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WORKING HOURS, HEALTH AND ABSENTEEISM, AND PERFORMANCE PAY

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ABSTRACT

Excessive working hours may induce exhaustion, workplace health problems, and absenteeism. These phenomena might be amplified by employers' use of performance-based pay, which may spur employees to work longer hours in pursuit of higher output and pay. These issues are investigated empirically in broad, worker-firm matched panel data from Britain from 2004 and 2011. A positive relationship between long hours and absenteeism is suggested. Long workplace hours tend to increase as the fraction of workers receiving performance-based pay rises, if the cutoff for "long weekly hours" is between 35 and 39, inclusive, but not for cutoffs of 40 or more.

Keywords: work hours, health, performance pay, workplace injury and illness, absenteeism

JEL Classification Code: J24, J22, J33, J28

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Jed DeVaro and John Pencavel*

I. Introduction

Two distinct workplace phenomena have been empirically documented, independently, concerning workers' productivity, working hours, health and absenteeism, and mode of compensation. First, beyond a certain threshold, long working hours are associated with diminished productivity. That result has been found both at the level of individual workers and of workplaces, for both labor productivity and financial performance, and across a wide variety of occupations and industries operating under different conditions. Second, performance pay has been found, at the establishment level, to relate positively to absenteeism and to certain types of workplace health problems that dampen the productivity-enhancing effects of such pay.

These two phenomena are potentially related. The mechanism underlying the deleterious productivity effects of long hours might be fatigue-induced absenteeism and an increased incidence of the workplace health ailments that are associated with diminished productivity. To the extent that performance pay encourages workers to toil longer and harder, potentially to the point of exhaustion, illness, or absenteeism, the mechanism for the dampened productivity-enhancing effects of performance pay might be the fatigue induced by long working hours. A potential chain reaction is therefore suggested in which performance pay encourages long working hours, which in turn erode productivity via an increased incidence of workplace health problems and absenteeism. Exploration of the potential connection between the aforementioned two phenomena has not been conducted and is the contribution of this study. The topic has important implications for social welfare; it has been estimated that, in the United States alone, fatigue-related, health-related, lost productive work time to employers is $136.4 billion annually, which says nothing of the human costs that workers bear from adverse health outcomes (Ricci et al. 2007).

The U.S. Department of Labor's Occupational Safety and Health Administration (OSHA), on its web page entitled "Long Work Hours, Extended or Irregular Shifts, and Worker

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Fatigue",[1] cites the following examples of health problems and accidents arising from the decreased alertness of fatigued workers. In a survey of 2737 medical residents, every extended shift scheduled in a month increased the monthly risk of a motor vehicle crash during the commute home from work by 16.2% (Barger et al. 2005). Medical patients suffered increased needle sticks and other errors in care at the hands of fatigued healthcare workers; a study of 393 nurses over more than 5300 shifts found that nurses who work shifts of at least 12.5 hours triple their probability of committing an error in patient care (Rogers et al. 2004). The aforementioned OSHA website also cites worker fatigue as a contributing factor in famous historical industrial disasters such as the 2005 Texas City BP oil refinery explosion, the 2009 Colgan Air Crash, the 1986 explosion of the Challenger space shuttle, and the nuclear disasters at Chernobyl (1986) and Three Mile Island (1979).

In all of the preceding examples, the adverse health consequences were borne heavily, and in most cases entirely, by people other than the fatigued workers themselves. Such spillover effects suggest the value of studying the connection between long hours and adverse health outcomes at the workplace level rather than the individual level. That is the approach taken in the present analysis, which uses longitudinal observations from the most recent waves of the British Workplace Employment Relations Study (WERS). Workplace-level indicators of illnesses, injuries, and absenteeism are examined, and the role of performance-based pay is investigated to assess whether the documented greater incidence of personal injuries of workers on payments-by-results systems relate to these workers' longer work hours. A further advantage of using the WERS matched worker-establishment panel to explore the potential connection between the two phenomena described at the start of this introduction is that both phenomena have been documented in that data set.

II. Related Literature

Evidence concerning the first empirical phenomenon described in the introduction was revealed in a sample of British munition workers assembling artillery shells during the First

[1] See https://www.osha.gov/SLTC/workerfatigue/hazards.html#ref4, last accessed December 21, 2019.

World War, where a nonlinear hours-productivity relationship was found in which long hours reduce productivity (Pencavel 2015). The data from that study could not have been used to address the second empirical phenomenon described in the introduction, both because of lack of variation concerning performance pay (i.e., most munition workers were paid piece rates) and because of lack of information on absenteeism and work-related health problems. The main result of the study on munition workers was corroborated in DeVaro (2020) – for a wide variety of occupations and industries operating under different conditions – in the same WERS sample analyzed in the present study, i.e., a non-monotonic relationship was found in which the incidence of superior establishment-level outcomes (for both labor productivity and financial performance) first rises with weekly hours and then eventually falls.

Evidence concerning the second empirical phenomenon described in the introduction was found in DeVaro and Heywood (2017), using the same WERS sample explored here. That establishment-level study analyzed performance-based pay, productivity, workplace health, and absenteeism; it did not consider work hours, so it did not address the first empirical phenomenon. That study found that performance-based pay relates positively to establishment-level productivity, though such pay is also associated with higher absenteeism and work-related health problems (mitigating the overall positive productivity effects of performance-based pay). The particular class of health problems that was found to be exacerbated by performance pay was "bone, joint, and muscle problems, including back problems and repetitive stress injuries", which is the most prevalent workplace health affliction in the WERS data.[2]

The present inquiry sheds light on whether the adverse effects of performance-based pay on both workplace health and productivity operate through the intermediate channel of inducing long work hours and, therefore, fatigue. Other research provides reason to suspect that long hours might play such a mediating role. In a study of 30,074 workers from the 1988 National Health Interview Survey, Guo (2002) found that the number of hours spent on repeated activities at work was associated with the prevalence of back pain. In addition to the preceding evidence concerning the two empirical phenomena, a long line of research exists, dating back to Goldmark (1912) and earlier, documenting the damaging effects on output of the fatigue and stress that

[2]Back pain is the most common source of workers' compensation claims in the U.S. (Guo 2002).

accompanies long work hours. References to more recent work on the subject are contained in Golden (2012). There are also claims that long work schedules increase accidents, impair the health of workers, and increase the incidence of spoiled goods. On accidents and hours, see Vernon (1921) and, on health and hours, see Hulst (2003).

The connection between working hours and performance pay is a relatively neglected research topic. The standard labor supply model incorporates input-based rather than output-based compensation, i.e., there is a fixed hourly wage that might vary with variables like income or total work hours but not explicitly with output as is the case with piece-rate pay. An exception is Pencavel (1977), which incorporates performance-based pay into the static labor supply framework.

The effect of performance-based pay on absenteeism is theoretically ambiguous. On one hand, employees spurred by such pay might work to the point of exhaustion, sustaining illnesses or injuries that lead to absenteeism. On the other hand, such pay might increase the value of attending work for the ill or injured, a phenomenon referred to as "presenteeism" (Chatterji and Tilley 2002).[3] Paralleling the ambiguous theoretical relationship between performance-based pay and absenteeism, empirical evidence on that relationship is positive in some studies (e.g., Frick et al. 2013 and DeVaro and Heywood 2017) and negative in others (e.g., Dale-Olsen 2012 and Pouliakas and Theodoropoulos 2012). It should be noted, however, that unobserved, time-invariant employer heterogeneity is an important consideration in measuring this relationship. With the exception of DeVaro and Heywood (2017), previous work does not incorporate establishment fixed effects, whereas that study finds a strong positive relationship between performance-based pay and absenteeism that emerges only in the presence of workplace fixed effects. Thus, focusing on within-establishment variation over time, performance pay appears positively associated with absenteeism, and the present study inquires into whether long working hours (leading to fatigue and exhaustion) are an intermediate channel for this association.

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[3]Another possibility is that income effects create a positive association between performance pay and absenteeism, to the extent that employees make more money under that mode of compensation.

III. Workplace Employment Relations Study

The two most recent waves of the British Workplace Employment Relations Study (WERS) are used to construct an establishment panel. A cross-section of 2295 establishments was sampled in 2004, each of which completed an employer survey. In each establishment, 5 to 25 randomly sampled workers completed a survey. This process was repeated in 2011, with new employer survey responses from a sample of 2680 establishments and worker survey responses from 5 to 25 randomly sampled workers in each establishment.[4] The worker and employer survey instruments in 2011 closely correspond to their 2004 counterparts. The full sample of 1978 observations is a balanced panel of 989 establishments interviewed in both years.[5]

A key feature of the establishment sample in 2011 is that, by design, 989 of those establishments were drawn from the set of 2295 establishments that also completed the 2004 employer survey.[6] Sampling weights correct for this design feature. Specifically, two sets of inverse-probability sampling weights (i.e., establishment weights and employee weights)

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[4] Supervisors are among the surveyed workers. The survey population for the 2011 establishment survey accounts for 35% of all establishments and 90% of all workers in Britain and includes all workplaces in Britain with 5 or more employees and that operate in Sections C-S of the Standard Industrial Classification (2007). For greater detail on the design of the 2011 survey, see The Workplace Employment Relations Study (WERS) 2011/12: Technical Report (Deepchand et al, 2013), or the full technical report which is available upon request from wers@bis.gsi.gov.uk. For details on the 2004 WERS, see either the technical appendix to the 2004 sourcebook (Kersley et al, 2006), or the WERS 2004 Technical Report (Chaplin et al, 2005).

[5] The panel is based on a 2004 stratified random sample covering British workplaces with at least 5 to 9 employees, except for local units in Northern Ireland and those in the following 2003 Standard Industrial Classification (SIC) divisions: agriculture, hunting, and forestry; fishing; mining and quarrying; private households with employed persons; and extra-territorial organizations. The sampling frame is the Inter-Departmental Business Register (IDBR) which is maintained by the Office for National Statistics (ONS). According to Chaplin et al. (2005), "The IDBR is undoubtedly the highest quality sample frame of organisations and establishments in Britain."

[6] Because workers are randomly sampled in each establishment in each year, individual workers are not followed over time. If it were to happen that the same worker was surveyed both in 2004 and 2011 (either in the same establishment or two different ones), this could not be detected because the worker would receive a different identifier in the two years.

accompany the panel. Establishment weights render the resulting statistics reflective of a representative sample of establishments, whereas employee weights yield statistics reflecting the proportion of employees to whom a particular workplace characteristic pertains. Establishment-weighted statistics are reported throughout the analysis, as in DeVaro and Heywood (2017).

Much of the information in the sample comes from the employer surveys. Some of the information (including weekly hours and performance-based pay) is from the worker surveys, and this information is aggregated to the establishment level for use in establishment-level panel regressions. Missing information on hours worked reduces the analysis sample to 1200 observations.[7] Repeated observations on establishments permit analyses that account for unobserved, time-invariant, establishment-level heterogeneity via fixed effects.[8]

IV. Measures

Table 1 provides descriptive statistics on the key variables (to be defined subsequently) for the 2004-2011 establishment panel, other than the dichotomous industry identifiers that are used as controls in the multivariate statistical models.[9]

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[7] Descriptive statistics (arithmetic mean, median, standard deviation) of the key variables in the sample of 1978 workplace-year observations and the sample of 1200 workplace-year observations were similar.

[8] Two design innovations in the 2011 WERS make this possible, whereas it was not in earlier waves. One innovation broadened the survey instrument used for establishments in the 2004-2011 panel. A second innovation repeated the worker survey for establishments that were re-interviewed in 2011 after having been interviewed initially in 2004. In prior WERS establishment panels, worker-level information is available only for the first year of the panel.

[9] The industry categories are manufacturing; electricity, gas, and water; construction; wholesale and retail; hotels and restaurants; transport and communication; financial services; other business services; public administration; education; health; and other community services.

Working Hours

Workers' responses to the following question in both the 2004 and 2011 surveys serve as the measure of the hours variable: "How many hours do you usually work in your job each week, including overtime or extra hours? Exclude meal breaks and time taken to travel to work." Given this study's focus on establishment-level analysis, the hours responses must be aggregated to the establishment level. The within-establishment hours distribution is divided into two regimes, those above and those below a threshold, *c*, which is varied in the empirical analysis. Define H_{cjt} as the fraction of establishment *j*'s (5 to 25) surveyed workers whose reported weekly hours are at least *c* in year *t*.

Table 2 reports descriptive statistics on the distribution of H_{cjt} for three different values of the threshold *c*, using all 1200 workplace-year observations in the 2004-2011 panel. Figure 1 plots the mean and standard deviation of H_{cjt} (over all *j* and *t*) for values of *c* ranging from 25 to 65 weekly hours. Table 2 and Figure 1 reveal that although the right tail of the distribution is thin at very high levels of hours, there are still some observations and enough variation to investigate the effects of long work schedules empirically.

Health and Absenteeism

The 2004 and 2011 employer surveys ask, "In the last 12 months, have any employees suffered from any of the following illnesses/injuries, disabilities or other physical problems that were caused or made worse by their work?" The question is asked separately for "illnesses" and "injuries". Employers can list multiple ailments, and Table 3 tabulates their first responses. Employers who report the occurrence of *any* of the illnesses listed in Panel A are then asked, "How many employees have been absent owing to these problems over the last 12 months?"[10] Dividing that answer by the establishment's total employment yields a ratio called *AbRate*: the fraction of the establishment's workers who experienced an absence during the previous year

[10] The question was not asked for the injuries in Panel B.

due to an illness listed in Panel A of Table 3. *AbRate* has a mean of 0.028, and a standard deviation of 0.065.

The answer to the following question is used as an alternative absenteeism measure called *AbDays*: "Over the last 12 months what percentage of work days was lost through employee sickness or absence at this workplace? INTERVIEWER: Please exclude authorized leave of absence, employees away on secondment or courses or days lost through industrial action." *AbDays* has a mean of 4.431 and a standard deviation of 7.847.

Performance Pay

The 2004 and 2011 employer surveys ask whether establishment *j* uses performance-based pay in year *t*.[11] But that binary measure exhibits limited temporal variation (e.g., it would assume a value of 1 in both years if a particular establishment paid only 1 percent of its workforce using performance-based pay in 2004, and 100 percent in 2011).[12] The fraction of an

[11]The question asks "Do any of the employees in this workplace get paid by results or receive merit pay?" Answer choices include "payment by results", "merit pay", and "neither", and the respondent can select multiple answers. The interviewer clarifies for the respondent what the definitions are of "payment by results" and "merit pay". Respondents are instructed that the former "includes any method of payment where the pay is determined by the amount done or its value, rather than just the number of hours worked. It includes commission, and bonuses that are determined by individual, workplace or organisation productivity or performance. It does not include profit-related pay schemes", whereas the latter "is related to a subjective assessment of individual performance by a supervisor or manager."

[12]As noted in DeVaro and Heywood (2017), there are 203 establishments that experience a switch in performance pay (94 switch from not using the pay to using it, and 109 switch from using it to not using it), and there are 786 establishments that do not experience a switch (706 do not use such pay in either year, and 80 use it in both years).

establishment's workers receiving performance-based pay exhibits significantly more temporal variation. The worker surveys are used to construct an estimate of this fraction.

Workers in the 2011 survey are asked if they receive "payments based on your individual performance or output". The fraction of surveyed workers responding affirmatively is the measure of $PBR_{j\,t}$ for $t = 2011$. The question is not asked in the 2004 worker survey. However, the 2004 employer survey asks whether *any* workers at the establishment receive performance-based pay. If the answer is negative, then it can be inferred that the workers responding to the 2004 survey did not receive such pay, i.e., $PBR_{j\,2004} = 0$. If the answer is positive, then in most cases it cannot be determined whether the workers surveyed in 2004 were among those receiving such pay. However, employers are asked to list in which (of nine) one-digit occupational groups there are workers receiving such pay.[13] Employers who report that performance-based pay is used (and that it is not restricted entirely to managers) are then asked what proportion of non-managerial workers receive such pay. If the response is "All (100%)" then $PBR_{j\,2004}$ is coded as 1 in the subsequent analysis. In the analysis sample of Section VI, $PBR_{j\,t}$ has a mean of 0.143 and a standard deviation of 0.320.

V. Working Hours, Health, and Absenteeism

The first step of the empirical analysis is to measure the effects on absenteeism and workplace health problems of a shift in the within-establishment distribution of weekly working hours. The approach parallels the analysis of hours and productivity in DeVaro (2020). A threshold, c, is defined for weekly working hours, beyond which hours are considered "long". Given that the choice of c is arbitrary, various values of c are considered to assess the sensitivity of results to different definitions of the distribution's right tail. The research hypothesis is that, for a sufficiently extreme definition of the distribution's right tail (i.e., for a sufficiently high

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[13] The occupations are: managers and senior officials; professional; associate professional and technical; administrative and secretarial; skilled trades; caring, leisure and other personal service; sales and customer service; process, plant and machine operatives and drivers; routine.

value of *c*), shifting some of the establishment's workers from below *c* to above it is associated with reduced health and higher absenteeism.

Starting with the absenteeism analysis, two series of linear regressions of the following form are estimated in which the dependent variable, Y_{jt}, is either *AbRate* or *AbDays*, varying *c* from 25 to 65.

$$Y_{jt} = \alpha + \beta_c H_{cjt} + \boldsymbol{X}_{jt}\boldsymbol{\delta} + \gamma D_t + \eta_j + \varepsilon_{jt} \qquad (1)$$

In equation (1), $\boldsymbol{X}_{jt}$ includes the establishment's employment[14] and indicators for industry, private sector, and the presence of a union. D_t is a binary indicator for year 2004 that allows a change in the relation between the two years, and ε_{jt} is a stochastic component incorporating variables unobserved to the researcher. Differences among workplaces in inputs that do not change between 2004 and 2011 are accounted for by an individual establishment effect, η_j. Although one might anticipate that some of the included industry controls (e.g., industry and union dummies) are time invariant, they in fact exhibit a modest amount of temporal variation[15] that permits the identification of their coefficients even in the presence of establishment fixed effects. These parameters are estimated with low precision, however, and when those variables are dropped from the specification the results are qualitatively unchanged.

To facilitate estimation using survey sampling weights, estimation of the parameters is by least squares, with standard errors adjusted to account for heteroskedasticity. When the binary dependent variable is either *AbRate* or *AbDays*, results are qualitatively the same from a conditional logit model estimated on the subset of workplaces with different Y_{jt} values between 2004 and 2011. The same is true for other binary dependent variables to be considered subsequently in the analysis.

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[14] The survey question is, "Currently how many employees do you have on the payroll at this workplace? Remember to include yourself if you are an employee at the workplace but do NOT include casual workers without a contract of employment, freelance, self-employed or agency workers."

[15] Recall that a span of 7 years separates both waves of the panel, which is a substantial span of time during which changes can occur.

The key issue is whether and how the estimated parameter β_c, i.e., the least-squares effect of an increase in the fraction of the establishment's employees working beyond *c* weekly hours, varies with *c*. Forty-one estimations of equation (1) are conducted for each dependent variable, each estimate corresponding to forty-one different integer values of *c,* from 25 hours to 65 hours. The forty-one estimates of β_c are graphed in Figure 2 (for *AbRate*) and Figure 3 (for *AbDays*).

In the models for *AbRate*, the estimated β_c is positive for all values of *c* except for $c = 47$ (where it is slightly negative, with a standard error that exceeds the magnitude of the point estimate by a factor exceeding 100), though no clear pattern emerges concerning its magnitude and degree of statistical significance. In the models for *AbDays*, the estimated β_c is positive for all values of *c*, though statistical significance at levels of ten percent or below is attained only for values of *c* from 51 to 60 (inclusive), with the exception of $c = 59$, where the *p*-value is 0.116. At $c = 51$, the estimated β_c peaks at 9.143 with a *p*-value of 0.022. That is, a doubling (from its sample mean of 0.046) in the fraction of workplace hours that is 51 or higher is associated with an increase of 0.42 (i.e., 0.046 × 9.143) in *AbDays*, which is a 9.5 percent increase from its sample mean value of 4.431. Estimates of β_c are somewhat smaller for other values of *c* in [51, 60], ranging from 6.918 to 8.756. Overall, the results suggest modest statistical evidence of a positive establishment-level relationship between long hours and absenteeism.

The preceding results concern the effect of shifting some workers into the right tail of the within-establishment weekly hours distribution. To allow for differential impacts based on the region of the hours distribution (outside of the right tail) from which the hours are drawn that are shifted to the right tail, the weekly hours distribution is partitioned into three regimes by adding a second threshold, *b*, where $0 < b < c$. The "left (or lower) tail" refers to $[0,b)$, the "middle region" refers to $[b,c)$, and the "right (or upper) tail" refers to the remainder. Defining H_{bjt} as the fraction of establishment *j*'s surveyed workers whose reported weekly hours are at least *b* in year *t*, the linear equation to be estimated is:

$$Y_{jt} = \alpha + \beta_c H_{cjt} + \beta_b H_{bjt} + \boldsymbol{X}_{jt}\boldsymbol{\delta} + \gamma D_t + \eta_j + \varepsilon_{jt} \qquad (2)$$

Now β_c measures the effect of shifting workers from the middle region of the hours distribution into the right tail, β_b describes the effect of shifting workers from the left tail to the middle part of the hours distribution, and $\beta_b + \beta_c$ describes the effect of shifting workers from the left tail into the right tail.[16] When $b \to 0$, $H_{bjt} \to 1$, the middle bin disappears, and $\beta_b H_{bjt}$ is subsumed by α, yielding the original regression and interpretation of β_c. When $b \to c$, $H_{bjt} \to H_{cjt}$, and again the middle bin disappears, H_{bjt} and H_{cjt} are perfectly collinear, and the original regression returns. Thus, the regression is poorly identified if b is too large (i.e., too close to c) or too small (i.e., too close to the lower bound of the observed hours data).[17]

Figure 4 (for *AbRate*) plots least-squares estimates of β_b, β_c, and $\beta_b + \beta_c$, each as a function of b, for values of b ranging from 25 to 56, assuming $c = 61$. As a benchmark, note that, in the original regressions from equation (1) with $c = 61$ and H_{bjt} omitted from the right-hand side, the estimated β_c is 25.901 with a standard error of 33.171. Estimating those regressions with H_{bjt} included on the right-hand side as in equation (2), where $b = 25$, the estimated β_c is 26.698 with a standard error of 32.771, and the estimated β_b is 18.482 with a standard error of 15.431. The estimates of β_c in the preceding two specifications differ little, implying that the magnitude of the productivity loss when hours are shifted to the right tail is about the same whether the hours are drawn from the middle or from the middle and left tail combined. The same result holds across the full range of values of b, given that the graphs for β_c are similar in Figures 2 and 4.

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[16] In an alternative regression with H_c and $(H_b - H_c)$ on the right-hand side, the coefficient on H_c would capture the marginal effect of a shift in hours from $[0,b)$ to the right tail. Rewriting the alternative regression so that H_b (rather than $H_b - H_c$) appears alongside H_c on the right-hand side reveals that the aforementioned marginal effect is $\beta_b + \beta_c$.

[17] A related point about identification concerns the number of bins. The hours distribution could be partitioned into four regions by introducing a third threshold, a, with $0 < a < b < c$. This is not pursued because there is a small sample of worker responses per establishment, and the regression becomes poorly identified as the number of thresholds increases. Two thresholds already offer considerable flexibility, and a third would offer little more given that the interpretation of β_c remains unchanged whether or not H_a is included in the regression alongside H_b and H_c.

Figure 5 (for *AbDays*) plots least-squares estimates of β_b, β_c, and $\beta_b + \beta_c$, each as a function of b, for values of b ranging from 25 to 56, assuming $c = 61$. As a benchmark, note that, in the original regressions from equation (1) with $c = 61$ and H_{bjt} omitted from the right-hand side, the estimated β_c is 5.724 with a standard error of 4.841. Estimating those regressions with H_{bjt} included on the right-hand side as in equation (2), where $b = 25$, the estimated β_c is 6.881 with a standard error of 4.655, and the estimated β_b is 5.771 with a standard error of 4.666. The estimates of β_c in the preceding two specifications differ little, which implies that the magnitude of the productivity loss when hours are shifted to the right tail is about the same whether the hours are drawn from the middle or from the middle and left tail combined. As was true for *AbRate*, the preceding result holds for the full range of value of b.

The preceding results all concern absenteeism. Turning now to health, the preceding regressions are repeated for the following four dependent variables measuring workplace health problems: *Injuryrate* is a ratio with total employment in the denominator and the answer to the following question (which is asked of employers who report the occurrence of ailments from Panel B of Table 3) in the numerator "During the last 12 months, how many employees in all have sustained any of these types of injury?"; *Illness* equals one if the employer reports that *any* of the illnesses in Panel A of Table 3 occurred during the last year, and 0 otherwise; *Injury* equals one if the employer reports that *any* of the injuries in Panel B of Table 3 occurred during the last year, and 0 otherwise; *Joint* equals one if the employer reports that "bone, joint, or muscle problems (including back problems and repetitive stress injuries)" occurred during the last year, and zero otherwise.[18] For all four dependent variables the β_c parameters are estimated with low precision, and no clear patterns emerge as c varies. For these reasons, and for the sake of brevity, the results are omitted but are available upon request. On balance, the data cannot reject the null hypothesis of no establishment-level relationship between long hours and the workplace health problems measured in the data.

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[18]That class of ailments is the most commonly reported in the WERS, as seen in Table 3, and is found to be negatively related to productivity (both labor productivity and financial performance) in DeVaro and Heywood (2017).

Although the preceding results for the four health variables are “nulls results” they narrow the scope of possible explanations for the “inverted-*U*-shaped” hours-productivity patterns documented in the first empirical phenomenon described in the introduction. The data provide no support for the notion that long hours cause the measured workplace injuries or illnesses that have been found to relate negatively to productivity. A plausible interpretation is that fatigue (rather than the more immediate and acute health problems listed in Table 3) is the intermediate channel through which long hours reduce productivity. Fatigue, particularly when it is extreme and accumulates over days and weeks, may cause absenteeism as workers pursue necessary recovery and rejuvenation.

Perhaps a more common manifestation of fatigue is that it simply makes workers less productive on the job. An example would be fatigue-induced misuse of machines, causing more frequent maintenance and replacement costs. DeVaro (2020) found that the “peak” of the weekly hours-productivity profile (i.e., the threshold for usual weekly hours beyond which productivity begins to decline) occurs earlier when the establishment-level productivity measure is financial performance than when it is labor productivity. A potential selection-based explanation for this result was proposed in that study. In particular, labor productivity measures are conditional on who actually shows up for work, so the costs to the employer of absenteeism are incorporated in financial performance measures but not in labor productivity measures. The results of the present section – in particular that there is modest evidence of a positive relationship between long hours and absenteeism – suggest that factors other than selection are at work. A likely explanation is simply exhaustion and fatigue from long hours, which is not a measured health outcome in Table 3.

VI. Performance-Based Pay and Hours Worked

If long working hours are associated with lower plant-level productivity, less satisfactory financial performance, and a greater incidence of fatigue and possibly absenteeism, can an employer avoid these undesirable outcomes by scheduling shorter hours and moving away from a payment system based on time rates of pay and towards a payment-by-results or performance-based wage system? Or, alternatively, does performance-based pay make matters worse for employers, by encouraging employees to work even longer hours, which in turn induces fatigue and (as found in DeVaro and Heywood 2017) an increased incidence of absenteeism? The relationship between hours and performance pay is theoretically ambiguous, and the forthcoming analysis endeavors to shed empirical light on it.

When performance-based pay is introduced, a worker may increase effort and leave hours of work unchanged, or substitute effort for hours and work fewer hours per day or week, or work more hours with or without changing effort.[19] How H_{jt} varies with and without performance-based pay is, therefore, an empirical question.[20]

A balanced panel is assembled in which PBR_{jt} is available in both years. The sample size is smaller than in the preceding analyses, because the variable can be constructed in 2004 for only a subset of the workplaces. The empirical model is:

$$H_{cjt} = \alpha + \beta_c PBR_{jt} + \boldsymbol{X}_{jt} \boldsymbol{\delta} + \gamma D_t + \eta_j + \varepsilon_{jt} \qquad (3)$$

where PBR_{jt} is the fraction of surveyed workers in establishment j in year t who receive pay based on individual performance, and all other notation is defined in Section IV. The parameter of interest is β_c, which is identified by within-establishment changes over time in the fraction of workers receiving performance-based pay. The parameter captures the change in the fraction of

[19] These various possibilities for substitution are curtailed when the employer imposes constraints on hours, in which case the worker's response to performance-based pay must rely more heavily on effort adjustments. Most employers impose minimum hours constraints (i.e., to be paid and to avoid being fired, workers must work at least a prescribed number of hours). Some employers also impose maximum hours constraints (e.g., to avoid overtime pay regulations, or to exploit complementarities such as occur in team settings when coworkers' schedules coincide).

[20] The conjecture that performance-based pay may increase the intensity of work to the point of fatigue and health problems dates back at least to Adam Smith's observation that "workmen ... when they are liberally paid by the piece, are very apt to overwork themselves, and to ruin their health and constitution in a few years" (1776, p. 83).

workers whose weekly hours are at least *c* that is associated with a marginal increase in PBR_{jt}.[21] As in the earlier analyses, the model is estimated for values of *c* ranging from 25 to 65.

Figure 6 displays a graph of β_c as a function of *c*, and hovers from 0.15 to 0.16 for values of *c* from 25 to 30, achieving statistical significance at the ten percent level. It is positive but insignificant at conventional levels from $c = 31$ to $c = 34$, returning to 0.15 and attaining significance at five percent at $c = 35$. It increases to a level of 0.23 to 0.26 between $c = 36$ and $c = 39$, attaining significance at five percent. For values of *c* from 40 to 65, it is statistically indistinguishable from zero, though for values of *c* from 61 to 65 it is close to attaining significance at ten percent (i.e., *p*-values are around 0.11 and 0.12) and for these values the coefficient is about -0.03.

The results suggest a discontinuity at around 40 weekly hours. For weekly hours cutoffs of 40 or less, a greater incidence of performance-based pay is associated with a greater fraction of the establishment's workers having long hours. This result usually attains statistical significance in the neighborhood of at least ten percent for *c* values of 40 or less. Beyond 40 hours, however, the effect is statistically indistinguishable from zero, with a possible negative effect (that is small in magnitude and imprecisely estimated) emerging for *c* values in excess of 60.

The pattern of evidence in Figure 6 permits different interpretations according to what is assumed about who (i.e., workers or employers) chooses hours. Under the extreme assumption that employers set work schedules unilaterally, the interpretation is that workplaces that pay more of their workers using individual performance-based pay tend to require longer hours, up to 40 per week. There is no evidence that employers wish to push workers beyond the 40-hour threshold when performance-based pay is increasingly used. An interpretation is that, beyond a certain hours threshold, productivity declines due to worker exhaustion. DeVaro (2020), using the same data analyzed here, indeed found evidence of such an inflection point in the hours-

[21] The change in the fraction of workers whose weekly hours are *below c* that is associated with a marginal increase in PBR_{jt} is $-\beta_c$.

productivity relationship. That inflection point, however, occurred at weekly hours somewhat higher than 40. Specifically, it occurred at 48 when the measure of workplace performance was labor productivity and at 43 when the measure was financial performance. That analysis, however, did not account for performance-based pay. If workers who receive such pay expend more effort per hour (in pursuit of higher compensation via higher output) then the point of exhaustion may arrive earlier, which would explain employers' reluctance to push workers beyond 40 weekly hours when such pay is increasingly used at the workplace.

An alternative extreme assumption is that workers are entirely free to choose hours.[22] In that case the interpretation of the pattern in Figure 6 is that workers receiving performance-based pay choose to increase their output (and, hence, their pay) at least in part by increasing weekly hours, but only up to 40.[23] For extreme definitions of the "right tail" (i.e., very high values of c), it might be conjectured that workers would increase their output by *lowering* their hours, i.e., substituting effort for hours, as suggested by the hours-productivity patterns documented in DeVaro (2020).[24] If the productivity-hours relationship is concave and non-monotonic (increasing over a range of hours and then decreasing) then introducing performance-based pay might reduce the incidence of long hours, since such a reduction would imply increased productivity and higher pay. The pattern of results in Figure 6 does not support the aforementioned conjecture. Although the point estimates are negative for all but two values of c beyond 41, statistical significance is not achieved at conventional levels. For extreme values of c (i.e., those exceeding 60) precision improves, suggesting that in a larger sample the conjecture that workers who receive performance-based pay substitute effort for hours might be supported by conventional statistical criteria.

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[22]This assumption is in the spirit of the "labor supply" literature, though that literature assumes a fixed (i.e., time) wage rather than pay-by-results. See Pencavel (1977) for an application of the static labor supply framework to the case of performance-based pay.

[23]An alternative possibility, to be addressed shortly, involves selection.

[24]Strict convexity in the worker's disutility of both hours and effort, as well as natural (or employer-imposed) constraints on work hours ensure workers' tendencies to choose a mix of hours and effort.

A more realistic assumption than either of the two preceding extremes is that hours represent a blend of worker and employer choices (Pencavel 2016). Direct evidence on the extent to which observed hours represent employer choices versus worker choices is elusive, but indirect evidence may be extracted from the WERS by comparing “usual” and “contracted” hours. In addition to “usual weekly hours” the worker survey asks about scheduled, or “contracted”, hours, which might be assumed to reflect mostly employer choices.[25] Workers’ discretion over hours would then be revealed in the extent to which “usual” hours exceed “contracted” hours. In the estimation sample for the three subsequent regressions, the means of usual and contracted weekly hours are about 32.7 and 30.2, respectively, with the difference between them slightly exceeding 2.5 weekly hours.

Consider the average *contracted* hours (across all surveyed workers in establishment j in year t) as the dependent variable in a first regression, with the right-hand side specified as in (3). The estimated coefficient of *PBR* is 3.816 with standard error 2.054. In a second regression in which the dependent variable is average *usual* hours, the estimated coefficient of *PBR* is 3.865 with standard error 2.146. In a third regression in which the dependent variable is the difference of the preceding two dependent variables (i.e., “average usual” minus “average contracted”) the estimated coefficient of *PBR* is 0.049 with standard error 0.799. These results suggest that scheduled hours increase with the fraction of an establishment’s workforce receiving performance pay, but usual hours increase by a comparable magnitude, so that the difference between usual and contracted hours remains stable. Overall, this evidence is consistent with observed hours (and their responsiveness to performance-based pay) reflecting a blend of worker and employer choices.

With hours choices partially reflecting worker behavior, one possibility is that weekly hours increase (up to 40) in response to greater use of performance-based pay because the establishment’s existing workers aim to increase their outputs by logging longer hours. But an

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[25]In the 2011 worker survey the question is, “What are your basic or contractual hours each week in your job at this workplace, excluding any paid or unpaid overtime?” The same information can be extracted from the 2004 worker survey via similar questions.

alternative possibility involves selection, i.e., an employer's decision to increase the fraction of an establishment's workers that receive performance-based pay changes the composition of workers attracted to and retained by the workplace, such that workaholics are increasingly represented. A decomposition of the total effect of a change in *PBR* into the "incentive" and "sorting" effects (as in Lazear, 2000) cannot be executed because the workers randomly surveyed in 2011 in establishment *j* may not be the same ones surveyed in 2004. However, it can be verified that the establishments' basic demographic compositions remain relatively stable despite the introduction of performance-based pay.[26]

The preceding empirical analysis has divided the hours distribution into two regimes separated by a threshold, *c*. The estimated marginal effect of interest then describes how the frequency distribution in these two regions changes when the fraction of workers receiving performance-based pay increases. A more refined picture could potentially emerge if the distribution is partitioned into three regions rather than two. Such an analysis proceeds by creating a second threshold, *b*, where $b < c$. Then for each ordered pair, (b,c), a pair of regressions is estimated, each corresponding to one of the three regions of the distribution.[27] Regression (3) is estimated twice (the second time changing the subscript *c* to *b*), and the parameter β_c ($-\beta_b$) describes the change in the "right tail" ("left tail") associated with a marginal increase in *PBR*. The associated change in the "middle region", i.e., [b,c), can then be inferred as $\beta_b - \beta_c$. Alternatively, the change in the middle region can be found by estimating regression (3)

[26]More precisely, regressions are estimated in which the dependent variable is a demographic characteristic in establishment *j* in year *t* (e.g., the fraction of employees who are male). The right-hand side includes a constant, PBR_{jt}, and establishment fixed effects. Three dependent variables are considered (fraction male, fraction married, and age). The coefficients of PBR_{jt} in the "age" and "married" models are statistically insignificant at conventional levels. For the "male" ratio the coefficient is statistically significant but has a magnitude of only about 0.06, meaning that if an establishment increases its fraction of workers on PBR_{jt} from 0% to 100% then the male ratio will increase by only 6%. The coefficient of PBR_{jt} in the hours regressions remains statistically significant even if "fraction male" is added as a control.

[27]More generally, for *k* hours regimes, there would be *k*-1 threshold parameters and *k*-1 regressions. Given the modest number of workers observed per establishment, values of *k* beyond 3 are impractical.

but using H_{bjt} - H_{cjt} as the dependent variable, in which case the coefficient of PBR_{jt} yields the estimate of β_b - β_c. This approach has the added convenience of producing a direct estimate of the standard error of β_b - β_c.

Such an analysis generates voluminous output,[28] some of which is summarized in Figures 7 and 8. Assuming $c - b = 5$, Figure 7 plots the estimates of β_b - β_c and their corresponding *p*-values for values of *c* ranging from 30 to 65, where *c* is on the horizontal axis. For example, if $c = 42$ (meaning $b = 37$), the estimated β_b - β_c is about 0.303, and the result is precisely estimated with a *p*-value of 0.004. The result says that an increase in PBR_{jt} of one standard deviation (i.e., an increase of 0.320) is associated with an increase of about 0.097 (i.e., 0.303 × 0.320) in the fraction of establishment *j*'s workers with usual weekly hours of 37 to 42, inclusive. The magnitude of this increase is substantial, amounting to about 33 percent, given that the mean of H_{bjt} - H_{cjt} is 0.297.

If the fraction of establishment *j*'s workers in the middle region increases by 0.097 then it must decrease by that same amount in the rest of the distribution (i.e., the right and left tails combined). The question of which part of the distribution shrinks in the wake of the aforementioned increase is answered in Figure 8, which again plots the estimated β_b - β_c (replicated from Figure 7, and again assuming $c - b = 5$) this time alongside the estimated β_c. Again consider the example of $c = 42$. The estimated β_c is -0.068, and adding this to the estimated β_b - β_c yields the estimate of β_b, namely 0.235. Recall that -β_b measures the change in the left tail that is associated with an increase in PBR_{jt}. Thus, the corresponding change in the fraction of workers in the left tail when PBR_{jt} increases by one standard deviation is -0.075 (i.e., -0.235 × 0.320), and the change in the right tail is -0.022 (i.e., -0.068 × 0.320). It should be noted, however, that β_b is estimated with considerably greater precision (*p*-value = 0.025) than

[28]For example, if values of *c* from 30 to 65 and values of *b* from 25 to *c* - 1 are considered, there are 810 (*b*,*c*) pairs, or 1620 regressions, though some are duplicative.

β_c (p-value = 0.299). It is, therefore, reasonable to conclude that the increase of 0.097 in the middle region is supplied from the left tail.

The example highlighted in the preceding two paragraphs pertains to $c = 42$. The example is repeated for five additional values of c, in particular those (as revealed by Figure 7) that correspond to an estimated β_b - β_c that has a p-value of 0.1 or less. Table 4 reports the results. For all six values of c the same picture emerges. An increase of one standard deviation in the fraction of establishment j's workers that receives pay by results is associated with a shift in the establishment's workers from the lower tail of the hours distribution to the middle region. The largest such shift occurs when the middle region is defined from $b = 37$ to $c = 42$.

VII. Summary and Conclusion

The purpose of this research was to investigate a possible connection between two prior results that have been documented using the same WERS data set analyzed here and (in the case of the first prior result) in other data. The first prior result reveals a concave relationship between hours of work and establishment-level labor productivity (or financial performance). More precisely, productivity first increases in hours of work, up to an inflection point, and then peaks and eventually decreases when weekly hours become very long. The second prior result reveals a positive relationship, again estimated at the establishment level, between performance-based pay and both absenteeism and various indicators of workplace health ailments.

A connection between these two prior results might be expected because long working hours could lead to exhaustion, occupational health problems, and absenteeism that harm establishment-level productivity; moreover, performance-based pay might amplify this process by encouraging workers to work longer hours in pursuit of higher output (and therefore pay). Alternatively, performance-based pay might mitigate the aforementioned process by encouraging workers to substitute higher effort per hour for longer hours, in pursuit of higher output. The preceding mechanisms assume that workers have full control of their hours, but to the extent that employers set work schedules similar considerations apply. In particular, employers might pair performance-based pay policies with shorter (or longer) required work hours. A scenario in which observed hours are an amalgamation of worker and employer choices would involve a blend of the preceding considerations. In any case, a potential causal chain was conjectured in which performance-based pay affects observed hours of work, which in turn influence workers' health, exhaustion, and absenteeism, all of which ultimately affect workplace productivity.

The first result is that no empirical connection is detectable between long working hours and any of the workplace health ailments from a long list. At the same time, the second result is that there is some evidence of a positive relationship between long working hours and establishment-level absenteeism. Although it cannot be directly shown in these data, a plausible inference to draw from the two preceding results is that long working hours lead to exhaustion, which in turn induces workers to stay home from work to recuperate and rejuvenate.

The preceding results suggest that the strong positive relationship between performance-based pay and absenteeism due to sickness that has been found recently in other research is driven only partially by longer work hours. This leads to the third result, namely that an increased incidence of performance-based pay at the establishment level is associated with a shift towards longer working hours, but only up to 40 weekly hours. A discontinuity appears at 40 weekly hours, and beyond that point increases in the incentive of performance-based pay are not associated with longer hours. The results, therefore, reveal a shift from the left tail of the hours distribution to the middle region (i.e., towards full-time work) when performance pay is increasingly used. Earlier work that neglected performance-based pay found evidence that the establishment-level hours-productivity profile peaks at a level of weekly hours beyond 40 (with the peak occurring even higher for labor productivity than for financial performance). An interpretation is that workers who are paid for performance increase their work intensity (i.e., effort per hour), implying that the point of exhaustion arrives earlier in the week.

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Table 1

Descriptive Statistics on Key Variables

	Min	25 %	50 %	75 %	Max	Mean	σ
AbRate	0	0	0	0.023	0.714	0.028	0.065
AbDays	0	1	2.5	5	100	4.431	7.847
Injuryrate	0	0	0	0	414.201	5.835	22.540
Illness	0	0	0	1	1	0.319	0.466
Injury	0	0	0	0	1	0.110	0.313
Joint	0	0	0	0	1	0.178	0.383
PBR	0	0	0	0	1	0.143	0.320
year 2004	0	0	0.5	1	1	0.5	0.5
employment	5	9	15	35	11,566	49.073	196.645
union	0	0	0	1	1	0.366	0.482
private sector	0	1	1	1	1	0.779	0.415

Note: In the above table, x % is the value of the x^{th} percentile and σ is the standard deviation.

Table 2

Descriptive Statistics (across 1200 Workplace-Year Observations) on the Fraction of Employees Whose Usual Weekly Work Hours Exceed 35, 50, and 65

	usual weekly work hours		
	≥ 35	≥ 50	≥ 65
minimum	0	0	0
25th percentile	0.364	0	0
median	0.667	0	0
75th percentile	0.889	0.125	0
maximum	1	1	0.667
mean	0.616	0.084	0.009
standard deviation	0.326	0.154	0.054

Table 3: First-mentioned Illnesses & Injuries during Previous Year (2004 and 2011 pooled)

Panel A: Work-related illnesses, disabilities or other physical problems in previous year?

	Number	Percent
Bone, joint or muscle problems (incl. back problems & repetitive stress injuries)	590	14.92
Stress, depression, anxiety	313	9.05
Skin problems	26	0.83
Breathing or lung problems (including asthma)	13	0.50
Infectious disease (virus, bacteria)	12	0.37
Heart disease/attach or other circulatory problem	7	0.26
Eye strain	5	0.59
Hearing problems	5	0.01
Don't know + Item not applicable + None of these	959	73.36
TOTAL	1930	100

Panel B: Workplace injury in the previous year?

	Number	Percent
Bone fracture	269	4.08
Acute illness requiring medical treatment	78	1.93
Dislocated joint	30	0.74
Any other injury leading to unconsciousness	24	0.44
Eye injury (including loss of sight)	36	1.55
Amputation	6	0.10
Don't know + Refusal + Item not applicable + None of these	1483	91.07
TOTAL	1927	100

Table 4

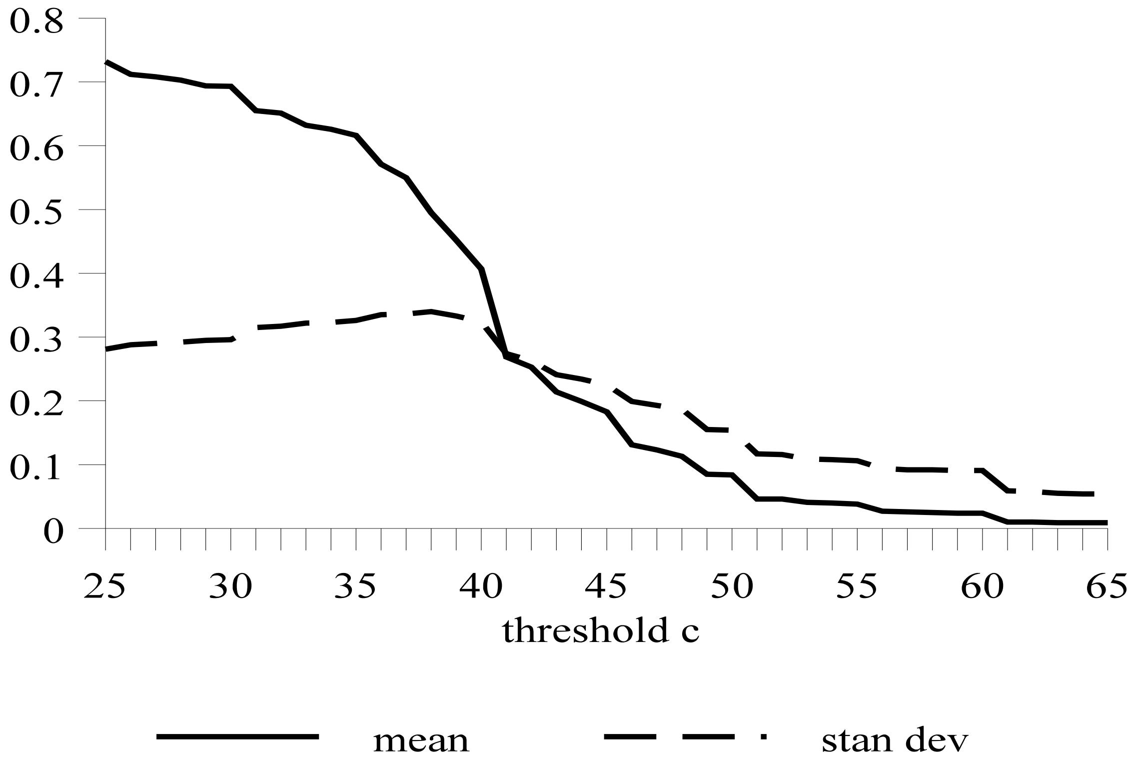
Change in the frequency distribution of hours when *PBR* increases by one standard deviation.

		Lower tail	Middle region	Upper tail
b	c	$-H_b$	$H_b - H_c$	H_c
28	33	-0.048*	0.018**	0.030
29	34	-0.051*	0.026**	0.025
36	41	-0.082**	0.064**	0.017
37	42	-0.075**	0.097***	-0.022
38	43	-0.075**	0.086***	-0.011
39	44	-0.079**	0.090***	-0.011

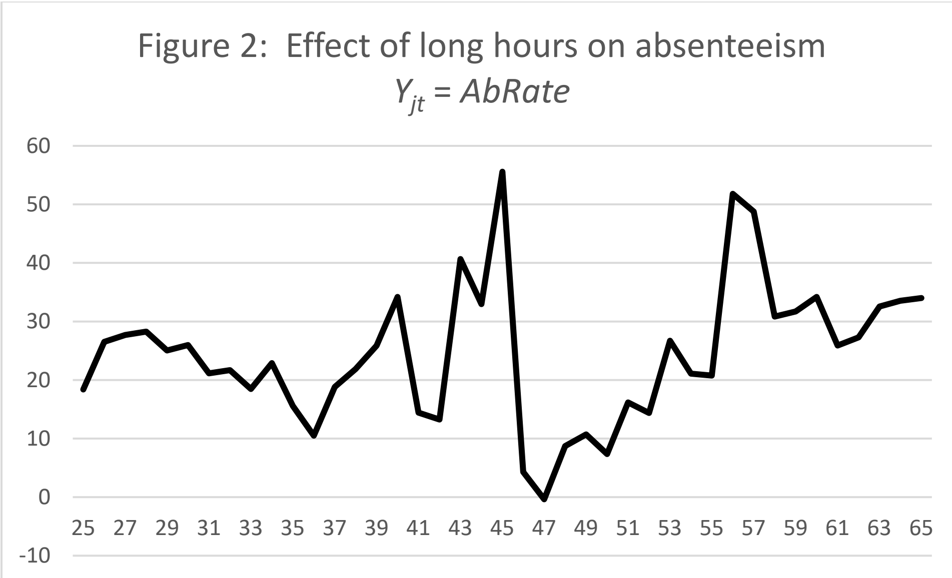
Cell entries are the (scaled) coefficients of *PBR* when (3) is estimated using as the dependent variable $-H_b$ (column 1), $H_b - H_c$ (column 2), or H_c (column 3). Coefficients are scaled by a factor of 0.320, which is the standard deviation of *PBR*. Statistical significance of the estimated coefficients at the 1 percent, 5 percent, and 10 percent levels is indicated by *, **, and ***.

Figure 1

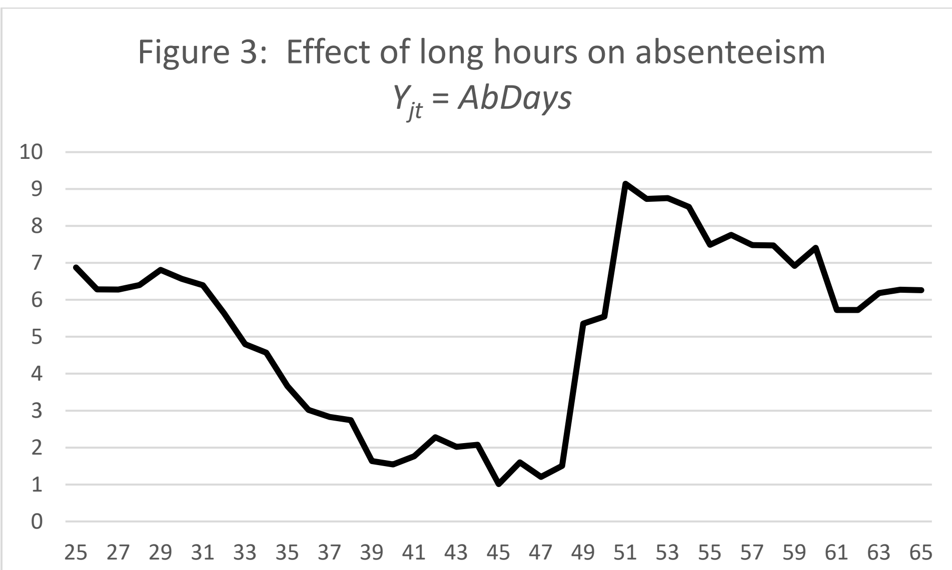
Mean and Standard Deviation of the Fraction of a Workplace's Surveyed Workers with Weekly Hours ≥c



With H_{cjt} defined as the fraction of surveyed employees in establishment j in year t who work c or more hours per week, the mean and standard deviation of H_{cjt} are graphed above as a function of c from 25 hours to 65 hours.

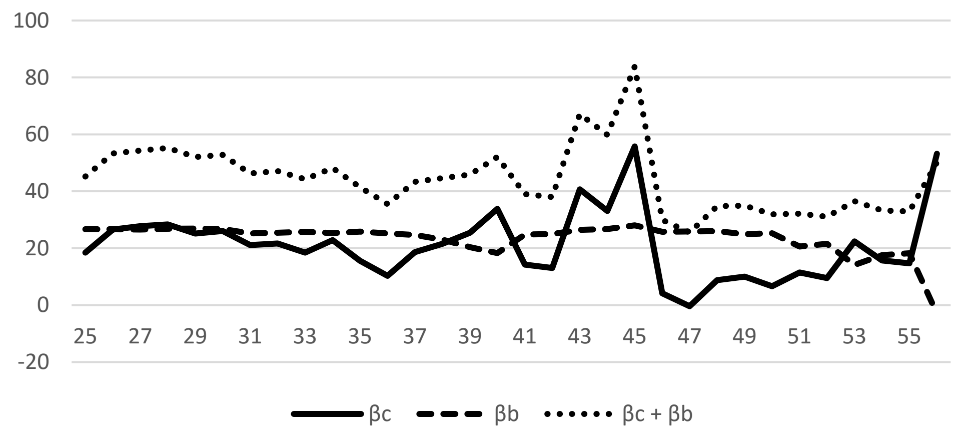


Note: Estimated β_c (for values of *c* ranging from 25 to 65) from equation (1). Dependent variable, Y_{jt}, is *AbRate*.



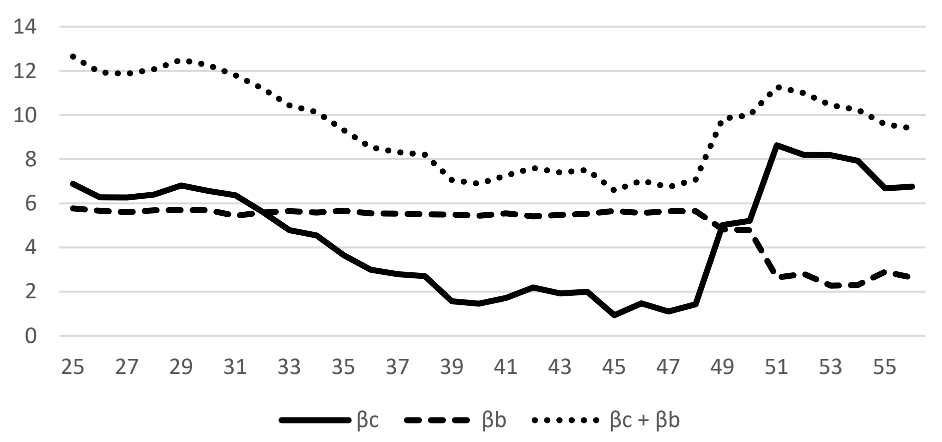
Note: Estimated β_c (for values of *c* ranging from 25 to 65) from equation (1). Dependent variable, Y_{jt}, is *AbDays*.

Figure 4: Effect of long hours on absenteeism
Y_{jt} = *AbRate* (2 hours cutoffs, *b* and *c*)



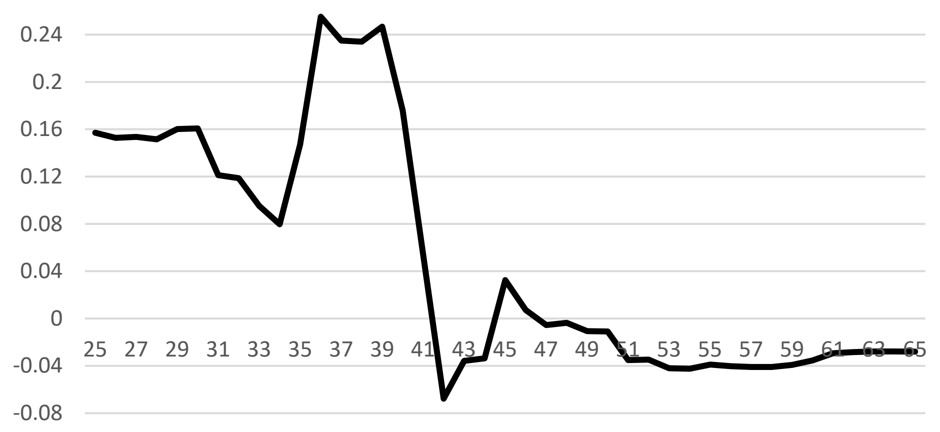
Note: Estimated β_c, β_b, and $\beta_c + \beta_b$ (for *c* = 61 and values of *b* ranging from 25 to 56) from equation (2). Dependent variable, Y_{jt}, is *AbRate*.

Figure 5: Effect of long hours on absenteeism
Y_{jt} = *AbDays* (2 hours cutoffs, *b* and *c*)



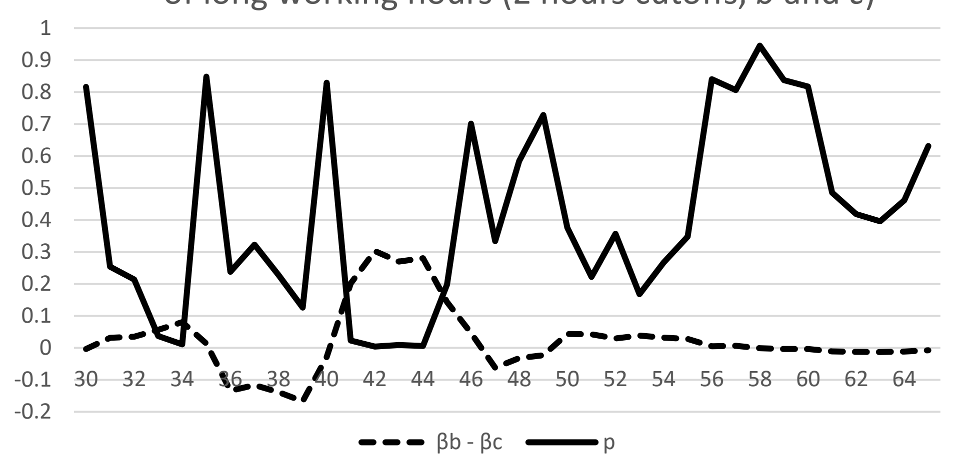
Note: Estimated β_c, β_b, and $\beta_c + \beta_b$ (for *c* = 61 and values of *b* ranging from 25 to 56) from equation (2). Dependent variable, Y_{jt}, is *AbDays*.

Figure 6: Effect of performance pay on incidence of long working hours

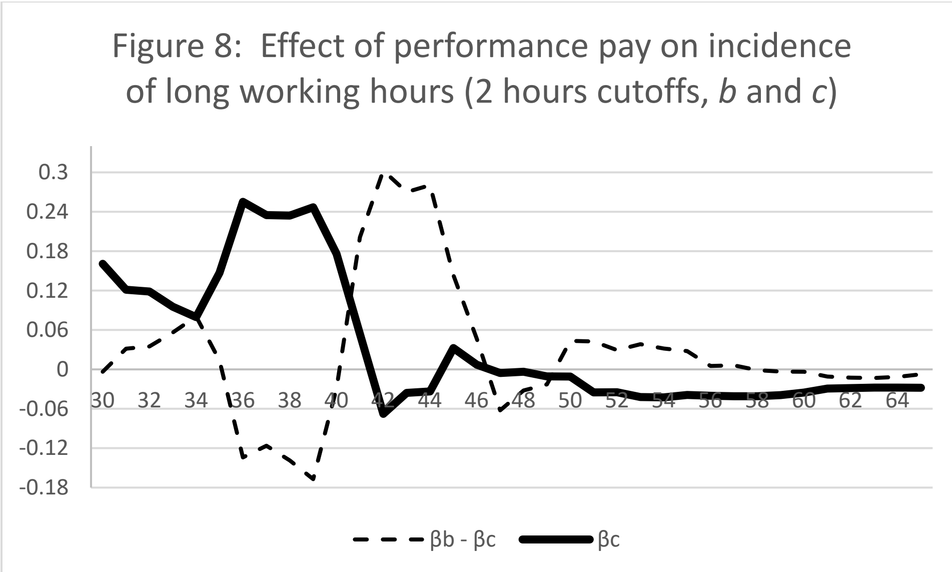


Note: Estimated β_c (for values of *c* ranging from 25 to 65) from equation (3). Dependent variable is H_{cjt}.

Figure 7: Effect of performance pay on incidence of long working hours (2 hours cutoffs, *b* and *c*)



Note: Estimated $\beta_b - \beta_c$ and its p-value, from equation (3), for values of *c* ranging from 30 to 65, assuming $c - b = 5$. Dependent variable is H_{cjt}.



Note: Estimated β_c and $\beta_b - \beta_c$, from equation (3), for values of *c* ranging from 30 to 65, assuming $c - b = 5$. Dependent variable is H_{cjt}.