The Society for Economic Studies
The University of Kitakyushu
Working Paper Series No.2014-8
(accepted in March 30, 2015)

Do firms consider the health status of workers in maximizing profits? Evidence from manufacturing industry

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Abstract

Firms may incur non-wage costs when workers work long hours, since increased fatigue of workers leads to additional costs such as accidents at work and a loss of output. This paper calls these costs “the costs of fatigue” and applies this idea to a measure for the importance of the health of workers for firms. We develop the dynamic labor demand model in which the costs of fatigue are parameterized. This model holds in the Japanese manufacturing industry. We find that the costs of fatigue significantly affect the decision making of firms, and firms prefer that workers work approximately 40 hours per week, which are the same as the standard working hours in Japan. These findings suggest that profit-maximizing firms have an incentive to keep the demand for hours at a level that creates healthy work environments.

Keywords: fatigue of workers; labor demand; Euler equation

1. Introduction

Long working hours generally increase the fatigue of workers and, consequently, lead to a deterioration in their health (Ruhm, 2000). This is an important issue for firms as well as workers, since factors such as illness and accidents at work impose additional costs on firms (Pencavel, 2014; Ricci et al., 2007; Stewart et al., 2003). For example, workers with fatigue have difficulty concentrating and are more likely to make mistakes at work.[1] In this case, firms suffer losses such as an implicit loss of output and a payment of damages. Accidents at work are likely to induce a loss of or damage to goods and services produced by oneself or others. Similarly, a loss of output occurs for the period during which firms and/or workers deal with accidents, since they cannot devote sufficient time and effort to production. If accidents are caused by overwork, firms may be required to pay damages. Furthermore, firms have to pay higher health care costs to maintain the health of workers. For convenience, this paper calls these costs “the costs of fatigue”, which are incurred by firms and are caused by the lack of the careful management of health at work.

As Pencavel (2014) points out, the prevalence of long working hours leads to not only a reduction in labor productivity, but also an increase in errors, accidents, and illness at work that impose costs on firms. Although several previous studies have examined non-wage costs of the number of workers such as hiring costs (e.g., Oi, 1962), non-wage costs of hours worked discussed above seem to be not fully examined

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[1] For example, Rogers et al. (2004) indicated that, among hospital staff nurses, the risk of making an error significantly increased when their work shifts were longer than 12 hours.

empirically. In this respect, Pencavel (2014) suggests that the importance of the health of workers for firms is not a new argument, whereas it seems to have been neglected in contemporary economic models.[2]

The profit-maximization behavior of firms depends on the cost structure. If the costs of fatigue are high, firms do not prefer the prevalence of long working hours. Firms consider the health status of workers in terms of profit-maximization, and may have an incentive to keep the demand for hours at a level that creates healthy work environments.[3] The adequacy of this hypothesis can be examined by checking the importance of the health of workers for firms, which is measured by the costs of fatigue.

The purpose of this paper is to examine the costs of fatigue empirically. Our investigation can provide useful insights into the subjects such as the health of workers, the labor demand, and the creation of better work environments. For example, this investigation is useful in assessing the effects of labor market policies that aim to reduce overwork and lead to better work-life balance of workers, since such policies are particularly effective in the case where the costs of fatigue are high.

An important issue is how to analyze the costs of fatigue. For example, the costs include implicit factors such as accidents at work and the loss of output, but their statistics are usually not available (Hamermesh and Pfann, 1996). To cope with this

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[2] The relationship between population health and economic growth has been examined empirically (e.g., Bhargava et al., 2001). On the other hand, our argument is based on the theory of the labor market.

[3] Recent studies suggest that firms have a significant influence on the determination of hours worked. For more details, see Section 2 of this paper.

problem, we use the Euler equation approach (Hansen, 2002), and the costs are parameterized in our model. Specifically, we construct a dynamic labor demand model in which firms incur non-wage costs when workers work long hours, and the adequacy of this assumption is examined by the estimation of the Euler equation. Since our model is derived as the solution to the profit-maximization problem, its estimation results can provide information on the costs of fatigue on the basis of the profit-maximization behavior of firms. Therefore, the adequacy of our hypothesis that profit-maximizing firms pay careful attention to the health of workers in determining hours worked can be examined within the framework of our model.

This paper is organized as follows: Section 2 briefly reviews several previous studies. In Section 3, we develop our model and explain its estimation procedure. Section 4 details the data. Section 5 presents the empirical results. Section 6 concludes the paper.

2. Brief review of previous studies

The empirical analysis of this paper is related to some literature, including the health of workers, the demand for hours worked, and labor efficiency and productivity.[4] In this section, we briefly review several previous studies.

Many studies demonstrated that long working hours, increased fatigue, and the

[4] Although this paper gives weight to the labor demand, many studies have also been conducted on the relationship between the labor supply and the health of workers. For details, see Currie and Madrian (1999).

resulting deterioration in the health of workers impaired the performance of workers. For example, Dawson and Reid (1997) compared the impact of sleep deprivation on cognitive psychomotor performance with the impact of alcohol intoxication. Using the laboratory data, they found that the performance after 17 hours of sustained wakefulness decreased to the level equivalent to the performance with a blood alcohol concentration of 0.05%, the proscribed level of alcohol intoxication in many countries.

Stewart et al. (2003) examined the impact of the depression of workers on the labor costs for firms (absenteeism and poor performance of workers). They used the survey data to measure the impact. The costs of lost productive time (LPT) from depression was defined as a difference in LPT between workers with depression and those without. They showed that the total annual costs of workers with depression were US$31 billion higher than those without depression.

Similarly, Ricci et al. (2007) focused on the impact of the fatigue of workers on the costs for firms. The costs of LPT due to fatigue and the other health-related issues were measured by the national cross-sectional telephone survey of U.S. workers. They found that the total annual costs of workers with fatigue were US$101.0 billion higher than those without fatigue. It was also found that the prevalence of fatigue among workers increased the other health-related costs.

In the literature on the demand for hours worked, several empirical studies pointed out that firms had a significant influence on the determination of hours worked. For example, Stewart and Swaffield (1997) stated that workers could not choose their hours worked freely since job offers typically involved hours constraint. They developed the econometric model to examine the gap between actual and desired hours for workers. Using the British Household Panel Survey, they showed that actual hours worked per week for male manual workers were 4.3 longer than their desired hours.

Hamermesh and Trejo (2000) examined the impact of overtime penalty on the labor demand. They applied the difference-in-difference estimator to their empirical analysis. Using the data from the Current Population Survey, they found that the extension of the daily overtime penalty to male workers in California substantially decreased overtime hours and the incidence of overtime workdays for those workers.

Kuroda and Yamamoto (2013) used the friction model developed by Stewart and Swaffield (1997) and found that hours worked in Japan were partially determined by demand-side factors. Furthermore, they pointed out that the demand for hours worked was an increasing function of the user costs of labor such as hiring and training costs, and that the prevalence of long working hours was a rational strategy for Japanese firms to protect highly skilled workers from dismissal.

The characteristics of labor efficiency have not been fully examined empirically. The following are a few notable examples. Lee (2003) estimated the efficient working hour function in Korea. The function was specified as a polynomial of hours worked. Using the semiparametric vector error correction approach, he showed that the most efficient working hours per month ranged from 180 to 190. It was also found that a reduction in hours worked did not create new employment.

Pencavel (2014) examined the relationship between output and hours worked for munition workers. He found a non-linear relationship. Output was proportional to hours worked for the regime in which weekly hours worked were less than 49. However, for the regime in which weekly hours worked exceeded 49, output increased at a decreasing rate as hours worked increased.

3. Model and Estimation Procedure

In this section, we develop our model based on the theory of the dynamic labor demand. This model is used to examine the importance of the health of workers for firms, which is measured by the costs of fatigue. In the literature on the dynamic labor demand, it is common to include adjustment costs of labor inputs as key variables in the model. In this paper, this basic specification is adjusted by including the costs of fatigue.

3.1. Costs of fatigue

An increase in hours worked leads to a decrease in leisure and sleeping time for workers, and makes it difficult for them to pursue health-promoting activities such as exercise (Ruhm, 2000). It is widely accepted that long working hours increase the fatigue of workers and consequently have a negative impact on their health. As mentioned in Section 2, several previous studies indicate that the costs arising from poor health of workers amounted to hundreds of millions of dollars. Along these lines, we assume that the costs of fatigue depend on hours worked.

As Dawson and Reid (1997), Lee (2003), and Pencavel (2014) suggest, a serious impact of the fatigue of workers appears when hours worked exceed a certain level. Therefore, in this paper, the costs of fatigue per worker are specified as

$$G(H_t) = \frac{c_L}{2}(H_t - H^*)^2, \tag{1}$$

where H_t denotes hours worked per worker; H^*, optimal working hours per worker;

and c_L, a positive parameter. This specification assumes that the costs of fatigue increase at an increasing rate as hours worked exceed H^*, and this assumption seems to be reasonable in describing the impact of fatigue. Let N_t denotes the number of workers. Since N workers are employed and they work H hours, $G(H_t)N_t$ can be regarded as the costs at the industry or firm level (Cahuc and Zylberberg, 2004).[5]

This specification is in line with previous studies on the labor demand. Specifically, $G(H_t)N_t$ can be rewritten as

$$G(H_t)N_t = aN_t - (bH_t - cH_t^2)N_t, \tag{2}$$

where $a = c_L(H^*)^2/2$, $b = c_L H^*$, and $c = c_L/2$. The first term of the right-hand side of equation (2) represents fixed non-wage costs such as social security (Ehrenberg and Smith, 2003). The second term represents labor efficiency (Cahuc and Zylberberg, 2004), and cH_t^2 can be regarded as a gross impact of fatigue per worker. For $H_t < H^*$, fixed non-wage costs are offset by the improvement of labor efficiency. However, for $H_t > H^*$, the fatigue of workers becomes apparent and labor efficiency decreases. Therefore, the costs of fatigue increase at an increasing rate as hours worked exceed H^*.

Our main focus is on c_L and H^* since the costs of fatigue are characterized by these structural parameters. In particular, c_L determines the size of the costs of fatigue.

[5] Since $G(H_t)$ increases consistently as hours worked exceed H^*, overtime premium seems to be reflected in this term to some extent.

Therefore, the significance of c_L suggests that the health status of workers, which is measured by the costs of fatigue, significantly affects the decision making of firms. In other words, our hypothesis that profit-maximizing firms pay careful attention to the health of workers can be examined by the estimation of c_L.[6]

3.2. Euler equation

Our model allows for the existence of labor adjustment costs, since it is widely accepted that employers must incur costs when adjusting labor inputs (e.g., Hamermesh and Pfann, 1996). Examples of labor adjustment costs include search costs (costs of advertising, screening, and processing new employees), severance pay, negotiation costs, and the time taken to readjust the schedule and pattern of production.[7] Let $C_H(\Delta H_t)$ and $C_N(\Delta N_t)$ be the costs of adjusting hours worked and the number of workers, respectively, where $\Delta H_t = H_t - H_{t-1}$ and $\Delta N_t = N_t - N_{t-1}$. In this paper, we assume that $C_H(\Delta H_t)$ and $C_N(\Delta N_t)$ have the following quadratic forms:

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[6] In this paper, we adjust the basic model of the dynamic labor demand by including equation (1). If c_L is zero, our modified model is reduced to the former one. Therefore, the adequacy of our model can be examined by checking the significance of c_L.

[7] Negotiation costs may arise when hours worked are adjusted, since decreased hours lead to a reduction in the salaries of workers and increased hours lead to a reduction in the leisure time of workers.

$$C_H(\Delta H_t) = \frac{c_H}{2}(\Delta H_t)^2 \tag{3}$$

$$C_N(\Delta N_t) = \frac{c_N}{2}(\Delta N_t)^2 \ , \tag{4}$$

where c_H and c_N are the positive parameters that determine the size of the labor adjustment costs.[8]

Let $L_t = H_t N_t$ be the effective labor force. The aggregate production function is usually given by $F(L_t, \varepsilon_t)$, where $\partial F / \partial L_t > 0$ and $\partial^2 F / \partial L_t^2 < 0$, and ε_t denotes a productivity shock observed at the beginning of period t.

A risk-neutral decision maker maximizes the present discounted value of profits (V). The optimization problem is defined as

$$\begin{aligned} V(H_{t-1}, N_{t-1}) = \max\ & F(L_t, \varepsilon_t) - w_t L_t - G(H_t) N_t \\ & - C_H(\Delta H_t) - C_N(\Delta N_t) + \beta \mathrm{E}_t[V(H_t, N_t)], \end{aligned} \tag{5}$$

where E_t denotes the expectations at the end of period t; β, the discount factor; and w_t, the real wage per hour. The first-order conditions with respect to H_t and N_t

[8] This paper assumes symmetric labor adjustment costs since this assumption enables us to more easily estimate equation (1), which is our main focus. Although our model can be extended to the case where labor adjustment costs are asymmetric, we leave this issue for future research. For example, see Azetsu and Fukushige (2009) and Inagaki (2012).

yield the following Euler equations:

$$M_t N_t - c_L (H_t - H^*) N_t - c_H \Delta H_t + \beta \mathrm{E}_t [c_H \Delta H_{t+1}] = 0 \tag{6}$$

$$M_t H_t + \frac{c_L}{2} (H_t - H^*)^2 - c_N \Delta N_t + \beta \mathrm{E}_t [c_N \Delta N_{t+1}] = 0 , \tag{7}$$

where $M_t = F'(L_t, \varepsilon_t) - w_t$. To estimate this model, the actual values of ΔH_{t+1} and ΔN_{t+1} are substituted into equations (6) and (7). Then, these equations are rewritten as

$$M_t N_t - c_L (H_t - H^*) N_t - c_H (\Delta H_t - \beta \Delta H_{t+1}) = u_{1t} \tag{8}$$

$$M_t H_t - \frac{c_L}{2} (H_t - H^*)^2 - c_N (\Delta N_t - \beta \Delta N_{t+1}) = u_{2t} , \tag{9}$$

where u_{1t} and u_{2t} are the error terms. Combining equations (8) and (9) yields the following equation:

$$\frac{\Delta H_t - \beta \Delta H_{t+1}}{H_t N_t} = \lambda + \alpha \frac{\Delta N_t - \beta \Delta N_{t+1}}{H_t^2} + \sigma \frac{1}{H_t^2} + u_t , \tag{10}$$

where $\lambda = -c_L / 2c_H$, $\alpha = c_N / c_H$, $\sigma = c_L (H^*)^2 / 2c_H$, and $u_t = u_{2t} / c_H H_t^2 - u_{1t} / c_H H_t N_t$. To estimate our model, we rewrite equation (10) as

$$h_t = \lambda + \alpha n_t + \sigma x_t + u_t , \tag{11}$$

where $h_t = (\Delta H_t - \beta \Delta H_{t+1}) / H_t N_t$, $n_t = (\Delta N_t - \beta \Delta N_{t+1}) / H_t^2$, and $x_t = 1/H_t^2$.

3.3. Estimation Procedure

Equation (11) is used to examine the costs of fatigue. When a specific value is substituted into the discount factor β, equation (11) can be regarded as a linear regression model that includes three variables, h_t, n_t, and x_t. Therefore, using time series data on these variables, we can estimate the structural parameters λ, σ, and α. This estimation procedure is relatively easy to implement since it is based on a linear regression model and requires only two types of data, H_t and N_t, which are used to calculate the data for h_t, n_t, and x_t.

The estimation procedure of our model involves four steps. The first step involves the estimation of equation (11). Our model holds if the following conditions are satisfied: $\lambda < 0$, $\alpha > 0$, and $\sigma > 0$. To correct for endogeneity and serial correlation in equation (11), we use the generalized method of moments (GMM) developed by Hansen (1982).

The second step involves the test for the significance of the structural parameters λ, σ, and α. An important point to note is that the significance of λ and σ in equation (11) is directly related to the significance of c_L in equation (1). Therefore, the significance of the costs of fatigue described by equation (1) can be checked by the estimation of λ and σ.

The third step involves the calculation of optimal working hours per worker (H^*). In the framework of our model, this parameter can be calculated as follows:

$$\sqrt{\frac{\sigma}{-\lambda}} = H^* . \tag{12}$$

As mentioned in Section 3.1, the main focus of this paper is on c_L and H^* since the costs of fatigue are characterized by these structural parameters. Therefore, the first three steps of this estimation procedure are particularly important for our purpose.

The fourth step involves the investigation of the dynamic adjustment process of the labor demand in response to shocks. This information is reflected in α, which is the ratio of the costs of adjusting the number of workers (c_N) to the costs of adjusting hours worked (c_H), given that $\Delta N_t = \Delta H_t = 1$. In our model, the long-run equilibrium of hours worked is given by H^*. However, hours worked deviate from this equilibrium in the short-run when shocks occur, since the existence of the adjustment costs prevents instantaneous adjustment of hours worked in response to shocks. Therefore, the condition that $\alpha < 1$ implies that the adjustment of hours worked is slower than that of the number of workers, but the condition that $\alpha > 1$ implies that the adjustment of hours worked is quicker than that of the number of workers.

4. Data

4.1. Use of industry-level data for Japan

Given that long working hours are prevalent in a particular industry, the use of industry-level data seems to be helpful in examining the costs of fatigue. In the case of Japan, the Ministry of Health, Labour and Welfare (MHLW) reported that 72.4% of the workers in the manufacturing industry were tired from usual work.[9] Therefore, it is likely that the impact of fatigue can be well described by using the data for the Japanese manufacturing industry.

Figure 1 around here

Figure 1 indicates the relationship between fatigue and hours worked in Japan. It is clear that the impact of fatigue becomes more apparent as hours worked increase. This characteristic is consistent with the assumption of our model and is in line with previous studies on fatigue (e.g., Dawson and Reid, 1997). Therefore, Japanese data seems to provide useful information on the costs of fatigue.

4.2. Data explanation

We use seasonally adjusted monthly data for the Japanese manufacturing industry (Major Group 9 of the Japan Standard Industrial Classification). In this paper, we focus on Japan mainly because hours worked in Japan tend to be longer than those in other major countries (Kuroda and Yamamoto 2013). Therefore, the costs of fatigue are likely to be more significant in Japan.

The data comprise of the regular employment index (2010=100) and the hours worked index (2010=100). We use index data because data units are different. Both data are constructed by the MHLW. The regular employment index is constructed from the data on the number of regular employees. The hours worked index is constructed from the data on total hours worked (total of scheduled and non-scheduled hours worked) per

[9] The data source is the Survey on State of Employees' Health 1997. This survey does not report this industry-level data on fatigue after 1997.

regular employee.

The sample period is from January 2002 to December 2013. This paper uses the data from 2002 since the MHLW established new recognition criteria for brain and cardiac diseases that stem from long working hours in December 2001. The data source is the Monthly Labor Survey, and the time series data are downloadable from the website of the Japan Institute for Labor Policy and Training (JILPT).

5. Empirical Results

Before estimating equation (11), it is necessary to examine the unit root properties of the variables included in equation (11) since we use time series data. In this paper, we use the unit root test developed by Phillips and Perron (1988). To check the robustness of our results, the discount factor β is set to 0.999, 0.950, and 0.900.

Table I around here

The results are reported in Table I. The null hypothesis of a unit root is rejected for all the variables. Therefore, we can use the GMM technique, which corrects for both endogeneity and serial correlation in equation (11).

Table II around here

Table II reports the estimation results of equation (11). The set of instruments includes n_t and x_t with 1 and 2 lags and a constant term. Similar to the above, the discount factor β is set to 0.999, 0.950, and 0.900 to check the robustness of our results. The main findings are summarized as follows.

First, the conditions that $\lambda < 0$, $\alpha > 0$, and $\sigma > 0$ are satisfied, and all the parameters are significant at the 5 percent level. These results are consistent with the theoretical model presented in Section 3 and are not affected by the assumption of the discount factor β. Furthermore, the validity of overidentifying restrictions is not rejected, and the null hypothesis of weak instruments is rejected. These diagnostic tests suggest that equation (11) is successfully estimated.[10]

Second, we find that λ and σ are significant. As mentioned in Section 3, the significance of these parameters directly relates to the significance of c_L in equation (1), which determines the size of the costs of fatigue. Therefore, the estimation results suggest that the costs of fatigue significantly affect the decision making of firms. In other words, profit-maximizing firms prefer that workers work approximately H^* hours.

Third, we find that H^* is approximately 100. As mentioned in Section 4, our empirical analysis uses the hours worked index (2010=100), which is constructed from the data on total hours worked. The annual average of total hours worked per month in 2010 is 161.5 for the manufacturing industry.[11] Given that one month includes four work weeks, our results suggest that H^* is approximately 40 per week. It is noteworthy that this value is the same as the standard working hours in Japan. Since the

[10] We also examine a possible impact of the U.S. financial crisis in 2008 and the Great East Japan Earthquake in 2011. Using the test developed by Hall and Sen (1999), we find that the structural stability of our model is not significantly affected by these events. The results are not reported in this paper but are available from the authors upon request.

[11] The data source is the Monthly Labor Survey.

standard working hours are legally established so as to maintain the health of workers, we may reasonably state that there is evidence in favor of the hypothesis that profit-maximizing firms pay careful attention to the health of workers.

Finally, we find that the costs of adjusting hours worked are lower than the costs of adjusting the number of workers. Since α is significantly larger than 1, our results indicate that $c_H < c_N$.[12] This suggests that when firms decide to change labor inputs in response to shocks, they prefer to adjust hours worked rather than the number of workers since the former adjustment is less expensive than the latter. Therefore, in the short-run, actual hours worked quickly deviate from the long-run equilibrium H^*. For example, firms are likely to reduce hours worked remarkably in response to large negative shocks. In this respect, our finding is consistent with the conclusion of Kuroda and Yamamoto (2013), who pointed out that in Japan, a reduction in hours worked was a useful buffer in protecting workers from dismissal.

6. Conclusion

This paper applies the idea of the costs of fatigue to a measure for the importance of the health of workers for firms. We develop the dynamic labor demand model in which non-wage costs increase as hours worked exceed a certain level. Since our model is derived as the solution to the profit-maximization problem, its estimation results can provide information on the costs of fatigue on the basis of the profit-maximization

[12] For example, in the case where the discount factor is set to 0.999, the *t*-value is 2.6 and the associated *p*-value is less than 0.05.

behavior of firms. Our main findings are summarized as follows: (i) our model is empirically supported; (ii) the costs of fatigue significantly affect the decision making of firms; and (iii) firms prefer that workers work approximately 40 hours per week, which are the same as the standard working hours in Japan.

These findings suggest that firms have an incentive to keep the demand for hours at a level that creates healthy work environments. Therefore, this paper concludes that firms pay careful attention to the health status of workers in maximizing profits, at least during the sample period 2002–2013. As mentioned in Section 4, the MHLW established new recognition criteria for brain and cardiac diseases that stem from long working hours in December 2001. Therefore, firms may have been required to successfully manage physical and mental health issues at the workplace during the sample period.

Finally, we discuss some implications of our findings. We find that the health of workers is an important factor for profit-maximizing firms, and the optimal working hours are the same as the standard working hours. Therefore, at least in the Japanese manufacturing industry, long working hours are inefficient in the long-run from the viewpoint of the labor demand. However, hours worked tend to be longer in Japan than in other major countries. A possible explanation for this fact is that the short-run adjustment of labor inputs is achieved by making changes to hours worked. This is found from our estimation results of the labor adjustment costs. Given that the costs of adjusting the number of workers such as hiring costs are much higher than the costs of fatigue, firms allow that long working hours are prevalent in the short-run. In this respect, our findings are consistent with the situation in Japan. Therefore, although the health of workers is a significant factor for profit-maximizing firms, they attempt to adjust hours worked in response to shocks even though the health of workers deteriorates in the short-run.

Acknowledgments

We would like to thank Akira Yakita, Hideki Toya, Eiji Okano, Kenji Kondoh, Akiyoshi Furukawa, Junya Masuda, Kunihiro Hanabusa, and Taiyo Yoshimi, and seminar participants at Nagoya City University and Chukyo University for their useful comments. We are solely responsible for any errors.

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Table I
Unit root test

		$\beta = 0.999$	$\beta = 0.950$	$\beta = 0.900$
x_t	–3.192*	—	—	—
h_t		–88.155**	–85.467**	–82.426**
n_t		–32.227**	–28.864**	–23.546**

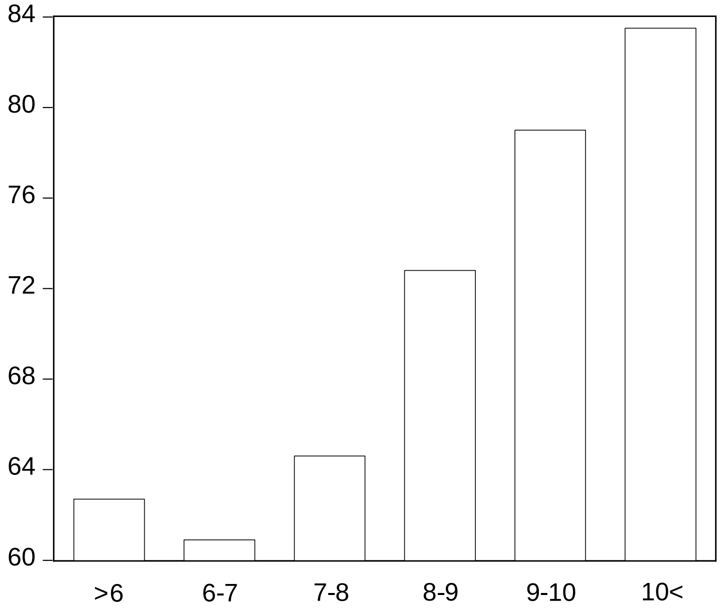
The unit root test includes a constant term. The spectral estimation method used is the Bartlett kernel, and the bandwidth parameter is selected by the Newey and West (1994) procedure. ** and * indicate significance at the 1% and 5% levels, respectively.

Table II
Estimation results of equation (11)

	$\beta = 0.999$	$\beta = 0.950$	$\beta = 0.900$
(A) Parameter estimates			
λ	–0.329*	–0.355*	–0.375*
	[0.162]	[0.171]	[0.173]
α	2.828**	2.501**	2.360**
	[0.711]	[0.702]	[0.713]
σ	3.326*	3.605*	3.813*
	[1.670]	[1.758]	[1.776]
H^*	100.546	100.776	100.839
(B) Diagnostic tests			
J-statistic	2.352	2.528	2.710
	(0.308)	(0.283)	(0.258)
Cragg-Donald *F*-statistic	24.402	23.699	22.432

The estimate of λ and its standard error is multiplied by 1,000 for convenience.
Numbers within square brackets are heteroskedasticity and autocorrelation consistent (HAC) standard errors. The spectral estimation method used is the pre-whitened Bartlett kernel with a vector autoregression (VAR) model. The bandwidth parameter is selected by the Newey and West (1994) procedure. ** and * indicate significance at the 1% and 5% levels, respectively.
The *J*-statistic is the test for the validity of overidentifying restrictions, and numbers within parentheses are *p*-values. The Cragg-Donald *F*-statistic is the test for the null hypothesis of weak instruments (Cragg and Donald, 1993), and the critical values are tabulated in Stock and Yogo (2002).

Figure 1
Relationship between fatigue and hours worked in Japan



The horizontal axis shows hours worked per day, and the vertical axis shows the percentage of the workers who are tired from work. The data source is the Survey on State of Employees' Health 1997.