The Society for Economic Studies
The University of Kitakyushu
Working Paper Series No.2012-8
(accepted in February 21, 2013)

Long working hours and loss of productivity in the health care industry: Evidence from Japan

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Abstract

This paper proposes a simple approach to examine the impact of long working hours on the loss of productivity. This approach does not require data on productivity in examining the loss of productivity. Therefore, this approach is easily applicable to the health care industry, in which output is usually unpredictable. A measure of the impact is theoretically derived from the dynamic labor demand model, and its significance can be checked by the estimation of the Euler equation. We use data for Japan where the overwork of health care workers is a serious problem. There is evidence in favor of the assumption that long working hours lead to a serious loss of productivity in the case of the health care industry. However, this assumption is not supported in other industries such as manufacturing. Therefore, our results suggest that the performance of health care workers is particularly affected by long working hours.

Keywords: productivity; working hours; overwork; health care industry

JEL classification: I10; J23; C51

1. Introduction

According to the World Population Prospects, the aging population is expected to increase rapidly in many countries. Since the elderly require more health care services, both in terms of quality and quantity, it is likely that the demand for labor in the health care industry increases remarkably in these countries. The labor force is usually defined as $L_t = H_t N_t$, where H_t denotes the number of working hours per worker, and N_t denotes the number of workers. Therefore, a rapidly aging population increases the demand for the number of health care workers and/or the demand for the number of working hours per health care worker. However, it seems to be difficult to immediately increase the number of health care workers such as physicians and nurses, since they are highly skilled professionals. When the number of the elderly increases much faster than the number of health care workers, the demand for the number of working hours per health care worker must increase remarkably in order to increase the production of health care services. Hence, the overwork of health care workers is likely to occur in countries with a rapidly aging population.[1]

The aging population is a common problem for many countries. This implies that the overwork of health care workers may also become a common problem for these countries in the near future. For these reasons, it is important to examine the impact of the overwork of health care workers.

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[1] This is an explanation for a possible situation that leads to long working hours of health care workers. In the health care and other industries, long working hours may be caused by different reasons. For example, Sousa-Poza and Ziegler (2003) point out that firms use long working hours as a mechanism to sort productive workers.

It seems reasonable to suppose that the overwork of health care workers means extremely long working hours in the health care industry (e.g., Spurgeon et al., 1997). This notion is helpful in examining the problems that arise from the overwork of health care workers, since we can confine our attention to the impact of long working hours.

In general, long working hours lead to an increase in the fatigue of workers and, consequently, a deterioration in their health, since an increase in the number of working hours leads to a decrease in their leisure time and makes it difficult for them to pursue health-promoting activities such as exercise (e.g., Ruhm, 2000). Hence, it is widely accepted that long working hours have a negative impact on labor productivity (e.g., Barzel, 1973). For example, a disruption in production occurs when workers spend time to improve their own health. Workers with fatigue have difficulty concentrating, which negatively affect their performance in the workplace (e.g., Cahuc and Zylberberg, 2004). They are more likely to make mistakes at work, and this has particularly important implications in the health care industry, which plays an important role in improving and maintaining population health (e.g., Gaba and Howard, 2002).

The purpose of this paper is to examine the impact of long working hours on the loss of productivity in the health care industry. Long working hours are directly related to factors such as fatigue and absenteeism, which lead to the loss of productivity. This concept is applicable to health care workers (e.g., Spurgeon et al., 1997). Therefore, our investigation is helpful to interpret the impact of the overwork of health care workers. For example, if the loss of productivity in the health care industry is high, a decrease in the number of working hours significantly improves productivity, and this improvement may offset a large part of the loss of output that arises from a decrease in the number of working hours (e.g., Leveson, 1967). In other words, our investigation can provide useful interpretations of the effects of labor market policies that aim to reduce the overwork of health care workers. Information obtained from our investigation seems to be a major concern for countries with a rapidly aging population.

An important issue is how to analyze the impact of long working hours on the loss of productivity in the health care industry. For example, several previous studies examined the elasticity of output with respect to the number of working hours based on the estimation of the production function (e.g., Anxo and Bigsten, 1989; Leslie and Wise, 1980). This approach is useful in examining the impact of long working hours, but seems to be not easily applicable to the health care industry since it is difficult for empirical researchers to determine the appropriate measure of output in the health care industry (e.g., Bothwell and Cooley, 1982).[2]

In this paper, we propose a simple approach for the investigation of the impact of long working hours on the loss of productivity. Our approach requires only two types of data (the number of workers and the number of working hours), and therefore is little affected by data constraints. In other words, this approach is easily applicable to the health care industry since we can examine the impact of long working hours on the loss

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[2] Many previous studies in this literature used data for the manufacturing industry (e.g., Anxo and Bigsten, 1989; Leslie, 1984; Leslie and Wise, 1980). However, in the case of the health care industry, output is usually unpredictable and imperfectly understood by producers. Therefore, it is more difficult to determine the appropriate measure of output in the health care industry than in the manufacturing industry. For example, Bothwell and Cooley (1982) used ambulatory encounters and hospital discharges as measures of output in the health care industry.

of productivity without using data on output.

Our approach is based on the theory of the demand for labor. As mentioned above, if a rapidly aging population leads to a remarkable increase in the demand for the number of working hours per health care worker, an empirical investigation based on the theory of the demand for labor can provide useful insights into the overwork of health care workers.[3] The impact of long working hours on the loss of productivity is parameterized in our model. This model has a theoretical foundation since it is derived as the solution to the optimization problem. Furthermore, this model is expressed as a linear regression model. Therefore, in the framework of our model, the estimation of the impact of long working hours on the loss of productivity in the health care industry is relatively easy to implement.

In this paper, we pay careful attention to the estimation of our model. Specifically, we examine the unit root properties of the variables included in our model (e.g., Dickey and Fuller, 1979). In addition, we use the generalized method of moments (GMM) technique to correct for both endogeneity and serial correlation in our model (Hansen, 1982). To assess the appropriateness of the GMM estimation results of our model, we use the test for weak instruments (Stock and Yogo, 2002). Hence, this paper seems to provide reliable estimation results for the impact of long working hours on the loss of productivity in the health care industry.

This paper is organized as follows: Section 2 explains our model. Section 3 describes the data. Section 4 reports our findings. Section 5 offers a discussion. Section

[3] Several previous studies examined the supply of health care workers. For example, see Phillips (1995) and Rizzo and Blumenthal (1994).

6 presents the conclusions.

2. Model

In this paper, we use the dynamic labor demand model.[4] To describe the impact of long working hours on the loss of productivity, the specification of the production function is important. Therefore, we discuss this point first.

Let $L_t = H_t N_t$ be the effective labor force, where H_t denotes the number of working hours per worker and N_t denotes the number of workers. The aggregate production function may usually be given by $F(L_t, \varepsilon_t)$, where $\partial F / \partial L_t > 0$ and ε_t denotes a productivity shock observed at the beginning of period t. In this paper, to describe the impact of long working hours on the loss of productivity, this production function is modified as follows:

$$Y_t = F(L_t, \varepsilon_t) - G(H_t) \tag{1}$$

where $\partial G / \partial H_t > 0$ and Y_t denotes output.

In our model, the number of working hours is allowed to have both positive and negative impact on output. The gross positive impact of the number of working hours

[4] Inagaki (2012) also uses the dynamic labor demand model in examining the labor market structure in the health care industry. We distinguish our work from this study by assuming the production function in which long working hours lead to a serious loss of productivity. Since our focus is on the impact of long working hours on the loss of productivity, this assumption serves our purpose.

on output is described by the first term $F(L_t, \varepsilon_t)$ on the right-hand side of equation (1), and this is usually assumed in the theory of production. On the other hand, the gross negative impact of the number of working hours on output (i.e., the loss of productivity) is described by the second term $G(H_t)$, which represents the impact of factors such as fatigue. Since $G(H_t)$ is an increasing function of H_t, long working hours lead to a fairly large loss of productivity. Therefore, the inclusion of $G(H_t)$ in the production function provides useful information about the negative impact of long working hours discussed in Section 1.

In this paper, we assume that $G(H_t)$ has the following form:

$$G(H_t) = \frac{c_L}{2}(H_t)^2 \tag{2}$$

where c_L is the positive parameter that determines the size of the loss of productivity and, therefore, is the main focus of this paper.[5]

Information on the impact of long working hours on the loss of productivity is

[5] This functional form does not describe the positive impact on productivity such as the on-the-job training, since labor productivity does not increase as the number of working hours increases. However, this positive impact is usually assumed in the case of short working hours (e.g., Barzel, 1973). In other words, our model implicitly assumes that long working hours are prevalent. As mentioned in Section 1, the overwork of health care workers is likely to become a common problem for many countries. Hence, this assumption seems to be useful in examining the health care industry.

reflected in c_L. If c_L is not significant, the modified production function is reduced to the former one. However, if c_L is positive and significant, the inclusion of $G(H_t)$ in the production function is empirically supported and, consequently, long working hours lead to a fairly large loss of productivity. Therefore, the adequacy of the modification can be examined by checking the significance of c_L.[6]

Our model allows for the existence of labor adjustment costs, since it is widely accepted that employers must incur costs when adjusting labor inputs (Hamermesh and Pfann, 1996). Examples of labor adjustment costs include search and training costs for new employees and extra pay for overtime. Let $C_H(\Delta H_t)$ and $C_N(\Delta N_t)$ be the costs of adjusting the number of working hours 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:

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

[6] The inclusion of $G(H_t)$ is also useful for examining heterogeneity between the number of workers and the number of working hours in terms of productivity (e.g., Feldstein, 1967). For example, if c_L is positive and significant, the impact of the number of working hours on output is smaller than that of the number of workers. However, this point is open to debate in the case of the manufacturing industry (e.g., Anxo and Bigsten, 1989), and little is known about the heterogeneity in the health care industry. Therefore, it is important to examine the sign and significance of c_L.

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

where c_H and c_N are the positive parameters that determine the size of the labor adjustment costs.[7]

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

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

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

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

$$M_t H_t - c_N \Delta N_t + \beta \mathrm{E}_t[c_N \Delta N_{t+1}] = 0 \tag{7}$$

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[7] This paper assumes symmetric labor adjustment costs since this assumption enables us to more easily estimate the impact of long working hours on the loss of productivity, which is the main focus of this paper. Although our model can be extended to the case where labor adjustment costs are asymmetric, we leave this issue for future research.

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

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

$$M_t H_t - c_N (\Delta N_t - \beta \Delta N_{t+1}) = u_{2t} \tag{9}$$

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

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

where $\alpha = c_N / c_H$, $\sigma = c_L / c_H$, and $u_t = (u_{2t}/H_t - u_{1t}/N_t)/c_H$.

The most important point to note is that the significance of σ in equation (10) is directly related to the significance of c_L in equation (2). Therefore, the adequacy of the assumption that long working hours lead to a fairly large loss of productivity can be checked by the estimation of σ.

To estimate σ, we rewrite equation (10) as

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

where $h_t = (\Delta H_t - \beta \Delta H_{t+1})/N_t$, $n_t = (\Delta N_t - \beta \Delta N_{t+1})/H_t$, and $x_t = H_t / N_t$. When a specific value is substituted into the discount factor β, equation (11) is regarded as a linear regression model that includes three variables h_t, n_t, and x_t.[8] Hence, using time series data on these variables, we can estimate 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. Our model has a theoretical foundation since it is derived as the solution to the optimization problem. Furthermore, using this model, we can examine the impact of long working hours on the loss of productivity without specifying $F(L_t, \varepsilon_t)$, which is a usual positive relationship between the labor force and output. This seems to provide an advantage for empirical researchers who are particularly interested in the possible negative relationship between the number of working hours and productivity $G(H_t)$.

3. Data

3.1. Explanations for data

[8] As Azetsu and Fukushige (2009) point out, it is likely that the composite error term u_t has non-zero mean even if u_{1t} and u_{2t} have zero mean, since u_{1t} and u_{2t} are divided by N_t and H_t, respectively. In this case, the composite error term may be rewritten as $u_t = \gamma + e_t$, where γ is a constant term and e_t is a random variable with zero mean. Hence, the inclusion of a constant term in equation (11) seems to be useful for maintaining the econometric assumption that the error term in the regression model has zero mean. For this reason, we include a constant term in the regression model.

We use seasonally adjusted monthly data for the Japanese health care industry (medical and other health services; Major Group 83 of the Japan Standard Industrial Classification). In this paper, we focus on Japan for the reasons provided in Section 3.2. The sample period is from January 2000 to December 2010 because of data availability issues. The data comprise of the regular employment index (2005=100) and the hours worked index (2005=100). The data source is the website of the Japan Institute for Labor Policy and Training.

The Japanese health care industry includes establishments engaged in medical treatment (e.g., hospitals, clinics of medical practitioners, dental clinics, and maternity clinics and nursing). According to the Population Census 2005, nurses accounted for the highest proportion of workers who were engaged in medical treatment in the health care industry (45.4%), and physicians accounted for the second highest proportion of those workers (11.3%).[9]

As mentioned in Section 2, our estimation procedure does not require output data in examining the loss of productivity. To estimate equation (11), only two types of data (i.e., the number of workers and the number of working hours) are required. Since data

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[9] More than half of physicians in Japan are hospital physicians. For example, according to the Survey of Physicians, Dentists and Pharmacists in 2008, physicians who were engaged in hospital practice accounted for 60.8% to total physicians, and 3.1% of those physicians (1.9% of total physicians) opened hospitals (including representatives of corporations). On the other hand, physicians who were engaged in clinical practice accounted for 34.1% to total physicians, and 73.7% of those physicians (25.1% of total physicians) opened clinics (including representatives of corporations).

units are different, we use index data.

The regular employment index is used as a measure of the number of workers. The base year is 2005, and the base value is 100. This index is constructed from the data on the number of regular employees, and is published by the Japan Institute for Labor Policy and Training.

The hours worked index is used as a measure of the number of working hours. Similar to the regular employment index, the base year is 2005 and the base value is 100. This index is constructed from the data on the number of total hours worked (total of scheduled and non-scheduled hours worked) per regular employee, and is published by the Japan Institute for Labor Policy and Training.

3.2. Overwork of health care workers in Japan

In this paper, we focus on Japan to examine the impact of long working hours on the loss of productivity in the health care industry, mainly because the overwork of health care workers in Japan is a serious problem.

For example, the Ministry of Health, Labor and Welfare (MHLW) reported that the average number of working hours per week for physicians in Japan was 63.3 in 2006. Physicians under 29 years of age worked about 80 hours per week on average, and physicians between 30–59 years of age worked 60 or more hours per week on average. Since the legal working hours in Japan are set at 40 hours per week, it is clear that most physicians in Japan work extremely long hours. Furthermore, these figures are higher than those in Europe and the U.S.[10]

[10] Simoens and Hurst (2006) and Staiger et al. (2010) reported that in nine European

Similarly, in 2007, the Japan Federation of Medical Worker's Unions indicated the results of a survey that was conducted on 1,355 physicians in Japan. The average number of overtime hours per month was 62.9, and 30.9% of the physicians worked more than 80 hours of overtime. The MHLW points out that overtime exceeding 80 hours per month has a strong relevance to pathogenesis of the brain and cardiac diseases. In fact, the survey results indicated that 43.5% of the physicians were worried about their health. Furthermore, the Japan Federation of Medical Worker's Unions reported that similar observations were also found for nurses in Japan.

It is clear that the prevalence of long working hours among health care workers in Japan influences their health status. Hence, in the case of Japan, the loss of productivity in the health care industry is likely to be high.

Figure 1 around here

Furthermore, as mentioned in Section 1, the aging population can be one of the important factors that lead to the overwork of health care workers. The aging rate in Japan was 23.0 in 2010, and this figure was higher than those of most other countries such as France (16.8), Germany (20.4), the U.K. (16.6), and the U.S. (13.1). Therefore, more health care services are required in Japan. However, Japan had 2.2 practicing physicians per 1,000 population, which was the lowest among the G7 countries. Hence, as mentioned in Section 1, the number of working hours per health care worker must increase remarkably in order to increase the production of health care services. In fact, as indicated in Figure 1, elderly (population over 65 years of age) per physician in Japan was considerably high. Similar observations were also found for nurses. These results

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countries and the U.S., physicians worked about 40 to 50 hours per week on average.

imply that, in the case of Japan, a large amount of work in the health care industry is accomplished by a small number of health care workers. For this reason, long working hours are prevalent in the Japanese health care industry, and our model presented in Section 2 seems to be useful in examining the impact of this problem.

4. Empirical results

In this section, we report our 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).[11]

Table 1 around here

The results are reported in Table 1. To check the robustness of our results, the discount factor β is set to 0.999, 0.950, and 0.900. The null hypothesis of a unit root is rejected for all the variables. Therefore, we are not required to use cointegration techniques when we estimate equation (11).[12]

Since it is found that all the variables do not have a unit root, the next step is to

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[11] If we use the augmented Dickey-Fuller (ADF) test developed by Dickey and Fuller (1979), the results remain unchanged. The ADF test results are not reported in this paper but are available from the authors upon request.

[12] The deterministic trend for x_t is found to be significant. However, if we use the detrended data on x_t, the following results remain essentially unchanged. Therefore, to maintain consistency with the structure of the theoretical model, the deterministic trend for x_t is not adjusted in this paper.

estimate equation (11). For this purpose, we use the GMM technique, which corrects for both endogeneity and serial correlation in 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.

Table 2 around here

The estimation results of equation (11) are reported in Table 2. We find that σ and α are positive and significant. This result is consistent with the theoretical model presented in Section 2. Furthermore, the validity of overidentifying restrictions is not rejected. These results are not affected by the assumption of the discount factor β.

Table 3 around here

To assess the appropriateness of the estimation results of equation (11), it is also important to test weak instruments.[13] We follow Stock and Yogo (2002) and use the statistic developed by Cragg and Donald (1993). The results are reported in Table 3. The null hypothesis of weak instruments is rejected. Hence, it seems reasonable to suppose that equation (11) is successfully estimated.

Our main findings for the health care industry can be summarized as follows. First, we find that σ is positive and significant. Therefore, in the case of Japan, the health care industry has the aggregate production function in which extremely long working hours lead to a serious loss of productivity. For example, the overwork of health care workers in Japan discussed in Section 3 may decrease their production

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[13] The problem of weak instruments arises when instruments are weakly correlated with endogenous variables. For example, Stock et al. (2002) point out that standard GMM inference is potentially unreliable if instruments are weak.

performance.

Second, we find that the gross negative impact of the number of working hours on output, $G(H_t)$, is relatively large in the health care industry. For example, this impact relative to the costs of adjusting the number of working hours, $C_H(\Delta H_t)$, is calculated from equations (2) and (3) as

$$R_t = \frac{G(H_t)}{C_H(\Delta H_t)} = \frac{c_L(H_t)^2}{c_H(\Delta H_t)^2} = \sigma\left(\frac{H_t}{\Delta H_t}\right)^2 \qquad (12)$$

For simplicity, let us assume that the number of working hours per week is 55 for $t=0$ and 60 for $t=1$.[14] Using the estimate of σ in the case where the discount factor β is set to 0.999, we obtain $R_1 = 2.0$. Hence, in this case, the gross negative impact of the number of working hours on output is 2 times larger than the costs of adjusting the number of working hours.[15]

Third, we find that the costs of adjusting the number of working hours are lower than the costs of adjusting the number of workers. This finding is confirmed from the

[14] For example, the average number of working hours per week for physicians in Japan was 63.3 in 2006. For more details, see Section 3.

[15] It is important to note that $G(H_t)$ depends on the level of H_t, whereas $C_H(\Delta H_t)$ depends on the first difference of H_t. Therefore, although we find that the estimates of $\sigma = c_L/c_H$ are small, this result does not necessarily imply that $G(H_t)$ is smaller than $C_H(\Delta H_t)$.

estimation of α. This parameter is defined as $\alpha = c_N / c_H$. From equations (3) and (4), c_H and c_N are the parameters that determine the sizes of the costs of adjusting the number of working hours and the number of workers, respectively. Since it is found that α is significantly larger than 1, our result imply that $c_H < c_N$.[16] This result provides useful insights into the source of the overwork of health care workers. For example, employers in the Japanese health care industry may prefer to increase the number of working hours rather than the number of workers when they attempt to increase the production of health care services, since the adjustment of the number of working hours is less expensive. In other words, the overwork of health care workers in Japan is likely to occur because of the cost structure in this industry.

5. Discussions

To interpret the relationship between long working hours and productivity in the health care industry in greater detail, a comparison with other industries is useful. For this purpose, seasonally adjusted monthly data for the manufacturing (fabricated metal products), wholesale trade (textile and apparel), and transport (transport and postal activities) industries are used. The definition and source of the data are the same as those reported in Section 3. However, to avoid the effects of the U.S. financial crisis in 2008, we use the data for the sample period from January 2000 to July 2008.[17]

To estimate equation (11), we use the GMM technique. For all the industries, the

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[16] The *t*-value is 2.5, and the *p*-value is less than 0.01.

[17] The results for the health care industry reported in Section 4 remain unchanged if we use the data for the sample period from January 2000 to July 2008.

set of instruments includes n_t and x_t with 1 and 2 lags and a constant term. This set is the same as that used in the case of the health care industry. The null hypothesis of a unit root is rejected for all the variables, and the null hypothesis of weak instruments is rejected for all the industries.[18]

Table 4 around here

The estimation results of equation (11) for the manufacturing, wholesale trade, and transport industries are reported in Table 4. For all the industries, α is positive and significant, but σ is not significant. Hence, our results suggest that the impact of long working hours on the loss of productivity is larger in the health care industry than in other industries such as manufacturing and wholesale trade.

We find that the relationship between long working hours and productivity in the health care industry is different from those in other industries such as manufacturing. One possible explanation for this difference is that the ratio of workers who are not healthy is higher in the health care industry than in other industries. As mentioned in Section 2, the significance of σ (or c_L) reflects the impact of factors such as fatigue. For example, the Japan Federation of Medical Worker's Unions found that the ratio of female nurses who are not healthy to total female nurses was 38.2% in 2010. On the other hand, the MHLW found that for all industries, the ratio of female workers who are not healthy to total female workers was 16.0% in 2007. These results suggest that the health status is lower in the health care industry than in other industries. Furthermore, the Japan Federation of Medical Worker's Unions also found that 81.4% of the female

[18] These results are not reported in this paper but are available from the authors upon request.

nurses could not provide sufficient nursing care because of their overwork.[19] This implies that the overwork of female nurses in Japan decreases their productivity. From these results, it seems reasonable to suppose that the overwork of health care workers and the resulting deterioration in their health increase the significance of σ in the health care industry.

Another possible explanation for the difference is that the work load is higher in the health care industry than in other industries. Since health care workers are required to provide high quality services for improving and maintaining the health of patients, it is likely that their physical and mental fatigue increases remarkably as the number of working hours increases. This implies that the labor performance in the health care industry is strongly affected by long working hours. Hence, σ may tend to be more significant in the health care industry than in other industries.

6. Conclusion

This paper examines the impact of long working hours on the loss of productivity in the health care industry. The novelty of this paper is the application of the dynamic labor demand model to the empirical analysis of this impact. In this paper, we assume the aggregate production function in which long working hours lead to a fairly large loss of productivity, and the adequacy of this assumption is examined by the estimation of the Euler equation. Although it is difficult to determine the appropriate measure of output in the health care industry, our approach is little affected by such data constraints

[19] Justina et al. (2009) suggest that low job satisfaction is significantly related to a deterioration in the health of workers.

since this approach requires only two types of data (i.e., the number of workers and the number of working hours). In this framework, the impact of long working hours on the loss of productivity can be examined without using data on productivity. Therefore, it is relatively easy for empirical researchers to apply this approach to the analysis of the health care industry.

In this paper, we use data for Japan where the overwork of health care workers is a serious problem. We find that long working hours lead to a serious loss of productivity in the health care industry. However, this impact is not significant in the manufacturing, wholesale trade, and transport industries. Since work load is higher in the health care industry than in other industries, the labor performance in the health care industry may be more strongly affected by long working hours. On these grounds, we conclude that, at least in the case of Japan, the health care industry is characterized by the aggregate production function in which extremely long working hours lead to a serious loss of productivity.

Finally, we discuss some policy implications. Our results suggest that labor market policies that aim to reduce the overwork of health care workers are effective in improving productivity in the health care industry. Although the loss of output occurs when decreasing the number of working hours, it is expected that a large part of the loss is offset by the improvement of productivity and, consequently, the same amount of output is produced by a slight increase in the number of health care workers. However, employers in the health care industry may have less incentive to increase the number of health care workers, since our results also indicate that the costs of adjusting the number of health care workers are high in Japan. Given the rapidly aging population in Japan, it is important to minimize the loss of output in the health care industry. Therefore, labor market policies that reduce the costs of increasing the number of health care workers are also an important consideration for policy makers attempting to reduce the overwork of health care workers in Japan.

Appendix. Data source

(A) Regular employment index (2005=100)

Source: Japan Institute for Labor Policy and Training

Industrial classification: Medical and other health services

Frequency: Seasonally adjusted monthly data

Sample period: January 2000 to December 2010

(B) Hours worked index (2005=100)

Source: Japan Institute for Labor Policy and Training

Industrial classification: Medical and other health services

Frequency: Seasonally adjusted monthly data

Sample period: January 2000 to December 2010

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Figure 1
Elderly per health care worker

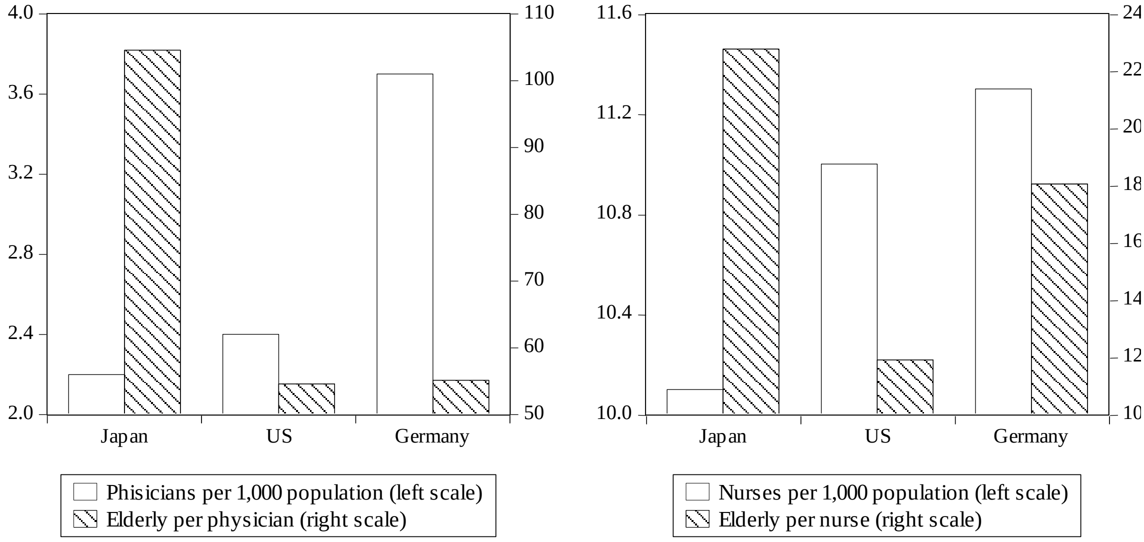

Table 1
Unit root test: Health care industry.

		$\beta = 0.999$	$\beta = 0.950$	$\beta = 0.900$
x_t	–9.2011**	—	—	—
h_t		–86.7634**	–86.7810**	–86.6567**
n_t		–125.4605**	–85.4801**	–49.1328**

The test includes a constant term and a linear trend. The spectral estimation method used is the Bartlett kernel, and the bandwidth parameter is selected by the Newey and West (1994) procedure. ** indicates significance at the 1% level.

Table 2
Estimation results of equation (11): Health care industry.

	$\beta = 0.999$	$\beta = 0.950$	$\beta = 0.900$
α	2.8359**	3.3413**	3.3082**
	[0.7330]	[0.8479]	[0.9300]
σ	0.0138**	0.0123*	0.0116*
	[0.0046]	[0.0055]	[0.0058]
J-statistic	2.5533	3.0488	3.3604
	(0.2790)	(0.2177)	(0.1863)

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. The J-statistic is the test for the validity of overidentifying restrictions. Numbers within parentheses are *p*-values. ** and * indicate significance at the 1% and 5% levels, respectively.

Table 3
Test for weak instruments: Health care industry.

	$\beta = 0.999$	$\beta = 0.950$	$\beta = 0.900$
Cragg-Donald statistic	24.1218	23.9786	23.4705

A constant term and variables n_t and x_t with 1 and 2 lags are used as instruments. The critical values are tabulated in Stock and Yogo (2002).

Table 4
Estimation results of equation (11): Other industries.

	Manufacturing	Wholesale trade	Transport
α	2.4150**	2.5030**	1.4273**
	[0.8224]	[0.6878]	[0.5395]
σ	0.0518	0.0441	0.0282
	[0.0346]	[0.0312]	[0.0183]
J-statistic	1.9583	2.0777	2.2889
	(0.3756)	(0.3538)	(0.3184)

The discount factor is set to 0.999. Numbers within square brackets are HAC standard errors, and numbers within parentheses are *p*-values. See the notes to Table 2 for the estimation procedures. ** indicates significance at the 1% level.