schedules and their productivity.

*Value Functions.* Workers and firms meet at an exogenous Poisson rate $\lambda$. Upon meeting they draw a match-specific productivity $x$ from a distribution $G(x)$. When they decide to match, the worker and firm bargain over the wage and whether the schedule will be volatile or not. Matches are terminated at a Poisson rate $\eta$. The instantaneous discount rate is $\rho$. We abstract from on the job search, and do not allow workers and firms to direct their search efforts.

As shown in Flabbi and Moro (2012), the value of employment ($V_E$) is defined by:

$$V_E(w, v) = \frac{u(w, v) + \eta V_U}{\rho + \eta}, \tag{5}$$

which is the sum of the instantaneous flow utility and the value of unemployment ($V_U$) weighted by the probability of becoming unemployed $\eta$. These values are discounted by both the intertemporal discount rate and the risk of job loss.

For an unemployed worker, the value function is:

$$V_U = \frac{U_b + \lambda \int \max\left[V_E(w, v), V_U\right] dG(x)}{\rho + \lambda}, \tag{6}$$

[6]We could allow for $U_b$ to be different for individuals with varying tastes for schedule volatility $\alpha$.

which is correspondingly defined as the flow utility from unemployment plus the option value of remaining in the unemployed state, in which the worker meets employers of different match qualities at a rate $\lambda$ and can decide to match with them or remain in unemployment. These values are again discounted by the inter-temporal discount rate and the probability of receiving an offer.

The value of filling a job on the firm side is defined by:

$$V_F(w, v, x) = \frac{\Pi(w, v, x)}{\rho + \eta}, \tag{7}$$

which are the discounted instantaneous profits net of the vacancy posting costs. As in Flabbi and Moro (2012) we assume the latter to be zero.

*Bargaining over Wages and Schedules.* When a worker and firm meet, they bargain over the match surplus. We assume that they play a Nash bargaining game, where workers' outside option is to remain unemployed and receive the value $V_U$, and firms' outside option is normalized at zero. Letting $\beta$ denote the workers' bargaining weight, the Nash product is given by:

$$S(w, v) = [V_E(w, v) - \rho V_U]^{\beta} [V_F(w, v, x)]^{1-\beta}. \tag{8}$$

This defines the equilibrium wage and flexibility level. Conditional on the level of schedule volatility, the optimal wage is given by (see details in Appendix A.1):

$$\tilde{w}(v, x) = \beta [(1 + \epsilon v)x + \kappa v] + (1 - \beta)\frac{\gamma v + \rho V_U}{1 - \alpha v}. \tag{9}$$

The first term is the share of the firm's surplus the worker is able to bargain. This increases in the worker's bargaining power $\beta$. The second part is related to the worker's outside option and dislike of working a volatile schedule. When schedules are not volatile ($v = 0$) this simplifies to the discounted outside option $\rho V_U$. When schedules are volatile workers are paid a compensation for their direct utility loss $\gamma$, which may increase when there is a strong consumption-leisure complementarity ($\alpha \to 1$).

The bargaining outcome in terms of schedule volatility is determined by the total surplus both regimes. The optimal choice can thus be reduced to the cut-off value where the surplus is equal. This indifference point is defined by (see Appendix A.2):

$$w^{**}(x) = \frac{\epsilon x + \kappa - \gamma}{\alpha}. \tag{10}$$

This expression tells us that, conditional on the productivity level $x$, workers and firms agree on a volatile schedule if the Nash bargained wage is below the cut off wage $w^{**}(x)$, which decreases in workers' dislike of volatility $\gamma$ and the complementarity between consumption and leisure $\alpha$, and increases in the additional profits that firms can make through $\epsilon$ and $\kappa$.[7] We further discuss the equilibrium strategies and conditions in Appendix A.3.

*Minimum Wages.* We can now study how introducing a minimum wage affects the equilibrium labor market outcomes. We do so by introducing minimum wages into our search and bargaining model in a similar manner to Cahuc et al. (2006). In their model, minimum wages act as a bargaining floor, assuring that workers are guaranteed a fallback option that pays $\underline{w}$ if no better match is available. This alters the threat point of workers by raising $V_U$, which affects the bargaining process. We will similarly assume that workers are guaranteed a job that pays the minimum wage with a volatile schedule. This means that the outside option changes from $U_b$ to $(1-\alpha)\underline{w} - \gamma$, the flow utility of working the volatile schedule job.

We derive a closed form expression for how this affects the cut-off value to choose the amenity when match specific productivity is uniformly distributed (see Appendix A.4):

$$\underline{w}^{**} \sim A \pm \sqrt{B - (1-\alpha)\underline{w} + \gamma}), \tag{11}$$

where $A$ and $B$ are functions of the model's primitives. This highlights that, depending on the primitives, minimum wages could increase or decrease the equilibrium level of schedule volatility in the labor market. The intuition is that minimum wages increase the outside option of the worker, elevating their bargaining power, and allowing them to obtain better contracts.

[7]Note that if we set $\alpha = 0$, the cut-off is no longer depends on wages, but only on productivity. If we then also set $\kappa = 0$ and $\gamma = -\alpha$, and $\epsilon = -\kappa$, we obtain the same results as in Flabbi and Moro (2012). If $\epsilon = 0$ productivity does not influence the disamenity choice.

## 4.1 Identification and Estimation

*Identification.* The parameters we need to identify are workers' preferences for schedule volatility ($\gamma$) and the complementarity parameter ($\alpha$), the effects of volatility on firms' production technologies ($\epsilon$ and $\kappa$) and the match-specific productivity distribution $G(x)$. We also need to identify the arrival ($\lambda$) and termination rates ($\eta$) of jobs, the intertemporal discount rate ($\rho$) and workers' bargaining power ($\beta$). In our proof of concept application, we take several parameters from Flabbi and Moro (2012), who estimate a similar model on the same data. Like them, we model productivity shocks as lognormally distributed with mean $3.01$ and standard deviation $0.48$. We also take over the separation rate $\eta = 0.02$ and the job arrival rate $\lambda = 0.22$. We also set the discount rate $\rho = 0.05$ and assume symmetric bargaining power $\beta = 0.5$.

The remaining parameters are identified as follows. Firm side production technologies $\epsilon$ and $\kappa$ are identified through differences in the means and standard deviations of wages in the two contract types. Worker-side preferences $\gamma$ and $\alpha$ are identified from the fraction of workers in a volatile contract and in unemployment, as seen in the reservation wage and the volatility cut-off functions. We define the parameters to be estimate by $\theta = \{\epsilon, \kappa, \gamma, \alpha\}$.

*Estimation.* We estimate the model's parameters through a Simulated Method of Moments (SMM) procedure that minimizes a loss function with various moments of the wage distribution. For a given vector $\theta$, we simulate moments, and compare these with those estimated from the data. More formally the SMM estimator solves:

$$\hat{\theta}_{smm} = \arg\min_{\theta} \left[\Psi(\theta) - \delta\right]' W \left[\Psi(\theta) - \delta\right], \tag{12}$$

where $\delta$ is the vector of moments calculated from out data, and $\Psi(\theta)$ is the corresponding vector of simulated moments. In this proof of concept application, we fix the weighting matrix $W$ as the identify matrix.

# 5 Results

## 5.1 Model Estimation

*Sample and Moments.* We limit our sample from the Current Population Survey to the 2014-2019 period, and aggregate the data for different minimum wage levels. We observe 85 different minimum wages across the period. For each different minimum wage level, we calculate a vector of six moments. The first is the fraction of workers with a volatile contract. The second and third are the mean and standard deviation of workers with a volatile contract. The fourth and fifth are the analogous moments for those without a volatile contract. The sixth is the unemployment rate, which we set at 0.04 for each minimum wage level. This builds on previous work such as Cengiz et al. (2019) that finds no clear employment effects of minimum wage policies.

The unemployment rate in the model is calculated as $u_r = \frac{\eta}{\xi\lambda+\eta}$, where $\xi$ is the job acceptance rate, i.e., the fraction of meetings that result in a match. Given that we have closed-form solutions for wages and an explicit amenity cut-off choice, we only need to solve numerically for the value of unemployment. We do so by simulating 100,000 productivity draws and looking for a fixed point.

*Results.* The estimated parameters are reported in Table 3. Standard errors can be obtained by bootstrapping. As expected, we find that workers dislike schedule flexibility, which reduces their utility by 0.03, in addition to a cost of 0.0006 due to consumption leisure complementarities. On the firm-side, we find a large gain of having flexibility in scheduling workers' hours, at 1.09. We also find a negative effect on productivity of -0.05, which could either be driven by scheduling flexibility being more valuable in low productivity matches, or because volatility reduces workers' productivity as in Kamalahmadi et al. (2021). These results are overall mainly driven by firm-side factors.

Table 3: Estimated parameters

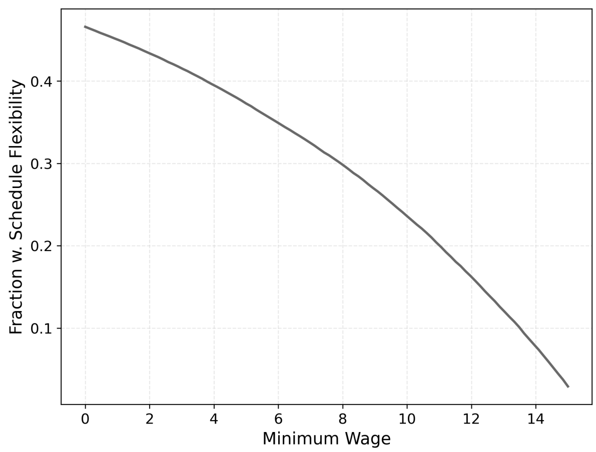
| Parameter | Estimate |
|---|---|
| $\alpha$ | 0.0006 |
| $\gamma$ | 0.0308 |
| $\epsilon$ | -0.0454 |
| $\kappa$ | 1.0871 |

## 5.2 Simulations

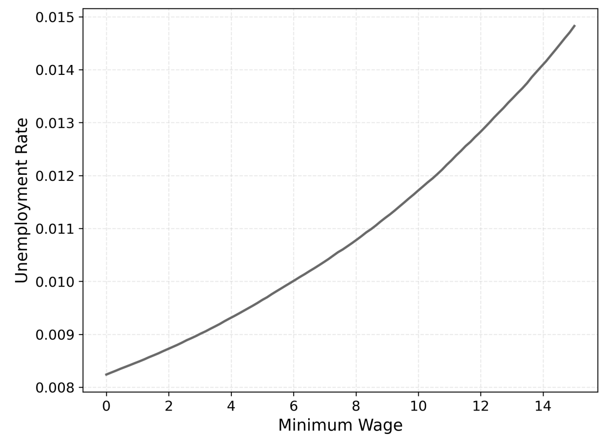
To evaluate how minimum wage changes affect equilibrium employment and scheduling volatility, we simulate the outcomes for various minimum wages, ranging from 0 to 15$. The results from this analysis can be seen in Figure 3.

Figure 3: Model Predictions for Different Minimum Wages

(a) Fraction of Workers with Volatile Schedules

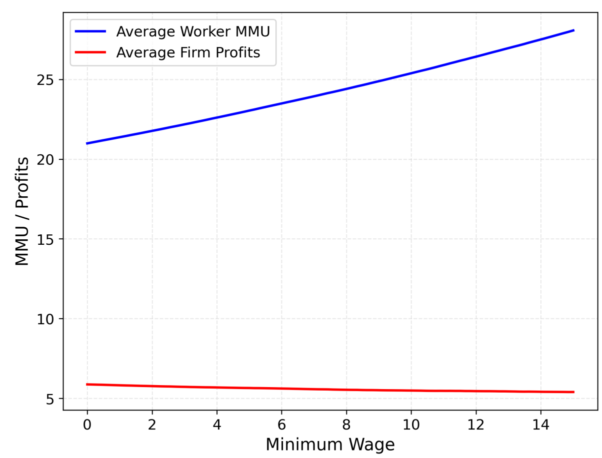



(b) Unemployment Rates




(c) Wages by Contract Type


(d) Worker and Firm Surplus




In Panel (a) we study the relation between minimum wages and the equilibrium fraction of workers with a volatile contract. We find a strongly negative relation – as minimum wages increase, workers' bargaining power increases, and they are less and less willing to accept volatile contracts. When there is no minimum wage, almost half of the workers have a volatile contract, but this reduces to less then 10% when the minimum wage is at 15 dollars. This aligns with our empirical evidence, and shows that, at higher wage floors, the surplus generated from the volatility of these contracts is insufficient to compensate for the disutility of schedule volatility.

We do find a strong unemployment increase in Panel (b). The model predicts an increase in unemployment of almost 40% when the minimum wage increases from 7.5 to 15 dollars. But this is mainly due to the functional forms we imposed. We also see in Panel (c) that the wages in volatile jobs increase with the minimum wage, while the wages for non-volatile jobs remain consistent. For the volatile worker, this is consistent with the theoretical predictions. For the non-volatile worker, we see counteracting forces. First, the wages of the incumbent non-volatile workers increase the average wage. On the other hand, low-productivity workers who used to choose the volatile contract now choose the non-volatile contract, thus decreasing the average wage. The upward wage pressure prevails over the compositional effect, increasing wages but at a lower rate than for volatile workers.

*Welfare Analysis.* Because we have homogeneous agents, we can express a money-metric utility (MMU) to capture the changes in welfare. For firms, this can be expressed as their profits. For workers without disamenities, it can be expressed as their wage, and for workers with disamenities, it can be expressed as their wage plus the welfare loss from the disamenity, expressed in dollars: $w_0 = (1-\alpha)w_1 - \gamma$, which represents their utility value.

The results from this analysis are shown in Panel (d) of Figure 3 alongside the firm profits. Note that we only show the profits and MMU for the matched pairs. This is not an issue given that the unemployment rate remains almost unchanged. We see that the average worker's utility increases with the minimum wage, while firm profits decrease. This is due to the increased bargaining power of the worker. However, the MMU of the workers increases more than the profits decrease. This is likely because the individuals switching from volatile to non-volatile contracts are the highest-productivity workers. Because of the substitution effect between productivity and disamenity, the economic value of the switching is rather small. Additionally, the lowest-productive workers will drop out of the labor market, thus increasing the average productivity of the workers.

In general, we can conclude that the welfare of the worker increases as the minimum wage increases, at the expense of profits and individuals who drop out of the labor market.

# 6 Conclusion

This paper contribute to the vast literature that studies how minimum wages affect various dimensions to employment. We consider an attribute that has thus far been under explored – the volatility of workers' schedules. To do so, we first introduce a novel individual-level schedule volatility measure in the United States. We find that minimum wage increases lead to a statistically significant five percent reduction in volatility.

We interpret these results through a model of search and bargaining in the spirit of Flinn (2006) and Cahuc et al. (2006), where minimum wages affect the bargaining process between workers and firms. We estimate the model.. [**to do**]

To summarize, our results suggests that minimum wage policies may offer benefits in terms of stabilizing work schedules – a dimension that traditional analyses have overlooked. Accounting for these side effects would lead to more comprehensive evaluations of minimum wage interventions, and can better inform policy debates regarding the desirability and optimum level of minimum wages.

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# A Appendix: Derivations search and bargaining

## A.1 Derivation of the Nash Equilibrium Wage

The worker's surplus is:

$$S_W(w, \mathcal{V}) = u(w, \mathcal{V}) - \rho\, V_U,$$

the firm's surplus is:

$$S_F(x, w, \mathcal{V}) = \pi(x, w, \mathcal{V}).$$

The Nash product to be maximized is

$$S(w, \mathcal{V}) = \Big[S_W(w, \mathcal{V})\Big]^{\beta} \Big[S_F(x, w, \mathcal{V})\Big]^{1-\beta}. \tag{13}$$

Since the common factor $1/(\rho + \eta)$ cancels, we substitute (5) and (7) to obtain:

$$S(w, \mathcal{V}) = [(1 - a\,\mathcal{V})w - \mathcal{V}\,b - \rho\,V_U]^{\beta}\,[(1 + e\,\mathcal{V})x + K\,\mathcal{V} - w]^{1-\beta}.$$

Taking logarithm yields:

$$\begin{aligned} \ln S(w, \mathcal{V}) = \beta\, \ln\left[(1 - a\,\mathcal{V})w - \mathcal{V}\,b - \rho\,V_U\right] \\ + (1-\beta)\, \ln\left[(1 + e\,\mathcal{V})x + K\,\mathcal{V} - w\right]. \end{aligned} \tag{14}$$

Differentiating (14) with respect to $w$ (treating $\mathcal{V}$ as a parameter) gives the first-order condition:

$$\frac{\beta(1 - a\,\mathcal{V})}{(1 - a\,\mathcal{V})w - \mathcal{V}\,b - \rho\,V_U} - \frac{(1-\beta)}{(1 + e\,\mathcal{V})x + K\,\mathcal{V} - w} = 0. \tag{15}$$

Rearranging (15) leads to

$$\frac{\beta(1 - a\,\mathcal{V})}{(1 - a\,\mathcal{V})w - \mathcal{V}\,b - \rho\,V_U} = \frac{(1-\beta)}{(1 + e\,\mathcal{V})x + K\,\mathcal{V} - w}. \tag{16}$$

Multiplying both sides by the denominators yields:

$$\beta(1-a\,\mathcal{V})\Big[(1+e\,\mathcal{V})x+K\,\mathcal{V}-w\Big]=(1-\beta)\Big[(1-a\,\mathcal{V})w-\mathcal{V}\,b-\rho\,V_U\Big].$$

For notational convenience, define

$$A=1-a\,\mathcal{V},\quad C=1+e\,\mathcal{V},\quad D=K\,\mathcal{V}.$$

Then the above becomes

$$\beta\,A\Big[Cx+D-w\Big]=(1-\beta)\Big[A\,w-\mathcal{V}\,b-\rho\,V_U\Big].$$

Solve for $w$ by first expanding:

$$\beta\,A\,Cx+\beta\,A\,D-\beta\,A\,w=(1-\beta)A\,w-(1-\beta)\Big(\mathcal{V}\,b+\rho\,V_U\Big).$$

Collect the $w$ terms:

$$\beta\,A\,Cx+\beta\,A\,D+(1-\beta)\Big(\mathcal{V}\,b+\rho\,V_U\Big)=\beta\,A\,w+(1-\beta)A\,w.$$

Thus, the solution is

$$w(\mathcal{V},x)=\frac{\beta\,A\,C\,x+\beta\,A\,D+(1-\beta)\Big(\mathcal{V}\,b+\rho\,V_U\Big)}{A}. \tag{17}$$

Substituting back $A=1-a\,\mathcal{V}$, $C=1+e\,\mathcal{V}$, and $D=K\,\mathcal{V}$, we obtain

$$w(\mathcal{V},x)=\frac{\beta(1-a\,\mathcal{V})(1+e\,\mathcal{V})x+\beta(1-a\,\mathcal{V})(K\,\mathcal{V})+(1-\beta)(\mathcal{V}b+\rho\,V_U)}{(1-a\,\mathcal{V})}.$$

## A.2 Optimal Disamenity Choice: Wage Cutoff

The decision whether to choose $\mathcal{V}=0$ or $\mathcal{V}=1$ is determined by comparing the total flow surplus.

**Total Surplus When $\mathcal{V} = 0$:**

$$TS_0 = x.$$

**Total Surplus When $\mathcal{V} = 1$:**

$$TS_1 = (1 + e)x + K - b - aw.$$

Setting $TS_0 = TS_1$:

$$x = (1 + e)x + K - b - aw.$$

Rearranging:

$$-e\,x + b - K = -aw.$$

Solving for $w$:

$$w^*(x) = \frac{e\,xK - b}{a}.$$

This wage cutoff determines the optimal disamenity choice: for a given productivity $x$, if the unconstrained Nash wage under $\mathcal{V} = 1$ (i.e. $w(1, x)$) is below $w^*(x)$ then the match will choose $\mathcal{V} = 1$; otherwise, it will choose $\mathcal{V} = 0$.

We can also express the cut-off in function of the productivity, conditional on the wage:

$$x^*(w) = \frac{b - K - (c - a)w}{e}.$$

Note that we can subsitute the Nash wage into the wage cut-off formula to retrieve an expression in function of $x$. We can also invert the nash wage to make $x$ a function of $w$. This can also be substitued in to get a formula only dependent on $w$. However these closed form expression are intractable. To simplify it we set $K = 0$, this gives a producutivty treshold of:

$$x^{**} = \frac{-V_U a\beta\rho + V_U a\rho - ab\beta + b}{a^2\beta e + a^2\beta - a\beta e - a\beta - ae + e}$$

And a wage treshold of:

$$w^{**} = \frac{-V_U \beta e\rho + V_U e\rho - ab\beta e - ab\beta + b\beta + be}{a^2\beta e + a^2\beta - a\beta e - a\beta - ae + e} \tag{18}$$

Note thet the cut-offs are therefore explecitly dependent on the bargaining power and the outside option.

### A.3 Equilibrium Conditions

#### Reservation Wage

The reservation wage:

$$w^* = \frac{\rho V_U + b\mathcal{V}}{1 - a\mathcal{V}}.$$

This means:

- If $\mathcal{V} = 0$, the reservation wage simplifies to $w^*(0) = \rho V_U$.
- If $\mathcal{V} = 1$, the reservation wage is $w^*(1) = \frac{\rho V_U + b}{1-a}$.

Thus, a worker **rejects** any wage below $w^*(\mathcal{V})$ and **accepts** any wage above it.

#### Optimal Disamenity Choice: Wage Cutoff

The wage cutoff where the worker is indifferent between working with or without the disamenity is:

$$w^{**}(x) = \frac{b - e\,x - K}{c - a}.$$

Thus:

- If the bargained wage $w(1, x) < w^{**}(x)$, the worker accepts the disamenity ($\mathcal{V} = 1$).
- Otherwise, the worker prefers not having the disamenity ($\mathcal{V} = 0$).

#### Equilibrium Cases

The equilibrium outcome depends on three key threshold productivities:

- $x^*(0)$ – reservation productivity under no disamenity (i.e., $w^*(0)$).
- $x^*(1)$ – reservation productivity under disamenity (i.e., $w^*(1)$).
- $x^{**}$ – productivity at which the job market is indifferent between $\mathcal{V} = 0$ and $\mathcal{V} = 1$.

**Case 1:** $x^{**} < x^*(1)$

Dependingen on the parameters it is possible that the reservation wage under having the disamenity is higher than the wage cut-off for choosing the disamenity. This is means that even for low wage workers, the productivity increase does not outweight the utility costs. In this case, the worker will never choose the disamenity. The equilibrium strategy is then to reject any job offer below $x^*(0)$ and accept any job offer above $x^*(0)$.

$$x^*(1) < x^{**} < x^*(0).$$

The equilibrium strategy is:

- Reject jobs where $x < x^*(0)$.
- Accept a job without disamenity ($\mathcal{V} = 0$) if $x \geq x^*(0)$.

**Case 2:** $x^{**} > x^*(1)$

When the reservation wage is under the disamenity cut-off, i.e. for low wage workers, the productivity increase does outweight the utility costs:

$$x^*(1) < x^*(0) < x^{**}.$$

The equilibrium strategy is:

- Reject jobs where $x < x^*(1)$.
- Accept a job with disamenity ($\mathcal{V} = 1$) if $x^*(1) \leq x < x^{**}$.
- Accept a job without disamenity($\mathcal{V} = 0$) if $x \geq x^{**}$.

### Equilibrium Condition

At equilibrium, the unemployment value $V_U$ must satisfy:

$$(\rho + \lambda)V_U = u_b + \lambda \int \max\Big\{V_E\big(w, \mathcal{V}\big), V_U\Big\} dG(x).$$

where the hazard rate out of unemployment is:

$$r(i) = \lambda\big[1 - G(x^*(0))\big] \quad \text{(Case 1)}. \tag{19}$$

or

$$r(i) = \lambda\big[1 - G(x^*(1))\big] \quad \text{(Case 2)} \tag{20}$$

Where $i$ denotes the worker type. The equilibrium **unemployment rate** is then:

$$U = \frac{\eta}{\eta + \langle r(i) \rangle}.$$

where $\langle r(i) \rangle$ is the average hazard rate across worker types.

### Wage Distribution at Equilibrium

The final wage distribution is a **mixture** of:

- The Nash bargaining outcome $w(\cdot, 0)$ if $x \geq x^{**}$.
- The Nash bargaining outcome $w(\cdot, 1)$ if $x^*(1) \leq x < x^{**}$.

## A.4 Closed form equilibrium

In order to get closed form solutionS for the equilibrium, we need a closed form solution for the unemployment value $V_U$. We will make the very strict assumption that G(x) is a uniform distribution. This allows us to get a closed form solution for the unemployment value.

Note that we can write the value of employment as:

$$\begin{aligned} V_E(w, \mathcal{V}) &= \frac{u(w, \mathcal{V}) + \eta V_U}{\rho + \eta}, \\ &= \frac{(1 - a\mathcal{V})w(\mathcal{V}, x) - b\mathcal{V} + \eta V_U}{\rho + \eta}. \end{aligned} \tag{21}$$

Where $w(\mathcal{V}, x)$ is the Nash wage. Note that we can rewirte $w(\mathcal{V}, x) = A'x + B' + C'V_u$, where A',B' and C' are only dependent on exogonous parameters.

$$V_E(w,\mathcal{V}) = \frac{(1-a\mathcal{V})A'x + (1-a\mathcal{V})B' + (1-a\mathcal{V})C'V_U - b\mathcal{V} + \eta V_U}{\rho+\eta}, \\ = \frac{(1-a\mathcal{V})A'x + (1-a\mathcal{V})B' - b\mathcal{V} + ((1-a\mathcal{V})C'+\eta)V_U}{\rho+\eta} \\ = Ax + B + CV_U. \tag{22}$$

Note that when $\mathcal{V}=0$, this reduces to: $V_E(w,0) = \beta x + (1-\beta)\rho V_U$. When $\mathcal{V}=1$ this becoms:

$$A = \frac{\beta(1-a)(e+1)}{(\eta+\rho)}, B = \frac{K\beta(1-a)^2 + b(1-\beta)}{(1-a)(\eta+\rho)}, C = \frac{\eta-\rho(\beta-1)}{\eta+\rho}.$$

If we assume $G(x)$ to be uniformally distrubted between $0$ and $M$, $V_U$ satisfies the standard Bellman equation:

$$(\rho+\lambda)V_U = b_0 + \lambda\int_0^M \max\big[V_E(x),\, V_U\big]\frac{dx}{M}.$$

This is the key equation from which we want to solve for $V_U$.

## Reservation Productivity

We let $x^*$ be the reservation productivity, i.e. the smallest $x$ that is accepted. Then

$$\begin{cases} x < x^* \implies V_E(x) < V_U \quad \text{(reject)} \\ x \geq x^* \implies V_E(x) \geq V_U \quad \text{(accept)}. \end{cases}$$

Hence $x^*$ is pinned down by $V_E(x^*) = V_U$. Substituting $V_E(x^*) = A\,x^* + B + C\,V_U$ yields

$$A\,x^* + B + C\,V_U = V_U \implies A\,x^* + (B + (C-1)\,V_U) = 0, \tag{23}$$

which gives us:

$$x^* = \frac{V_U - B - C\,V_U}{A} = \frac{V_U(1-C) - B}{A}.$$

### Bellman Equation for $V_U$

Rewrite:

$$(\rho+\lambda)\,V_U = b_0 + \lambda \left[\int_0^{x^*} V_U \,\frac{dx}{M} + \int_{x^*}^{x^{**}} V_E(x,\mathcal{V}=1)\,\frac{dx}{M} + \int_{x^{**}}^{M} V_E(x,\mathcal{V}=0)\,\frac{dx}{M}\right].$$

We used $\max\{V_E(x), V_U\} = V_U$ for $0 \le x < x^*$ (reject region), $V_E(x,\mathcal{V}=1)$ for $x^* \le x < x^{**}$ (accept with disamenity) and $V_E(x,\mathcal{V}=0)$ for $x \ge x^{**}$ (accept without disamenity) .

### Reject Region Integral

$$\int_0^{x^*} V_U\,\frac{dx}{M} = V_U\,\frac{x^*}{M}.$$

### Accept with Disamenity Integral

$$\int_{x^*}^{x^{**}} V_E(x,\mathcal{V}=1)\,\frac{dx}{M} = \int_{x^*}^{x^{**}} \left[A\,x + B + C\,V_U\right]\frac{dx}{M}.$$

Pull out the $1/M$ factor:

$$\frac{1}{M}\int_{x^*}^{x^{**}} \left[A\,x + B + C\,V_U\right] dx = \frac{1}{M}\left[\int_{x^*}^{x^{**}} A\,x\,dx + \int_{x^*}^{x^{**}} B\,dx + \int_{x^*}^{x^{**}} C\,V_U\,dx\right].$$

Compute each piece:

$$\int_{x^*}^{x^{**}} A\,x\,dx = A\left[\tfrac{x^2}{2}\right]_{x^*}^{M} = \frac{A}{2}\big((x^{**})^2 - (x^*)^2\big),$$

$$\int_{x^*}^{x^{**}} B\,dx = B\,(x^{**}-x^*), \qquad \int_{x^*}^{x^{**}} C\,V_U\,dx = C\,V_U\,(x^{**}-x^*).$$

Hence,

$$\int_{x^*}^{x^{**}} V_E(x,\mathcal{V}=1)\,\frac{dx}{M} = \frac{1}{M}\Big[\frac{A}{2}\big((x^{**})^2-(x^*)^2\big) + B\,(x^{**}-x^*) + C\,V_U\,(x^{**}-x^*)\Big].$$

### Accept without Disamenity Integral

$$\int_{x^{**}}^{M} V_E(x,\mathcal{V}=0)\,\frac{dx}{M} = \int_{x^{**}}^{M} \left[\beta x + (1-\beta)\rho\,V_U\right]\frac{dx}{M}.$$

$$= \frac{1}{M}\Big[\frac{\beta}{2}\big(M^2 - (x^*)^2\big) + (1-\beta)\rho\, V_U\, (x^{**} - x^*)\Big].$$

## Combine into the Bellman Equation

Putting it all into (**??**):

$$(\rho+\lambda)\, V_U = u_b + \lambda\Big\{ \underbrace{V_U\,\frac{x^*}{M}}_{\text{reject region}} + \underbrace{\frac{1}{M}\Big[\frac{A}{2}\big((x^{**})^2 - (x^*)^2\big) + B(x^{**} - x^*) + C\, V_U(x^{**} - x^*)\Big]}_{\text{disamenity region}}$$

$$+ \underbrace{\frac{1}{M}\Big[\frac{\beta}{2}\big(M^2 - (x^{**})^2\big) + (1-\beta)\rho\, V_U\, (M - x^{**})\Big]}_{\text{no-disamenity region}}\Big\}.$$

Note that $x^{**}$ is a linear function of $V_U$, and $x^*$ is a linear function of $V_U$ as well. . Hence, $V_U$ is a linear function of $V_U$:

$$0 = (b_0 + D) + E\, V_U. + F\, V_U^2.$$

where $D$, $E$ and $F$ are functions of the exogenous parameters. This is a quadratic equation in $V_U$ that can be solved for $V_U$.

We thus find that:

$$\textbf{??} V_U \sim G' \pm \sqrt{H' - u_b} \tag{24}$$

This is an important result because the **?** style minimum wage will replace $u_b$ with the minimum wage. If we fill this in in 18, we see that the wage cut-off is linear in the value of the outside option. Combining this with **??** gvies us a wage cut-off:

$$w^{**} \sim G \pm \sqrt{H - w_m in - b} \tag{25}$$

Where $H$ and $G$ are composites of the model primitives.

### A.5 Constructing Experiments

This Appendix contains further details on the construction of our experiments. We follow the literature such as Wursten and Reich (2023) and only consider minimum wage increases of at least five percent. To implement the stacked event study method of Cengiz et al. (2019), we start by constructing sub experiments. The data starts in the first quarter of 1994 and ends in the last quarter of 2019. This means that we have 112 quarters. Since we make cohorts of observations of at least 8 quarters, we can consider 103 cohorts. We construct a treatment indicator as a dummy variable to indicate a minimum wage increase in the fourth quarter in this cohort. The control group is made up of all the states that had no minimum wage increase at all in the cohort period. If a treated state experiences multiple minimum wage experiences, we keep it as treated, but control for the additional increases in our regression.

### A.6 Concave Utility

The previous model was interesting to derive the equilibrium conditions and to get intuition in the potential pathways. However, it is not very realistic. In reality we would suspect concave utility in wages. This makes the solution of the bargaining problem not closed form anymore. We will therefore simulate the model to get a better understanding of the potential pathways.

The utility function for the worker is given by:

$$u(w, \mathcal{V}) = a \log(w) - b\mathcal{V},$$

where $a > 0$ is a scaling paramter independent of the disamenity choice, and $b > 0$ is the utility cost of the disamenity. The firm's profit function is:

$$\pi(x, w, \mathcal{V}) = x + c\mathcal{V} - w.$$

With $c0$ is the productivity increase of the disamenity.

The structure of the rest of the model remains the same. The Nash wage is thus givne by the solution to:

$$
\begin{aligned}
w(\mathcal{V},x) &= \arg\max_{w} \left[S_W(w,\mathcal{V})\right]^{\beta}\left[S_F(x,w,\mathcal{V})\right]^{1-\beta} \\
&= \arg\max_{w} \left[a\log(w) - b\mathcal{V} - \rho V_U\right]^{\beta}\left[x + c\mathcal{V} - w\right]^{1-\beta}.
\end{aligned}
$$

### First-Order Condition

We take the logarithm of the Nash product and differentiate with respect to $w$:

$$
\ln \mathcal{S}(w(\mathcal{V},x)) = \beta \ln\left(a\ln w - b\mathcal{V} - \rho V_U\right) + (1-\beta)\ln\left(x + c\mathcal{V} - w\right).
$$

Differentiating and setting to zero gives the first-order condition:

$$
\begin{aligned}
\frac{\beta a}{w(a\ln w - b\mathcal{V} - \rho V_U)} &= \frac{1-\beta}{x + c\mathcal{V} - w} \\
\beta a(x + c\mathcal{V} - w) &= (1-\beta)w(a\ln w - b\mathcal{V} - \rho V_U) \\
aw(\beta + (1-\beta)\ln w) &= (1-\beta)(b\mathcal{V} + \rho V_U) + \beta(x + c\mathcal{V})
\end{aligned}
$$

This equation contains $w$ both outside and inside the logarithmic term, preventing an closed-form solution. The Nash wage can be found numerically.

### Intuition for the Choice of $\mathcal{V}$

Once we obtain $w(0,x)$ and $w(0,x)$ numerically, the worker and firm must decide whether to choose $\mathcal{V} = 1$. The decision is based on a total surplus comparison. Choosing $\mathcal{V} = 1$ occurs when:

$$
x + c - w(1,x) + [a\log(1,x) - b] > x - w(0,x) + a\log w(0,x)
$$

The treshold wage for choosing the disamenity now again does not have a closed form solution as we have $w$ and $\log w$ in the equation. We will have to solve this numerically as well. The decision to adopt $\mathcal{V} = 1$ is driven by the tradeoff between the productivity gain $cx$ and the disamenity cost $b$. If $c$ is large relative to $b$, the firm is more likely to offer a wage that compensates the worker for the disamenity, making $\mathcal{V} = 1$ optimal for a larger range of productivity values. Conversely, if $b$ is large relative to $c$, the worker is unlikely to accept a contract with $\mathcal{V} = 1$, unless the firm offers a substantially higher wage. Due to the concavity of the utlity, if wages increases, the workers are naturally more likely to not accept the disamenity.

The rest of the model remains the same. The equilibrium strategies for workers and the equilibrium conditions are thus similar to the one discussed in appendix A.3, but all the cut-offs are now to be solved numerically.

# B Estimation

We use the same callibration as for our main specification outline in 5.1. We use Brent's method to solve the Nash wage and a fixed-point mapping to recover the value of unemployment. We use the L-BFGS-B method to estimate the parameters. We also use Nelder-Mead and Differential Evolution to check the robustness of the results. We find that the Nelder-Mead method gives the best results, i.e., the lowest sum of squares. The estimated parameters are reported in Table 4. The standard errors are currently derived based on the Hessian. The results indicate that $a$, the scale parameter in utility, is estimated at 10.027. The disamenity cost $b$ is estimated at 0.800, while the fixed productivity gain from flexibility $c$ is estimated at 1.104.

| Parameter | Estimate | Standard Error |
|---|---|---|
| $a$ | 10.027 | (0.0100) |
| $b$ | 0.800 | (0.0072) |
| $c$ | 1.104 | (0.0093) |

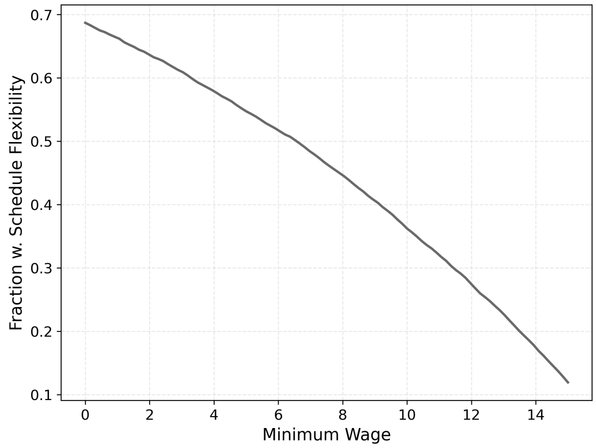
Table 4: Estimated parameters for the concave utility model.

## B.1 Model Predictions

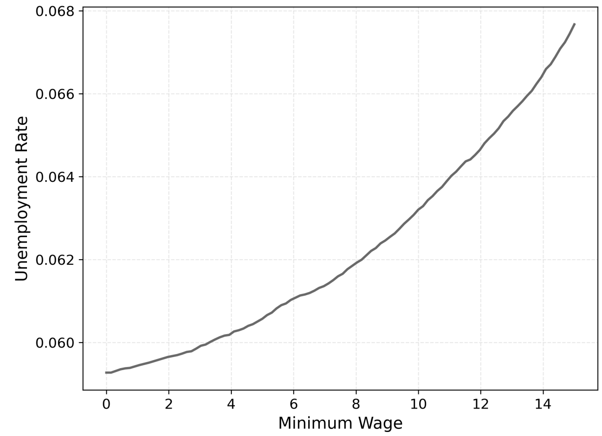
To evaluate how minimum wage changes affect employment and flexibility decisions, we simulate equilibrium outcomes across a range of minimum wages from 0 to 15. Figure 4 displays the fraction of flexible workers and the unemployment rate as a function of the minimum wage. It also displays the wages for volatile and non-volatile jobs, as well as the profits for firms and the utility of workers.

The results indicate a strong negative relationship between the minimum wage and the fraction of workers choosing flexible contracts. As the minimum wage increases, workers are less

Figure 4: Model Predictions for Different Minimum Wages

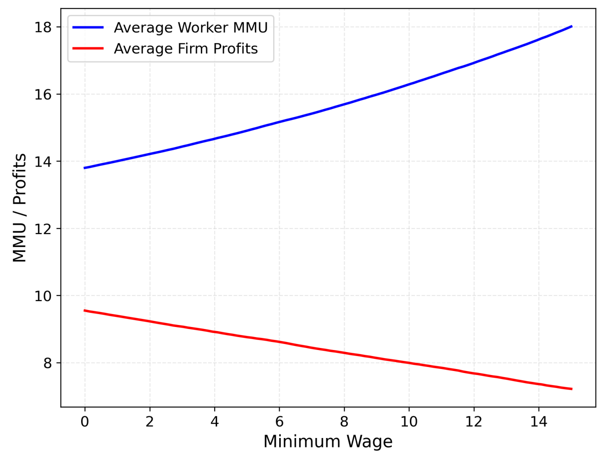



(a) Fraction of Workers with Schedule Flexibility




(b) Unemployment Rate


(c) Wages per Contract Type




(d) Worker and Firm Surplus

willing to accept volatile schedules, reducing the prevalence of these contracts in equilibrium. This outcome aligns with theoretical expectations: at higher wage floors, the surplus generated from the flexibility of these contracts is insufficient to compensate for the disutility of schedule volatility. Additionally, because the utility of the individual is logarithmic in wages and profits are linear in wages, the Nash bargaining favors firms. However, the minimum wage increases the outside option of the worker, thus giving them higher wages. The resulting higher wage makes the disutility of the disamenity not worth it anymore. The impact on unemployment is almost non-existent, consistent with the data. The small increase, however, is due to the functional forms. We can see in Figure 4c that the wage for volatile jobs increases with the minimum wage, while the wage for non-volatile jobs remains consistent. For the volatile worker, this is consistent with the theoretical predictions. For the non-volatile worker, we see counteracting forces. First, the wages of the incumbent non-volatile workers increase the average wage. On the other hand, low-productivity workers who used to choose the volatile contract now choose the non-volatile contract, thus decreasing the average wage.

Because we have homogeneous agents, we can express a money-metric utility (MMU) to capture the changes in welfare. For firms, this can be expressed as their profits. For workers without disamenities, it can be expressed as their wage, and for workers with disamenities, it can be expressed as their wage plus the welfare loss from the disamenity, expressed in dollars. This is given by:

$$a \log(w_0) = a \log(w_1) - b \quad \Leftrightarrow \quad w_0 = w_1 \exp\left(-\frac{b}{a}\right) \tag{26}$$

We can then calculate the money-metric utility for each group and compare the changes in welfare. This is shown in Figure 4d alongside the firm profits. Note that we only show the profits and MMU for the individuals/firms that remain matched. This is not an issue given that the unemployment rate remains almost unchanged. We see that the average worker's utility increases with the minimum wage, while firm profits decrease. This is due to the increased bargaining power of the worker.

In general, we can conclude that the welfare of the worker increases as the minimum wage increases, at the expense of profits.