ABSTRACT
Observations from a worker-employer matched panel of British workplaces surveyed in 2004 and 2011 are organized to investigate the links, if any, between weekly hours and both labor productivity and financial performance. A non-monotonic relationship is found, with the probability of high workplace performance first increasing and eventually decreasing in hours. A possible positive relationship between long hours and absenteeism is suggested. The incidence of long workplace hours is increasing in the fraction of workers receiving performance-based pay, if the cutoff for “long weekly hours” is between 31 and 35, inclusive, but not otherwise.

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

JEL Classification Code: J24, J22, J33, J28

* The Wang Family Professor, Departments of Management and Economics, California State University East Bay; Hayward, CA 94542 USA (jed.devaro@csueastbay.edu)
** Levin Professor, Department of Economics, Stanford University; Stanford, CA 94305-6072 USA (pencavel@stanford.edu)
WORK HOURS, PRODUCTIVITY, HEALTH, AND PERFORMANCE PAY

Jed DeVaro and John Pencavel*

“Few studies offer more promise of adding to welfare and contributing to wise decisions in a matter that may greatly affect the future growth rate than a really thorough investigation of the present relationship between hours and output. Such an investigation would deal with a wide variety of occupations and industries operating under different conditions.”

(Denison, 1962, p. 39)

I. Introduction

In economics research, in many cases, it has been a convenient simplification to assume that the input of labor is measured by the number of worker-hours, i.e., the product of the number of workers and average hours of work per unit of time. The purpose of this paper is to inquire into whether this packaging of hours with employment hides a distinct role for working hours in production and the organization of workplaces. This role arises because of what Alfred Marshall called the “intensity of work” or what others have termed work effort.¹

In this paper, “effort” means the bundle of characteristics that workers apply to their tasks, including their energy, diligence, cooperation, and initiative. These attributes are difficult to observe for scholars making use of large data sets on different workplaces. However, there are indicators of these dimensions of the effectiveness with which individuals work and, faute de mieux, these indicators will be used to determine the relevance of effort in affecting workplace outcomes. The

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¹ Marshall argued that “....the effective supply of labour is [not] a fixed quantity for even if the number of hours of work in the year were rigidly fixed, which it is not, the intensity of work would remain elastic” (1920, p.438,fn. 2). Analogously, Hicks (1932, p.2) recognized that “labour is a two-dimensional quality, depending both on the number of labourers available and upon their ‘efficiency’ - the amount of labour each is able and willing to provide.” From her investigations, Behrend (1957, p. 511) concluded that “....while the economist thinks primarily of an increase in the number of workers when he speaks of a change in the supply of labor, managers in practice - especially in times of full employment - think in terms of increasing the supply of effort from their existing labor force.”
hours that individuals work is one such indicator, and there already exists a long line of research documenting the damaging effects on output of the fatigue and stress that accompanies long work hours.\(^2\) There are also claims that long work schedules increase accidents, impair the health of workers, and increase the incidence of spoiled goods.\(^3\)

Abstracting from other cooperating inputs, a conceptual framework for the empirical research that follows starts with an individual worker’s production function: \(x_{ijt} = \varphi(h_{ijt}, e_{ijt})\) where \(x_{ijt}\) denotes the output of worker \(i\) in workplace \(j\) over a period that ends at time \(t\), \(h_{ijt}\) is the hours worked of individual \(i\) over period \(t\) in establishment \(j\), and \(e_{ijt}\) is his effort per hour worked (with effort defined in the previous paragraph). The worker’s production function is assumed to exhibit the familiar properties of positive but decreasing marginal products of \(h_{ijt}\) and \(e_{ijt}\), and, possibly, \(h_{ijt}\) and \(e_{ijt}\) are substitutable to some degree for one another. A worker may increase \(x_{ijt}\) by working more hours (holding constant his effort each hour) or by working with greater hourly intensity for a given number of hours. Assuming that the workplace’s employees are sufficiently similar, aggregating over workers within an establishment yields a plant-level production function, \(X_{jt} = \Phi(H_{jt}, E_{jt}, N_{jt})\), where \(X_{jt}\) is the establishment’s output over a time period that ends at \(t\), \(H_{jt}\) is average hours worked over the same period, \(E_{jt}\) is work effort per hour, and \(N_{jt}\) is establishment \(j\)’s employment at time \(t\).

Researchers do not observe the effort that individuals apply to their work\(^4\), but a plausible hypothesis is that it varies with the hours devoted to work, or \(E_{jt} = G(H_{jt})\). Substituting \(G(H_{jt})\) for \(E_{jt}\) in \(\Phi\) results in the establishment-level production function expressed as a function of \(H_{jt}\) and \(N_{jt}\). This motivates the empirical specifications in Sections III and IV. An interpretation of the nonlinear relationships estimated there is that the labor input in establishment-level production

\(^2\)These go back to Goldmark (1912) and earlier. More recently, see the references in Golden (2012).

\(^3\)On accidents and hours, see Vernon (1921) and, on health and hours, see Hulst (2003). Spoiled output may be reflected in output and productivity.

\(^4\)Effort may also be difficult (costly) for employers to observe. Even if observable to employers, effort is usually unverifiable to third parties (such as courts) and thus is often assumed to be non-contractible.
functions cannot be consigned to “worker-hours” because the productivity of those hours varies by how many hours are worked. By setting starting and ending hours of work through each day, an employer can directly affect $H_{jt}$, but $E_{jt}$ is at the workers’ discretion and can be influenced by the employer by structuring the incentives that workers face.

This paper investigates these links between hours and other features of contemporary workplaces by making use of observations from recent waves of the British Workplace Employee Relations Survey (WERS). Workplace-level indicators of productivity, injuries, and absenteeism are examined, and the role of performance-based pay is investigated to assess whether the greater incidence of personal injuries of workers on payments-by-results systems (as documented by DeVaro and Heywood 2016) relate to these workers’ longer work hours.

Working hours may affect an establishment’s operations in ways not measured by conventional measures of labor productivity. For instance, an increase in working hours may entail rising hourly earnings of production and of supervisory workers and will raise the costs of operating machines longer and of heating, ventilating, and lighting workplaces longer. If employees’ long hours of work have damaging health consequences, an employer’s experience-rated insurance costs may rise. Because of these concerns, in addition to labor productivity, an indicator of financial performance is used to measure the consequences of hours of work for a firm’s net returns. A further advantage of financial performance (or profit) is that it accounts for all costs related to absenteeism, whereas typical labor productivity measures are conditional on who actually shows up for work.

The analysis is set in three interrelated parts. The first (Sections III and IV) examines the relationship between long work hours and productivity. The second (Section V) investigates how long hours relate to health problems and absenteeism. The third (Section VI) considers how performance-based pay relates to hours, shedding light on whether long hours are encouraged or discouraged by performance-based pay.

All three parts involve longitudinal analysis at the establishment level. One advantage of establishment-level (as opposed to worker-level) analysis is that it allows for broad measures of performance such as profit, which account for operational costs of fatigue-induced mistakes that would otherwise be missed (e.g., damage to plant or equipment). A second advantage is that cross-worker productivity and health effects are fully captured in workplace-level analysis but not in
worker-level analysis (e.g., one worker’s fatigue induced by long hours might affect the productivity and health of coworkers).

In work that relates to this study’s first part, Pencavel (2015) finds a nonlinear hours-productivity relationship in which long hours reduce productivity in a sample of British female munition workers assembling artillery shells during the First World War. The study does not consider performance-based pay because of lack of variation in the data (i.e., most munition workers were paid piece rates); the data also lack information on absenteeism and health problems. The present analysis determines whether the results for British munition workers a century ago extend to a modern sample spanning a wide variety of occupations and industries operating under different conditions, as recommended in Denison’s epigraph. It also sheds light on whether the negative productivity effects that accompany long work hours operate through the intermediate channels of increased incidences of workplace health problems and absenteeism.

In another complementary study using the same WERS sample explored here, DeVaro and Heywood (2016) analyze performance-based pay, productivity, workplace health, and absenteeism, but do not consider work hours. Their results suggest that performance-based pay relates positively to productivity, though at the same time such pay is associated with higher absenteeism and health problems (mitigating the overall positive effect of performance-based pay on productivity). 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).

II. Workplace Employment Relations Study

The analysis is based on the British Workplace Employment Relations Study (WERS) which has had six waves since 1980. The two most recent (in 2011 and 2004) are used to construct an establishment panel. In 2004, a cross-section of 2,295 establishments was sampled, and each completed an employer survey. In each establishment, each of 5 to 25 randomly sampled workers completed a survey. In 2011 this process was repeated, with new employer survey responses from a sample of 2,680 establishments and worker survey responses from each of 5 to 25 randomly
sampled workers in each establishment. The worker and employer survey instruments in 2011 closely correspond to their 2004 counterparts. A key feature of the establishment sample in 2011 is that, by design, 989 of those establishments were drawn from the set of 2,295 establishments that also completed the 2004 employer survey. Sampling weights correct for this design feature.

The sample is a balanced panel of 989 establishments interviewed in both 2004 and 2011, a total of 1,978 observations. Much of the information in the sample comes from the employer surveys. Some of the information (including weekly hours) 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 and productivity reduces the analysis sample to 1,200 observations. Repeated observations on establishments permit analyses that account for unobserved, 

5 The surveyed workers include supervisors. 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).

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.

7 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.”

8 Descriptive statistics (arithmetic mean, median, standard deviation) of the key variables in the sample of 1,978 workplace-year observations and the sample of 1,200 workplace-year observations were similar.
time-invariant, establishment-level heterogeneity as expressed in fixed effects.\(^9\)

Two sets of inverse-probability sampling weights (i.e., establishment weights and employee weights) 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 (2016).

**Labor Productivity and Financial Performance**

In both 2004 and 2011, managers in each establishment were asked to compare their establishment with other workplaces in the same industry and to assess labor productivity on a five-point Likert scale from “a lot below average” to “a lot above average.” Managers were asked the same question about financial performance. For each of the performance indicators (productivity and financial), the five categories are aggregated into two to allow estimation of linear probability models (or logit models) that include establishment fixed effects. The productivity and the financial performance measures take the value of unity for responses of “above average” or “a lot above average” and zero otherwise.\(^10\) The distribution of establishment-year observations by these labor productivity and financial performance indicators is shown in Table 1 where \(L_{jt} = 1\) and \(F_{jt} = 1\) identify superior labor productivity and superior financial performance, respectively. The complements of superior performance are \(L_{jt} = 0\) and \(F_{jt} = 0\). It is evident from Table 1 that those establishments with superior labor productivity tend to reveal better financial performance. At the same time, the covariation is far from perfect, suggesting that the two indicators embody different information.

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\(^9\) This would not have been possible using the earlier waves, but two design innovations in the 2011 WERS make this possible. 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 for only the first year in the panel.

\(^10\) These indicators have been used in other research such as Machin and Stewart (1990 and 1996), Pencavel (2004), DeVaro and Morita (2013), and DeVaro and Heywood (2016). Wall et al. (2004) provide support for the use of such indicators.
Hours Worked

The values of the hours variable are reported by the worker in both the 2004 and the 2011 surveys and are responses to a question about “usual weekly hours”.\(^{11}\) Table 2 provides descriptive statistics on the key variables (some of which will be defined subsequently) for the 2004-2011 establishment panel.\(^{12}\)

### III. Workplace Labor Productivity

**Two Hours Regimes**

The empirical problem is to measure the effect of a shift in the within-establishment distribution of weekly hours on the within-establishment productivity distribution. Various shifts of the within-establishment hours distribution are possible. The procedure used here is illustrated first by dividing the distribution of hours into two regimes, those above and those below a certain threshold, \(c\), and by examining the consequences of varying that threshold.

Initially, consider three different weekly hours thresholds (values of \(c\)), each separated by 15 hours: 35 weekly hours, 50 weekly hours, and 65 weekly hours. Let \(H_{c,j,t}\) be the fraction of establishment \(j\)’s (5 to 25) surveyed workers whose reported weekly hours are at least \(c\) in year \(t\). For the 1,200 workplace-year observations in the 2004-2011 panel, Table 3 reports descriptive statistics on the distribution of \(H_{c,j,t}\) as \(c\) varies across these three values: for instance, when the threshold is set at 35 weekly hours, the average (arithmetic mean) value of the fraction of workers at these workplaces working 35 hours or more is 0.62; the average value of the fraction of workers reporting 50 hours or more is eight percent; the average value of the fraction of workers reporting 65 or more hours is less than one percent. The research hypothesis is that, for a sufficiently extreme definition of the hours distribution’s right tail (i.e., for a sufficiently high \(c\) threshold), shifting weekly hours into that tail from below is associated with a reduction in the probability of a workplace having superior labor productivity.

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\(^{11}\) The question about usual weekly hours is “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.”

\(^{12}\) The only variables omitted from Table 2 are the (dichotomous) industry identifiers.
To test this hypothesis, let $L_{jt}$ be a dichotomous variable that takes the value of unity if establishment $j$’s performance (labor productivity) in year $t$ is reported to be above the industry average and of zero otherwise. For ease of interpretation, a linear probability specification is applied, although results from a conditional logit model estimated to the subset of workplaces whose value of $y$ differs in 2011 from its value in 2004 are similar:

\[
\text{prob}(L_{jt} = 1) = \alpha + \beta c H_{cjt} + X_{jt} \delta + \gamma D_t + \eta_j + \epsilon_{jt} \tag{1}
\]

where $X_{jt}$ is a vector of observed establishment characteristics, $D_t$ is a binary indicator for year 2004, $\eta_j$ and $\epsilon_{jt}$ are stochastic components unobserved to the researcher, and $\epsilon_{jt}$ has mean zero. The calendar year and establishment fixed effects are designed to remove differences in an establishment’s physical capital.

Of primary interest is the parameter $\beta c$, the least-squares effect of an increase in the fraction of the establishment’s employees working beyond the threshold hours, $c$, on the probability that establishment-level productivity is above the industry average. Identification of $\beta c$ requires sufficient data on either side of the threshold, a condition that becomes harder to achieve as $c$ increases, given that only 5 to 25 workers per establishment are surveyed each year. If a non-monotonic hours-productivity relationship exists, observations to the right of the peak are required to identify it.

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. Whereas over 73 percent of workplace-year observations have average weekly hours greater than 24, over 8 percent of establishments in the sample have average weekly hours of 50 or more, and 2.4 percent have an average of 60 or more. From $c = 61$ this drops to 1 percent. Although the right tail becomes thin at very high levels of hours, 1,200 workplaces is a large enough sample for meaningful inference.

In equation (1), $X_{jt}$ includes the establishment’s employment\textsuperscript{13} and indicators for industry\textsuperscript{14},

\textsuperscript{13} 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.”

\textsuperscript{14} 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.
private sector, and the presence of a union. A nationally representative establishment sample can be expected to exhibit considerable heterogeneity in both observed and unobserved characteristics. As indicated in Denison’s epigraph, a broad sample is appealing in that it encompasses a wide variety of occupations and industries operating under different conditions. On the other hand, unobserved establishment-level heterogeneity can lead to biased estimates of $\beta_c$. To the extent that such heterogeneity does not change between 2004 and 2011, it is reflected in $\eta_j$, and improvements in the design of the 2011 WERS allow $\eta_j$ to be treated as a fixed effect.\(^{15}\)

The least-squares estimates of the coefficients attached to the right-hand side variables of equation (1) corresponding to $c = 35$ hours, $c = 50$ hours, and $c = 65$ hours are reported in Table 4 along with heteroskedastic-robust standard errors. The estimates imply that an increase in the fraction of workplace $j$’s employees working at least 35 hours raises the probability of a workplace having superior productivity by almost 0.6. This effect becomes negative (though statistically indistinguishable from zero) for an increase in the fraction of employees working at least 50 hours, and at 65 hours the effect is negative, large in magnitude, and precisely estimated.

Now consider not just three linear probability estimates of equation (1), but forty-one estimates, each one corresponding to forty-one different integer values of the threshold $c$, from 25 hours to 65 hours. The forty-one estimates of $\beta_c$ with associated estimated confidence intervals are graphed in Figure 2.\(^{16}\) For $c$ ranging from 25 to 40, the estimated $\beta_c$ varies in the range from around 0.3 to 0.6, with an estimated p-value for $|t|$ always less than 0.1. A discontinuity occurs just beyond 40 weekly hours, with the estimated $\beta_c$ dropping precipitously and, over values of $c$ ranging up to

\(^{15}\) In the 1998-2004 panel, the worker survey was not repeated in 2004, so the linear probability model would need to be estimated on an establishment cross section (either 1998 or 2004), and $\eta_j$ would be subsumed in the constant, $a$. In the 2004-2011 panel, results from random effects and pooled OLS models (which are similar) differ somewhat from the fixed effects models. This is unsurprising, because $\eta_j$ may be correlated with observed covariates. Therefore, the fixed effects results are preferred; others are available upon request.

\(^{16}\) The estimated coefficients on the union and employment variables are, respectively, negative and positive in all labor productivity and all financial performance models. A negative association between productivity and union presence in these surveys is not an unusual finding. For instance, see Fernie and Metcalf (1995) who use the third Workplace Industrial Relations Survey.
60, failing to achieve statistical significance at the ten percent level in all cases except $c = 45$. The point estimates for $\beta_c$ are negative for all values of $c$ beyond 48, though statistical significance at conventional levels is not attained until $c$ exceeds 60. Beyond $c = 60$, the magnitude of $\beta_c$ increases dramatically (from -0.31 at $c = 60$ to -1.19 at $c = 61$). The coefficient is estimated with very high precision for all values of $c$ beyond 60.

The general pattern of results is consistent with a non-monotonic hours-productivity relationship. If usual weekly hours are below 40, increases in hours are associated with a higher probability of establishment-level labor productivity exceeding the industry average. However, once 40 usual weekly hours are reached, there are no productivity gains associated with further increases in hours. As hours cross 60 per week, labor productivity is less likely to be above the industry average.

Three Hours Regimes

The preceding results concern the effect of shifting some probability mass 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 the right tail) from which the hours are drawn that are shifted to the right tail, a second threshold is added, $b$, where $0 < b < c$. This partitions the weekly hours distribution into three regimes. The “left (or lower) tail” refers to $[0, b)$, the “middle” refers to $(b, c)$, and the “right (or upper) tail” refers to the remainder. Defining $H_{b,j,t}$ as the fraction of establishment $j$’s surveyed workers whose reported weekly hours are at least $b$ in year $t$, the linear probability model is:

$$\text{Prob}(L_{jt} = 1) = \alpha + \beta_c H_{c,j,t} + \beta_b H_{b,j,t} + X_{jt} \delta + \gamma D_t + \eta_j + \epsilon_{jt}$$  \hspace{1cm} (2)

Now $\beta_c$ measures the effect of a small shift in hours from $(b, c)$ into the right tail, $\beta_b$ describes a shift

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$^{17}$At $c = 45$, $\beta_c = 0.34$ and is statistically significant at the ten percent level.
from \([0, b)\) into \([b, c)\), and \(\beta_b + \beta_c\) indicates a shift from \([0, b)\) into the right tail.\(^{18}\) When \(b = 0\), 
\(H_{bjt} = 1\), the middle bin disappears, and \(\beta_b H_{bjt}\) is subsumed by \(a\), yielding the original regression and interpretation of \(\beta_c\). When \(b = c\), \(H_{bjt} = H_{cjt}\), 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).\(^{19}\)

Figure 3 plots least-squares estimates of \(\beta_b\), \(\beta_c\), 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 regression with \(c = 61\) and only \(H_{cjt}\) on the right-hand side, the estimated \(\beta_c\) is -1.195 with a standard error of 0.324. Estimating the same regression with \(H_{bjt}\) also on the right-hand side, where \(b = 25\), the estimated \(\beta_c\) is -1.181 with a standard error of 0.311, and the estimated \(\beta_b\) is 0.323 with a standard error of 0.159. The estimates of \(\beta_c\) 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.

The positive estimated \(\beta_b\) suggests a productivity increase when hours are shifted from the left tail to the middle, and comparing \(\beta_b + \beta_c = -0.858\) with -1.181 indicates that the productivity loss when hours are shifted from the left to the right tail is smaller in magnitude than when the hours shifted to the right tail come from the middle. The results are consistent with the productivity of the within-establishment weekly hours distribution being higher in the middle than in the extremes. The preceding patterns are even more apparent for \(b = 35\), when the estimated \(\beta_c\) is -1.196 with a

\(^{18}\) 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 \(\beta_b + \beta_c\).

\(^{19}\) 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 \(\beta_c\) remains unchanged whether or not \(H_a\) is included in the regression alongside \(H_b\) and \(H_c\).
standard error of 0.280, and the estimated $\beta_b$ is 0.582 with a standard error of 0.163.

A discontinuity appears just beyond 40 hours. At $b = 41$, although the estimated $\beta_c$ remains roughly unchanged at -1.196 with standard error 0.323, the estimated $\beta_b$ decreases considerably to 0.035 with standard error 0.149. And at $b = 42$, the estimated $\beta_b$ is -0.014 with standard error 0.184. Thus, beyond 40 weekly hours, the null hypothesis $\beta_b = 0$ cannot be rejected at conventional levels. An interpretation is that as the $b$ threshold increases beyond 40 hours, the left tail already contains the most productive hours, so shifting hours from the left tail into the middle is no longer associated with a productivity increase.

Disaggregated Production Functions

Do the damaging effect of long hours differ across occupations, industries, or other workplace characteristics? The preceding analyses assume that the workplace’s employees are sufficiently similar that individual-worker production functions can be aggregated to a meaningful establishment-level production function, $X_{jt} = \Phi(H_{jt}, E_{jt}, N_{jt})$, as defined earlier. However, the production function may differ across groups of observations. For example, the inflection point of labor productivity with respect to hours may come earlier and be stronger for some industries/occupations/activities/workers than others. Such possibilities are explored and briefly summarized next. The significant reduction in degrees of freedom necessitated by disaggregated analysis has three implications: only two hours regimes are considered rather than three, standard errors are large, and interactive specifications (using the full sample) are sometimes employed rather than estimating models within subsamples.

Equation (1) was estimated (for each of the 41 values of $c$) within the 3 largest industry groups, namely health (21%), education (14%), and manufacturing (13%), where the percentages are (unweighted) sample frequencies. Equation (1) was then estimated using the full sample (again for each of the 41 values of $c$) but including on the right-hand side both a new covariate and its interaction with $H_{cjt}$. The following new covariates were investigated: the percentage of surveyed workers at the establishment whose ages are 16-29, the percentage whose ages are 50+, the percentage who are male, an indicator for “heavy industries” (i.e., production industries like manufacturing and construction, noting that mining is excluded from the sampling frame), the
“union” indicator that was already included in (1) but is now included interactively as well, the percentage of the workplace’s employees that are in blue-collar (or production) occupations versus white-collar (supervisory) ones, and the percentage of the workplace’s employees that are in each of 9 occupational groups.\textsuperscript{20}

Standard errors increase in the preceding analyses relative to the earlier results, particularly when estimating within the three industry subsamples. Nonetheless, the pattern of point estimates in those estimations mirrors the full-sample results in the cases of manufacturing and health but not in education (where a discernible pattern does not emerge). The fact that the point estimates for 2 of the 3 largest industry groups are consistent with the pattern for the full sample suggests that the result in Figure 2 is not merely an artifact of aggregation. Nonetheless, standard errors are large and do not allow for the rejection of various interesting hypotheses (including that the results of Figure 2 hold within industry subsamples). Results from the various interactive specifications that use the full sample were unremarkable, with no clear pattern concerning how the marginal effect of long work hours on the probability of high productivity varies with the worker or workplace attribute in question. All of these results are available upon request.

IV. Workplace Financial Performance

Two Hours Regimes

Consider now the results when variations in superior financial performance are related to working hours. The dichotomous variable $F_{jt}$ replaces $L_{jt}$ in equation (1) where, for establishment $j$ in year $t$, $F_{jt}$ takes the value of unity for superior financial performance and of zero for its complement.

First, when just three values of $c$ are specified (namely, 35, 50, and 65 hours), the coefficient estimates and estimated standard errors are reported in Table 5. Again, as the fraction of an establishment’s employees working beyond a threshold level (a level that increases from 35

\textsuperscript{20}The occupational groups are managers and senior officials; professionals; associate professional and technical; administrative and secretarial; skilled trades; caring, leisure, and personal service; sales and customer service; process, plant and machine operators and drivers; routine occupations.
hours to 50 hours to 65 hours) increases, the marginal probability of superior financial performance declines from 0.46 to -0.42 and then to -0.61.

Using $F_j$, as the dependent variable, when equation (1) is estimated forty-one different times corresponding to forty-one different integer values of the hours threshold $c$, the resulting estimates of $\beta_c$ with 95 percent confidence intervals are graphed in Figure 4. For values of $c$ from 25 to 30, the estimated $\beta_c$ is positive but statistically insignificant at conventional levels; for values of $c$ in $[31, 39]$ it is positive with a magnitude from 0.25 to 0.46, achieving statistical significance at least at the ten percent level; beyond $c = 40$ the estimated $\beta_c$ drops precipitously in magnitude and becomes statistically insignificant at conventional levels; for all values of $c$ above 43 the estimate is negative, though statistical significance at conventional levels is attained only beyond $c = 50$, when the estimated $\beta_c$ increases sharply in magnitude. At $c = 50$, the estimated $\beta_c$ is -0.42 with a standard error of 0.33, whereas as $c = 51$ it is -0.97 with a standard error of 0.39.

Overall, the results suggest a non-monotonic relationship between hours and financial performance, as was the case for labor productivity. Shifting weekly hours from the lower part to the upper part of the distribution is associated with little change in the probability that financial performance exceeds the industry average, as long as the threshold defining the right tail does not exceed 50. But at thresholds beyond 50, shifts in weekly hours from below the threshold to above it are associated with a lower probability of high financial performance. The result parallels that for labor productivity but with a lower critical threshold for weekly hours. The analyses of disaggregated production functions discussed at the end of the preceding section were repeated using $F_j$, as a dependent variable in equation (1) rather than $L_j$. Although they are omitted for brevity, they are available upon request and largely echo those for labor productivity.

Three Hours Regimes

According to the results reported in the previous sub-section, for the financial performance indicator, when two hours regimes are specified and with only $H_{c,j}$ on the right-hand side (with $c = 51$), the estimated $\beta_c$ is -0.967 with a standard error of 0.388. Now, applying
the three hours regime specification with $H_{bjt}$ added to the right-hand side, when $b = 25$, the estimated $\beta_c$ is -0.975 with a standard error of 0.389, and the estimated $\beta_b$ is 0.154 with a standard error of 0.140. Like the corresponding results for labor productivity, there is little change in the estimated $\beta_c$ when $H_{bjt}$ is added to the regression. But in contrast to the labor productivity results the estimated $\beta_b$ is statistically indistinguishable from zero. Thus, the magnitude of the effect on financial performance when hours are shifted to the right tail is insensitive to whether those hours are drawn from the middle, the left tail, or from the middle and left tail combined.

This pattern of results persists for a range of values of $b$ up to 30. However, starting at $b = 31$, the estimated $\beta_b$ become positive and statistically significant at conventional levels, as in the labor productivity model. For example, at $b = 31$, the estimated $\beta_c$ is -0.980 with a standard error of 0.369, and the estimated $\beta_b$ is 0.261 with a standard error of 0.142, so the null hypothesis $\beta_b = 0$ can be rejected at the ten percent level. This pattern of results persists for values of $b$ up to 40, though beyond that the estimated $\beta_b$ drops precipitously in magnitude and fails to attain statistical significance at conventional levels. The preceding results for superior financial performance are summarized in Figure 5, which plots $\beta_b$, $\beta_c$, and $\beta_b + \beta_c$ each as a function of $b$, for values of $b$ ranging from 25 to 46, assuming $c = 51$.

Comparing Labor Productivity with Financial Performance

The results for both the labor productivity and financial performance equations are consistent with a non-monotonic relationship in which the incidence of superior outcomes first rises with weekly hours and then falls. The two indicators differ in the weekly hours threshold beyond which superior performance is decreasing. This threshold occurs earlier for financial performance than for labor productivity. This difference may reflect the discontinuous effect of long hours on hourly earnings and labor costs as hours pass overtime thresholds, an effect reflected in financial performance but not in labor productivity.
Another possibility is that selection bias affects the labor productivity analysis but not the financial performance analysis. To the extent that longer working hours increase the incidence of fatigue, accidents, and work-related health problems, establishments with longer hours schedules may exhibit higher absenteeism, a hypothesis investigated in the next section. Labor productivity measures are conditional on workers being present, so the costs of absenteeism would not be reflected in those measures but would be reflected in financial performance. The productivity profile with respect to weekly hours would then be expected to peak earlier for financial performance than for labor productivity.

V. Absenteeism, Health Problems, and Hours Worked

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 6 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?” When the answer is divided by employment, a ratio called AbRate is generated: the fraction of the establishment’s workers who experienced an absence during the previous year due to an illness listed in Panel A of Table 6. AbRate has a mean of 0.028, and a standard deviation of 0.065. An alternative absenteeism measure, AbDays, is the answer to the following question: “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.

Two series of linear regressions are estimated in which the dependent variables are AbRate and AbDays, with the right-hand sides specified as in (1), varying c from 25 to 65. As

21 The question was not asked for the injuries in Panel B.
with the regression estimates concerning labor productivity and financial performance, the key issue is whether and how the estimated parameter $\beta_c$ varies with $c$. In the fixed-effects models for $AbRate$, the estimated $\beta_c$ is positive for all values of $c$ except for $c = 47$ (where it is slightly negative, with a very large standard error), though no clear pattern emerges concerning its magnitude and degree of statistical significance. In the fixed-effects models for $AbDays$, the estimated $\beta_c$ 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 only 0.116. At $c = 51$, the estimated $\beta_c$ is 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 in $AbDays$, which is a 9.5 percent increase from its sample mean value. Estimates of $\beta_c$ are somewhat smaller for other values of $c$ in $[51, 60]$, ranging from 6.918 to 8.756. Overall, the results suggest, at best, weak statistical evidence of a positive establishment-level relationship between long hours and absenteeism.

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 (asked of employers who report the occurrence of ailments from Panel B of Table 6) 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 6 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 6 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. For all four dependent variables the $\beta_c$ parameters are estimated with low precision, and no clear patterns emerge as $c$ varies. On

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22 That class of ailments is the most commonly reported in the WERS, as seen in Table 6, and is found to be negatively related to productivity (both labor productivity and financial performance) in DeVaro and Heywood (2016).
balance, the data cannot reject the null hypothesis of no establishment-level relationship between long hours and workplace health problems.

The preceding results narrow the scope of possible explanations for the “inverted-U-shaped” hours-productivity patterns documented in Sections III and IV and for the result that the peak of the financial performance profile occurs earlier than that of the labor productivity profile. The data provide no support for the notion that long hours cause workplace injuries or illnesses that, in turn, reduce productivity. A plausible interpretation is that fatigue (rather than the more immediate and acute health problems listed in Table 6) 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. But perhaps a more common manifestation of fatigue is that it simply makes workers less productive on the job. The fact that the absenteeism results reveal, at best, weak evidence of a positive relationship with long hours suggests that factors other than those discussed at the end of Section IV underlie the result that the financial productivity profile peaks earlier (i.e., at a lower value of $c$) than the labor productivity profile. An example would be fatigue-induced misuse of machines, causing more frequent maintenance and replacement costs.

**VI. Performance-Based Pay and Hours Worked**

If long work 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?

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. How $H_{jt}$ varies with and without performance-based pay is, therefore, an empirical question.

The 2004 and 2011 employer surveys ask whether establishment $j$ uses performance-based pay in year $t$. But the 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). The fraction of an establishment’s workers receiving performance-based pay exhibits significantly more temporal

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23 These various possibilities for substitution are curtailed when the employer imposes constraints on hours, in which case the worker can respond to performance-based pay only by adjusting effort. 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).

24 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).

25 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.”

26 As noted in DeVaro and Heywood (2016), 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).
variation. An estimate of this fraction can be constructed for a subset of workplaces using the worker surveys.

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. 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.

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

$$H_{c,j,t} = \alpha + \beta_c PBR_{j,t} + X_{j,t} \delta + \gamma D_t + \eta_j + \epsilon_{j,t}$$  (3)

where $PBR_{j,t}$ 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 III. The parameter of interest is $\beta_c$, 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 workers whose weekly hours are at least $c$ that is associated with a marginal increase in $PBR_{j,t}$.\(^{27}\)

As in Section III, the model is estimated for values of $c$ ranging from 25 to 65.

\(^{27}\)Given two “hours regimes”, the change in the fraction of workers whose weekly hours are below $c$ that is associated with a marginal increase in $PBR_{j,t}$ is $-\beta_c$. 
A figure 6 (unreported for brevity, but available upon request) that displays a graph of $\beta_c$ as a function of $c$ hovers from 0.02 to 0.04 for values of $c$ from 25 to 30, though achieving statistical significance at the ten percent level only when $c = 25$ and $c = 27$. It increases to 0.06 to 0.07 from $c = 31$ to 35, achieving statistical significance at the five percent level throughout that range, whereas at $c = 36$ it drops precipitously (to -0.017) and remains statistically indistinguishable from zero from $c = 36$ to $c = 65$.

The results suggest a non-monotonic “inverted-U” shaped relationship. A greater incidence of performance-based pay is associated with a greater fraction of the establishment’s workers having long hours, if the threshold for “long” is between 31 and 35 weekly hours. But if the threshold is set above 35 hours, no such positive relationship exists. The fact that graph is increasing over part of its range (i.e., that the estimated $\beta_c$ is positive for values of $c$ from 31 through 35) 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, though the relation appears to be nonlinear. An alternative extreme assumption is that workers are entirely free to choose hours.28 In that case the interpretation is that workers receiving performance-based pay choose to increase their output (and, hence, their pay) at least in part by increasing hours;29 but for extreme definitions of the “right tail” (i.e., very high values of $c$), such workers might increase output by lowering hours, i.e., substituting effort for hours, as suggested by the hours-productivity patterns documented in Sections III and IV.30 If the productivity-hours relationship is concave and non-

28This 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.

29An alternative possibility (to be addressed shortly) involves selection.

30Strict convexity in the worker’s disutility of both hours and effort, as well as natural (or employer-imposed) constraints on work hours will ensure workers’ tendencies to choose a mix of hours and effort.
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.

A more realistic assumption than either of these 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. 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 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 regressions 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.

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31 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.
With hours choices reflecting (at least in part) worker behavior, one possibility is that hours increase 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 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 “effort” 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.\footnote{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 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.}

As in Sections III and IV, an analysis with three hours regimes is possible and would proceed as follows. Given a second threshold, $b$, where $b < c$, for each ordered pair $(b, c)$ a pair of regressions would be estimated, each corresponding to one of the three regions.\footnote{More generally, for $k$ hours regimes, there would be $k-1$ threshold parameters and $k-1$ regressions.} For example, if regression (3) is estimated twice (the second time changing the subscript $c$ to $b$), the parameter $\beta_c$ ($-\beta_b$) 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., the half-open interval $[b, c)$, can then be inferred as $\beta_b - \beta_c$. If values of $c$ from 30 to 65 and values of $b$ from 25 to $c - 1$ are considered, there would be 810 $(b, c)$ pairs, or 1,620 regressions. Such analysis is omitted to avoid voluminous output that is not easily summarized.
VII. Conclusions

This investigation suggests that, beyond a certain point, long work hours are damaging to establishment-level productivity. That inflection point occurs earlier for financial performance than for labor productivity, implying that some of the deleterious effects of long hours (e.g., overtime wage premia, and absenteeism related to fatigue) are not captured in conventional measures of labor productivity but are captured in broader measures like financial performance. The results are found for a wide variety of occupations and industries operating under different conditions, as recommended in Denison’s epigraph. No evidence of a link between long work hours and health problems was found, though exhaustion is not measured in the data. Weak evidence was found of a positive relationship between long hours and absenteeism. This suggests that the strong positive relationship between performance-based pay and absenteeism due to sickness that has been found recently in other research using this data set is likely driven only partially by longer work hours.

Two advantages of conducting such a productivity inquiry at the establishment level, as opposed to the individual worker level, are worth noting. First, mistakes induced by fatigue can negatively influence coworkers’ productivity. For example, if fatigue causes misuse of a machine, or an error in calculations, this affects all workers who use that machine or rely on that calculation. Second, focusing on the establishment facilitates the use of broad performance measures (i.e., financial performance) that are inclusive of the full spectrum of benefits and costs of long hours, some of which may not be reflected in conventional measures of individual labor productivity.

The results have managerial implications. Managers are well aware of costs such as overtime wage premia that attach to long hours, but the negative productivity effects may be less well known and have implications for human resource (HR) management policies. For example, the damaging productivity effects of long hours might be mitigated by HR policies like flextime, telecommuting, and fringe benefit offerings such as on-site childcare. In other words, it may be that what matters for workplace productivity is not just the number of hours worked but where, when, and how those hours are worked, how much discretion workers have over when they are
worked, and what demands on their time workers face outside the workplace. There are also implications for the overall structure of compensation; for example, the optimal mix of fringe benefits and monetary compensation may be influenced by optimal work schedules, because benefits are a fixed cost of labor, and shorter work schedules might necessitate hiring more workers.
REFERENCES


Table 1
The Pattern of Superior Labor Productivity \((L = 0, 1)\) and Superior Financial Performance \((F = 0, 1)\) in 1,200 Workplace-Year Observations

<table>
<thead>
<tr>
<th>Labor Productivity ((L))</th>
<th>Financial Performance ((F))</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(L = 0)</td>
<td>0.471</td>
<td>0.135</td>
</tr>
<tr>
<td>(L = 1)</td>
<td>0.139</td>
<td>0.255</td>
</tr>
<tr>
<td>Total</td>
<td>0.610</td>
<td>0.390</td>
</tr>
</tbody>
</table>

In the table above, \(L_{jt} = 1\) and \(F_{jt} = 1\) identify superior labor productivity and superior financial performance, respectively. The complements of superior performance are \(L_{jt} = 0\) and \(F_{jt} = 0\). (Establishment-weighted) cell proportions are displayed.

Table 2
Descriptive Statistics on Key Variables

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>25 %</th>
<th>50 %</th>
<th>75 %</th>
<th>Max</th>
<th>Mean</th>
<th>(\sigma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(L)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0.394</td>
<td>0.489</td>
</tr>
<tr>
<td>(F)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0.390</td>
<td>0.488</td>
</tr>
<tr>
<td>AbRate</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.023</td>
<td>0.714</td>
<td>0.028</td>
<td>0.065</td>
</tr>
<tr>
<td>AbDays</td>
<td>0</td>
<td>1</td>
<td>2.5</td>
<td>5</td>
<td>100</td>
<td>4.431</td>
<td>7.847</td>
</tr>
<tr>
<td>Injuryrate</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>414.201</td>
<td>5.835</td>
<td>22.540</td>
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<tr>
<td>Illness</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0.319</td>
<td>0.466</td>
</tr>
<tr>
<td>Injury</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0.110</td>
<td>0.313</td>
</tr>
<tr>
<td>Joint</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0.178</td>
<td>0.383</td>
</tr>
<tr>
<td>year 2004</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>employment</td>
<td>5</td>
<td>9</td>
<td>15</td>
<td>35</td>
<td>11,566</td>
<td>49.073</td>
<td>196.645</td>
</tr>
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<td>union</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0.366</td>
<td>0.482</td>
</tr>
<tr>
<td>private sector</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.779</td>
<td>0.415</td>
</tr>
</tbody>
</table>

In the above table, \(x\%\) is the value of the \(\alpha\)th percentile and \(\sigma\) is the standard deviation.
Table 3
Descriptive Statistics on the Fraction of Employees Usually Working 35, 50, and 65 Weekly Hours or More across 1,200 Workplace-Year Observations

<table>
<thead>
<tr>
<th>usual weekly hours</th>
<th>≥ 35</th>
<th>≥ 50</th>
<th>≥ 65</th>
</tr>
</thead>
<tbody>
<tr>
<td>minimum</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>25th percentile</td>
<td>0.364</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>median</td>
<td>0.667</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>75th percentile</td>
<td>0.889</td>
<td>0.125</td>
<td>0</td>
</tr>
<tr>
<td>maximum</td>
<td>1</td>
<td>1</td>
<td>0.667</td>
</tr>
<tr>
<td>mean</td>
<td>0.616</td>
<td>0.084</td>
<td>0.009</td>
</tr>
<tr>
<td>standard deviation</td>
<td>0.326</td>
<td>0.154</td>
<td>0.054</td>
</tr>
</tbody>
</table>
Table 4

Linear Probability (of Superior Workplace Labor Productivity) Estimates of Equation (1) where \( H \) measures the Fraction of Workplace-Year Observations at which Employees Usually Work at Least 35, 50, and 65 Hours each Week

<table>
<thead>
<tr>
<th>variable</th>
<th>estimates when ( c ) corresponds to</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>35 hours</td>
</tr>
<tr>
<td>( H_c )</td>
<td>0.582 (0.165)</td>
</tr>
<tr>
<td>Employment</td>
<td>-0.039 (0.111)</td>
</tr>
<tr>
<td>Union</td>
<td>-0.222 (0.114)</td>
</tr>
<tr>
<td>Private</td>
<td>0.009 (0.186)</td>
</tr>
<tr>
<td>Year 2004</td>
<td>-0.003 (0.047)</td>
</tr>
</tbody>
</table>

Heteroskedastic-robust standard errors are in parentheses next to estimated coefficients. Each of the three equations whose estimates are reported above include fixed effects for 12 industry categories. Employment is measured in thousands of workers.
Table 5

Linear Probability (of Superior Workplace Financial Performance) Estimates of Equation (1) where $H$ measures the Fraction of Workplace-Year Observations at which Employees Usually Work 35, 50, and 65 Hours each Week

<table>
<thead>
<tr>
<th>variable</th>
<th>35 hours</th>
<th>50 hours</th>
<th>65 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_c$</td>
<td>0.460 (0.155)</td>
<td>-0.420 (0.327)</td>
<td>-0.606 (0.356)</td>
</tr>
<tr>
<td>Employment</td>
<td>0.049 (0.054)</td>
<td>0.063 (0.049)</td>
<td>0.058 (0.052)</td>
</tr>
<tr>
<td>Union</td>
<td>-0.272 (0.091)</td>
<td>-0.254 (0.107)</td>
<td>-0.266 (0.106)</td>
</tr>
<tr>
<td>Private</td>
<td>0.216 (0.128)</td>
<td>0.204 (0.158)</td>
<td>0.190 (0.139)</td>
</tr>
<tr>
<td>Year 2004</td>
<td>0.042 (0.040)</td>
<td>0.053 (0.041)</td>
<td>0.056 (0.043)</td>
</tr>
</tbody>
</table>

Heteroskedastic-robust standard errors are in parentheses next to their estimated coefficients. Each of the three equations whose estimates are reported above include fixed effects for 12 industry categories. Employment is measured in thousands of workers.
Table 6: First-mentioned Illnesses & Injuries during Previous Year (2004 and 2011 pooled)

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

<table>
<thead>
<tr>
<th>Illness / Condition</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone, joint or muscle problems (incl. back problems &amp; repetitive stress injuries)</td>
<td>590</td>
<td>14.92%</td>
</tr>
<tr>
<td>Stress, depression, anxiety</td>
<td>313</td>
<td>9.05%</td>
</tr>
<tr>
<td>Skin problems</td>
<td>26</td>
<td>0.83%</td>
</tr>
<tr>
<td>Breathing or lung problems (including asthma)</td>
<td>13</td>
<td>0.50%</td>
</tr>
<tr>
<td>Infectious disease (virus, bacteria)</td>
<td>12</td>
<td>0.37%</td>
</tr>
<tr>
<td>Heart disease/attack or other circulatory problem</td>
<td>7</td>
<td>0.26%</td>
</tr>
<tr>
<td>Eye strain</td>
<td>5</td>
<td>0.59%</td>
</tr>
<tr>
<td>Hearing problems</td>
<td>5</td>
<td>0.01%</td>
</tr>
<tr>
<td>Don’t know + Item not applicable + None of these</td>
<td>959</td>
<td>73.36%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1930</td>
<td>100%</td>
</tr>
</tbody>
</table>

Panel B: Workplace injury in the previous year?

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone fracture</td>
<td>269</td>
<td>4.08%</td>
</tr>
<tr>
<td>Acute illness requiring medical treatment</td>
<td>78</td>
<td>1.93%</td>
</tr>
<tr>
<td>Dislocated joint</td>
<td>30</td>
<td>0.74%</td>
</tr>
<tr>
<td>Any other injury leading to unconsciousness</td>
<td>24</td>
<td>0.44%</td>
</tr>
<tr>
<td>Eye injury (including loss of sight)</td>
<td>36</td>
<td>1.55%</td>
</tr>
<tr>
<td>Amputation</td>
<td>6</td>
<td>0.10%</td>
</tr>
<tr>
<td>Don’t know + Refusal + Item not applicable + None of these</td>
<td>1483</td>
<td>91.07%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1927</td>
<td>100%</td>
</tr>
</tbody>
</table>
Mean and Standard Deviation of the Fraction of a Workplace’s Surveyed Workers with Weekly Hours ≥c

With $H_{c,j}$ 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 $H_{c,j}$ are graphed above as a function of $c$ from 25 hours to 65 hours.
Figure 2

Labor Productivity and Two Hours Regimes

Estimated $\beta$, and 95 Percent Confidence Intervals from fitting the linear probability equation (1) for labor productivity for values of $c$ from 25 weekly hours to 65 weekly hours, 2004-2011 Panel of Establishments
Figure 3

Labor Productivity and Three Hours Regimes

In the above graph, c is fixed at 61.
Estimated $\beta_c$ and 95 Percent Confidence Intervals around $\beta_c$ from fitting the linear probability equation (1) for financial performance for values of $c$ from 25 weekly hours to 65 weekly hours, 2004-2011 Panel of Establishments.
Figure 5

Financial Performance and Three Hours Regimes

In the above graph, $c$ is fixed at 51.